DRY WEST COAST HEMLOCK AND DOUGLAS FIR 1 1/2 INCH DIMENSION TO THE NEW MOISTURE SPECIFICATION WITH A MINIMUM AMOUNT OF DEGRADE

By Tom L. Abner

Introduction

Weyerhaeuser Company is now manufacturing and selling softwood dimension lumber under a new size and moisture content specification. Our specifications call for the lumber to be at an average moisture content of 15% and a maximum of 19% at time of surfacing. Surfaced thickness is 1 1/2". Thus, size and moisture content are tied together. The widths with the exception of 2" stock have not been changed.

On the fact of it, drying to meet these new specifications doesn't seem to be a very difficult task. However, past studies by Weyerhaeuser and others have proven that as the moisture content is decreased on dimension lumber the loss in value from drying degrade is increased. Figure 1 shows a summary of a company-wide study of the degrade of 1 5/8" West Coast hemlock dimension at various moisture content levels. Figure 2 shows the same information for 1 5/8" Douglas fir dimension.

Another problem that existed was the large variability of dry moisture content of West Coast hemlock.

With this background, we set out to develop or adopt the best schedules that would reduce degrade to a minimum and also reduce the variation in dry moisture content of hemlock.

Determining Moisture Content in the Kiln

One of the first problems that arose while we were studying various schedules was the lack of a good method of determining the moisture content of a kiln charge of lumber while it was still in the kiln. In the past the moisture content has been determined by taking a few oven-dry samples, by visual inspection of the end shrinkage of the boards or by a set length schedule. None of these methods have proved to be very satisfactory now that we are drying dimension lumber to a lower and more exact moisture specification. A miscalculation of the average moisture content on either side of the target moisture content of 15% can be very costly.

Figure 3 shows the results of a study in which five widths of Douglas fir dimension were dried to an average moisture content of 12 and 15% on the same schedule. As you can see, the drier stock shows a loss of $1.80 - $5.00/MBF greater than that dried to 15%. Thus over-drying by 3% can be extremely costly.

On the other hand, if a charge is pulled at 17-18% moisture content too many pieces will be wet and have to be redried. You can readily see the importance of a better method of determining the moisture content of lumber in a kiln.

We are now using a hot meter check at all of our mills drying 1 1/2" dimension. This consists of going into the kiln while the lumber is hot and probing the edges of the lumber with a long pin Delmhorst moisture meter. The needles are driven one inch into the edges of the lumber. We take approximately 100 readings along the length of the kiln and from the top to the bottom of the loads. This gives us a considerably larger and more representative sample than can be obtained by other methods. We then have a temperature correction table to adjust to the true moisture content. Figure 4 shows this table. These temperature corrections are similar to those developed by Delmhorst Instrument Company and others.

Our ability to predict the moisture content of lumber in a kiln with the hot meter check has been good. We can generally hit the target moisture content within 1%; and rarely miss by over 2%. However, certain precautions must be used. One of these involves multiple track kilns. If there is a large temperature

