SEASONING AND SURFACING DEGRADE IN KILN-DRYING WESTERN HEMLOCK IN WESTERN WASHINGTON

By Douglas L. Hunt

This report presents the results of a study on degrade (loss in volume and value) of western hemlock, kiln-dried under conditions considered average for Pacific Northwest sawmills. The study measured (1) loss in volume of surfaced dry lumber because of surfacing, seasoning, and manufacturing defects; (2) loss in value (degrade) because of surfacing, seasoning, and manufacturing defects. Degrade is expressed both as a percentage of the rough green lumber volume and as a loss in value per thousand board feet of lumber.

The study was made at a western Washington sawmill in the summer of 1962. Over 175,000 board feet of lumber, consisting of three widths and two grades in 1-inch Finish and four widths in all grades of 2-inch Dimension, was studied. Lengths in both Finish and Dimension were from 8 to 20 feet, inclusive.

STUDY PRACTICES

This degrade study was undertaken in conjunction with a much larger lumber recovery study for western hemlock. The size of the lumber grade recovery study made it necessary to surface and tally the lumber in its green condition. The final information used, however, was recovery data on a surfaced dry basis. To accomplish this, conversion factors were needed to apply to the surfaced green lumber that would accurately reflect is surfaced dry volume and value. Since the development of the conversion factors required an accurate rough green grade and a subsequent surfaced dry grade, it was decided to go one step further and record the reason for any drop in grade. The company had only recently installed dry kilns and were interested in knowing the degrade experienced in changing from a surfaced green shipping basis to one of surfaced dry. For this reason, shake was included as a seasoning defect. Whether shake is a true seasoning defect or not, its inclusion provides sawmill operators with some indication of the losses they incur in drying a species containing shake.

During the study, the services of a Pacific Lumber Inspection Bureau grader were secured. All rough green lumber was removed from the green chain and transported to a sorting chain in the mill yard. The PLIB grader then carefully graded and marked each piece to establish its potential grade[1] and value. All grading, both rough green and surfaced dry, was in accordance with Standard Grading Rule No. 15, as revised May 1, 1962, of the West Coast Lumber Inspection Bureau. The lumber was then kiln-dried using the company's usual schedules. After drying, it was planed, regraded, and tallied. Any pieces that were misgraded or pulled into the wrong packages were removed from the original tally at this point. The difference between the potential grade and volume and the final grade and volume of surfaced dry lumber is shown as degrade.

Initial Grading

As the rough green lumber was removed from the green chain it was carried to a sorting chain in the yard. Here the PLIB grader had as much time as necessary to establish the potential grade. Pieces that could be upgraded by trimming were excluded from the study. The lumber was then pulled into carrier unit packages containing one grade, one thickness, and one width. The lengths contained in each package were either 8 and 10 feet, 12 and 14 feet, 16 feet, or 18 and 20 feet. Grades and widths included for study were 4- through 8-inch C and Better and D Select in 1-inch thickness; and 4- through 10-inch Select Structural, Construction, Standard, Utility, and Economy in 2-inch Dimension. A

[1] Potential grade is the surfaced dry grade of lumber that one could obtain if no defects resulted from missawing, seasoning or surfacing.

tally was made and recorded of each unit package as it was completed at the sorting chain.

Kiln-Drying

After sorting, the loads were sent to an automatic stacker and flat-piled using 7/8-inch by 1-7/8 inch stickers. Packages leaving the stakcer were approximately 52 inches square by the lumber length. These were built into kiln-crib size by forklift truck; two packages wide and three high for each crib. Schedules for drying the Dimension are shown in Table 1. The dry kilns were end-loaded, steam-heated, internal fan, double-track with automatic temperature and humidity controls. Track length is 106 feet, and kiln charges were built up to utilize as much of the kiln length as possible. Cribs did not include mixed-package lengths so a minimum of short circuiting of air occurred. This was considered important because air velocities in the kiln were said to range from 600 to 1,000 f.p.m. Air reversal was carried on at regular intervals. Kiln operation was satisfactory throughout the entire study.

