Effect of post-treatment steaming on the bending properties of southern pine treated with copper naphthenate

H.M. Barnes*
J.M. Linton*
G.B. Lindsey*

Abstract

The effect of steaming after treatment was evaluated for southern pine treated with a waterborne copper naphthenate formulation. Little practical effect on the mechanical properties was noted. Steaming for 2 hours had a greater effect than a 30-minutes steam period. No difference in modulus of elasticity and modulus of rupture, work to proportional limit, work to maximum load, or fiber stress at proportional limit between samples steamed following treatment and those only treated was shown. Differences between untreated and treated samples were ascribed to treatment rather than steaming. This treatment effect is common with waterborne preservative treatments.

Preservative treatments or treating regimens should not have a deleterious effect on wood properties. Many studies (Barnes and Winandy 1986) have been conducted on the effect of various treatments on the mechanical properties of wood. For example, research by Winandy and others (Barnes and Winandy 1989, Barnes et al. 1990, Winandy and Barnes 1991, Winandy et al. 1992) recommended drying temperature limitations for CCA-treated wood, which were adopted by Standards organizations. Other work has shown ACQ and other treatments do not cause significant reductions in mechanical properties (Barnes and Winandy 1986, Barnes et al. 1993). A 2005 paper presented to the American Wood-Preservers' Association (AWPA) showed no practical deleterious effects of waterborne copper naphthenate treatment on the bending properties of southern pine (Barnes et al. 2005).

Post-treatment conditioning cycles have varying effects on the resultant strength of wood depending on species, treatment, and type of conditioning. Losses in modulus of rupture (MOR) from 8 to 33 percent have been reported depending on the steaming time, temperature, and preservative retention (Barnes 1985). This paper reports on the testing of southern pine treated with waterborne copper naphthenate and subsequently steamed after treatment.

Methods and materials

Materials

All-sapwood, defect-free southern pine samples were cut from commercial dimension stock into samples measuring 1.5 by 1.5 inch in cross section by 24-in long (38 by 38 by 610 mm). Samples were randomly assigned to four treatment groups of 30 samples each such that each group would have a similar density range, ring count, and earlywood/latewood ratio. The groups tested were water-treated, water-treated steamed (30 min), copper naphthenate (CN)-treated, and CN-treated steamed (30 min). Since AWPA Standard T1–06 section 8.1.6.2 for southern pine allows steaming for up to 2 hours (AWPA 2007), an additional treated group containing only 12 replicates was steamed for 2 hours in order to get some idea of the effect of the longer steaming period.

Treatment

Treating solutions were prepared from a waterborne concentrate of copper naphthenate by water dilution. The formulation was CuNap-5 W™ (Merichem Co.) which meets the AWPA P5–07 specifications (#21) for CuN-W, meaning it contained monoethanolamine as the cosolvent (AWPA 2007). The concentrate contained a nominal 5 percent Cu, but did not contain any additives such as water repellants, moldicides, or

The authors are, respectively, Professor, Student Assistant, and Research Associate II, Dept. of Forest Products, Mississippi State Univ., Starkville, Mississippi (mbarnes@cfr.msstate.edu; jlinton@cfr.msstate.edu; blindsey@cfr.msstate.edu). Accepted as Journal Article No. FP–401, Forest & Wildlife Research Center, Mississippi State Univ. This paper was received for publication in March 2007. Article No. 10333.
*Forest Products Society Member.

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colorants. All samples were treated using a full-cell cycle consisting of 30 minute vacuum at 25 in Hg. The cylinder was filled while under vacuum and pressure applied for 30 minutes at 145 to 150 psig. The samples were removed, wiped of excess solution, and weighed. Post-treatment steaming for 30 minutes or 2 hours was accomplished by injecting live steam into the treating cylinder at atmospheric pressure. Temperature typically rose to 105 to 110 °C in the cylinder and approximately three liters of condensate were collected during a 30-minute steaming period. Samples were allowed to condition at 68 °F, 65 percent relative humidity before testing.

Testing and analysis

Samples were tested in static bending with center-point loading according to D143 (ASTM International 2006). Moisture content (MC) and specific gravity (SG) were determined on small samples cut from near the break of the bending samples. Average MC was 10.6±1.4 percent. SG (od wt, volume at test) averaged 0.56±0.06. Modulus of elasticity (MOE), modulus of rupture (MOR), work-to-maximum load (W_{ml}), work-to-proportional limit (elastic resilience, W_{pl}), and fiber stress at proportional limit (S_{pl}) were computed. The data were analyzed by covariate analysis using SG, MC, and preservative retention as covariates. Least square mean separation techniques were used to separate the means (SAS Institute 2001).

