Effect of Source, Drying Method and Treatment Schedule on Treatability of Red Pine

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ABSTRACT

Although sapwood of pine species is generally considered to be readily treated with preservatives, penetration is sometimes variable. The cause of this variability is poorly understood. This study evaluated the effect of geographic source, method of drying, and treatment parameters on penetration of a preservative in red pine lumber. Lumber from Wisconsin and Michigan was air or kiln dried and then conditioned to uniform equilibrium moisture content. Matched specimens were then treated with schedules that vaned in intensity of vacuum and pressure periods. The results indicate that penetration was influenced by anatomical properties inherent to the geographic source of the material. Adequate penetration was achieved using treatment schedules with longer pressure periods, but these schedules also resulted in higher weight gains. The method of drying appeared to have no affect on preservative penetration.

Keywords: red pine, sapwood, preservative penetration, geographic source, drying method, treatment schedule.

INTRODUCTION

The sapwood of most pine species is readily treated with preservatives, but in occasional charges treaters may have difficulty obtaining adequate preservative penetration. This problem has been reported for Southern Pine species, and authors have postulated that factors such as geographic source, drying method, and the use of more mild treatment schedules may play a role (Jewell, et al., 1990; Winandy, et al., 2001). One study concluded that much of the variability within the Southern Pine species group results from treatability differences among the individual species (Jewell et al., 1990). The Jewell et al. study did not find any correlation between kiln schedule and treatability. A more recent study found no correlation between anatomical characteristics and treatability but postulated that milder kiln conditions might improve treatability.

There has been less effort to explore causes of treatment variability in other pine species such as red pine. Although the range of red pine (Pinus resinosa Ait.) is small compared to some other timber species, it represents an important softwood resource for Michigan, Wisconsin, Minnesota, and the northeastern states (Michigan DNR, 2004; Wisconsin DNR, 2005). In comparison to other softwood species native to these areas, red pine's combination of relatively high strength properties and treatability offer advantages for pressure treatment. Red pine is recognized as a treatable wood species by the American Wood Preservers' Association and has penetration and assay zone requirements similar to Southern Pine and ponderosa pine (AWPA, 2005). However, inconsistencies in treatability are occasionally noted for red pine sapwood. This paper reports on a screening study to identify possible causes of treatment variability in red pine. The variables evaluated in this study were geographic source, method of drying, and treatment schedule.

MATERIALS AND METHODS

Specimens were prepared from 38 mm by 88.9 mm by 2.4 m (2-in. by 4-in. by 8-ft nominal) boards (graded as Standard and Better) that were shipped to the USDA Forest Products Laboratory (FPL) from mills in Wisconsin or Michigan. Fifteen boards (each) of kiln-dried and green lumber were provided. The

green boards were air-dried indoors at the FPL until the bulk of drying had occurred and then transferred, along with the kiln-dried boards, to a room maintained at 23°C (74°F) and 65% relative humidity. Following conditioning, each board was cut to obtain four end-matched specimens 254 mm (10 in.) in length. During cutting of specimens, thin cross sections were also removed and oven-dried to determine moisture content. The average moisture content of all groups was between 10% and 11%, except for the air-dried boards from Michigan that had an average moisture content of 13.5%. The four 254 mm (10 in.) specimens cut from each board were end-sealed with a neoprene rubber coating and then randomly assigned to one of four treatment schedules shown in Table 1.