TABLE 1.

TYPICAL KILN-DRYING SCHEDULE FOR WESTERN HEMLOCK; 1962 STUDY IN WESTERN WASHINGTON

Thickness and grade	Time from start of drying	Temperature		Equilibrium moisture content
		Dry bulb	Wet bulb	
	Hours	Degrees F.		Percent
2-inch Dimension	0	155	145	11.7
	20	160	145	9.4
	38	165	145	7.9
	54	170	142	6.2
	62	175	142	5.5
	70	180	142	4.6
	94	out	---	----

The 1-inch Selects develop so slowly at the plant that it would have been impossible to make up a kiln charge in the course of the study. Selects, therefore, were custom dried in a single crib size, compartment-type, steamheated kiln.

The 1-inch Selects were dried to an average moisture content of about 9 percent and the 2-inch Dimension to an average of about 14 percent. No conditioning or equalizing treatments were used to relieve casehardening stresses.

Surfacing

After drying, the stickered loads were brought to the planing mill for surfacing. The piece count, by length, of each unit became the uncorrected input volume. As each load consisted of a single load, it was initially thought that the regrading and tallying could be done on the planer chain. However, planer feed speeds ranged from 475 f.p.m. for 2 x 10's to 625 f.p.m. for 2 x 4's, and it became evident at once that accurate regrading and tallying could not be accomplished under these conditions. The PLIB grader then simply checked each piece for on-grade or off-grade at the planer chain. No trimming was done at this time. All pieces that held their original rough green grade were pulled off the chain and released to the company. All other pieces, i.e., those that degraded or upgraded, or required trimming were removed from the chain and taken out to the yard. Load identification was maintained during this time by requiring short intervals between each load going into the planer.

Final Grading

The PLIB grader carefully reinspected the loads in the yard, establishing the new grade of each piece and specifying the reason for its degrade. Since the loads in the yard consisted of one width, one or two lengths, and various grades, a simple recording form was devised. This allowed for tallying each piece, by length, and for recording the new grade of the piece and rason for degrade. As mis-graded (or mispulled) pieces were found, they were also tallied. This volume was then subtracted from the rough green input volume to arrive at a corrected input volume.

RESULTS AND DISCUSSION

Grade Recovery

The volume of rough green lumber tested and the percentages of grade recovery after kiln-drying and surfacing are shown by lumber grade item in Tables 2 and 3. Percent of cull-and-trim loss is also shown.

TABLE 2

GRADE RECOVERY OF WESTERN HEMLOCK FINISH LUMBER
FOLLOWING KILN-DRYING AND SURFACING;
1962 STUDY IN WESTERN WASHINGTON

Rough green lumber input			Grade recovery of surfaced dry lumber as percent of input							
Thickness and grade	Width	Corrected volume tested	C & Btr.	D	Construction	Standard	Utility	Economy	Cull and trim loss	Total degrade
	In.	Bd. ft.	Percent							
1-inch Finish										
C & Btr.	4	914	42.6	21.4	---	18.0	16.5	.3	1.2	57.4
	6	1,958	48.4	8.0	6.6	25.4	9.4	.5	1.7	51.6
	8	2,451	52.4	6.5	4.9	22.9	8.9	2.0	2.4	47.6
D	4	59	----	69.4	---	15.3	15.3	---	---	30.6
	6	196	----	68.4	---	20.4	6.2	2.0	3.0	31.6
	8	474	----	68.4	2.7	19.4	7.6	---	1.9	31.6

