Seasoning

Red Alder Lumber

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SUMMARY

Tests were made on red alder lumber to study effects on drying time and degrade of various dry-bulb temperatures, Emc (equilibrium moisture content) conditions, air velocities, fan-reversal periods, presteaming times, and conditioning periods.

Conditions were judged favorable if they led to reduction of drying time without excessive increase in degrade. On that basis, 4-quarter red alder can be dried in about 85 hours by the following schedule:

1. Warm to 200 F in 4-6 hours.
2. Presteam 12 hours at 190-200 F with 5 F wet-bulb depression.
3. Dry at least 12 hours at 200 F dry bulb; lower Emc to 6 per cent and hold until wettest piece at 14 per cent.
4. Equalize 14 hours at 5 per cent Emc (if final moisture content is to average 8 per cent).
5. Condition 12 hours at 190-200 F dry-bulb temperature and 13 per cent Emc.

Five-quarter stock can be dried by the same conditions, but more time is needed. Six-quarter lumber should be dried by less severe conditions to avoid excessive degrade.

SEASONING RED ALDER LUMBER*

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INTRODUCTION

To meet increasing demand for kiln-dried lumber of red alder, mills are attempting to speed production. Most mills, unfortunately, can not increase their volume of kiln-dried stock with present kilns and schedules. Two means are available: one is to install additional dry kilns, which requires a large capital investment; the other is to adjust kiln schedules for faster drying.

Adjustment of schedules seems practical. However, presently recommended schedules for red alder lumber suggest starting with low dry-bulb temperatures and conditions for high equilibrium moisture content, thus prolonging drying time. As many as 8 days are required to dry No. 1 Common, four-quarter, red alder lumber to a final moisture content of 7 per cent. Developing a kiln schedule to reduce total time in the kiln, but retain high quality in the product, would increase kiln capacity for any given mill and reduce unit cost for drying.

EXPERIMENTAL PROCEDURE

Lumber was not selected especially for the study, except to insure that no drying had occurred. Pieces ranged from very fine to coarse grain, and from entirely sapwood to inclusion of the pith. Lumber collected was stored under water sprays at the Laboratory. Moisture content of the pieces for various charges ranged from 232 to 65 per cent before drying.

Lumber was either No. 1 or No. 2 and Better Commons. Material was 8 feet long, and ranged in width from 3 to 14 inches. Thickness

*Presented at the annual meeting of the Western Dry Kiln Clubs, June 14 and 15, 1962, at Berkeley, California.

was four-quarter, except for 6 charges of five- and six-quarter. Volume dried in each charge was from 300 to 400 board feet.

Defects in individual boards, such as checks or splits and shake, were marked prior to drying so that degrade developed during drying could be evaluated. Pieces containing tension wood were marked to account for warpage and for areas of high final moisture content.

All charges were weighted, as shown in Figure 1. A charge with the weights removed after being dried is shown in Figure 2. Straight flat lumber resulted from weighting compared to lumber that was dried without weighting, as shown in Figure 3. Weights were 3 wooden timbers that had a combined weight of 120 pounds.

<u>Test charges for four-quarter lumber</u>

In developing schedules for drying lumber, 2 variables--dry-bulb temperature and conditions for equilibrium moisture content (Emc)--must be studied closely. Another variable, air velocity, also is important, but since the modern conventional dry kiln delivers an ample volume of air, this phase was only touched upon.

Six series of tests were made, each including several charges designed to study a particular variable, or phase in developing a schedule.

In all charges before commencing with presteaming or drying periods, 4-5 hours were utilized in heating the dry kiln and lumber to near the wet-bulb temperature. The wet- and dry-bulb temperatures were maintained as closely alike as possible, with only 2-4 F difference, during this period. In Table 9, this warm-up time is not shown separately, but is included in total kiln time. Kiln time in Table 9 is the number of hours a charge was in the kiln, not including time used for periodic weighings of kiln samples.

Series 1 studied the effect of dry-bulb temperatures, while maintaining constant Emc conditions and air velocity. Charge 1A was dried at 200 F, 1B was held at 180 F, and 1C was held at 150 F.

Series 2 was used to study effect of initial Emc conditions, while maintaining constant dry-bulb temperature and air velocity. Charge 2A was dried at conditions for 12 per cent Emc, 2B was held at conditions for 9 per cent Emc, and 2C was held at conditions for 6 per cent Emc.

Series 3 studied effect of different air velocities, while maintaining constant dry-bulb temperature and Emc conditions. Air velocity was measured on the exit side of the charge with a hot-wire air meter. Charge 3A was dried with an air velocity of 600 feet a minute, 3B was held at air velocity of 400-450 feet a minute, and 3C was held at an air velocity of 100-150 feet a minute.

