A COMPARISON OF WESTERN HEMLOCK AND BALSOM FIR DIRED AT HIGH AND AT CONVENTIONAL TEMPERATURES

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Introduction

On the coast of British Columbia the cut (3) of western hemlock lumber has increased annually until in 1964 it amounted to 1650 million board feet or 48.1 per cent of the total lumber production. Coast hemlock (Tsuga heterophylla (Haf.) Sarg.) mixed in varying proportions with balsam fir (Abies amabilis (Dougl.) Forb.) is marketed as "hembal" and the mixture is reported for statistical purposes as hemlock. Normally about one-half of the clear hemlock is kiln-dried, but only a small amount of common lumber is dried. At present market trends show an increased interest in the kiln-drying of common lumber.

The unseasoned moisture content of both species is high and varies widely, consequently the drying time is long for both the clears and the commons. The clear lumber is usually dried to a uniform moisture content of 10 per cent and to reach this level requires a long kiln residence time. The commons are dried to an average of 15 per cent and here because of the lower value of the products a compromise must be reached between drying time and uniformity of final moisture content. The segregation of unseasoned lumber into moisture classes is not practiced at the present time.

Small scale tests have shown (9) that the drying time of hemlock can be substantially reduced without an adverse effect on strength properties or grade by employing temperatures above 212°F. Furthermore, it was shown that a narrower distribution of moisture content can be achieved by using a combined low-high temperature schedule than by using conventional drying. To test the commercial feasibility of these experimental results pilot-kiln drying tests were made and their moisture content distribution and seasoning degrade compared with those of hemlock and balsam fir dried at conventional temperatures in industrial operations. The information on degrade at conventional industrial kilns was obtained in another study which will be published shortly.

Moisture content distribution has been reported on hemlock (1, 2, 4) dried at temperatures not exceeding 180°F. Seasoning and surfacing degrade studies were also reported (5, 6) on hemlock dried in industrial operations. The relationships between drying schedules, seasoning degrade and moisture content distribution were also studied (7). In this study the seasoning degrade and moisture content distribution of hemlock and balsam dried at high temperatures in the pilot kiln are compared with industrial practice in British Columbia.

The Kilns

The pilot kiln used at the laboratory is steam heated with three individually driven overhead fans which give air circulation rates of about 450 f. p. m. and 850 f. p. m. Capacity of the kiln is about 8000 fbm of 2-inch lumber.

The conventional dry kilns studied at the industrial operations were representative of commercial practice. All were steam heated with air circulation rates of 250 to 400 f. p. m.

Material

Two charges, one of common lumber and one of clear were obtained from local mills. Each charge consisted of about 300 pieces of 7/4 inch by 4 to 12 inch wide lumber in lengths of 14 to 22 feet. The quality of the lumber and the proportion of hemlock and balsam was representative of that being dried at the mills.

To measure the wide distribution of moisture content in the unseasoned lumber, the moisture content of each piece was determined by the oven method.

Figure 1 shows the unseasoned moisture content distribution for hemlock and balsam and it is typical of common dimension lumber that the average was 73 per cent and about 20 per cent of all the pieces were above 100 per cent moisture content. Figure 2 shows the unseasoned moisture content distribution for clears and in this case the average was 85 per cent and 30 per cent of the pieces were above 100 per cent moisture content. The specific gravity of samples from each board was also calculated.

Many factors contribute to the rate of drying. Initial weight, unseasoned moisture content, density and number of growth rings per inch were found (8) to determine in this order the magnitude of change in the drying rate. The initial weight combines two factors, the moisture content and the density. Therefore, besides the distribution of unseasoned moisture content, that of specific gravity is shown in this study and the wide variation in specific gravity of the sample is illustrated in Figure 3. The weighted averages for hemlock and balsam were 0. 410 and 0. 360 and overall weighted average was 0. 384.