TABLE 3

GRADE RECOVERY OF WESTERN HEMLOCK DIMENSION LUMBER
FOLLOWING KILN-DRYING AND SURFACING;
1962 STUDY IN WESTERN WASINGTON

Rough green lumber input			Grade recovery of surfaced dry lumber as percent of input						
Thickness and grade	Width	Corrected volume tested	Select structural	Construction	Standard	Utility	Economy	Cull and trim loss	Total degrade
	In.	Bd. ft.				Percent			
2-inch Dimension:									
Select structural	4	6,768	75.9	.7	6.3	14.8	1.6	.7	24.1
	6	7,012	74.8	1.4	10.6	11.0	.6	1.6	25.2
	8	10,125	83.3	2.1	5.5	8.2	.8	.7	17.3
	10	4,951	71.8	5.9	13.6	6.5	---	2.2	28.2
Construction	4	9,520	----	78.1	4.6	14.5	1.9	.9	21.9
	6	15,248	----	78.6	7.7	11.9	.6	1.2	21.4
	8	7,761	----	77.5	2.6	16.6	2.3	1.0	22.5
	10	16,980	----	80.6	8.3	9.2	.3	1.6	19.4
Standard	4	6,753	----	----	83.8	13.7	2.0	.5	16.2
	6	7,414	----	----	80.9	17.4	.8	.9	19.1
	8	7,718	----	----	81.8	16.6	.9	.7	18.2
	10	6,974	----	----	86.1	12.5	.4	1.0	13.9
Utility	4	12,398	----	----	----	92.9	6.7	.4	7.1
	6	7,378	----	----	----	94.5	5.2	.3	5.5
	8	15,332	----	----	----	89.8	10.0	.2	10.2
	10	6,404	----	----	----	93.3	6.4	.3	6.7
Economy	4-10	21,707	----	----	----	----	99.6	.4	.4

The degrade percentages of the 1-inch Finish are not considered meaningful in this particular study. The mill involved was cutting for 2-inch Dimension items. The 1-inch Finish developed from jacket boards and other side cuts. This material was sawn in Dimension thicknesses and the 1-inch was recovered by resawing and re-edging. Normally, this 1-inch Finish was sold rough green to local mill work plants. However, after kiln-drying, the Dimension thicknesses as sawn, did not privide sufficient material for satisfactory planing. Since company policy dictates this procedure, the degrade volumes and values for 1-inch Finish are not considered representative of industry in general.

Table 4.--Seasoning, surfacing, and manufacturing degrade in kiln-dried western hemlock lumber; 1962 study in western Washington

