Establishing Color in Red Alder Lumber

By
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CONCLUSIONS

Steaming red alder lumber at 212 F and 100 percent relative humidity for at least 4 hours before air or kiln drying eliminated sticker stain and prevented mottling of board color. This preliminary treatment produced a uniform color in the wood, ranging from white in the sapwood to ivory in the heartwood.

Steaming at temperatures of 183-205 F at relative humidities of 90 percent and higher for 6-15 hours before air drying, or imposing initial dry-bulb temperatures of 150 F or lower during kiln drying, eliminated sticker stain. Final color, reddish tan, had a mottled pattern serious enough to cause degrade. Applying the same steaming conditions before kiln drying at dry-bulb temperatures of 183 F or higher produced a uniform color, but lighter areas under the sticker crossings caused degrade in many boards. With steaming temperatures of 183-205 F, color varied with length of steaming period. With steaming for 6 hours, color ranged from honey tan to reddish tan; for 12 hours, reddish tan to reddish brown; and for 15 hours, dark reddish brown.

Steaming air-dried lumber at 212 F and 100 percent relative humidity for 4-24 hours eliminated previous sticker stain and produced a uniform color with very little mottling, not enough to cause degrade. Short steaming periods of 4 or 8 hours produced a white color in the sapwood and ivory in the heartwood. Longer steaming periods of 12 or 24 hours produced an ivory color in the sapwood and light tan in the heartwood; the boards lacked luster.

Forced-air drying of No. 2 and No. 3 Shop was not economically feasible for the prevailing weather conditions. Drying costs were $5.06 a thousand board feet and additional kiln drying was required.

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INTRODUCTION

Color, sticker stain, and mottling in red alder lumber can be controlled by steaming before kiln drying, but the conditions in the kiln required for efficiently setting specific colors have not been reported. At the request of Paul Barber Hardwoods Company of Salem, Oregon, the Forest Research Laboratory studied the establishment of different colors by various steaming treatments before air drying or kiln drying. Investigated at the same time were means of eliminating sticker stain and mottling of color in lumber that has been air-dried without previous steaming treatments and the feasibility of forced-air drying of No. 2 Shop and lower grade lumber.

Generally, a light brown or honey tan color is preferred by the buyers, and most producers are establishing this color. In red alder, color is set best on freshly sawed lumber. Anderson and Frashour (1)* investigated the steaming conditions required to set a light brown color and stated that color could be varied from white to chocolate brown by varying time, dry-bulb temperature, and relative humidity during the steaming treatment.

*Numbers in parentheses refer to literature cited.

PROCEDURE

Altogether 29 charges were studied: 21 of green lumber to study different steaming treatments to set color and prevent sticker stain and mottling; 4 charges of air-dried lumber to determine the possibilities of removing stain by steaming; and 4 charges, 1,200 board feet each, selected from 19,000 board feet of low grade lumber that had been forced-air dried.

Twenty-one charges, each of about 400 board feet, of random-width, 8-foot-long, unseasoned, 1-inch red alder lumber were grouped into Series 1 and 2. In Series 1, the effects were studied of steaming at 212 F dry-bulb temperature and 100 percent relative humidity to establish a light color. Steaming temperature ranging from 183 F to 205 F with various relative humidities to establish dark colors in the lumber were investigated in Series 2. Setting and maintaining color during air drying were studied. Matched charges were designated with a double-letter suffix. Part were steamed, then air-dried, and finally kiln-dried, and part were steamed and immediately kiln-dried.

Four charges of about 800 board feet of air-dried lumber in a third series were steamed at 212 F dry-bulb temperature and 100 percent relative humidity in an attempt to remove sticker stain and mottled color. Previous commercial practice had shown that stains in air-dried lumber cannot be corrected by steaming the lumber before kiln drying at temperatures of 150-180 F. Steaming at 212 F with 100 percent relative humidity, in this study, and boiling stained red alder lumber in a solvent at 260 F in a pilot-plant study in Bend, Oregon, bleached unseasoned lumber to white or ivory.