Drying Schedules, Dry Moisture Distribution

The high temperature schedules used were the low-high schedules reported earlier (9). These schedules utilize conventional temperatures from the beginning of drying until the fiber saturation level is reached, then temperatures above the boiling point of water are maintained until the end of drying. The air-circulation rate used was 450 f. p. m. in the first part of the schedule and 850 f. p. m. in the second part.

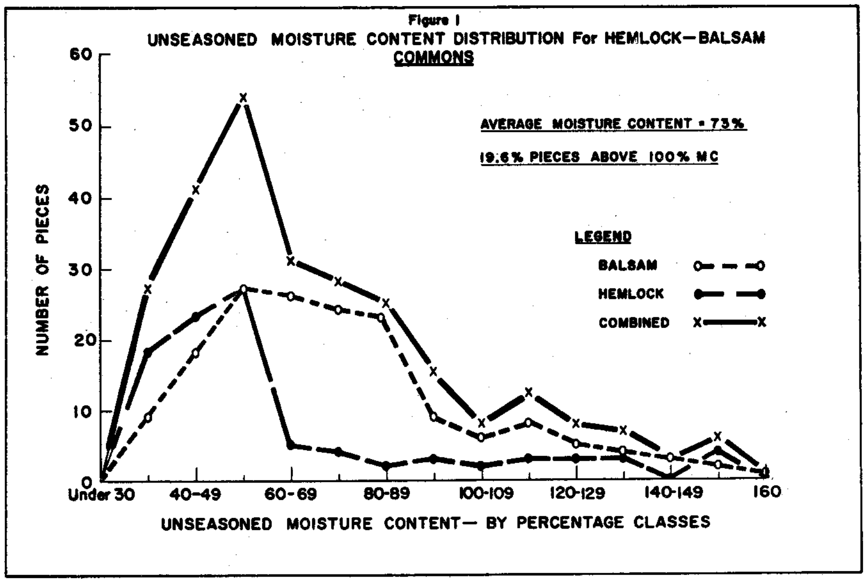


Figure 1
UNSEASONED MOISTURE CONTENT DISTRIBUTION For HEMLOCK—BALSAM
COMMONS
AVERAGE MOISTURE CONTENT = 73%
19.6% PIECES ABOVE 100% MC
LEGEND
BALSAM
HEMLOCK
COMBINED
NUMBER OF PIECES
0
10
20
30
40
50
60
Under 30
40-49
60-69
80-89
100-109
120-129
140-149
160
UNSEASONED MOISTURE CONTENT— BY PERCENTAGE CLASSES