FIGURE 1

SUMMARY - HEMLOCK DEGRADE STUDY

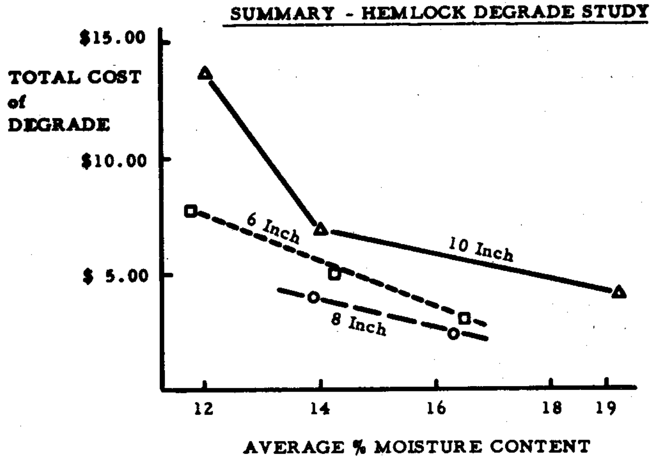

FIGURE 2

SUMMARY - DOUGLAS FIR DEGRADE STUDY

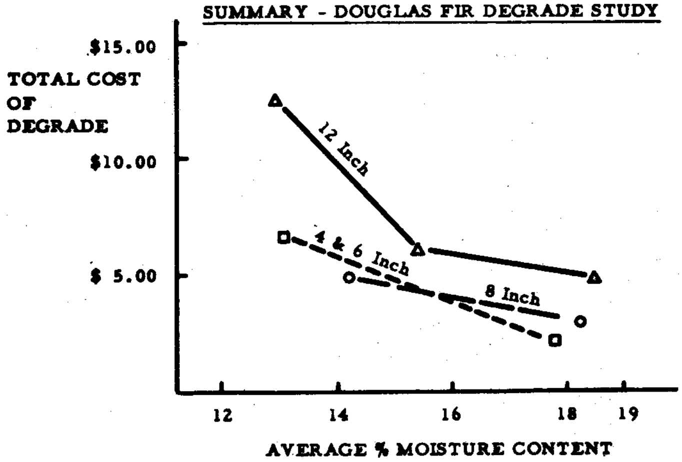

FIGURE 3

COMPARISON OF THE DEGRADE OF DOUGLAS-FIR DIMENSION DRIED TO 12 AND 15% AVG. M.C.

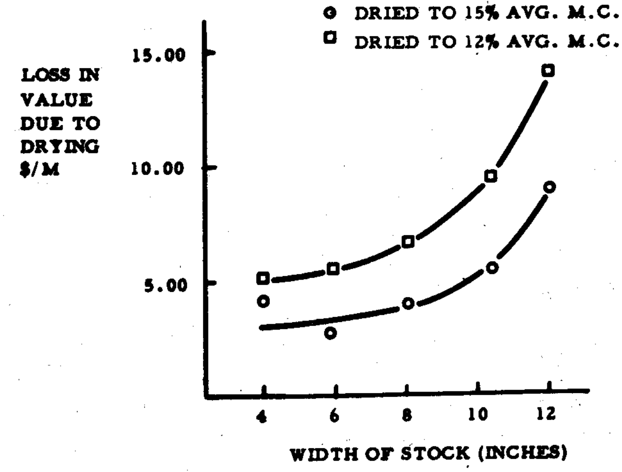

FIGURE 4. TEMPERATURE CORRECTION TABLE

Wet Bulb Temperature of

Meter Reading	110	120	130	140	150	160	170
8	7	-	-	-	-	-	-
9	7	7	-	-	-	-	-
10	8	8	7	7	-	-	-
11	9	9	8	8	7	7	7
12	10	9	9	9	8	8	8
13	11	10	10	9	9	9	9
14	11	11	11	10	10	9	9
15	12	12	11	11	10	10	10
16	13	13	12	12	11	11	10
17	14	13	13	12	12	11	11
18	15	14	14	13	13	12	12
19	16	15	14	14	13	13	12
20	16	16	15	15	14	13	13
21	17	17	16	16	15	14	14
22	18	17	17	16	15	15	14
23	19	18	17	17	16	16	15
24	20	19	18	18	17	16	16
25	21	20	19	18	18	17	16
26	22	21	20	19	18	18	17
27	22	21	20	20	19	18	18
28	23	22	21	21	20	19	18
29	24	23	22	21	21	20	19
30	25	24	23	22	21	21	20
31	26	25	24	23	22	21	21
32	27	25	24	24	23	22	21
35	28	27	26	25	24	23	22
40	31	29	28	27	26	25	23
50	38	36	34	32	30	29	27
60	-	-	-	35	33	31	29

Values of moisture content under solid line are only indicative, since they are above fiber saturation point.

FIGURE 5. PROPORTION OF PIECES OVER 19% DRY MOISTURE CONTENT IN GREEN WEIGHT CLASSES

Green Weight Class

	Heavy			Light						
Pieces over 19% Moisture	10	9	8	7	6	5	4	3	2	1
# Pieces	41	41	51	23	20	13	10	9	4	1
% in Each Class	19.3	19.3	23.8	10.8	9.4	6.1	4.7	4.2	1.9	0.5
Cumulative Percentage	19.3	38.6	62.4	73.2	82.6	88.7	93.4	97.6	99.5	100.0

About 2/3 of "wet" pieces are in the heaviest 30% by green weight (10% in each class). Total number of pieces in each "green" weight class approximately 100.

or velocity drop across the loads the edge relationship will not hold. Also if fan reversals are more than 6 hours apart both sides of the charge should be hot metered.