Table 1. — Descriptive statistics for unadjusted bending property values.

Value	W_{ML}	W_{PL}	FS_{PL}	MOR	MOE
	----- (in-lbf/in^3) -----		--------------- (psi) ---------------		
Water treated, unsteamed [UT]					
Mean	12.2	1.14	4,384	9,204	983,803
SD	4.9	0.47	1,252	1,364	194,503
COV	40%	41%	29%	15%	20%
Water treated, steamed 30 minutes [UT-S30]					
Mean	12.7	1.12	4,557	9,322	1,075,176
SD	4.0	0.38	1,474	2,024	418,502
COV	32%	34%	32%	22%	39%
Treated, unsteamed [TRT]					
Mean	11.4	0.88	3,729	8,340	927,408
SD	4.4	0.29	931	1,227	232,868
COV	38%	33%	25%	15%	25%
Treated, steamed 30 minutes [TRT-S30]					
Mean	11.8	0.98	3,850	7,950	871,376
SD	4.9	0.28	869	1,175	210,314
COV	41%	29%	23%	15%	24%
Treated, steamed 2 hrs [TRT-S120]					
Mean	9.96	0.77	3,225	7,179	819,079
SD	3.64	0.33	960	935	188,030
COV	37%	43%	30%	13%	23%

Results and discussion

Raw data means are shown in **Table 1**. Adjusted means and mean comparisons from the covariate statistical analysis are given in **Table 2**.

Compared to the untreated adjusted value, no significant impact of steaming for either 30 minutes or 2 hours on the MOE for the treated stock was noted. These data are compared in **Figure 1**.

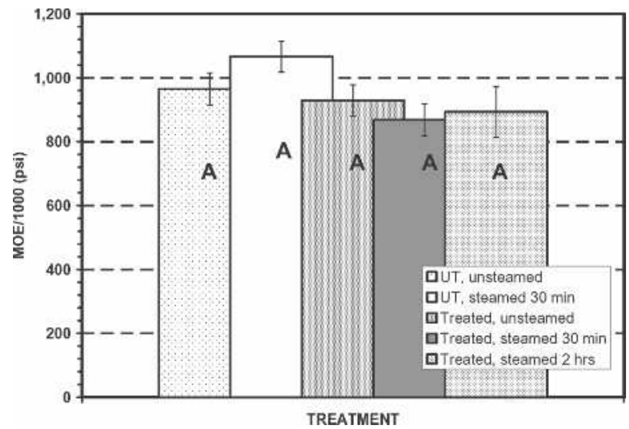

Figure 1. — Comparison of MOE values (bars without a common letter are significantly different one from another at p *= 0.05).*

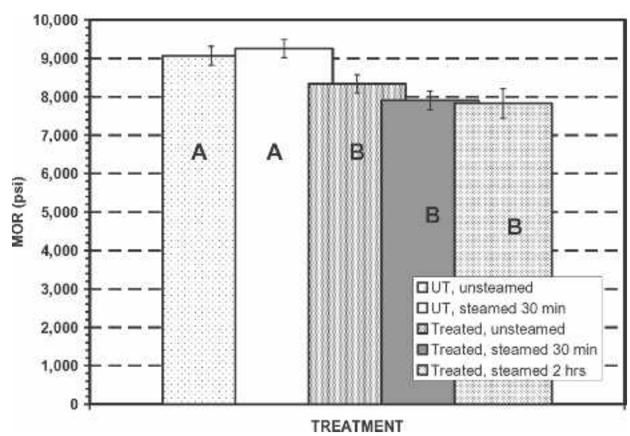

Figure 2. — Comparison of MOR values (bars without a common letter are significantly different one from another at p *= 0.05).*

Table 2. — Least-square adjusted mean values for bending properties.[1]

Treatment	MOR	MOE	FS_{PL}	W_{PL}	W_{ML}
	---------- (psi) ----------			------- (in-lbf/in^3) -------	
Untreated	9,067 A	964,814 A	4,388 A	1.14 A	12.1 A
Untreated, steamed 30 minutes	9,250 A	1,065,908 A	4,530 A	1.11 A	12.6 A
Treated	8,336 B	929,126 A	3,712 B	0.87 B	11.3 A
Treated, steamed 30 minutes	7,904 B	868,164 A	3,814 A	0.96 AB	11.7 A
Treated, steamed 120 minutes	7,825 B	893,190 A	3,539 B	0.85 B	10.9 A

[1]Means not followed by a common letter are significantly different one from another at $p = 0.05$.