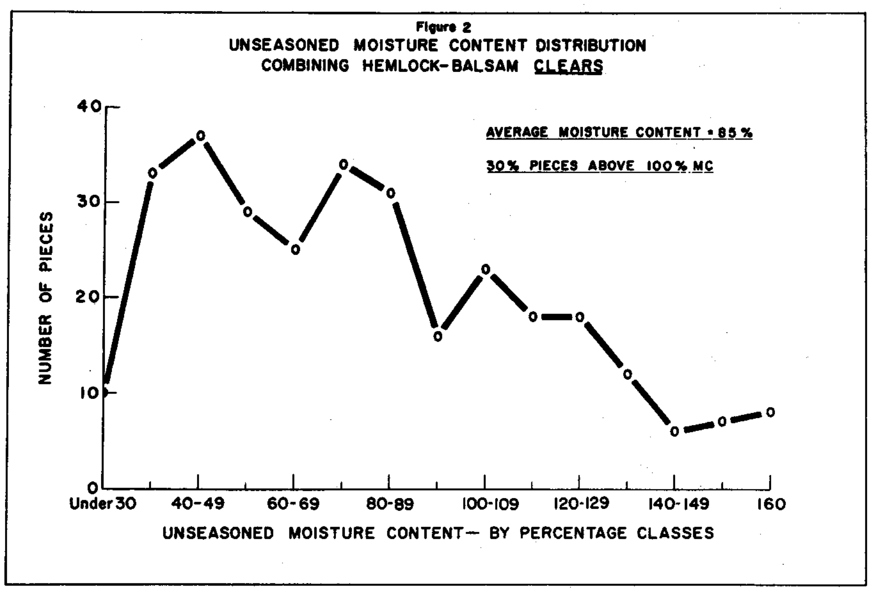


Figure 2
UNSEASONED MOISTURE CONTENT DISTRIBUTION
COMBINING HEMLOCK-BALSAM CLEARS
AVERAGE MOISTURE CONTENT = 85%
30% PIECES ABOVE 100% MC
NUMBER OF PIECES
0
10
20
30
40
Under 30
40-49
60-69
80-89
100-109
120-129
140-149
160
UNSEASONED MOISTURE CONTENT— BY PERCENTAGE CLASSES

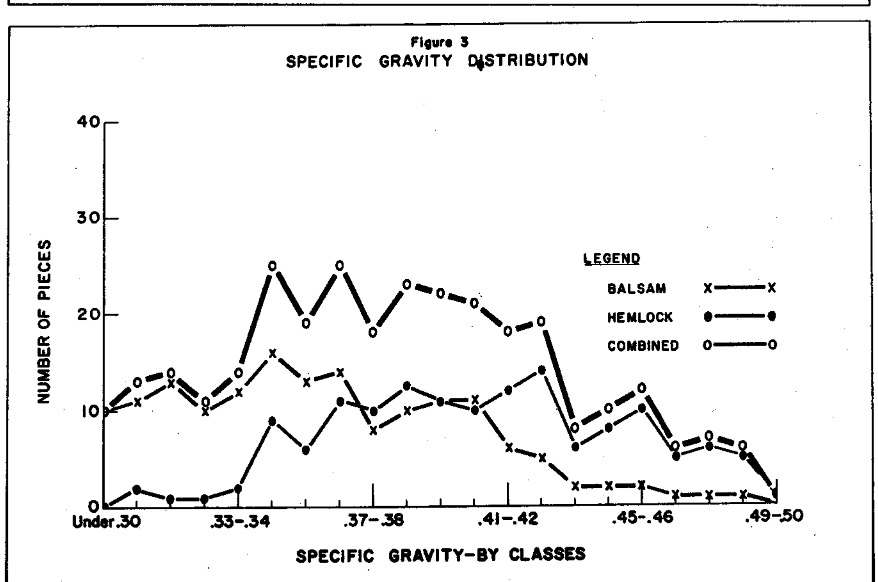
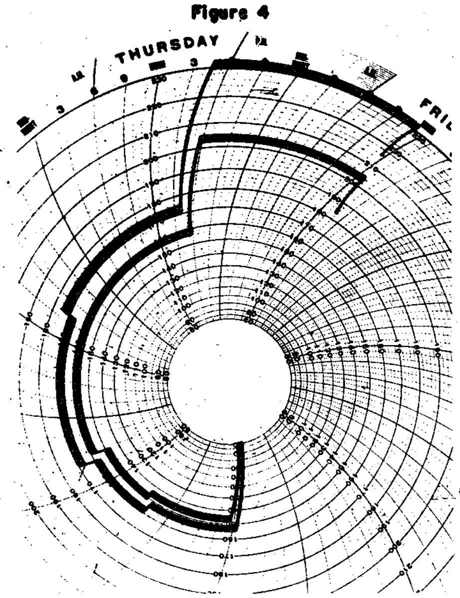


Figure 3
SPECIFIC GRAVITY DISTRIBUTION
LEGEND
BALSAM
HEMLOCK
COMBINED
NUMBER OF PIECES
0
10
20
30
40
Under .30
.33-.34
.37-.38
.41-.42
.45-.46
.49-.50
SPECIFIC GRAVITY-BY CLASSES