Series 4 studied effect of different intervals between fan reversals while holding constant the dry-bulb temperature, Emc conditions, and air velocity. Fans were reversed at intervals of 3 hours for charge 4A, 6 hours for charge 4B, and 9 hours for charge 4C. For charges in other series, fans were reversed at equal intervals that ranged in the several series from 1 to 3 hours, except in series 1 where the interval was 24 hours.

Since color and uniformity of color can be influenced greatly by presteaming red alder lumber, a fifth series was added to study the effect of steaming time on uniformity of color. Charge 5A was steamed for 4 hours, 5B for 12 hours, 5C for 11 hours, and 5D for 8 hours.

The first five series provided information for formulating a basic schedule. A sixth series was set up, however, to study the effect of changing the Emc conditions throughout a test run for improving quality and time; Emc conditions required for uniformity of final moisture content; and time and Emc conditions required during the conditioning period for adequate relief of drying stresses.

Measuring results

In stacking unseasoned lumber for a charge, representative boards were selected for kiln samples. Usually, 6 pieces were placed in each charge to furnish information on moisture content during drying. At the end of each run, small cross sections of the kiln samples were tested for moisture content by the oven-test method, and sections to test for drying stresses were cut from the remaining portion of the kiln sample. The average and range of final moisture content were determined with a moisture meter at a depth of one-half the board thickness on all of the pieces in each charge. In all charges, the average of moisture-meter readings closely agreed with the final average moisture content of the kiln samples.

The primary evaluation of all charges was based on kiln time and percentage loss of clear-cutting area from seasoning degrade such as checks, splits, and warpage. General degrade also was noted as follows: After lumber was dried and surfaced, it was graded twice in accordance with rules of the Northwest Hardwood Association. The first grading discounted any seasoning defects, but the second grading was determined while taking into account all seasoning defects. Comparing the two gradings gave an indication of degrade encountered in each charge.

Seasoning degrade was determined also as percentage loss of clear-cutting area, as follows: Each board was measured in square inches for total clear-cutting area, disregarding seasoning defects, and then again while considering seasoning defects. The areas measured in each of the two instances were converted into the percentage loss of clear-cutting area by the following formula:

$$\frac{(Ng - Nd)}{Ng} \times 100 = \text{percentage loss of clear-cutting area}$$

where Ng = total square inches in clear cuts disregarding seasoning defects

Nd = total square inches in clear cuts considering seasoning defects

Each charge was evaluated also as to uniformity of color among boards, uniformity of final moisture contents, and relief of seasoning stresses.

RESULTS AND DISCUSSION

Effects of the various schedules are reported here in detail for four-quarter lumber. Pertinent results for each condition tested were abstracted for Tables 1-8. Complete results are shown in Table 9.

Results from charges of five- and six-quarter lumber are discussed only in general.

Dry-bulb temperature

The effects on drying time and degrade of 3 different dry-bulb temperatures are shown in Table 1.

Drying time increased as dry-bulb temperature was lowered, but there was little degrade, regardless of temperature. In fact, as can be seen in Table 1, the charge dried at 150 F had slightly more degrade than resulted from the charge dried at 200 F with other conditions unchanged.

Table 1. Relationship of Dry-Bulb Temperature to Drying Time and Degrade.

Charge	Dry-bulb temp	Kiln time	Loss of clear cuts	Degrade*
	Deg F	Hours	Per cent	
1A	200	98	1.2	0
1B	180	127	1.4	2 to 3
1C	150	147	2.8	2 to 3
				1 to 2

*Drop in grade is shown for each piece degraded.

The dry-bulb temperature of 200 F was most favorable, because of reduced time for drying.

Emc conditions

Effect of Emc conditions of 6, 9, and 12 per cent, while maintaining dry-bulb temperature of 200 F and air velocity of 600 feet a minute, is shown in Table 2.

Degrade and the percentage loss of clear-cutting area were not affected, but the charge dried at Emc conditions of 9 per cent required 23 hours more than the charge dried at 6 per cent Emc conditions. Twelve per cent Emc conditions required 50 hours more than for the charge dried at Emc conditions of 6 per cent. In checking the range in final moisture content and the averages (see Table 9), no outstanding differences were evident among charges of series 2. Therefore, considering time as the only evaluating factor, conditions for Emc of 6 per cent appeared most favorable.

Table 2. Relationship of Emc Conditions to Drying Time and Degrade.

Charge	Emc	Kiln time	Loss of clear cuts	Degrade*
	%	Hours	%	
2A	12	103	1.6	2 to 3
2B	9	75	1.5	0
2C	6	52	1.4	0

*Drop in grade is shown for each piece degraded.

Air velocity

While maintaining dry-bulb temperature of 200 F and conditions for Emc of 6 per cent, 3 air velocities, 100-150, 400-450, and 600 feet a minute, were tested in series 3. Range in final moisture content has been included in Table 3, since this factor would be influenced by different air velocities if each charge were dried for about the same number of hours.

