WESTERN WOOD SPECIES TREATED WITH CHROMATED COPPER ARSENATE: EFFECT OF MOISTURE CONTENT

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ABSTRACT

The effect of wood moisture content on treatability with chromated copper arsenate was examined for western hemlock, mountain hemlock, grand fir, white fir, noble fir, Pacific silver fir, and Douglas-fir lumber. Samples were removed over the course of drying, their moisture contents were determined, and the samples were treated with chromated copper arsenate by a full-cell process. Treatment of samples from individual boards varied widely, reflecting the inherent variations in treatability found in these species. Comparisons between rate of drying and treatability for individual boards suggested that sorting by drying rate could be used to improve treatment for western hemlock and grand fir. The implications of these findings are discussed with regard to current practices and commercial feasibility.

It is generally accepted that wood of most species must be dried prior to preservative treatment, but there is some debate about how dry wood must be to obtain optimum treatment. Recent studies have suggested that careful selection of pretreatment moisture content (MC) can improve treatment results while reducing drying costs (3,6); however, there is little information on optimum moisture levels for treatment of most western wood species. In this report we describe how drying to varying moisture levels affects chromated copper aresenate (CCA) treatment of lumber of six hem-fir species plus Douglas-fir.

MATERIALS AND METHODS

Freshly cut logs of grand fir *(Abies grandis* (Dougl. ex D. Don) Lindl.), noble fir *(Abies procera* Rehd.), Pacific silver fir *(Abies amabilis* Dougl. ex Forbes), mountain hemlock *(Tsuga mertensiana* (Bong.) Carr.), western hemlock *(Tsuga heterophylla* (Raf.) Sarg.), and Douglas-fir *(Pseudotsuga menziesii* (Mirb.) Franco) were collected from a site 15 miles east of Detroit, Oreg., in the Cascade Mountains. Log collections were necessary because of the difficulty in separating the hem-fir group by species on the basis of wood appearance (7). The logs were collected during the winter and stored for 1 month under a water spray prior to being sawed into forty-two 50-mm by 100-mm by 2.4-m-long boards. A seventh species, white fir *(Abies concolor* (Gord. & Glend.) Lindl. ex Hildeb.) was provided as dimension lumber from a mill near Klamath Falls, Oreg. These 42 boards were also stored under a sprinkler until needed. Boards were primarily heartwood or, in the case of western hemlock, came from the inner core of the log.

The boards were dried according to a conventional schedule for drying hem-fir lumber; the schedule called for end-coating the boards with an elastomeric paint to retard end-drying (4). All the boards of each of two species were dried in a single kiln charge. Over the course of drying, six or seven 25-cm-long sections were cut from the end of each board at different times and immediately placed in plastic bags. Six sections were collected from Douglas-fir and mountain hemlock; seven sections were removed from the remaining species. After each section was removed, the cut end on the remaining board was resealed and the drying process was continued.

After each cut section had cooled for a minimum of 5 hours, a 7.5-cm-thick slice was cut from the freshly cut end and weighed (nearest 0.1 g). The slice was then ovendried for 24 hours at 105°C and reweighed to determine wood MC. The remaining 17.5-cm section was end-coated with epoxy, weighed (nearest 0.1 g), and pressure-treated with 1 percent CCA Type C (oxide basis) according to a pressure cycle consisting of a 30-minute vacuum (88 kPa) followed by a 3-hour pressure period (880 kPa). These times were selected because they are often commercially used for treating hem-fir lumber with CCA (5).

After treatment, the sections were blotted dry and reweighed to determine gross preservative retention. They were