Table 1. Treatment schedules

Schedule	Initial vacuum		Pressure period		*Final vacuum*	
	Minutes	kPa	Minutes	kPa	Minutes	*kPa*
Full cell, no final vacuum	30	–78	60	1241	*none*	
Light vacuum and short press	10	–61	20	1241	55	–78
Full vacuum and short press	30	–78	20	1241	55	–78
Light vacuum and long press	*10*	*–61*	*60*	*1241*	*55*	*–78*

All treatments were conducted at ambient (indoor) temperature using a 1% solution of an amine copper preservative (the copper was solubilized in a solution of ethanolamine and water). Specimens were weighed before and after treatment to determine solution uptake. Following treatment, the specimens were allowed to air-dry and then were cut in half to expose a fresh cross-section. The cross section was first sprayed with a heartwood indicator (AWPA Standard M2-01, Section 4.3.1.1, AWPA 2005), and then sprayed with chrome azurol–S copper indicator solution prepared in accordance with AWPA Standard C31–02 (AWPA 2005). Penetration measurements similar to those determined commercially (by removal of increment cores) were obtained by measuring penetration at the midpoint of both narrow faces of each specimen (AWPA Standard M2–01,AWPA 2005). The two measurements from each specimen were averaged to obtain a single penetration value. Sapwood depth was measured at the same locations, and the percentage of sapwood penetrated was calculated.

The penetration data were analyzed to determine if percentage of sapwood penetrated was significantly affected by geographic source, drying method, or treatment schedule. A nonparametric analysis of variance was conducted on these data because of the absence of a normal distribution and the small sample sizes involved. A Tukey studentized range test was conducted to show group differences. Table 2 summarizes the statistical findings.

RESULTS AND DISCUSSION

Penetration in the specimens was significantly affected by geographic source (Michigan or Wisconsin) and by the treatment schedule (Table 2, Table 3). Percentage of sapwood penetration was generally greater in specimens from Michigan, and it is also apparent that average sapwood depth was greater in these specimens. The difference in percentage of sapwood penetration between the two sources was largely attributable to the one or two sapwood bauds immediately adjacent to the heartwood. In the specimens from Wisconsin, these bands tended to resist treatment, although they did not test positive with the heartwood indicator. Differences in treatability between the two sources were minimized with the use of the full cell treatment schedule.

The full cell schedule (30-minute initial vacuum and 60-minute press) significantly improved penetration in Wisconsin specimens when compared with the two schedules with shorter pressure periods. This finding agrees with a previous study that found that penetration in Southern Pine was significantly improved when a full schedule was used instead of a modified full schedule (Jewell, et al., 1990). The specimens from Michigan treated well with all schedules, but penetration was slightly lower for schedules with the short pressure period. The length and intensity of the initial vacuum appeared to have little effect on penetration.

The method of drying the specimens (air-drying versus Kiln-drying) had no effect on penetration regardless of source or treatment schedule. This finding also agrees with that of Jewell et al. (1990), who reported that drying schedule did not affect penetration in Southern Pine.

AWPA Standard T1-05 (Section 8.1.12) requires that a minimum of 80% of charge members evaluated have a minimum of 85% of the sapwood penetrated with preservarive (AWPA, 2005). The small number of replicate specimens in this study limits the value of a "percentage passing" comparison; although this problem was partially overcome by combing the results of the air- and kiln-dried groups from each source (statiscical analysis indicated that drying method had no effect on penetration). The percentage of cores meeting the minimum penetration requirements for each treatment schedule is shown in Table 4. Only the full cell treatment schedule achieved satisfactory penetration in 80% of samples for the material from Wisconsin. In contrast, only the schedule with the light initial vacuum and short pressure period failed to achieve adequate penetration in 80% of the samples from Michigan, and this treatment would have passed with one additional satisfactory sample.

The findings of this study indicate that much of the variablility in treatability of red pine is attributable to the source (or inherent anatomical properties) of the material. In some cases, the conversion of sapwood to heartwood may occur over gradually across several growth rings, and the physical changes that limit permeability may not always coincide with the development of the polyphenol compounds that react with heartwood indicator. However, the scope of this study was limited and does not provide strong evidence of regional differences in the treatability of red pine. The differences noted here may simply reflect localized growing or soil conditions for trees cut at the two sites.