Grades of No. 2 and No. 3 Shop are normally dried to an average moisture content of 12 percent with a maximum of 14 percent. About 19,000 board feet of 1-inch unseasoned red alder lumber in the low grades were forced-air dried to study the application and economic feasibility of this method of drying, though this experiment was not a major part of the study and collection of data was minimal. The procedure followed for piling and the type of equipment used were similar to those described by Kozlik (2), but the length of the charge was reduced by one-half, the lumber was only two units high, and only one fan was used, with the opposite end of the alleyway completely baffled.

RESULTS AND DISCUSSION

The data on steaming treatments, air-drying periods, kiln schedules, and final moisture contents are summarized in Table 1 for all charges except the four charges that were kiln-dried following forced-air drying. Table 2 lists the various kiln schedules followed in this study. These are shown by schedule number in Table 1 and Table 4. The percentages of scant boards and boards having sticker or blue stains, or mottled color pattern, are summarized in Table 3, which also describes final color and color uniformity. Color uniformity was rated as excellent (no boards degraded), good (10 percent or less of the boards degraded), and poor (10 percent or more of the boards degraded). Table 4 summarizes the information on forced-air drying.

The first eight charges, Series 1, were steamed at 212 F dry-bulb temperature and 100 percent relative humidity for 2-6 hours. Charges 1AA, 1BB, 1CC, 1DD, and 1EE were steamed, air-dried for 403-834 hours, and finally kiln-dried. Charges 1C, 1D, and 1E were steamed and immediately kiln-dried.

The color in all charges of Series 1 ranged from white to ivory with excellent uniformity, except that in charges 1C, 1D, and 1EE, 7-8 percent of the boards mottled, though not enough to degrade individual pieces. The mottling was confined to sapwood areas adjoining the bark, and in all instances the mottling was not severe enough to degrade the boards. Sticker stain was eliminated in all the charges, except for 1 percent of the boards in charges 1BB and 1C.

The next 13 charges, Series 2, were steamed at temperatures of 183-205 F, which are temperatures higher than those presently used by industry. The higher temperatures were used to establish dark colors.

Charges 2AA, 2BB, and 2CC were steamed at 183 F dry-bulb temperature and 96 percent relative humidity for 6, 9, and 12 hours. All three charges were air-dried about one month and finally kiln-dried. The color in charge 2AA, steamed for 6 hours, was honey tan; color in charge 2BB, steamed for 9 hours, was honey brown; and color in charge 2CC, steamed for 12 hours, was reddish tan. Sticker stain was eliminated, but a high percentage of the boards were mottled seriously enough to degrade individual boards.

Charges 2D, 2E, and 2F were steamed at 190 F for 7, 12, and 15 hours and immediately kiln-dried. Charges 2DD, 2EE, and 2FF were steamed at 190 F for 7, 12, and 15 hours and air-dried for 466-816 hours. Upon completion of air drying, the lumber was kiln-dried.

Table 1. Steaming and Drying Conditions for Random-Width, 8-Foot-Long, Unseasoned, 1-Inch Red Alder Lumber

Charge	Steaming			Air drying			Kiln schedule[1]	Final MC		
	Dry-bulb temp	Relative humidity	Time	Start	Stop	Time		Range		Average
								Low	High	
	Deg F	Percent	Hours			Hours		Percent	Percent	Percent
1AA	212	100	2	Jun 1	Jul 6	834	1	7.0	10.0	7.7
1BB	212	100	4	Jul 16	Aug 2	403	1	7.0	9.0	8.0
1C	212	100	4	None	None	---	2	7.0	9.0	7.8
1CC	212	100	4	Sep 9	Oct 4	593	1	7.5	8.0	7.9
1D	212	100	6	None	None	---	2	7.0	9.0	7.7
1DD	212	100	6	Sep 9	Oct 4	593	1	7.5	8.5	7.9
1E	212	100	4	None	None	---	2	8.0	9.0	8.4
1EE	212	100	4	Sep 16	Oct 7	492	1	8.0	9.0	8.2
2AA	183	96	6	Jun 1	Jun 25	564	2	7.0	8.5	7.1
2BB	183	96	9	Jun 2	Jun 25	544	2	7.0	9.0	7.2
2CC	183	96	12	Jun 2	Jun 30	648	2	7.0	10.0	7.8
2D	190	96	7	None	None	---	2[2]	7.5	8.0	7.7
2DD	190	96	7	Sep 17	Oct 7	466	1	7.5	8.0	7.8
2E	190	92	12	None	None	---	3	8.5	11.0	9.9

