INADEQUATE REDRYING LINKED TO DIMENSIONAL INSTABILITY OF CCA-TREATED SOUTHERN PINE LUMBER

TODD F. SHUPE*
STAN T. LEBOW*
ELVIN T. CHOONG*
MANZHEN XIONG

ABSTRACT

Some instances of severe warping of siding treated with a commercial waterborne preservative have been reported to the authors. We investigated this problem by evaluating 25-mm-, 51-mm-, and 102-mm- (1-, 2,- and 4-in.-) thick chromated copper arsenate (CCA) treated No. 1 southern yellow pine lumber shipped from three suppliers to a secondary manufacturer in Louisiana. The moisture content (MC), CCA retention, and adsorption/desorption ratio was determined for specimens cut from the lumber. For all lumber thicknesses and target retention levels, including untreated wood, the MC of many boards exceeded the secondary manufacturer's specification of a maximum of 16 percent MC. No consistent relationship was found between CCA retention and the adsorption/desorption ratio, indicating that the presence of the preservative oxides was not causing excessive fluctuations in wood MC. The results suggest that the source of the dimensional instability is the initial high MC due to inadequate redrying.

Louisiana's severe climate requires exceptionally high performance from wood. Lumber that is exposed to repeated cycles of warmth, precipitation, and humidity may suffer from fungal and insect attack. Therefore, it is often recommended that consumers purchase wood that has been treated with some type of preservative to prevent biodegradation. The most widely used preservative is the water-based chromated copper arsenate (CCA). CCA is effective at preventing attack by decay fungi and insects and leaves the wood with a dry, paintable surface. However, several instances of severe warping of wood siding that was commercially treated with CCA have been reported to the authors by a secondary lumber manufacturer. In each case, splitting and associated nail pulling has progressively increased with time. Loss of integrity of the outer surface of the installations was the result. The dominant question raised in each case was whether the degree of warping and associated problems were in part caused by the preservative treatment of the wood.

There is sparse literature that reports special problems of dimensional instability with commercially treated wood destined for service. Generally, problems with dimensional instability of wood in service are associated with high moisture content (MC) during installation, which causes warping, cupping, or twisting as the wood dries. Treatment with waterborne preservatives forces water into the wood, and some dimensional changes in service can be expected if the wood is not adequately redried before it is installed. In this case, however, the concern was raised that problems with dimensional instability were occurring even though the treated wood had reportedly been kiln-dried after treatment (KDAT). This raised the possibility that the preservative oxides themselves were somehow increasing uptake of moisture while the wood was in service. This study sought to address this concern by evaluating the CCA-treated lumber delivered to a secondary manufacturer in Louisiana. The company uses CCA-treated southern yellow pine (SYP) to manufacture outdoor furniture, and the dimensional stability of the lumber is critical. Therefore, the

The authors are, respectively, Assistant Professor, School of Forestry, Wildlife, and Fisheries, Louisiana State Univ. Agri. Center (SFWF/LSUAC), Baton Rouge, LA 70803-6202; Research Forest Products Technologist, USDA Forest Serv., Forest Prod. Lab., Madison, WI 53705; Professor (deceased), SFWF/LSUAC, and Visiting Scientist, Chinese Academy of Forestry, Beijing, People's Republic of China. This paper (No. 00-22-0249) is published with the approval of the Director of the Louisiana Agri. Expt. Sta. This paper was received for publication in June 2000. Reprint No. 9130.
*Forest Products Society Member.

Forest Prod. J. 51(5):59-62.

TABLE 1. — Mean MC of 25-, 51-, and 102-mm- (1-, 2-, and 4-in.-) thick CCA-treated and untreated southern yellow pine lumber at three target retentions.

Lumber thickness	CCA-treated			Untreated
	Target: 4.0 kg/m³ (0.25 pcf)	Target: 4.8 kg/m³ (0.3 pcf)	Target: 6.4 kg/m³ (0.4 pcf)	
	(%)			
25 mm (1.0 in.)	12.1[a] (4.2)[b]	18.2 (5.2)	15.5 (4.0)	15.0 (2.5)
51 mm (2.0 in.)	33.3 (9.3)	37.8 (10.3)	45.2 (12.7)	32.0 (6.1)
102 mm (4.0 in.)	47.5 (14.2)	68.6 (19.2)	55.4 (13.3)	50.8 (9.2)

[a] Each mean value represents 1,800 observations (the grand mean of 50 boards of 36 shipments).
[b] Values in parentheses represent one standard deviation from the mean.

TABLE 2. — Assay and target retention of CCA elements in treated southern yellow pine lumber.