Rough green lumber input: Thickness and grade	Width	Corrected volume tested	Proportion of input degraded during processing, by cause: Seasoning and surfacing defects: Warp	Season check	End check	Planer split	Machine burn	Planer gouge	Torn grain	Stain	Knotholes	Broken knots	Shake	Cull and trim loss	Total	Manufacturing defects: Thin	Narrow	Mechanical damage	Cull and trim loss	Total	Total degrade
	In.	Bd. ft.	Percent													Percent					Percent
1-inch Finish:																					
C & Btr.	4	914	2.6	0	0	.6	0	0	7.6	.6	0	0	0	.1	11.5	19.3	23.4	2.1	1.1	45.9	57.4
	6	1,958	2.6	1.7	0	1.0	0	0	2.1	0	0	0	0	1.0	8.4	14.4	26.6	1.4	.8	43.2	51.6
	8	2,451	2.1	1.3	0	2.5	0	0	3.1	0	0	0	0	1.3	10.3	9.5	24.2	2.5	1.1	37.3	47.6
D	4	59	0	0	0	0	0	0	0	0	0	0	0	0	0	30.6	0	0	0	30.6	30.6
	6	196	0	2.0	0	0	0	0	0	0	0	0	0	1.5	3.5	12.8	13.8	0	1.5	28.1	31.6
	8	474	1.9	0	0	1.6	0	0	0	0	0	0	0	1.9	5.4	8.9	17.3	0	0	26.2	31.6
2-inch Dimension:																					
Select structural	4	6,768	2.5	6.4	0	0	0	0	0	0	.2	.3	3.4	.4	13.2	4.7	4.7	1.1	.4	10.9	24.1
	6	7,012	2.0	10.7	.3	0	0	0	0	0	.2	.2	3.1	1.0	17.5	3.6	1.4	2.1	.6	7.7	25.2
	8	10,125	0	9.8	.6	0	0	0	0	0	0	.2	2.3	.4	13.3	1.1	1.5	1.1	.3	4.0	17.3
	10	4,951	0	12.6	.5	0	0	0	0	0	0	.5	.5	1.2	15.3	4.4	4.9	2.6	1.0	12.9	28.2
Construction	4	9,520	5.2	2.4	0	0	0	0	0	0	1.1	.1	1.8	.4	11.0	5.3	3.2	1.9	.5	10.9	21.9
	6	15,248	2.7	5.2	.1	0	0	0	0	0	1.4	1.3	3.4	1.0	15.1	3.4	1.2	1.5	.2	6.3	21.4
	8	7,761	.3	12.7	.3	0	0	0	0	0	.3	0	2.4	.7	16.7	1.0	2.4	2.1	.3	5.8	22.5
	10	16,980	0	11.0	.1	0	0	0	0	0	1.1	0	1.0	1.3	14.5	3.6	.7	.2	.4	4.9	19.4
Standard	4	6,753	2.0	2.9	0	0	0	0	0	0	1.4	.2	3.4	.3	10.2	2.6	2.9	.3	.2	6.0	16.2
	6	7,414	3.2	5.7	.2	0	0	0	0	0	2.2	.8	2.5	.5	15.1	1.5	1.1	1.0	.4	4.0	19.1
	8	7,718	0	8.3	.4	0	0	0	0	0	1.6	2.9	1.4	.6	15.2	.6	1.1	1.2	.1	3.0	18.2
	10	6,974	.5	6.3	0	0	0	0	0	0	2.6	0	1.5	.6	11.5	.8	.4	.8	.4	2.4	13.9
Utility	4	12,398	1.0	.6	0	0	0	0	0	0	.1	0	4.1	.2	6.0	.3	.7	0	.1	1.1	7.1
	6	7,378	0	.7	.3	0	0	0	0	0	0	0	3.6	.2	4.8	0	0	.5	.2	.7	5.5
	8	15,332	.1	3.6	.3	0	0	0	0	0	.3	.1	5.0	.1	9.5	0	.4	.2	.1	.7	10.2
	10	6,404	0	.4	.7	0	0	0	0	0	0	0	4.5	.1	5.7	.5	0	.4	.1	1.0	6.7
Economy	4-10	21,707	0	0	0	0	0	0	0	0	0	0	0	.3	.3	0	0	0	.1	.1	.4

Table 5.--Loss in value of kiln-dried western hemlock lumber due to seasoning, surfacing, and manufacturing degrade; 1962 study in western Washington