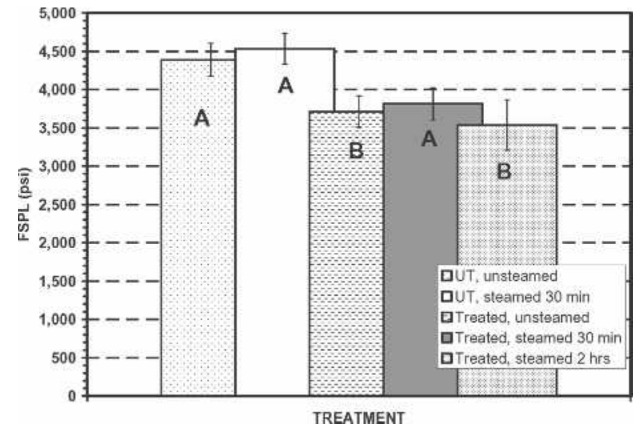

Figure 3. — Fiber stress values for the various treatment groups (bars without a common letter are significantly different one from another at p *= 0.05).*

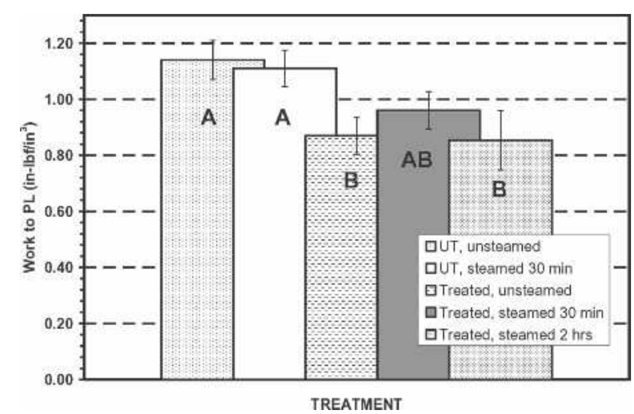

Figure 4. — Work-to-proportional limit for the various treatment groups (bars without a common letter are significantly different one from another at p *= 0.05).*

There was no significant difference in the adjusted untreated MOR means whether steamed or not (**Fig. 2**). Treated and treated-steamed (30 min and 2 h) values were lower than the untreated means. This difference is interpreted as being a treatment effect common with other waterborne preservative systems. A similar result was obtained for fiber stress (**Fig. 3**) except that the steamed (30 min) value was statistically equivalent to the untreated values.

A similar result was found for the work-to-proportional limit values (**Fig. 4**), but the treated and steamed for 30 minutes values were not different from the control steamed and unsteamed values. For work-to-maximum load, no significant differences were found for the adjusted treatment mean values (**Fig. 5**). Again, the differences seen in the work values are attributed to a treatment effect.

Summary and conclusions

This study has shown the effect of post-treatment steaming on the mechanical properties of southern pine tested in bending to have little practical effect on the treated wood for

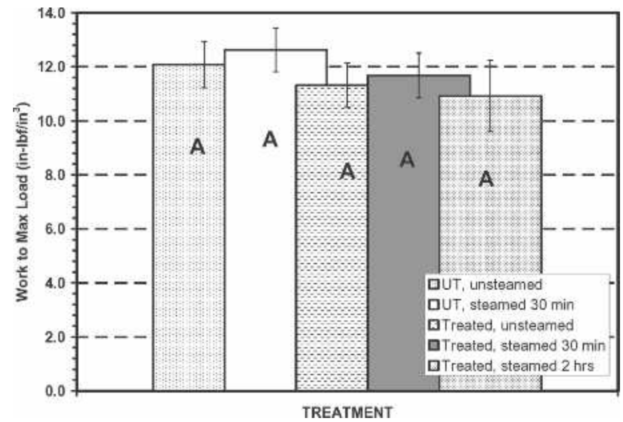

Figure 5. — Comparison of work-to-maximum load for the treatment groups (bars without a common letter are significantly different one from another at p *= 0.05).*

steaming periods for up to 30 minutes. Limited strength loss was apparent with steaming after 2 hours. Some care should be taken in judging the extended steaming period data as this experimental group was composed of only 12 samples. Any differences between treated and untreated wood are attributed to a treatment effect. These results suggest that southern pine treated with waterborne copper naphthenate can be successfully steamed after treatment with limited concern for loss in bending properties.

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