Drying West Coast Hemlock to the New Moisture Content Specifications

This species is characterized by a large variation in green moisture content which varies from 30 to over 150%. In addition, West Coast hemlock is dried and sold as a mixture containing West Coast hemlock and some of the coast true firs. This mixture as defined by WCLA Rules #15 consists of silver fir (Abies amabilis), noble fir (Abies procera), and grand fir (Abies grandis). This heterogeneous mixture presents a difficult drying problem.

To reduce the moisture non-uniformity we considered two possibilities. One was to use a pre-sort and separate by weight classes or other characteristics such as sap and heart and dry these separately. The other possibility was to develop better schedules for drying hemlock.

A study was made to determine the effectiveness of a green weight sort. One thousand 2" x 8" x 16' hemlock dimension boards were weighed and then dried in a commercial kiln. The lumber was dried to an average moisture content of 15.5% and surfaced. The moisture content of each board was then determined. The results of this study are shown in Figure 5. This data shows that approximately two-thirds of the wet pieces occurred in the heaviest 30% of the pieces by green weight.

The green weight sort showed some definite promise in reducing the dry moisture non-uniformity. However, the disadvantage is that twice as many sorts are needed on the green chain and the sort once made persists through the mill. Thus, we took the second approach which was to develop the best schedules possible for reducing moisture uniformity and then to install electronic moisture meters at the unstackers that would mark all "wet" boards.

In the past, many operators have used fast schedules on their hemlock dimension and have overdried the largest part of it in an effort to dry the wet portion. A typical accelerated high temperature-large wet bulb depression schedule of this type is shown in Figure 6, and the moisture distribution curve in Figure 7. The largest percentage of the pieces are below 12% moisture content and 11% of the pieces still exceed 19% moisture content. This type of drying results in both poor moisture uniformity and poor quality.

The reasons for poor quality are evident. Most kiln drying degrade is associated with shrinkage; cupped or warped boards are more apt to develop roller split, loose knots or skips during the machining operation, etc. As you can see from the moisture distribution curve, approximately two-thirds of the pieces are below 12% moisture content. This results in an excessive amount of drying degrade related directly to unnecessary shrinkage in the dry kiln. To illustrate this, Figure 8 is a summary of a hemlock dimension degrade study. One thousand pieces were graded in the rough green, kiln dried, regraded and the moisture content of each board determined. Each board was marked in the green so it could be identified after surfacing. The results in Figure 8 show that as the dry moisture content of individual boards increases, the frequency and cost of drying degrade decreases, except for the "wet" pieces over 21% moisture content. The degraded pieces in this "wet" group are generally characterized by a dry surface that is severely checked, yet they have a very wet core. You can readily see from this data the importance of improving moisture uniformity to keep as many pieces as possible out of the low end of the moisture distribution.

We have found that less severe and slower schedules give us much better moisture uniformity with a minimum amount of degrade, even at the lower moisture content levels. The first question that arises with the recommendation of slower schedules is the loss of kiln capacity. However, because of the reduced thickness of the 1 1/2" dimension, roughly an 18% increase in kiln capacity is available; about 5%

for the additional board feet in each load, and a theoretical decrease of 13% in drying time due to the reduction in green thickness.

Figure 9 shows the two basic types of schedules that we have used successfully in drying our 1 1/2" hemlock dimension. The first schedule is an equalizing type schedule where we slow up the drying at the end by setting up an equlibrium moisture content condition in the kiln of 10 to 12%. This prevents the fast drying pieces from becoming over-dried while still allowing some drying of the slower pieces.

The second schedule is a constant 20 degree depression schedule combined with 6 hours of conditioning. Figure 10 and 11 show the moisture distributions of three kiln charges of hemlock dimension dried to the same moisture content in the same kilns with each type of schedule. The moisture distributions are approximately the same. The mill degrade arising from drying 1 1/2" hemlock dimension on these schedules is shown in Figure 12. The quality of the lumber dried on both schedules is also approximately the same. The constant depression schedule has the advantage of using less kiln residence time. The equlization schedule has the advantage of reducing the possibility of over-drying because E. M. C. floor prevents the lumber from drying below about 10%. At one of our mills we have shown that by extending the drying time to 132 hours, and using a longer equlizing period, we can dry to an average moisture content of around 14% and reduce the number of pieces over 19% moisture content to 5%.