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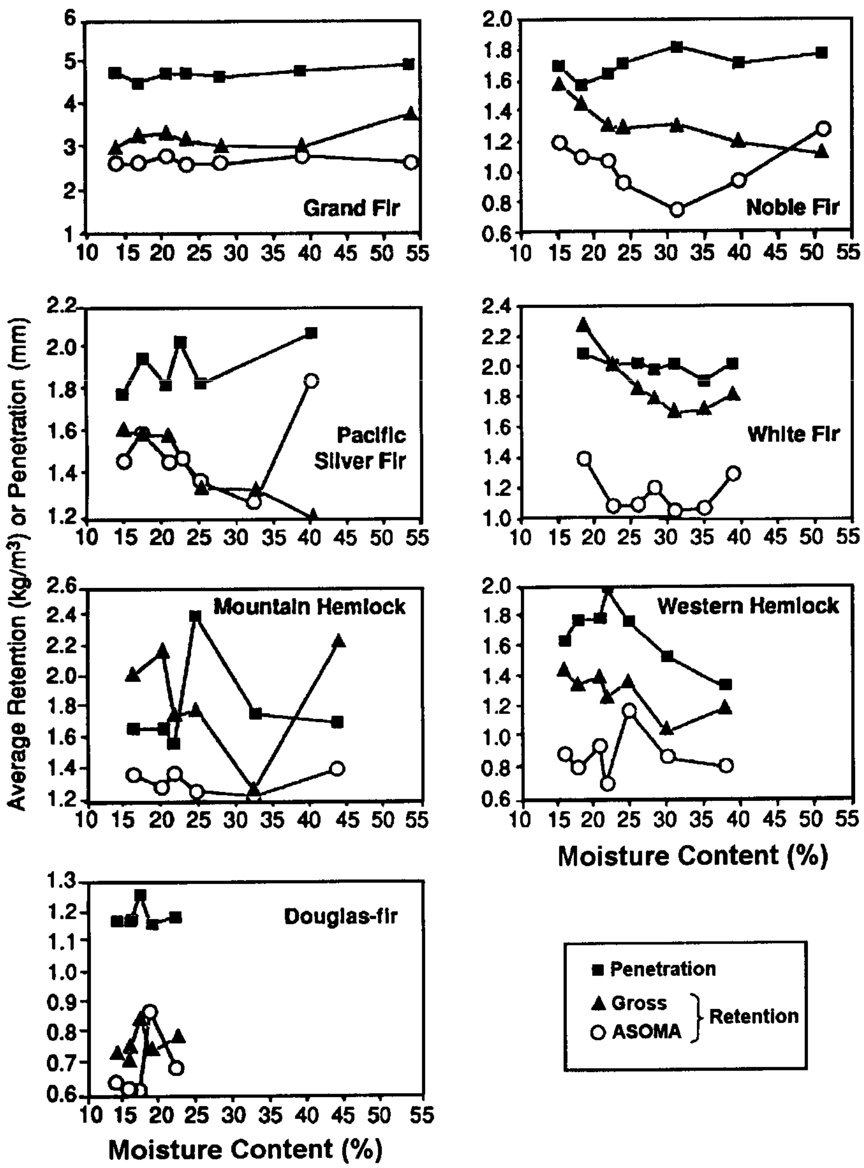

Figure 1. — Average penetration and retention (gross and chemically analyzed by ASOMA) of CCA in all hem-fir and Douglas-fir boards at various wood MCs.

hen air-dried for a minimum of 2 weeks at room temperature. A 1-cm-thick slice was cut from one end of each section, and the freshly cut surface was sprayed with chrome azurol S, an indicator for the presence of copper (l). Copper penetration was used as the measure of CCA penetration. Preservative penetration was measured at eight points around the cut surface of each section and averaged. A 15-mm-thick slice was then cut from the center 25-mm square on the wide face of each section and ground to pass a 20-mesh screen. The resulting sawdust was assessed for CCA content with an ASOMA 8620 x-ray fluorescence analyzer (ASOMA Instruments, Austin, Texas) using the density values specified in the Standards of the American Wood-Preservers' Association (2).

Often lumber is separated based on final MC, and the wet pieces are sold to treaters. If the pieces that were slow to dry are also difficult to treat, then this is clearly not a good practice. A drying curve was determined for each board based on the MCs and sampling times of the six or seven sections (4). The boards from each species were then separated into two groups: boards that were wetter than the average charge MC and those that were drier when the average charge MC was 15 percent. A t-test was then used to compare the average penetrations and retention for the two groups. These were the average values for the six or seven sections from each board.