Series 3 was planned to consider whether air velocity in the modern conventional kiln is sufficient for uniform drying. A normal range is from 400 to 500 feet a minute, with proper loading and adequate baffling. Drying time was only 62 hours at an air velocity of 600 feet a minute, but was 87 hours at an air velocity of 100-150 feet a minute. Although 24 hours' difference existed, range of final moisture content was exceedingly high (21.0 to 9.5 per cent) for the charge dried at an air velocity of 100-150 feet a minute (Table 3).

Some difference occurred in the percentage loss of clear-cutting area among the 3 charges. Since dry-bulb temperature and Emc conditions account for seasoning degrade, variability of the lumber must have caused the disparity in loss of clear-cutting area and degrade.

Table 3. Relationship of Air Velocity to Drying Time and Range in Moisture Content.

Charge	Air velocity	Kiln time	Loss of clear cuts	Degrade*	Final moisture content		
					High	Low	Avg
	Ft/min	Hours	%		%	%	%
3A	600	62	1.5	1 to 2	14.0	9.5	11.2
3B	400-450	77	3.3	1 to 2	12.0	9.0	10.6
				2 to 3			
3C	100-150	87	2.2	0	21.0	9.5	12.4

*Drop in grade is shown for each piece degraded.

Fan-reversal periods

Fan-reversal periods of 3, 6, and 9 hours, while maintaining a constant dry-bulb temperature of 200 F, conditions for 6 per cent Emc, and air velocity of 600 feet a minute, resulted in the ranges in final moisture content shown in Table 4.

Uniformity of final moisture content is closely tied to ability of air circulating through the kiln to remove moisture from wood surfaces regardless of location. If moisture is removed unequally, areas of high moisture content will remain for an undesirable interval.

Results in Table 4 show that, as fan-reversal periods were changed from 3, to 6, then 9 hours, the range in final moisture content for the charges moved from 2.5, to 4, then to 6 per cent.

Table 4. Relationship of Fan-Reversal Period to Range in Final Moisture Content.

Charge	Fan-reversal period	Kiln time	Final moisture content		
			High	Low	Avg
	Hours	Hours	%	%	%
4A	3	76	11.0	8.5	9.9
4B	6	66	13.5	9.5	11.2
4C	9	66	15.0	9.0	10.9

Uniformity of color

Color of red alder lumber, which can be varied considerably in drying, is of utmost importance where final use is for exposed parts, as in furniture or panelling. The factor varied in series 5 was time of presteaming. Uniformity of color had to be appraised by visual inspection, so the relative ratings in Table 5 were a matter of judgment.

Values assigned to color uniformity were based on occurrence of sticker stain, mottled areas caused by partial air drying, and uniformity of color imparted to the wood. Presteaming was done at a temperature near 200 F and at conditions for 15 per cent Emc. Presteaming periods of 4 or 8 hours did not produce best results, but 11 or 12 hours of presteaming were favorable (Table 5).

In a previous study by Anderson and Frashour[1], steaming periods of 18 hours were suggested for uniform color at temperatures of 140 F. However, the authors indicated that other dry-bulb temperatures and Emc conditions probably would produce different shades of color. Charges 6B, 7A, and 8A (see Tables 9 and 10), dried following a commercial schedule, were presteamed at 150 F (dry bulb) with conditions for 13 per cent Emc. This resulted in an excellently uniform light honey-brown shade. Presteaming at 200 F at conditions for 15 per cent Emc resulted in a reddish-brown color. At least 12 hours apparently are needed for presteaming at temperatures from 150 to 200 F at conditions for Emc of 13-15 per cent.

Table 5. Relationship of Presteaming Time to Uniformity of Color.

Charge	Presteaming time	Color uniformity
	Hours	
5A	4	Poor
5B	12	Excellent
5C	11	Excellent
5D	8	Good

Improving board quality

Three factors were investigated in series 6: the effect of high Emc conditions in the first stage of the drying cycle to improve quality,

[1] See first reference cited on page 19. References 2 and 3 are included as sources of general information.

conditions needed to promote uniformity of final moisture content, and effect of different treatments for relief of case-hardening stresses.