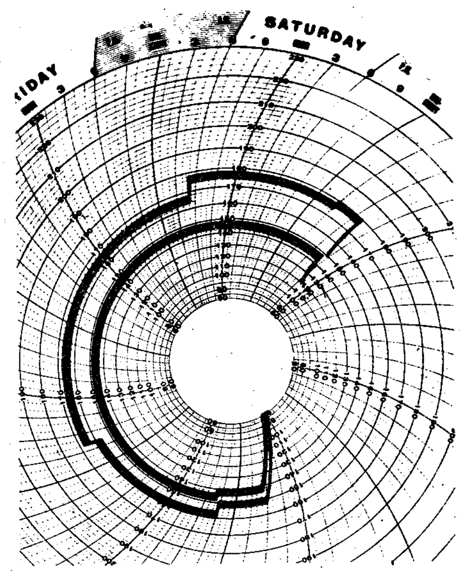
KILN DRYING SCHEDULES FOR COMMONS

Figure 4



LOW—HIGH TEMPERATURE

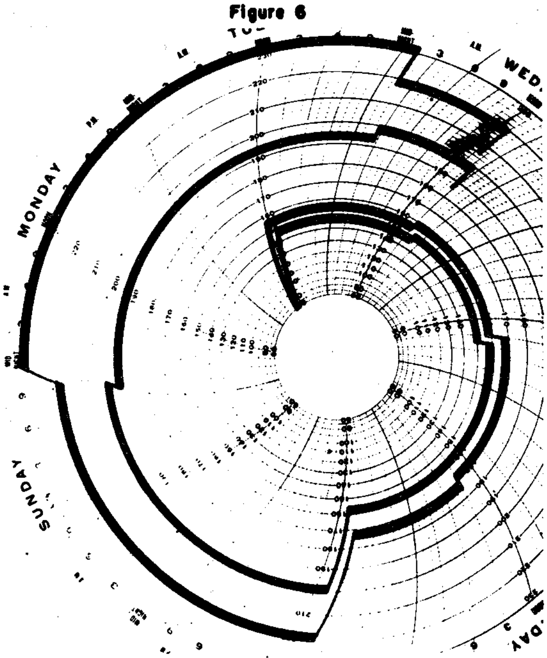
Figure 5



TYPICAL COMMERCIAL

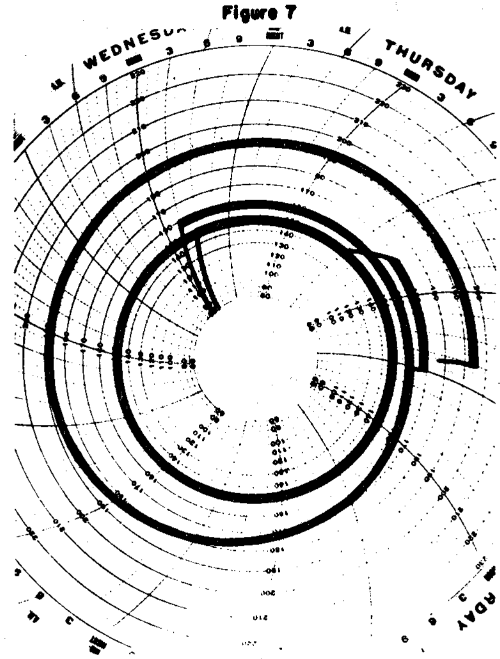
KILN DRYING SCHEDULES FOR CLEARS

Figure 6



LOW—HIGH TEMPERATURE

Figure 7



TYPICAL COMMERCIAL

Figure 4 shows the control chart for the pilot-kiln charge of the common grades of dimension lumber. It was a 96 hour schedule, starting at 158°F dry-bulb and 150°F wet-bulb temperature. The setting was gradually changed and after three days the temperatures were raised to 235°F dry-bulb and 204° wet-bulb and maintained at that level until the end of drying.

Figure 5 shows a typical commercial schedule for drying commons with a time of 115 hours and a maximum temperature of 180°F dry-bulb and 148° wet-bulb. The saving by using high temperatures was 15 per cent.

Figure 6 shows the chart of the pilot kiln schedule for clears. One hundred and ninety-six hours total drying time was necessary to reduce the clears to an average moisture content of 7 per cent. Conventional settings were used during the first four days. Then the temperatures were raised to 220°F dry-bulb and 200°F wet-bulb and maintained for two days, and for the two last days maintained at 235°F dry-bulb and 195°F wet-bulb temperature.