A drying rate (%/hour) was also calculated for each board based on the time required for it to dry from 35 to 25 percent MC. Average penetration and retention were then regressed against drying rate to determine if boards that gave up moisture slowly also were difficult to treat.

Results and discussion

As expected, there was wide variation in treatability within and among the species tested, and none of the results met the requirements of the American Wood-Preservers' Association (2) for CCA treatment of lumber (penetration = 10 mm, retention = 6.4 kg/m^3) **(Fig. 1).** In addition, there were dramatic variations in treatability among sections cut from the same board. While incising would theoretically improve these results, incising prior to drying would have affected both drying rate and the resulting moisture gradient, while the smallness of the sections precluded incising after drying. The results, however, do provide a relative guide to the effects of MC on treatment for each species.

Douglas-fir was the least treatable of the species tested, as is generally the case with this species. Average MCs of the six sections cut at different times ranged from 14.5 to 22.5 percent **(Fig. 1),** which is a relatively narrow span that reflects the lower initial MC of this species and its slower drying rate. In general, retention and penetration were uniform over this moisture range, although there was a slight improvement in retention (by assay) between MCs of 17 and 19 percent. This effect was, however, slight and probably not of practical use.

Of the remaining species, all but grand fir exhibited similar degrees of treatability, although there were slight differences in the recorded relationships between MC and treatment results **(Fig. 1).** Rententions (by assay) of noble fir, Pacific silver fir, and white fir declined slightly as the wood dried, then increased again to their former levels as the wood reached its final MC. Retention (by assay) varied little with MC in grand fir and mountain hemlock, while it increased slightly as western hemlock dried but finally returned to near its initial level. In general, the differences between retentions at various MCs were small, suggesting that within the ranges evaluated, moisture level had little influence on treatment.

Preservative penetration followed patterns similar to those found with retention, although there were some slight differences among species **(Fig. 1).** In white fir, grand fir, and noble fir, penetration was fairly uniform with varying MC; in Douglas-fir and Pacific silver fir it increased slightly at MCs between 17 and 25 percent. Substantial improvements in penetration were noted at MCs near 25 percent in both western hemlock and mountain hemlock; however, in both species, penetration declined sharply on either side of the optimum.

While the various sections from individual boards were end-matched and should therefore be reasonably comparable, variation within and among boards of a single species compromised generalizations drawn about the relation between treatability and moisture level. For example, linear regression of retentions (by assay) on MC of Douglas-fir and grand fir produced r^2 values of 0.0014 and 0.0159, respectively, suggesting that virtually none of the variation in retention was explained by MC **(Fig. 2).**

The process of sorting boards into two groups (high and low MC) suggested that the latter could be related to treatability in some species (namely grand-fir, white fir, and western hemlock), although this relation was not always consistent among the groups selected or the parameter measured **(Table 1).** The differences between wet and dry boards of grand fir were significant for retention ($\alpha = 0.05$) and penetration ($\alpha = 0.10$) at lower moisture levels. Conversely, penetration measurements, but not those for retention, differed significantly between the two groups for white fir. Separations for rate of drying produced significant improvements in both penetration and retention for western hemlock under nearly all conditions tested. Lower moisture levels improved treatment for grand fir, white fir, and western hemlock.

Thus, the limited number of mills that segregate lumber of western hemlock or white fir might benefit from presorting such lumber on the basis of moisture level before selling it to the treatment industry. It is doubtful, however, that the volume of lumber destined for treatment is adequate to support such selection.

Both penetration ($r^2 = 0.02$) and retention ($r^2 = 0.01$) appeared to be independent of drying rate, as neither regression was significant at the 95 percent confidence level. This occurred despite a wide range of drying rates for the hem-fir boards—varying from 0.5 percent/hour to 1.7 percent/hour as the boards dried from 35 to 25 percent MC. Douglas-fir was not included in this analysis because of the large differences in drying and treating between it and other species in the study.