A comparison between a commercial schedule and apparently favorable laboratory schedules was needed to illustrate possible differences in seasoning degrade. The commercial schedule included with series 6 had a dry-bulb temperature of 145 F and a wet-bulb temperature of 135 F for the first 24 hours, followed by a rise in the dry-bulb temperature of 5 degrees every 24 hours until 170 F was reached. Presteaming at 150 F for 12 hours, and equalizing and conditioning at dry-bulb temperature of 170 F were part of this commercial schedule. The percentage losses of clear-cutting area in charges 6A, a laboratory schedule, and 6B, the commercial schedule, were about the same. However, the amount of small end-checks and general appearance of the lumber dried at 200 F and conditions for 6 per cent Emc were not favorable in comparison to the commercial schedule. The change from the conditions for high Emc in presteaming to conditions for 6 per cent Emc (at 200 F) also caused considerable difficulties with kiln control. When this sudden change was made, the vents remained wide open from one to two hours. The heating system was on full demand, and considerable steam was wasted by venting, yet the dry-bulb temperature could not be maintained during this period.

With the factors of lumber quality and difficult control of the kiln in mind, charges 6C through 6J were run with initial Emc conditions of 8, 10, or 12 per cent for various lengths of time. Results are shown in Table 6.

Average initial moisture content for all charges listed in Table 6 dried at 200 F dry-bulb temperature (excluding charge 6C, which was dried at 220 F dry-bulb temperature) varied from 103 to 137 per cent. Considering the range of initial moisture contents and moisture contents at the end of the drying cycle for charges 6D to 6J, differences in total time between the charges were not great.

The percentage loss of clear-cutting area was the highest in charges 6C and 6J of this series, and initial Emc conditions for 8 per cent were held in these two charges. The percentage loss recorded for 6C no doubt was influenced by the dry-bulb temperature of 220 F. The reason for the dry-bulb temperature of 220 F was to investigate effect of increased temperature on drying times; results revealed no benefit obtained.

The other charges with initial Emc conditions of 10 or 12 per cent appeared to have less percentage loss of clear-cutting area than in previously tested charges. However, charges 6D through 6I had less end-checking and checking extending from areas having intergrown knots or

Table 6. Results on Improvement of Board Quality.

Charge	Emc	Time	Initial MC	MC at end of drying	Loss of clear cuts	Degrade*
	%	Hr	%	%	%	
6C	8	12	132	15.2	2.6	2 to 3
	6	18				2 to 3
6D	10	13	130	8.0	0.7	None
	6	42				
6E	10	8	125	10.0	0.6	None
	6	44				
6F	10	10	137	8.2	0.6	None
	6	35				
6G	12	10	106	11.9	1.0	1 to 3
	9	5				
	6	32				
6H	12	11	136	16.2	0.3	None
	9	6				
	6	26				
6I	12	19	118	11.0	0.8	None
	9	5				
	6	34				
6J	8	19	103	13.4	1.5	2 to 3
	6	27				2 to 3

*Drop in grade is shown for each piece degraded.

distorted grain. Color of the lumber was not reddish-brown as previously encountered, but nearly the honey-brown shade that appears desirable in many instances.

Initial conditions for 10 or 12 per cent Emc not only enhanced quality of lumber, but also efficiency of kiln operation. Changing from presteaming to the drying cycles at 10 or 12 per cent Emc did not cause difficulties in kiln control, for the amount of initial venting was not abrupt and the dry-bulb temperature was maintained easily. In changing from initial Emc conditions of 12 per cent, a second step of 9 per cent was introduced to improve control of the kiln. As shown in Table 6, conditions for 9 per cent Emc were held for only a few hours and did not effect materially either total drying time, or percentage loss of clear-cutting area.

Equalization

Following drying cycles of charges in series 6, a phase similar to an equalization period was introduced to determine the influence of time

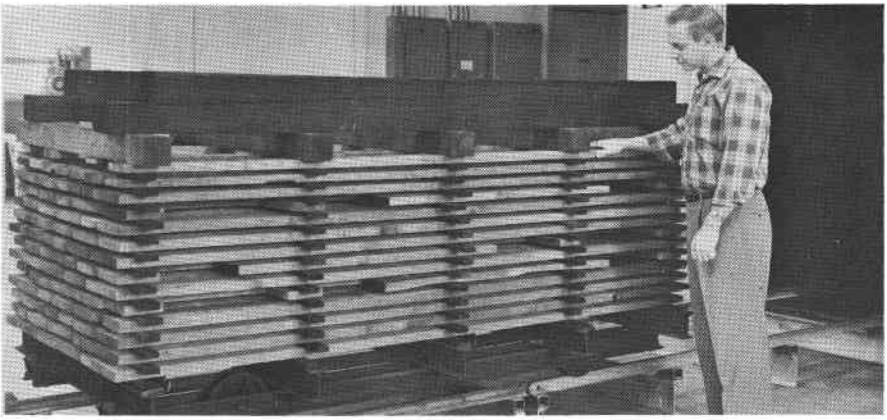

Figure 1. A charge of kiln-dried four-quarter red alder lumber with weights.