2EE	190	92	12	Sep 28	Nov 1	816	1[3]	7.5	10.0	8.5
2F	190	92	15	None	None	---	3	7.0	8.5	8.0
2FF	190	92	15	Oct 20	Nov 22	792	1	7.5	10.5	8.7
2G	197	99	12	None	None	---	2	7.0	9.0	8.3
2H	201	100	15	None	None	---	4	7.5	9.0	8.4
2HH	201	100	15	Oct 19	Nov 22	816	1	7.5	10.0	8.3
2II	205	100	6	Jul 16	Aug 2	403	1	7.0	9.0	7.8
3A	212	99	4	Jul 17	Aug 9	552	1	---	---	---
3B	212	100	8	Apr 9	Aug 10	2,952	1	7.0	8.5	7.9
3C	212	100	12	Sep 10	Oct 26	1,116	1	7.0	8.5	7.7
3D	212	100	24	Sep 10	Nov 11	1,487	1	7.0	9.0	7.4

[1] Refer to Table 2 for time, temperature, and EMC conditions.

[2] Same EMC conditions and time intervals as Schedule 2, except dry-bulb temperature was maintained at 190 F.

[3] Same EMC conditions and time intervals as Schedule 1, except dry-bulb temperature was maintained at 190 F.

Table 2. Dry Kiln Schedules.

Dry-bulb temperature	EMC conditions	Time
Deg F	Percent	Hours
Schedule 1		
155	9.5	0-24
160	8.0	24-34
170	6.0	34-58
180	12.0	58-70
Schedule 2		
150	12.0	0-24
155	9.5	24-48
160	8.0	48-72
170	6.0	72-102
180	12.0	102-114
Schedule 3		
190	11.0	0-12
190	6.0	12-84
190	5.0	84-96
195	15.0	96-108
Schedule 4		
200	9.0	0-12
200	6.0	12-84
200	5.0	84-96
205	15.0	96-106
Schedule 5		
170	9.0	0-10
170	6.0	10-28
180	12.0	28-37

The color in charges 2DD, 2EE, and 2FF was reddish tan, but an intense mottled pattern occurred in sufficient amounts to degrade individual boards. All sticker stain in these charges was eliminated. Charges 2D, 2E, and 2F, which were kiln-dried after steaming, were uniformly colored and ranged from reddish tan at 7 hours steaming, through reddish brown at 12 hours steaming, to dark reddish brown at 15 hours steaming. Charge 2D had only 7 percent of the boards with sticker stain; in charges 2E and 2F, however, sticker stain in as high

as 73 percent of the boards was a major problem. In charges 2E and 2F, the stain was associated with thin boards and appeared as lightened areas rather than the dark areas occurring in air-dried stock.

Charges 2E and 2F contained many thin boards after drying, but matched charges 2EE and 2FF did not. Charges 2E and 2F were dried rapidly at a high temperature, 190 F, which may have caused excessive shrinkage. The matched charges 2EE and 2FF were kiln-dried at 150 F. A high percentage of thin lumber was also found in charge 2H, which was dried at 200 F, but not found in the matched charge 2HH, kiln-dried at 150 F.

Charge 2G was steamed at 197 F dry-bulb temperature and 99 percent relative humidity for 12 hours and immediately kiln-dried at a low temperature (150 F). The lumber was tan in the sapwood and reddish tan in the heartwood. Color uniformity was good; 13 percent of the boards were mottled enough to degrade a few pieces. All sticker stain was eliminated.