It is noteworthy to mention at this point that the degrade due to drying and surfacing using either type of schedule is less than $2.50/MBF. This is approximately one-half the amount of degrade that we found resulted from the drying of 1 5/8" hemlock dimension on faster schedules to the same moisture content.

A question will probably arise at this point as to the benefits derived from the 6 hour conditioning period used with the constant depression schedule. There have been many pros and cons on this. However, we have seen almost equally as good stock dried on a similar schedule without conditioning.

<u>Drying Douglas Fir 1 1/2" Dimension</u>

Drying Douglas fir dimension to the new moisture specifications poses much less of a problem than West Coast hemlock. The raw material the kiln operator has to work with is of a more homogeneous nature. The green moisture content is much lower and less variable. Because of this, we have found moisture uniformity to be no problem in drying 1 1/2" Douglas fir dimension. With most commercial schedules Douglas fir 1 1/2" dimension can be dried to an average moisture content of 15%, while holding the number of pieces over 19% moisture content to 5% or less of the total.

We have, however, established one basic parameter in the drying of Douglas fir dimension that is essential in keeping the drying degrade to a minimum. This parameter is that the dry bulb temperature should not exceed 165°F. This coincides with the belief of the Forest Products Laboratory at Madison.

Figure 14 shows four schedules for drying various widths of Douglas fir 1 1/2" dimension. Schedules No. 1, 2, and 3 were being used by one of our mills which at that time was getting an excessive amoung of drying degrade. We suggested trying a lower temperature schedule. This is schedule No. 4 shown in Figure 14. The basic difference between these is that schedules No. 1 and 2 use high temperatures and schedules 3 and 4 low temperatures. Results from test charges showed very little difference in kiln residence time when the lower temperature schedule was used.

Figure 13 shows the data from a study comparing the degrade of Douglas fir 1 1/2" dimension dried on these schedules. These data show that schedules No. 1 and No. 2, which were those using

FIGURE 6

TYPICAL HIGH TEMPERATURE-LARGE
WET BULB DEPRESSION SCHEDULE USED FOR
DRYING WESTERN HEMLOCK DIMENSION

Hours	Dry Bulb (°F.)	Wet Bulb (°F.)
0-18	200	180
18-30	200	170
30-48	200	160
48-72	200	150
72-96	200	175

FIGURE 7

TYPICAL MOISTURE DISTRIBUTION OF WESTERN
HEMLOCK ON HIGH TEMPERATURE, LARGE
WET BULB DEPRESSION SCHEDULE

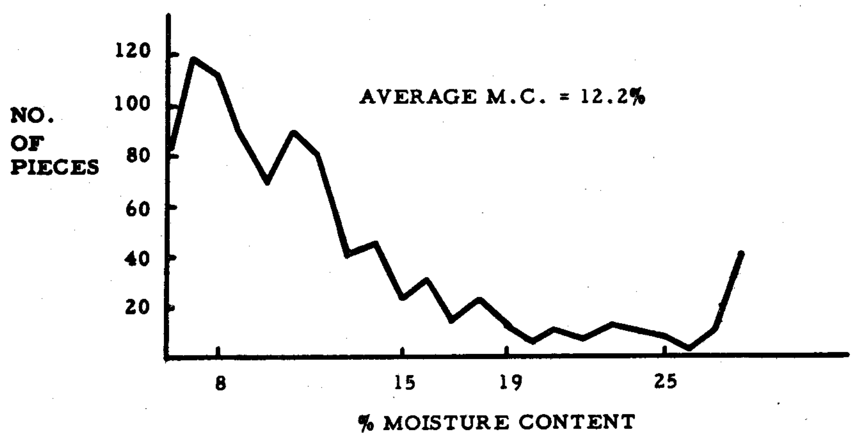

FIGURE 8. DEGRADE VS. DRY MOISTURE CONTENT

	Classes of Dry Moisture Content				
	-7 - 11%	12 - 13%	14 - 16%	17 - 20%	21 - 25+%
No. Pieces (2x8" x 16')	225	191	234	175	179
# Pieces Degrading	58	45	34	26	34
% Pcs. in M.C. Class that Degraded	25.8	23.6	14.5	14.9	19.0
Cost of Degrade in $/MBF	$5.20	$4.41	$2.63	$2.39	$3.94