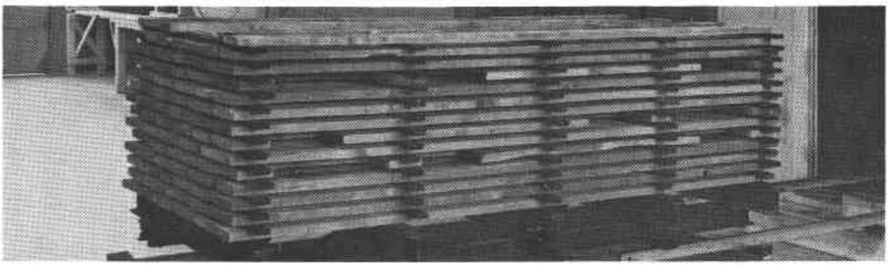

Figure 2. Same charge as in Figure 1, with the weights removed.

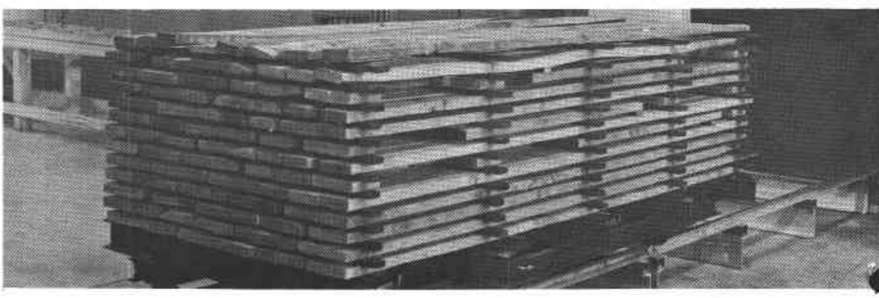

Figure 3. A charge dried at the same conditions as the charge in Figure 1, but without weights.

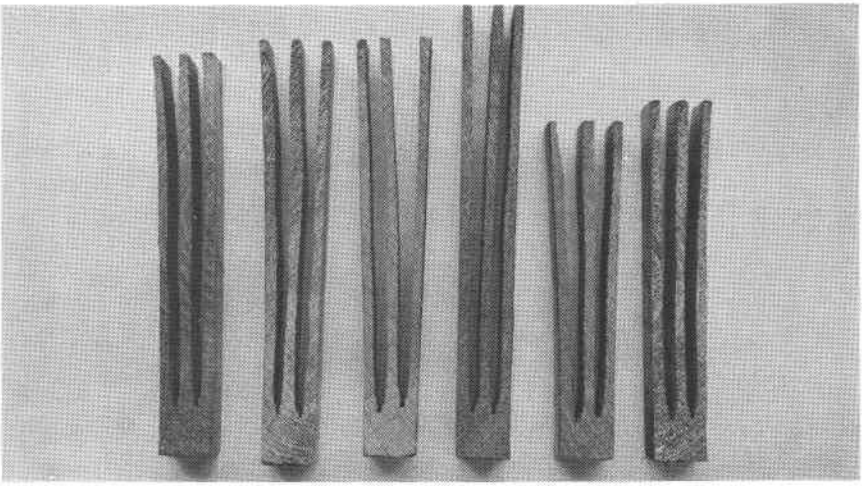

Figure 4. Casehardening stress samples from properly conditioned four-quarter red alder lumber.

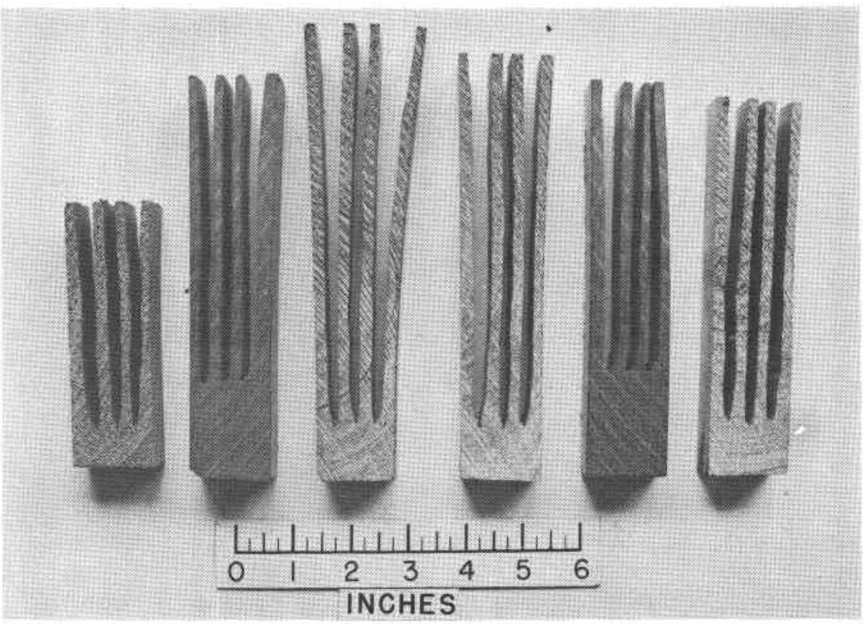

Figure 5. Casehardening stress samples from properly conditioned six-quarter red alder lumber.