Lumber thickness	Target: 4.0 kg/m³ (0.25 pcf)		Target: 4.8 kg/m³ (0.3 pcf)		Target: 6.4 kg/m³ (0.4 pcf)	
	kg/m³	pcf	kg/m³	pcf	kg/m³	pcf
Assay: chromium trioxide						
25 mm (1.0 in.)	2.87[a] (0.11)[b]	0.18 (0.007)	2.77 (0.11)	0.17 (0.007)	2.69 (0.13)	0.17 (0.008)
51 mm (2.0 in.)	1.92 (0.10)	0.12 (0.006)	2.15 (0.11)	0.13 (0.007)	2.13 (0.09)	0.13 (0.005)
102 mm (4.0 in.)	1.90 (0.10)	0.12 (0.006)	2.01 (0.10)	0.13 (0.006)	1.92 (0.08)	0.12 (0.005)
Assay: copper oxide						
25 mm (1.0 in.)	1.58 (0.05)	0.10 (0.003)	1.58 (0.05)	0.10 (0.003)	1.52 (0.05)	0.10 (0.003)
51 mm (2.0 in.)	1.22 (0.04)	0.08 (0.002)	1.26 (0.03)	0.08 (0.002)	1.25 (0.04)	0.08 (0.002)
102 mm (4.0 in.)	0.96 (0.03)	0.06 (0.002)	1.25 (0.04)	0.08 (0.002)	1.22 (0.04)	0.08 (0.002)
Assay: arsenic pentoxide						
25 mm (1.0 in.)	1.56 (0.06)	0.10 (0.004)	1.71 (0.05)	0.11 (0.003)	1.70 (0.05)	0.11 (0.003)
51 mm (2.0 in.)	1.20 (0.05)	0.08 (0.003)	1.30 (0.05)	0.08 (0.003)	1.46 (0.04)	0.09 (0.003)
102 mm (4.0 in.)	1.31 (0.05)	0.08 (0.003)	1.40 (0.04)	0.09 (0.003)	1.34 (0.04)	0.08 (0.003)
Assay: CCA total						
25 mm (1.0 in.)	6.01 (0.72)	0.38 (0.045)	6.07 (0.61)	0.38 (0.038)	5.92 (0.65)	0.37 (0.041)
51 mm (2.0 in.)	4.34 (0.52)	0.27 (0.033)	4.71 (0.52)	0.29 (0.032)	4.83 (0.48)	0.30 (0.030)
102 mm (4.0 in.)	4.17 (0.50)	0.26 (0.031)	4.66 (0.51)	0.29 (0.032)	4.49 (0.45)	0.28 (0.028)

[a] Mean values of actual chemical retention represent 150 observations. Three samples were taken from 50 randomly selected boards.
[b] Numbers in parentheses represent one standard deviation from the mean.

manufacturer specifies that the CCA-treated lumber supplied to his facility be KDAT to below 16 percent MC. The objectives of this study were to: 1) compare the MC of KDAT SYP lumber and untreated kiln-dried SYP lumber; 2) analytically measure the chemical concentration of copper, chromium, and arsenic oxides in the treated lumber; and 3) determine if the presence of the preservative affected the adsorption and desorption of water by the wood.

Experimental Procedure

This study was conducted in two phases. Phase 1 consisted of measuring the MC of CCA-treated and untreated SYP lumber. No. 1 SYP boards in nominal thicknesses of 25, 51, and 102 mm (1, 2, and 4 in.) were obtained from the secondary manufacturing facility. The secondary manufacturer received 12 shipments from each of the three suppliers (suppliers A, B, and C) over the 10-month duration of this study. The shipments included untreated lumber and lumber treated to target retentions of 4.0, 4.8, and 6.4 kg/m³ (0.25, 0.3, and 0.4 pcf). A resistance-type moisture meter was used to randomly sample 50 boards of each target retention and lumber thickness for the 36 shipments of lumber. Moisture meter readings were obtained from board faces with a Delmhorst Moisture Meter, Model RC-1E, with a 26-E two-prong electrode that was internally recalibrated before each MC determination. The resulting meter readings were adjusted for species, ambient conditions, and electrode as specified by Delmhorst. Although the error associated with resistance-type moisture meters increases substantially above the fiber saturation point (FSP), Chen et al.[1] have shown that a standard electrical resistance moisture meter can estimate high MC values within 5 percent MC of the actual value for red oak and within 10 percent MC for yellow-poplar. Oven-drying of a subset of samples in this study indicated that variation at MCs above the FSP was within 12 to 15 percent. In addition, because the MC specified by the manufacturer was only 16 percent, any reading above the FSP was considered to reflect inadequate redrying. A previous study also indicated that no adjustment is needed when using a resistance-type moisture meter to measure the MC of CCA-treated wood.[2]

[1] Chen, Z., E.M. Wengert, and F.M. Lamb. 1994. A technique to electrically measure the moisture content of wood above fiber saturation. Forest Prod. J. 44(9):57-62.