A typical commercial schedule for drying hemlock clears is shown in Figure 7. This schedule required 228 hours and used a maximum dry-bulb temperature of 193°F. The clear schedules for good industrial drying ranged from 188 to 288 hours and averaged 231 hours. Thus a saving of 15 per cent from the average time was achieved with the high temperature schedules.

After completion of the drying of each charge, the moisture content was measured with a resistance type electric moisture meter. Six measurements, three in the shell and three in the core, were made on each piece and the values averaged. The dry moisture content distribution for the charge of the common grades is shown in Figure 8 and that for the clear grade lumber in Figure 9.

Seasoning Degrade

All lumber of each shipment was first carefully graded, marked and tallied in the rough unseasoned condition to establish its potential grade and value. Then the lumber was kiln-dried, surfaced, transported to the mill yard and carefully regraded. The difference between the potential grade and volume of rough unseasoned lumber (input) and the final grade and volume of surfaced dry lumber (output) is recorded as degrade. Manufacturing degrade such as narrowness was ignored but torn grain was included because it was caused by planing wet lumber with knives set for dry lumber.

All grading was done by the same grade supervisor of the British Columbia Lumber Manufacturers' Association. Lumber was graded under "Standard Grading and Dressing Rules Number 59 of the British Columbia Lumber Manufacturers' Association".

Shake was treated as a seasoning defect when it showed in the dry lumber and its presence in unseasoned lumber had not been detected or when it had been extended by drying.

Tables 1 and 2 show the seasoning degrade by causes and widths for common hemlock and balsam. Open shake was the greatest source of loss. The 10 and 12 inch balsam showed a high amount of roller split indicating the need for segregation of widths to prevent over-drying.

The volumes of each grade of unseasoned common lumber and the percentages of grades recovered after drying and surfacing are shown for hemlock and balsam in Tables 3 and 4 respectively.

TABLE 1. PERCENTAGE AND VALUE OF LOSSES CAUSED BY SEASONING - 2-INCH HEMLOCK COMMONS

	Loss by Per cent Volume and by Value Per M fbm											
	2 x 4		2 x 6		2 x 8		2 x 10		2 x12		Total	
	% Vol.	$/M	% Vol.	$/M	% Vol.	$/M	%Vol.	$/M	%Vol.	$/M	% Vol.	$/M
TRIMS												
Season Check					0. 4	0. 25			0. 7	0. 51	0. 3	0. 20
Split Ends					0. 2	0. 12			-	-	0. 1	0. 05
DEGRADE												
Season Check									5. 9	1. 37	1. 0	0. 23
Twist					1. 3	0. 10					0. 6	0. 05
Torn Grain							4. 9	1. 42			0. 7	0. 22
Open Shake					7. 1	1. 79	5. 4	1. 58	17. 7	4. 73	7. 0	1. 84
Total % Vol.	Nil		Nil		9. 0		10. 3		24. 3		9. 7	
Loss $/M		Nil		Nil		2. 26		3. 00		6. 61		2. 59
Value Rough Unseasoned $/M	44. 90		57. 14		63. 12		66. 68		83. 50		66. 58	
Unseasoned Volume Volume fbm	40		862		1853		613		668		4036	

TABLE 2. PERCENTAGE AND VALUE OF LOSSES CAUSED BY SEASONING - 2-INCH BALSAM COMMONS

	Losses by Per cent Volume and by Value Per M fbm											
	2 x 4		2 x 6		2 x 8		2 x 10		2 x 12		Total	
	% Vol.	$/M	% Vol.	$/M	% Vol.	$/M	% Vol.	$/M	% Vol.	$/M	% Vol.	$/M.
TRIMS												
Split Ends					0. 3	0. 18	0. 8	0. 75			0. 2	0. 18
DEGRADE												
Roller Split							8. 3	3. 92	5. 5	1. 55	2. 7	0. 99
Twist					2. 5	0. 18					1. 0	0. 07
Open Shake	100. 0	20. 00	4. 0	1. 04	10. 0	2. 39	8. 4	1. 91	16. 7	4. 34	10. 8	2. 67
Total % Vol.	100. 0		4. 0		12. 8		17. 5		22. 2		14. 7	
Loss $/M		20. 00		1. 04		2. 75		6. 58		5. 89		3. 91
Value Rough Unseasoned $/M	73. 00		64. 73		69. 06		77. 83		70. 89		70. 05	
Unseasoned Volume fbm	13		502		1082		400		720		2717	