and Emc conditions on uniformity of final moisture content. Results of this phase are presented in Table 7, which includes moisture content before equalizing, Emc conditions, time, and range in final moisture content. Response of red alder to drying conditions showed that the desired final moisture content of 7 per cent nearly could be attained with conditions for Emc of 6 per cent. To bring final moisture content down to a narrow range in a short period of time, conditions for Emc of 3, 4, or 5 per cent were tested. For charge 6C, conditions for 3 per cent Emc were effective in lowering the boards of high moisture content to a limit of 9.5 per cent. Some of the boards were lower than 6 per cent moisture content, which is probably undesirable for remanufacturing. Best results were obtained with conditions for 4 or 5 per cent Emc (Table 7).

Table 7. Results of Various Conditions in an Equalization Period.

Charge	Initial moisture content*	Emc	Kiln time	Final moisture content High	Final moisture content Low	Final moisture content Avg
		%	Hours	%	%	%
6A	14.6	4	9	12.0	8.5	9.8
6C	15.2	3	17	9.5	6.0	7.1
6D	8.0	4	9	9.0	7.0	7.6
6E	10.0	4	19	9.0	7.0	7.3
6F	<12.0	5	7	10.5	7.0	8.5
6G	11.9	5	14	8.5	7.0	7.5
6H	16.2	5	14	12.0	7.5	8.3
6I	>11.0	5	5	11.0	7.0	8.2
6J	13.4	4	4	12.0	9.0	10.2

*Before equalization.

Moisture content at the start of this modified equalization period influenced the range of final moisture when maintaining identical Emc conditions and time for equalization. For example, charges 6A and 6D were held at conditions for 4 per cent Emc for 9 hours, but 6A ended with a range in final moisture content of 3.5 percentage points, while 6D, which started equalization with but 8.0 per cent moisture content, ended with a range of 2.0 percentage points (Table 7).

Length of the equalization period also affected the range of final moisture content. In charges 6G and 6I, with nearly the same beginning moisture content, 14 hours of equalization reduced range of final moisture content to 1.5 per cent, but 5 hours resulted in a final range of 4.0 per cent (Table 7).

Careful study of the results of the modified equalization period showed that conditions for 4 or 5 per cent Emc held for 7 hours, plus one hour for each additional percentage point of moisture content desired, would bring the range of final moisture content down to about 2 percentage points. When the wettest kiln sample registers 14 per cent or higher, the possibility of utilizing the above rule of thumb is doubtful, as indicated by results obtained in charges 6C and 6H.

Conditioning

Effect of a conditioning period in respect to time and Emc conditions also was tested by observing charges of series 6. Relief of stresses was rated visually by observation of cut-prong samples similar to ones shown in Figures 4 and 5. Results in Table 8 give time, dry-bulb temperature, Emc conditions, and a rating for stress relief.

Table 8. Results of Conditioning Periods.

Charge	Conditioning time	Dry-bulb temp	Emc	Stress relief
	Hours	Deg F	%	
6A	10	204	12	Good
6B	12	165	11	Excellent
6C	7	200	10	Good
6D	11	190	11	Excellent
6E	11	190	11	Excellent
6F	7	200	16	Excellent
6G	5	200	13	Good
6H	5	200	14	Fair
6I	6	200	16	Good
6J	7	190	18	Excellent

Conditioning was at dry-bulb temperatures between 190 and 200 F, except for charge 6B, which was held at 165 F in a commercial schedule. The relief of casehardening stresses was a visual observation, and the prong samples from each charge were rated as excellent (no casehardening stresses present), good (slight appearance of stresses), or fair (presence of slight to severe stresses).

With conditions that could be attained in commercial practices, results show 11 hours at conditions for 11 per cent Emc are required for relief of casehardening stresses, as in charges 6B, 6D, and 6E. If a commercial kiln could maintain conditions for 16-18 per cent Emc, as in charges 6F and 6J, time required for relieving stresses could be shortened to nearly 7 hours. Time can not be reduced much more, for charges 6H and 6I did not demonstrate adequate stress relief.

Table 9. Drying Conditions and Results for Four-Quarter Red Alder Lumber.