[2] Richards, M.J. 1990. Effect of CCA-C wood preservative on moisture content readings by the electronic resistance-type moisture meter. Forest Prod. J. 40(2):29-33.

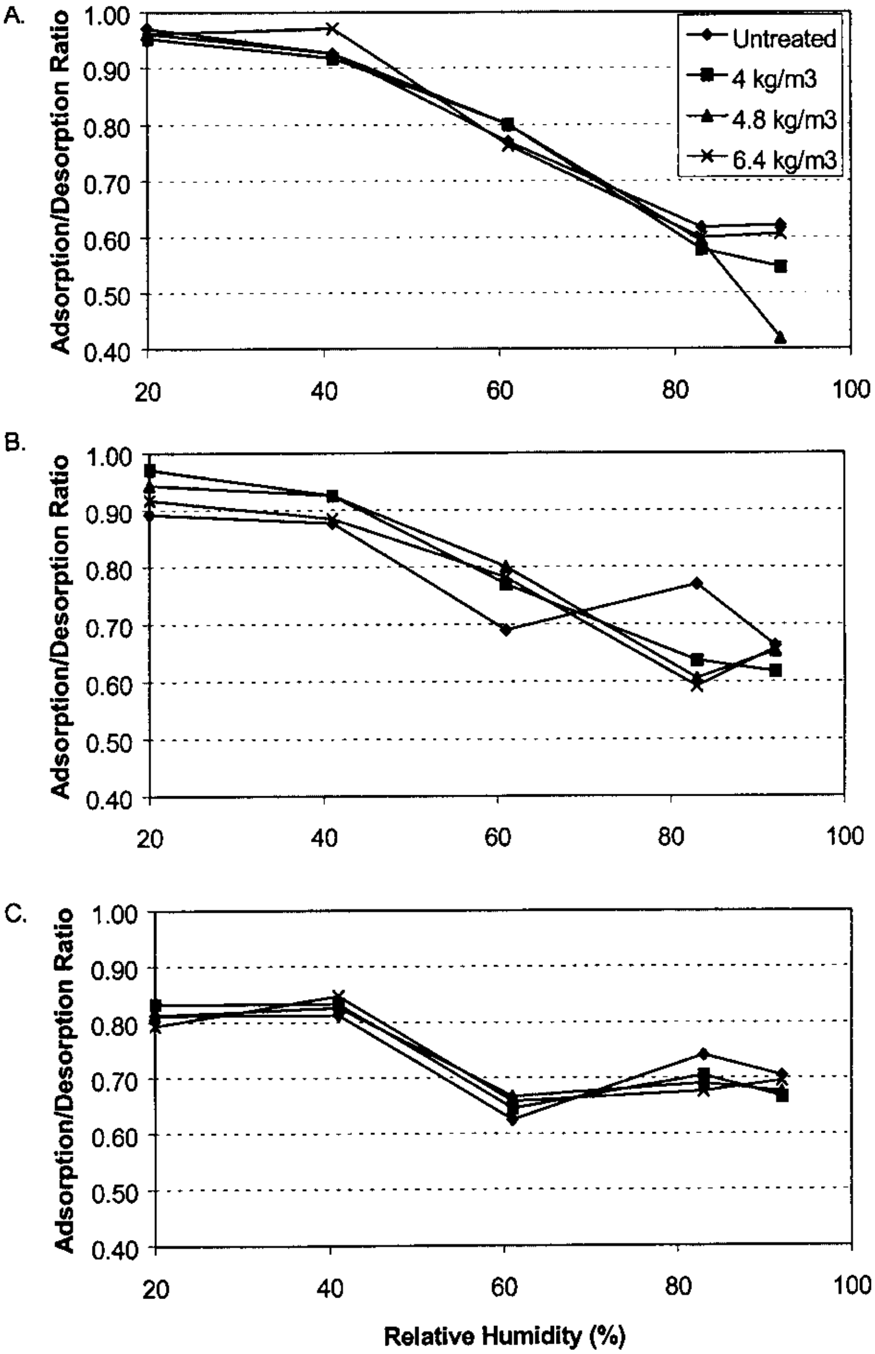

Figure 1. — Adsorption/desorption ratio of CCA-treated southern pine lumber with the following thicknesses and relative humidities. Thickness: A. 25 mm (1 in.); B. 51 mm (2 in.); C. 102 mm (4 in.). Relative humidity: 21, 41, 61, 83, and 92 percent.