FIGURE 9. EQUALIZATION SCHEDULE
FOR DRYING WESTERN HEMLOCK DIMENSION

Hours	Dry Bulb (°F.)	Wet Bulb (°F.)
0-12	180	170
12-24	180	165
24-48	175	155
48-72	175	145
72-96	165	145
96-115	155-160	145

CONSTANT DEPRESSION SCHEDULE

Hours	Dry Bulb (°F.)	Wet Bulb (°F.)
0-98	174	154
98-104	vents closed	spray on

FIGURE 10

WESTERN HEMLOCK 1-1/2" DIMENSION

MOISTURE DISTRIBUTION

CONSTANT DEPRESSION SCHEDULE

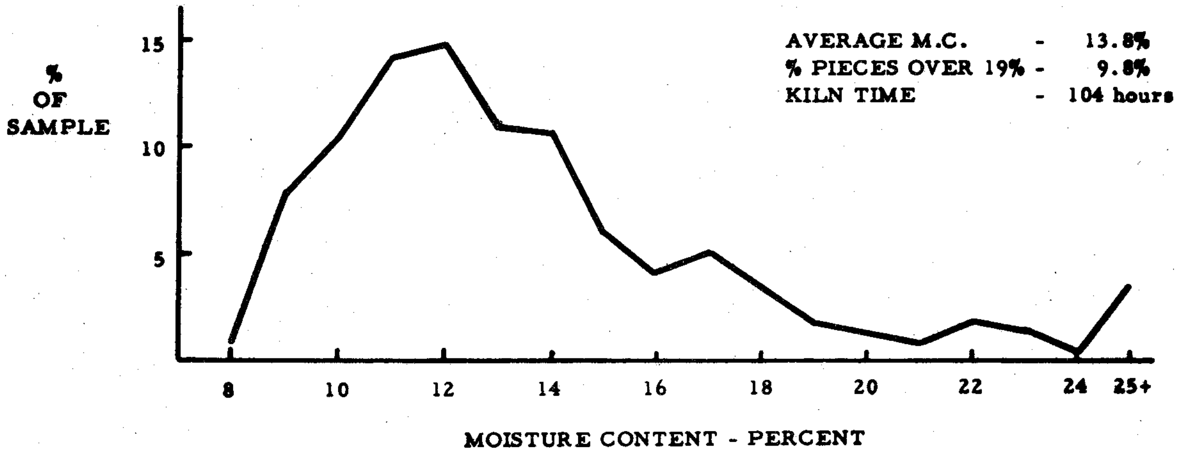

FIGURE 11

WESTERN HEMLOCK 1-1/2 " DIMENSION

MOISTURE DISTRIBUTION

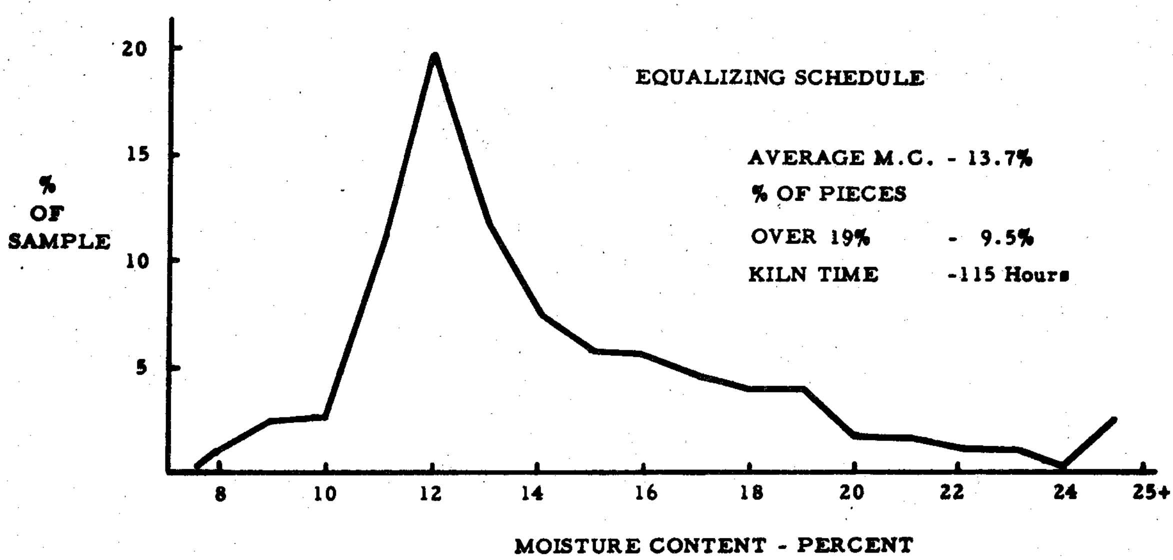

FIGURE 12. MILL DEGRADE AS A RESULT OF KILN DRYING AND OTHER CAUSES FOR 1-1/2" WESTERN HEMLOCK DIMENSION ($/MBF)