Charge	Kiln[1] time	Steaming		Drying cycle			Equalize		Condition		Moisture content				Loss of clear cuts	Degrade[2]
											Initial		Final			
		Temp	Time	Dry bulb	Emc	Time	Emc	Time	Temp	Time	Range	Avg	Range	Avg		
	Hr	Deg F	Hr	Deg F	Per cent	Hr	Per cent	Hr	Deg F	Hr	Per cent	Per cent	Per cent	Per cent	Per cent	
Series 1[3]																
A	98	--	--	200	12	69	9	18	200	6	109- 66	90	19.0-10.5	13.4	1.2	None
B	127	--	--	180	12	91	9	21	180	10	139- 98	105	19.0-12.0	13.1	1.4	2 to 3
C	147	--	--	150	12	108	9	21	170	13	129- 80	103	21.0-12.0	15.5	2.8	2 to 3
																1 to 2
Series 2																
A	103	--	--	200	12	75	10	14	200	11	124- 90	104	14.0-10.0	11.0	1.6	2 to 3
B	75	--	--	200	9	60	--	--	200	11	149-117	128	14.0- 9.0	11.0	1.5	None
C	52	--	--	200	6	35	--	--	200	10	136- 86	111	14.5- 9.0	11.2	1.4	None
Series 3[4]																
A	62	180	4	200	6	39	4	4	204	12	103- 75	82	14.0- 9.5	11.2	1.5	1 to 2
B	77	190	7	200	6	55	--	--	200	12	113- 83	97	12.0- 9.0	10.6	3.3	1 to 2
																2 to 3
C	87	190	6	200	6	64	--	--	200	13	116- 72	93	21.0- 9.5	12.4	2.2	None
Series 4[3]																
A	76	190	6	200	6	56	--	--	204	10	232- 97	141	11.0- 8.5	9.9	2.2	Sel to 2
																1 to 3
B	66	190	6	200	6	44	--	--	204	12	134- 76	118	13.5- 9.5	11.2	3.9	3-- 2 to 3
																Sel to 3
C	66	190	7	200	6	44	--	--	180	11	155- 91	116	15.0- 9.0	10.9	2.5	None
Series 5																
A	55	200	4	200	6	38	--	--	200	9	151- 98	123	14.0- 9.0	11.5	0.8	None
B	62	200	12	200	6	36	--	--	200	10	123- 73	96	17.0-10.0	13.6	1.6	None
C	56	210	11	210	6	31	--	--	215	9	128- 95	106	19.0-11.5	14.6	3.2	None
D	116	195	8	200	12	73	6	18	200	12	133- 90	115	13.5-10.0	11.4	2.8	3 to out
																1 to 2

Series 6																
A	64	200	10	200	6	29	4	9	204	10	159-109	126	12.0- 8.5	9.8	1.1	None
B	189	150	13	commercial		164	--	--	165	12	155-135	147	8.0- 7.0	7.2	1.0	None
C	73	195	14	220	8	12	3	17	200	7	150-119	132	9.5- 6.0	7.1	2.6	2-- 2 to 3
				200	6	18										
D	85	195	7	200	10	13	4	9	190	11	148-118	130	9.0- 7.0	7.6	0.7	None
				200	6	42										
E	93	195	7	200	10	8	4	19	190	11	137-111	125	9.0- 7.0	7.3	0.6	None
				200	6	44										
F	74	200	12	200	10	10	5	7	200	7	146-129	137	10.5- 7.0	8.5	0.6	None
				200	6	35										
G	70	--	--	200	12	10	5	14	200	5	127- 70	106	8.5- 7.0	7.5	1.0	1 to 3
				200	9	5										
				200	6	32										
H	67	--	--	200	12	11	5	14	200	5	154-113	136	12.0- 7.5	8.3	0.3	None
				200	9	6										
				200	6	26										
I	72	--	--	200	12	19	5	5	200	6	140- 85	118	11.0- 7.0	8.2	0.8	None
				200	9	5										
				200	6	34										
J	79	155	13	200	8	19	4	9	190	7	129- 72	102	12.0- 9.0	10.2	1.5	2-- 2 to 3
				200	6	27										

[1] Total time in kiln; includes warming period, but not time for weighing samples.

[2] Drop in grade is listed for each piece degraded.

[3] Fan-reversal period for all charges, except series 4 and series 1 (24 hours), was 1-3 hours.

[4] Air velocity for all charges, except series 3, was 500-600 feet a minute.

Of course, the range of moisture content prior to conditioning was of major importance. A charge having a wide range in moisture content, as in charges 6H and 6I, requires prolonged conditioning even at high Emc conditions. Even a charge like 6G, with a narrow range in moisture content, required additional time for relieving stresses. Therefore, range of moisture content prior to conditioning, time of conditioning period, and Emc conditions are all closely related.

General

Some pieces in all charges had areas of reddish-brown heartwood with extremely high moisture content. These areas exhibited severe honeycombing and collapse regardless of schedules followed.

After surfacing, areas of red heartwood showed considerable staining. Since stain is considered a defect in clear cuttings, seasoning degrade occurring in these areas was not considered in computing the percentage loss of clear-cutting area.