In phase 2, 50 No. 1 SYP boards of each target retention and lumber thickness were randomly selected from the 36 shipments, transported to the laboratory, and assayed to determine the retention of preservative in the wood. The boards were air-dried to below 18 percent MC, and then three wafers, each approximately 3 mm (0.125 in.) in thickness, were cut from the midpoint of each board. These wafers were dried and then ground for analysis. The amounts of copper, chromium, and arsenic in the cross sections were determined in accordance with American Wood Preservers' Association Standard A10-82.[3] Note that our approach was intended to quantify the amount of preservative in the entire cross section of each board, while the American Wood Preservers' Association Standards specify assaying only the outer 15 mm (0.6 in.) for lumber less than 51 mm (2 in.) in thickness or the outer 25 mm (1.0 in.) of lumber greater than 51 mm (2 in.) in thickness.[4] Therefore, it might be expected that the retention across the entire cross section would be less than that in an outer assay zone, especially for larger dimensions.

A subset of the same boards that were used for retention analysis was used to evaluate the effect of preservative treatment on the moisture adsorption/desorption (A/D) ratio of the wood. The A/D ratio represents the ratio of the equilibrium moisture contents (EMCs) at adsorption and desorption conditions. One 25-mm (1-in.) cube was cut from each of five boards for each target retention and lumber thickness. During cutting, an effort was made to produce two faces that were parallel, and two faces that were perpendicular, to the tangential surface of the wood. The adsorption-desorption samples were initially equilibrated at 20 percent relative humidity (RH) and then allowed to equilibrate at humidities of 41, 61, 83, and 92 percent at an ambient temperature of 32°C in an Aminco environmental chamber. The samples were saturated with distilled water, and then the sequence of equilibrations at each RH was reversed. The EMC was calculated for each RH during the adsorption and desorption sequences, allowing computation of the A/D ratio.

Results and Discussion

Phase 1

In Phase 1, the initial mean MC of all lumber varied from 12.1 to 68.6 percent (**Table 1**). Although the resistance-type moisture meter loses accuracy above the FSP, it is clear that a substantial proportion of the lumber, both treated and untreated, exceeded the secondary manufacturer's specification of 16 percent MC. The deviation from the specified MC increased as the thickness of the lumber increased. The inadequate re-

[3] American Wood Preservers' Association. 1987. Methods of analysis of CCA treating solutions and CCA treated wood by colorimetry. Standard A10-82, AWPA Book of Standards. AWPA, Granbury, TX.

[4] American Wood Preservers' Association. 1999. Lumber, timber, bridge ties and mine ties-preservative treatment by pressure processes. Standard C2-99, AWPA Book of Standards, Granbury, TX.

drying was not limited to one supplier. Nine of the shipments from supplier A were above 16 percent MC, and 10 and 8 of the shipments of suppliers B and C, respectively, were above 16 percent MC.

These results indicate that the treated, as well as the untreated, lumber is not being adequately dried prior to shipment to secondary manufacturers. The results suggest that many of the problems of unacceptable shrinkage and warping experienced by lumber users can be attributed to the high MC of wood when acquired, machined, and installed.

Phase 2

Chemical analysis of the CCA-treated lumber revealed that the retention of preservative was variable, with little practical difference in retention among the three target retention levels (**Table 2**). In general, the mean assay retentions of the 4.8 and 6.4 kg/m^3 (0.3 and 0.4 pcf) target retention groups were very similar, and only slightly greater than those of the 4.0 kg/m^3 (0.25 pcf) target retention. Variability in retentions achieved during pressure treatment is expected, since differences in wood structure affect treatability. As might be expected, the retention in the cross section was highest in the 25-mm- (1-in.-) thick lumber and lowest in the 102-mm- (4-in.-) thick lumber. It appears that the loadings achieved in the wood were at or above the target retentions for the 4 and 4.8 kg/m^3 (0.2 and 0.3 pcf) treatment groups. The assay retentions were lower than the target for the 6.4 kg/m^3 (0.4 pcf) retention group, especially in the thicker lumber. However, this may be a result of assaying the entire cross section, which is likely to contain a lower average concentration of CCA than the outer 15-to-25-mm (0.6-to-1.0-in.) assay zone specified by American Wood-Preserver's Association standards.[4]

Evaluation of the A/D ratios revealed little difference among the three CCA target retentions or the untreated lumber (**Fig. 1**). As expected, the A/D ratio generally decreased as the RH increased for all three lumber thicknesses. The lack of difference among the three CCA target retentions is not surprising, given the similarity in their assay retentions (**Table 2**). The similarity in A/D ratios between the untreated and treated lumber suggests that the CCA treatment is not contributing to excess fluctuations in the MC of the wood. The A/D ratio displayed by the samples indicates that this lumber, if properly dried, should perform adequately in service. The results of the A/D evaluations further support the supposition that the problems of dimensional instability noted for CCA-treated southern pine lumber are caused by inadequate redrying and are not caused by the presence of the preservative oxides within the wood.

Conclusions

The results of this study indicate that many of the problems of dimensional instability for treated lumber in service can be attributed to inadequate redrying after treatment and are not caused by the preservative oxides themselves. Such problems could be prevented through closer monitoring of lumber MC by suppliers and by secondary manufacturers.