It appears that more uniform penetration can be obtained with the use of a full cell treatment schedule, but this schedule also increases solution uptake (Table 2) and thus weight of the treated product. A schedule utilizing a short initial vacuum and longer pressure period may provide reasonable compromise between increasing penetration and minimizing uptake, although the increase in treatment time is a drewback to this approach.

Table 2. Statistical analysis of the effect of geographic source, drying method, and treatment schedule on the percentage of sapwood penetrated with a preservative.

Variable	Significant effect?	Mean separations for sapwood penetration (%)
Geographic Source	Yes	Michigan (95%) > Wisconsin (80%)
Drying method	No	Kiln Dry (88%) = Air Dry (87%)
Treatment schedule	Yes	Full cell (97%) = Short vacuum (93%) >
		Short press (80%) = Light vacuum and short press (80%)

Table 3. Average sapwood depth and penetration values for each type of material. Values in parentheses represent one standard deviation from the mean.

	Treatment Schedule			
Material	Full cell	Light vac, short press	Short press	Light vacuum
Michigan, air dry				
Sapwood depth (mm)	43.0 (3.9)	40.5 (7.5)	40.0 (8.3)	42.0 (5.6)
Penetration (mm)	43.0 (3.9)	36.6 (13.4)	36.0 (12.2)	42.0 (5.6)
Sapwood penetrated (%)	100.0 (0)	90.0 (26.7)	90.7 (24.0)	100.0 (0)
Uptake (kg/m^3)	668.8 (49.4)	421.6 (67.5)	524.6 (90.5)	476.0 (73.3)
Michigan, kiln dry				
Sapwood depth (mm)	40.2 (8.1)	36.3 (9.9)	35.1 (10.8)	40.6 (7.3)
Penetration (mm)	40.2 (8.1)	33.1 (13.4)	31.2 (11.6)	40.5 (7.5)
Sapwood penetrated (%)	100.0 (0)	90.3 (17.2)	90.1 (18.5)	99.5 (2.1)
Uptake (kg/m^3)	614.4 (77.2)	376.1 (78.7)	452.9 (111.5)	465.8 (60.7)
Wisconsin, air dry				
Sapwood depth (mm)	20.1 (9.6)	20.7 (12.2)	17.9 (12.6)	20.1 (8.5)
Penetration (mm)	18.9 (10.0)	11.2 (9.9)	10.8 (9.0)	16.1 (9.7)
Sapwood penetrated (%)	94.6 (11.4)	64.5 (28.4)	70.0 (26.02)	82.7 (18.9)
Uptake (kg/m^3)	398.9 (124.8)	239.3 (110.6)	245.2 (140.3)	328.5 (106.4)
Wisconsin, kiln dry				
Sapwood depth (mm)	28.7 (13.9)	23.6 (12.6)	20.2 (7.9)	22.7 (9.9)
Penetration (mm)	26.1 (13.1)	15.2 (9.3)	12.0 (4.3)	19.6 (7.5)
Sapwood penetrated (%)	93.1 (12.3)	74.0 (26.0)	68.7 (19.4)	89.6 (12.4)
Uptake (kg/m^3)	453.9 (110.0)	259.0 (90.1)	255.9 (56.3)	355.6 (80.4)

Table 4. Percentage of samples in with at least 85% of sapwood penetrated. Air- and kiln-dried specimens have been combined for a total of 30 specimens in each group.

Treatment schedule	Michigan		Wisconsin	
	Number passing	Percentage passing	Number passing	Percentage passing
Full cell, no final vacuum	30	100	27	90
Light vacuum and short press	23	77	10	33
Full vacuum and short press	25	83	19	63
Light vacuum and long press	30	100	11	37

CONCLUSIONS

It is clear within the limited scope of this study that the extent of sapwood penetration differed between samples obtained from Michigan and Wisconsin. This study does not establish a cause for this difference, but we noted that specimens from Michigan tended to have a greater proportion of sapwood. No link was found between treatability and method of drying. Penetration was improved through the use of a "true" full cell treatment schedule, or with the use of a longer pressure period.

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