Figure 8

FINAL MOISTURE CONTENT DISTRIBUTION For HEMLOCK-BALSAM COMMONS

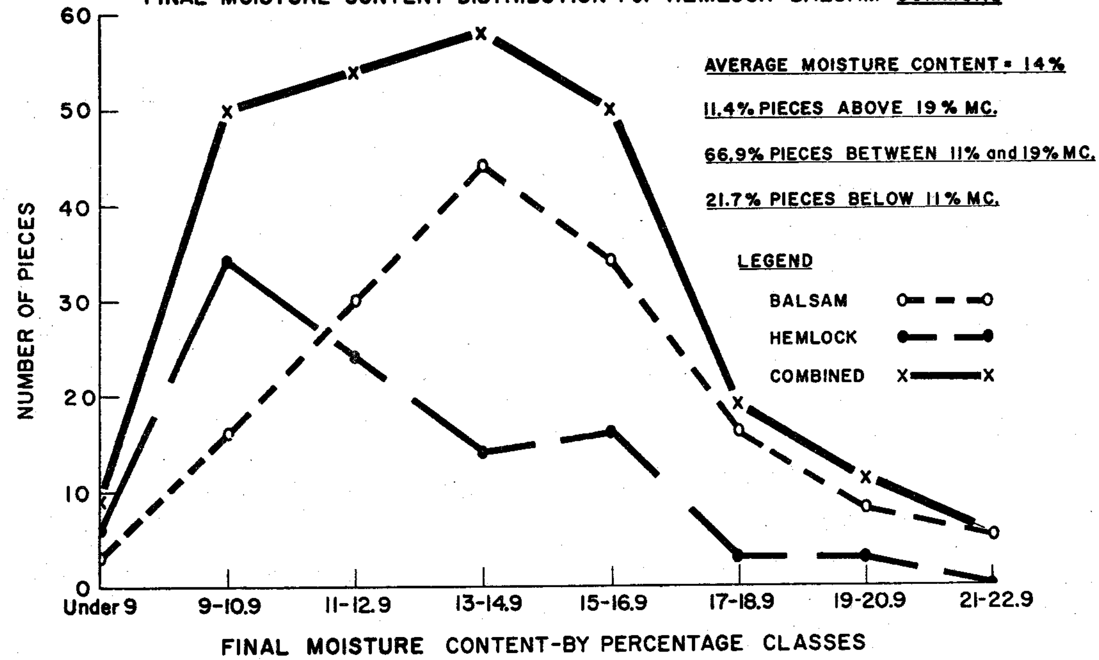


Figure 9

FINAL MOISTURE CONTENT DISTRIBUTION COMBINING HEMLOCK-BALSAM CLEARS

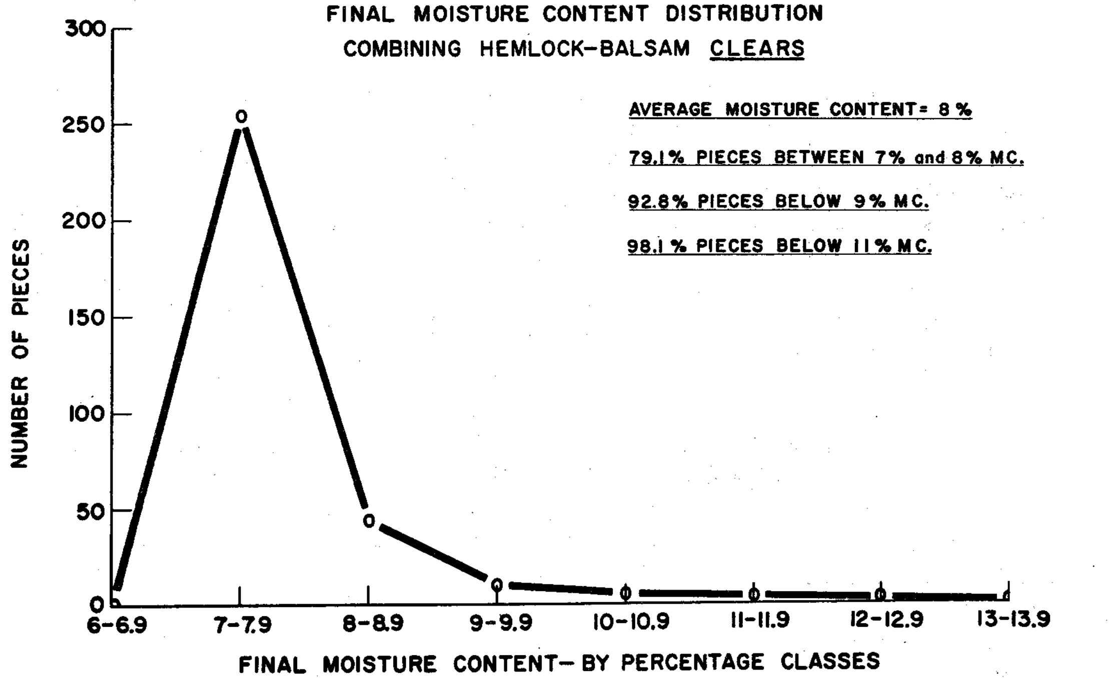


TABLE 3
PERCENTAGE CHANGE CAUSED BY SEASONING - FOR EACH LUMBER GRADE FROM ROUGH UNSEASONED TO DRESSED DRY

2-Inch Hemlock Commons - All Widths

Volume (fbm)	Grade	Per cent						Total Per cent	Loss $ Per/M
		SEL.	CON.	STD.	UT.	ECON.	TRIM		
902	Sel.	72	3	25	-	-	-	100	7.38
1387	Con.	-	90	9	-	-	1	100	2.77
818	Std.	-	-	100	-	-	-	100	-
789	Ut.	-	-	-	100	-	-	100	-
140	Econ.	-	-	-	-	100	-	100	-

TABLE 4
PERCENTAGE CHANGE CAUSED BY SEASONING - FOR EACH LUMBER GRADE FROM ROUGH UNSEASONED TO DRESSED DRY

2-Inch Balsam Commons - All Widths

Volume (fbm)	Grade	Per cent						Total Per cent	Loss $ Per/M
		SEL.	CON.	STD.	UT.	ECON.	TRIM		
1061	Sel.	83	3	14	-	-	-	100	4.38
780	Con.	-	86	9	5	-	-	100	4.37
375	Std.	-	-	79	21	-	-	100	5.28
394	Ut.	-	-	-	93	7	-	100	1.38
107	Econ.	-	-	-	-	100	-	100	-

The weighted average loss in value per thousand board feet (using average F. O. B. mill prices for B. C.) is given on the right hand column of both tables. The average loss for hemlock was $2.59 and for balsam was $3.91 and the weighted average on the basis of 20% balsam and 80% hemlock was $2.85. The industrial drying losses with the same mixture of species amounted to $2.59. The average losses from kilns were similar but in the industrial drying the balsam had lower degrade than the hemlock.

Tables 5 and 6 show average grade recovery for all widths of hemlock and of balsam clears respectively. As in Tables 3 and 4 the proportion of lumber changed grade, and the volume loss in trim is shown for original grade.