Charges 2H and 2HH were steamed at 201 F dry-bulb temperature and 100 percent relative humidity for 15 hours. Charge 2H was immediately kiln-dried at 200 F dry-bulb temperature, but 2HH was air-dried for 816 hours and then kiln-dried at 150 F dry-bulb temperature. Charge 2H was uniformly reddish brown, but 53 percent of the boards had sticker stain associated with thin boards. The matched charge 2HH was reddish tan, but 32 percent of the boards were mottled enough to degrade individual boards.

Charge 2II was steamed at 205 F dry-bulb temperature and 100 percent relative humidity for 6 hours. The charge was air-dried for 403 hours and kiln-dried at a low temperature (150 F). The lumber was tan in the sapwood and honey tan in the heartwood, but 36 percent of the boards were mottled enough to degrade individual pieces. No sticker stain was recorded.

Four charges of stained, air-dried lumber, Series 3, were steamed at 212 F and 100 percent relative humidity for periods from 4 to 24 hours. Before each charge was steamed, several boards were surfaced before drying to establish the occurrence of stain and mottling in the charge. In all instances, presurfaced boards were stained enough to cause degrade.

Color of charges 3A and 3B ranged from white to ivory; charges 3C and 3D were ivory in the sapwood and light tan in the heartwood. The uniformity was excellent in all charges except charge 3B, which had 14 percent of the boards mottled enough to degrade a few pieces. Charge 3B had air-dried the longest, and the staining was more pronounced than in the other three charges. Sticker stain did not occur

Table 3. Summary of Data on Color and Stain.

Charge	Boards stained or thin				Final color		
	Sticker stain	Blue stain	Thin	Mottled	Sapwood	Heartwood	Uniformity
	Percent	Percent	Percent	Percent			
1AA	None	None	--	0	White	Ivory	Excellent
1BB	1	1	--	0	White	Ivory	Excellent
1C	1	--	--	8	White	Ivory	Excellent
1CC	None	56	10	0	White	Ivory	Excellent
1D	None	--	--	7	Ivory	Ivory	Excellent
1DD	None	35	20	0	Ivory	Ivory	Excellent
1E	None	--	--	0	White	Ivory	Excellent
1EE	None	10	10	7	White	Ivory	Excellent
2AA	None	None	--	31	Honey tan	Honey tan	Poor
2BB	None	None	--	26	Honey brown	Honey brown	Poor
2CC	None	None	--	45	Reddish tan	Reddish tan	Poor
2D	7	--	None	0	Reddish tan	Reddish tan	Excellent
2DD	None	37	7	44	Reddish tan	Reddish tan	Poor
2E	50	12	50	0	Reddish brown	Reddish brown	Good
2EE	None	24	20	20	Reddish tan	Reddish tan	Poor
2F	73	3	73	0	Dark red brown	Dark red brown	Good
2FF	None	Mildew	21	21	Reddish tan	Reddish tan	Poor
2G	None	7	15	13	Tan	Red tan	Good
2H	53	8	53	0	Dark red brown	Dark red brown	Good
2HH	None	28	9	32	Reddish tan	Reddish tan	Poor
2II	None	None	--	36	Tan	Honey tan	Poor
3A	None	--	--	0	White	Ivory	Excellent
3B	None	14	4	14	White	Ivory	Good
3C	3	40	21	0	Ivory	Light tan	Excellent
3D	4	38	33	0	Ivory	Light tan	Excellent

Table 4. Summary of Data on Forced-Air Drying of Red Alder Lumber.