Drying Schedule	Size of Stock	Seasoning or Surfacing				Manufacturing					Total Loss in Value ($/M)
		Knot Holes	Shakes Checks Splits	Warp Crook Bow	Trim Loss	Thin	Narrow	Mach. Damage	Skip Face	Skip Edge	
Equalizing	2 x 6	0.49	0.48	0.41	0.39	0.19	0.17	0.00	0.00	0.05	2.14
	2 x 8	0.29	1.01	0.05	0.02	0.65	0.66	0.00	0.36	0.20	3.24
	2 x 10	0.12	1.25	0.05	0.00	0.00	0.34	0.00	0.16	0.00	1.92
	All	0.30	0.91	0.17	0.14	0.28	0.39	0.00	0.17	0.08	2.43
Constant Depression	2 x 6	0.21	0.48	0.34	0.38	0.25	0.11	0.18	0.07	0.02	2.04
	2 x 8	0.20	0.96	0.00	0.49	0.12	0.19	0.23	0.08	0.01	2.29
	2 x 10	0.20	1.28	0.00	0.26	0.35	0.06	0.21	0.11	0.06	2.53
	All	0.20	0.91	0.11	0.38	0.24	0.12	0.21	0.09	0.03	2.29

FIGURE 13. MILL DEGRADE AS A RESULT OF KILN DRYING AND OTHER CAUSES FOR 1-1/2" DOUGLAS FIR ($/MBF)

Schedule No.	Size of Stock	Seasoning or Surfacing				Manufacturing Defects				Total Loss in Value
		Knot Damage	Shake or Checks	Warp Crook Bow	Trim Loss	Thin	Narrow	Skip Face	Skip Edge	
1	2 x 6	4.45	1.15	0.00	0.34	0.00	0.47	0.30	1.46	8.17
2	2 x 8	2.14	1.02	0.06	0.53	0.00	0.00	0.30	0.00	4.05
3	2 x 10	1.05	1.29	0.00	2.14	0.00	0.00	0.35	0.78	5.61
	All	2.54	1.15	0.02	1.00	0.00	0.16	0.32	0.75	5.94
4	2 x 6	2.02	0.29	0.00	0.95	0.00	0.05	0.25	0.53	4.09
4	2 x 8	0.85	0.84	0.00	1.01	0.00	0.21	0.08	0.00	2.99
4	2 x 10	1.34	1.91	0.14	1.60	0.00	0.00	0.54	0.18	5.71
	All	1.40	1.01	0.05	1.19	0.00	0.09	0.29	0.23	4.26

high temperatures, gave roughly twice the toal amoung of degrade in the 6 and 8-inch widths than did the lower temperature schedule No. 4. The primary reason for this was more knot damage and fall-out. The 10-inch wide stock showed virtually no difference in degrade. This is not surprising since schedule No. 3 and 4 are very similar. It is of interest to note that the level of degrade obtained at the mill, even with the low temperature drying, is roughly $2/MBF greater than that obtained from another mill using the same schedule. The primary factor was the higher observed incidence of encased knots in the lumber.

Conclusions

West Coast hemlock 1 1/2" dimension can be dried to the new moisture specifications with a minimum amount of drying degrade and moisture non-uniformity with the schedules discussed above. Fast, severe schedules increase the drying degrade and result in poor moisture uniformity.

Schedules for drying 1 1/2" Douglas fir dimension should not use dry bulb temperatures of over 165°F. Temperatures over this cause severe knot damage and fallout. Dry moisture uniformity is not a problem with Douglas fir.

Acknowledgments

Much of the data presented in this paper was collected and prepared by James C. Oberg, development engineer for the Lumber Technical Department. I would also like to express my thanks for the cooperation and help received by the following kiln forement at our mills:

Ken Johnson - White River Branch
Ed Charron - Raymond Branch
Joe Robb - Springfield Branch