TABLE 5
PERCENTAGE CHANGE CAUSED BY SEASONING - FOR EACH LUMBER GRADE FROM ROUGH UNSEASONED TO DRESSED DRY
2-Inch Hemlock Clears - All Widths

Volume (fbm)	Grade	Per cent							Total Per cent
		B	C	D	STD.	UT.	ECON.	TRIM	
1116	B	74	10	8	-	2	3	3	100
807	C	-	86	9	-	3	-	2	100
928	D	-	-	97	-	2	-	1	100

TABLE 6

PERCENTAGE CHANGE CAUSED BY SEASONING - FOR EACH LUMBER GRADE FROM ROUGH UNSEASONED TO DRESSED DRY

2-Inch Balsam Clears - All Widths

Volume (fbm)	Grade	Per cent							Total Per cent
		B	C	D	STD.	UT.	ECON.	TRIM	
1392	B	82	7	6	-	2	-	3	100
1007	C	-	85	8	-	4	2	1	100
568	D	-	-	83	7	9	1	-	100

The average loss in value per thousand board feet of hemlock and balsam of $13.52, is very high and partially can be explained by the low average final moisture content.

When the 6 and 8 inch widths were compared there was no appreciable difference in degrade between the high temperature run and commercial drying, the degrade amounted to $8.04 and $8.13 respectively. The great difference occurred in the 10 and 12 inch widths which in the high temperature run suffered severely from roller split in the planer. This probably would have been much less if the lumber had not been over-dried, a condition that could be controlled more readily if the wider widths were dried separately.

Table 7 shows a comparison of the moisture distribution between industrial and high temperature drying for both clear and common lumber.

TABLE 7

COMPARATIVE DATA OF COAST HEMLOCK LUMBER DRIED AT HIGH TEMPERATURE AND AT CONVENTIONAL SCHEDULES

Grade	Clears		Commons	
	High Temp.	Av. of Good Industrial Practice	High Temp.	Av. of Good Industrial Practice
Drying Schedule				
Av. initial M.C. %	85	82	73	85
Av. final M.C. %	7	9	14	14
Percentage of pieces at the end of drying				
10% M.C. and under	98	95	28	15
15% M.C. and under	100	100	77	70
19% M.C. and under	-	-	90	81
30% M.C. and under	-	-	99	92
Drying time hrs.	196	231	96	138
Losses due to Seasoning $/M	13.52	9.74	2.85	2.95

Conclusions

The results from drying one charge of hemlock and balsam clears and one charge of common dimension in a pilot kiln under a low-high temperature schedule cannot be considered conclusive but are reported to show the progress being made in this project. The earlier studies made in a small experimental kiln are being confirmed in the pilot kiln runs.

The initial moisture content varied widely from 30 to 220 per cent and averaged 85 per cent for the clear lumber with an average of 90 per cent for the hemlock and 81 per cent for the balsam. For the common lumber the average was 73 per cent moisture content with 77 per cent for the hemlock and 64 per cent for the balsam.

The drying times to comparable moisture contents were 15 per cent less than good industrial practice for both types of lumber.

The distribution of final moisture content was narrower than industrial practice. The average moisture contents for the clear lumber were 7 per cent for the high temperature schedule with 98 per cent of the pieces 10 per cent and under, and 9 per cent for industrial drying with 95 per cent of the pieces 10 per cent and under.

For the common lumber the average moisture contents were 14 per cent for both types of drying with 90 per cent of the pieces 19 per cent moisture content and under in the high temperature run, and 81 per cent of the pieces in the commercial runs.

The range of specific gravity was wide for both species and this probably contributes to the wide range in final moisture content.

The loss in value from seasoning in the common dimension was comparable for both types of drying and amounted to just less than $3. 00 per M/fbm.

In the clear grades the losses in value were about 40 per cent higher for the high temperature run, than for the average of commercial runs amounting to $13. 52 as against $9. 74 per M/fbm.

The losses in the 10 and 12 inch width for the pilot-run and industrial clear schedules were high and mostly caused by roller split in the planer. It is felt that be segregating these two widths, overdrying could be prevented and the number of roller splits greatly reduced. This would apply particularly to the low-high schedule.

These preliminary results are encouraging and further studies are planned.

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