Collapse and honeycombing did not occur in any of the pieces without red heartwood. Most of the seasoning degrade recorded amounted to end checks that penetrated no more than one inch. Seasoning checks also were found extending from knots, or in areas of distorted grain.

Since all but one of the charges were weighted, cupping, twist, and bow nearly were eliminated. Crook was common in all charges, but it usually was traced to tension wood along one edge of the board.

Five- and six-quarter lumber

Series 7 consisted of five-quarter, and series 8 of six-quarter lumber. In these series, emphasis was placed on amount of degrade encountered when following a fast schedule (Table 10). Results indicated five-quarter stock can be dried satisfactorily with a fast schedule. Percentage losses of clear-cutting area in charges 7B and 7C were comparable to those of charges in series 6. Also, the fast experimental schedules resulted in less degrade and drying time than experienced with a commercial schedule for five-quarter lumber.

In charges of six-quarter lumber in series 8, results from experimental schedules indicated the percentage loss of clear-cutting area exceeded the loss occurring with a commercial schedule followed in charge 8A (Table 10). Seasoning degrade was confined to large end-checks penetrating as much as four inches. Checks occurring around knots and in areas of distorted grain were more numerous and larger than encountered in drying lumber of less thickness.

Table 10. Drying Conditions and Results for Five-Quarter (Series 7) and Six-Quarter (Series 8) Red Alder Lumber.

Charge	Kiln time[1]	Steaming Temp	Steaming Time	Drying cycle Dry bulb	Drying cycle Emc	Drying cycle Time	Equalize Emc	Equalize Time	Condition Temp	Condition Time	Moisture content Initial Range	Moisture content Initial Avg	Moisture content Final Range	Moisture content Final Avg	Loss in clear cuts	Degrade[2]
	Hr	Deg F	Hr	Deg F	Per cent	Hr	Per cent	Hr	Deg F	Hr	Per cent	Per cent	Per cent	Per cent		
7A[3]	153	153	13	commercial		102	5	28	155	6	108- 70	90	11- 7	8.6	1.7	None
7B	117	195	12	200	12	13	5	15	195	7	109- 95	98	16- 8	9.5	0.3	None
				200	9	58										
				200	6	8										
7C	67	--	--	200	10	15	5	12	195	12	116-100	108	16- 8	10.6	0.6	None
				200	6	23										
8A	167	150	13	commercial		133	5	11	180	8	146-113	131	12- 7	9.1	0.8	1 to 2
																1 to 2
8B	122	150	12	200	12	12	4	22	180	8	126-114	120	13- 7	8.3	1.6	2 to 3
				200	9	47										
				200	6	18										
8C	122	182	12	200	12	24	5	19	180	9	129- 85	106	12- 8	9.6	1.9	None
				200	9	24										
				200	6	31										

[1]Total time the charge was in the kiln, including warm-up, but not including weighing of samples.

[2]Drop in grade is listed for each piece degraded.

[3]Fan-reversal period was 6 hours; for other charges, it was 3 hours.

CONCLUSIONS

Four-quarter red alder lumber can be dried successfully with higher dry-bulb temperatures and conditions for lower Emc than presently adopted for commercial schedules. The shortened schedule developed is suitable for use in modern, conventional, steam-heated dry kilns where good practices are followed.

The following schedule is suggested for drying four-quarter red alder lumber in about 85 hours:

1. Warming to 200 F; 4-6 hours
2. Presteaming at 190-200 F with 5 F wet-bulb depression; 12 hours
3. Drying at 200 F dry bulb, 10-12 per cent Emc; at least 12 hours
   Lower Emc to 6 per cent; until wettest sample at 14 per cent
4. Equalization at 5 per cent Emc; 14 hours*
5. Conditioning at 190-200 F dry-bulb, 13 per cent Emc; 12 hours

*If final moisture content is to average around 8 per cent.

This schedule also recommends an air velocity on the leaving air side of 400 feet a minute, or higher, with fans reversed every six hours--especially if air travels more than 8 feet through the charge.

The suggested schedule was designed for unseasoned lumber and not for partially air-dried stock. If partially air-dried stock is utilized, drying time would be shortened, but color likely would not be uniform, since red alder lumber normally stains heavily in air drying.

Conclusion is that five-quarter stock can be dried successfully by the forementioned schedule. However, additional thickness must be compensated for by lengthening the drying cycle and periods of equalization and conditioning.

The proposed schedule is not advised for six-quarter stock because of losses in seasoning degrade.

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FOREST RESEARCH LABORATORY

The Forest Research Laboratory is part of the Forest Research Division of the Agricultural Experiment Station, Oregon State University. The industry-supported program of the Laboratory is aimed at improving and expanding values from timberlands of the State.

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