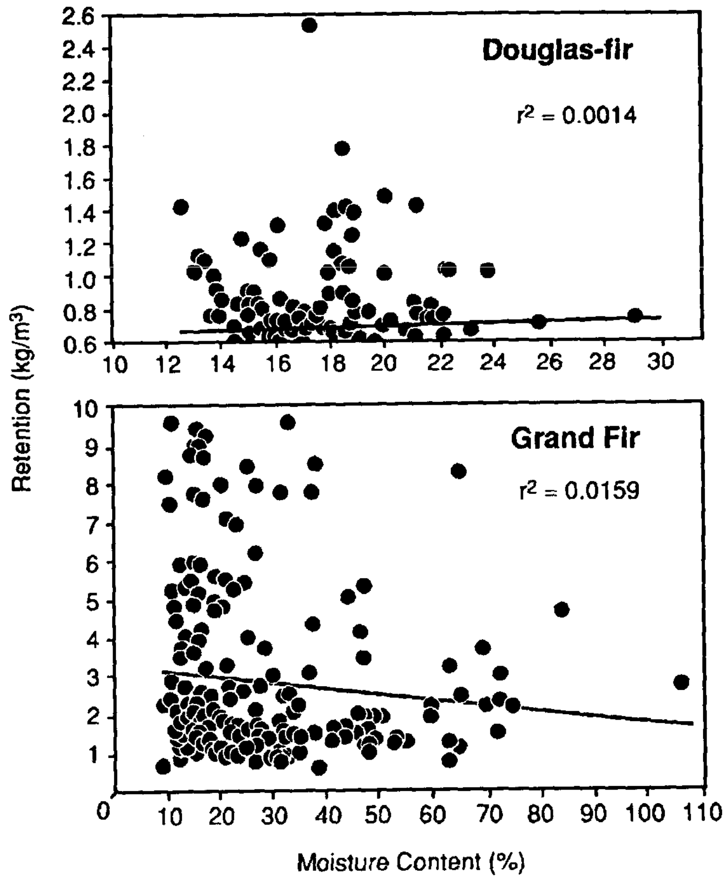

Figure 2. — Relationship between wood MC **of individual boards at the time of CCA treatment and retention (by assay), in Douglas-fir and grand fir.**

TABLE 1. — Penetration and retention of CCA in kiln-dried and Douglas-fir boards sorted into wet and dry groups.[a,b,c]

Species	Penetration Wet	Penetration Dry	Retention Wet	Retention Dry
	(mm)		(kg/m³)	
Grand fir	3.6 (3.0)	6.7 (5.6)*	2.2 (1.6)	3.8 (2.4)**
Noble fir	1.6 (0.5)	1.8 (0.4)	1.1 (0.3)	1.0 (0.2)
Pacific silver fir	1.4 (0.4)	1.3 (0.2)	1.4 (0.3)	1.4 (0.3)
White fir	1.7 (0.6)	2.4 (0.5)**	1.1 (0.3)	1.3 (0.3)
Mountain hemlock	1.8 (0.2)	8.0 (0.3)	1.3 (0.3)	1.4 (0.4)
Western hemlock	1.4 (0.3)	1.9 (0.3)**	0.8 (0.2)	1.1 (0.2)**
Douglas-fir	1.2 (0.3)	1.2 (0.2)	0.7 (0.2)	0.7 (0.2)

[a] "Wet" and "dry" refer to time required to reach the specific moisture content.
[b] Twenty-one boards of each species were placed in the high-moisture-content group and 21 in the low-moisture-content group. Figures in parentheses represent one standard deviation.
[c] * = significant difference at the 90 percent level between corresponding values for high- and low-moisture-content boards within a species. ** = significant difference at the 95 percent level between such corresponding values.

Waterremoval from the board when the surface is below the fiber saturation point depends largely on the diffision of gas or bound water through the piece, while treatment depends on the permeability. Therefore, it is not clear that there should be a strong relationship between dryability and treatability. Further investigation into this would be academically interesting; however, in practice, sorting based on drying rate would be difficult.

While drying to specific moisture levels prior to treatment appears to have little merit, kiln operators could use inline capacitance-type moisture meters after drying to select wood for treaters. Kiln operators already sell the wetter boards after kiln-drying to the wood-treating industry; however, this is done for economic reasons, not to enhance treatability. The results indicate that the practice of using wet-sorts does not have a significant negative impact on the resulting treatment of most hem-fir species.

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