Charge	Location	MC before kiln drying			Final MC			Boards stained or thin			
		Range			Range						
		Low	High	Avg	Low	High	Avg	Sticker stain	Blue stain	Thin	Mottled
		Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
A	Inner alley, next to fan	15.5	19.0	16.7	7.5	10.5	8.7	4	18	7	<10
B	Outer row, opposite fan	16.0	21.0	18.6	8.0	10.5	8.7	9	39	11	<10
C	Inner alley, middle of charge	17.0	20.0	18.6	8.5	11.0	9.8	42	10	28	<10
D	Outer row, next to fan	16.0	22.0	19.1	9.5	13.0	10.8	48	14	12	<10

in charges 3A and 3B but did occur in 3 and 4 percent of the boards in charges 3C and 3D. Boards in charges of Series 3 lacked luster, or could be termed "lifeless," as compared with previous charges and with lumber being produced by industry.

The lumber was stacked for forced-air drying from September 22 until October 19, and the fans operated 645 hours. Figure 1 shows the average, low, and high relative humidities, and Figure 2 shows the average, low, and high temperatures recorded each day during the drying. Drying conditions were excellent during the first week, but poor the final week. Air velocities, measured with a hot-wire meter on the leaving air side, ranged from 50 feet a minute through the lumber at the end opposite the fan to 550 feet a minute through the lumber next to the fan. The center third of the charge had air velocities of 180-300 feet a minute. Moisture content was measured with a resistance-type meter on about 30 boards after 2 weeks of drying. The average was 16.7 percent, and the range was 12-20 percent. After 4 weeks of drying, the moisture content was checked in about the same locations and averaged 15.6 percent, with a range of 12-18 percent.

Following forced-air drying, the portable roof was left on the lumber for protection from rain. Four 8-foot units from different locations in the charge were selected to be kiln-dried by schedule 5 listed in Table 2. About 3 weeks elapsed between kiln drying the first unit and the fourth unit, and in this period the weather was extremely damp. The average moisture content of the first unit, charge A, was 16.7 percent before kiln drying, and the average moisture content of the last unit, charge D, was 19.1 percent before kiln drying. Sticker stain in charge A, kiln-dried, was only 4 percent, but the longer the units remained in outside storage before kiln drying, the more sticker stain occurred, increasing to a maximum of 48 percent in charge D.

Color of the lumber was ivory in the sapwood and light tan in the heartwood, with good uniformity; fewer than 10 percent of the boards were mottled enough to degrade individual pieces.

The cost of fan, motor, mounts, and portable roof for a propeller fan would be about $1,000, including cost of fabrication. Amortization of this cost, computed on a basis of five 245-day years, was $0.82 a day or $22.14 for the charge. Cost of electricity was one cent a kilowatt-hour; 3,606 kilowatt-hours were consumed for a total cost of $36.06. Cost of operating a lift truck was estimated at $18.00, or $4.50 an hour for 4 hours. Cost of assembling and removing the roof was $20.00, or $2.50 an hour for 8 hours. The cost of stickering was disregarded, because this company stickers all No. 2 and No. 3 Shop lumber for air drying.

The total cost of forced-air drying was $96.20 or $5.06 a thousand board feet. The cost per thousand was high compared to forced-air drying of softwoods, as reported by Kozlik (2). Since the final average moisture content of the charge was above 12 percent, additional costs would be incurred by further kiln drying.

LITERATURE CITED

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PROGRAM AND PURPOSE

The Forest Research Laboratory of the School of Forestry combines a well-equipped laboratory with a staff of forest and wood scientists in a program designed to improve the forest resource and promote full utilization of forest products. The extensive research done by the Laboratory is supported by the forest industry and by state and federal funds.

The current report results from studies in forest products, where wood scientists and technologists, chemists, and engineers are concerned with properties, processing, utilization, and marketing of wood and of timber by-products.

The PROGRAM of research includes

- identifying and developing chemicals from wood,
- improving pulping of wood and wood residues,
- investigating and improving manufacturing techniques,
- extending life of wood by treating,
- developing better methods of seasoning wood for higher quality and reduced costs,
- cooperating with forest scientists to determine effects of growing conditions on wood properties, and
- evaluating engineering properties of wood and wood-based materials and structures.

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> developing products from residues and timber now wasted, and

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