Rough green lumber input: Thickness and grade	Rough green lumber input: Width	Rough green lumber input: Corrected volume tested	1962 lumber prices	Cause of loss — Seasoning and surfacing defects: Warp	Season check	End check	Planer split	Machine burn	Planer gouge	Torn grain	Stain	Knotholes	Broken knots	Shake	Cull and trim	Total	Manufacturing defects: Thin	Narrow	Mechanical damage	Cull and trim	Total	Total loss in value
	In.	Bd.ft.	Dollars per M bd. ft.	Dollars per M bd. ft.													Dollars per M bd. ft.					Dollars per M bd. ft.
1-inch Finish:																						
C & Btr.	4	914	130.67	1.11	0	0	.46	0	0	2.53	.16	0	0	0	.13	4.39	12.44	14.61	1.13	1.44	29.62	34.01
	6	1,958	130.67	1.77	1.17	0	.63	0	0	.74	0	0	0	0	1.30	5.61	10.22	17.05	.36	1.04	28.67	34.28
	8	2,451	130.67	1.95	.86	0	2.28	0	0	.80	0	0	0	0	1.70	7.45	7.05	16.49	.72	1.44	25.70	33.15
D	4	59	104.69	0	0	0	0	0	0	0	0	0	0	0	0	0	12.99	0	0	0	12.99	12.99
	6	196	104.69	0	.83	0	0	0	0	0	0	0	0	0	1.57	2.40	6.54	6.65	0	1.57	14.76	17.16
	8	474	104.69	.79	0	0	.98	0	0	0	0	0	0	0	1.99	3.76	4.78	7.12	0	0	11.90	15.66
2-inch Dimension:																						
Select structural	4	6,768	83.10	.93	2.44	0	0	0	0	0	0	.02	.04	1.43	.33	5.19	1.52	1.60	.28	.33	3.73	8.92
	6	7,012	83.10	.70	3.25	.10	0	0	0	0	0	.02	.02	1.33	.84	6.26	.94	.26	.42	.50	2.12	8.38
	8	10,125	83.10	0	3.00	.16	0	0	0	0	0	0	.02	1.08	.25	4.51	.32	.30	.23	.25	1.10	5.61
	10	4,951	83.10	0	3.19	.06	0	0	0	0	0	0	.06	.10	1.00	4.41	.78	1.12	.75	.08	2.73	7.14
Construction	4	9,520	71.05	1.47	.78	0	0	0	0	0	0	.15	.01	.59	.21	3.21	1.15	.69	.60	.36	2.80	6.01
	6	15,248	71.05	.77	1.11	.03	0	0	0	0	0	.19	.15	1.04	.71	4.00	.55	.15	.22	1.06	1.06	5.06
	8	7,761	71.05	.08	3.57	.08	0	0	0	0	0	.05	0	1.03	.50	5.31	.16	.55	.47	.21	1.39	6.70
	10	16,980	71.05	0	2.26	.03	0	0	0	0	0	.11	0	.26	.92	3.58	.51	.11	.06	.28	.96	4.54
Standard	4	6,753	63.00	.45	.57	0	0	0	0	0	0	.28	.04	.91	.19	2.44	.57	.67	.13	.13	1.50	3.94
	6	7,414	63.00	.65	1.13	.04	0	0	0	0	0	.44	.16	.59	.32	3.33	.30	.24	.24	.25	1.03	4.36
	8	7,718	63.00	0	1.73	.08	0	0	0	0	0	.32	.64	.35	.38	3.50	.12	.22	.24	.06	.64	4.14
	10	6,974	63.00	.10	1.34	0	0	0	0	0	0	.51	0	.30	.38	2.63	.16	.08	.16	.25	.65	3.28
Utility	4	12,398	43.20	.23	.14	0	0	0	0	0	0	.02	0	.93	.09	1.41	.07	.16	0	.04	.27	1.68
	6	7,378	43.20	0	.16	.07	0	0	0	0	0	0	0	.82	.09	1.14	0	0	.11	.09	.20	1.34
	8	15,332	43.20	.02	.82	.07	0	0	0	0	0	.07	.02	1.14	.04	2.18	0	.09	.05	.04	.18	2.36
	10	6,404	43.20	0	.09	.16	0	0	0	0	0	0	0	1.02	.04	1.31	.11	0	.09	.04	.24	1.55
Economy	4-10	21,707	20.43	0	0	0	0	0	0	0	0	0	0	0	1.31	1.31	0	0	0	.33	.33	1.64

The 2-inch Dimension, however, was manufactured in a manner consistent with general industry practices. Even so, somewhat more degrade was found than in the hemlock study by Knauss and Clarke.[2] Including shake is responsible for some of the additional degrade. Degrade studies between different sawmills are not necessarily comparable, though. It has already been shown how differences in sawing practices between mills can affect degrade volumes. Differences in sorting practices, i.e., use of moisture content sorts, type of timber, surfacing equipment, etc., all influence degrade. As these factors differ between mills, differences in degrade will appear. It is notable, though, that similar trends show up in both the hemlock degrade studies conducted by the Experiment Station. For instance, when construction lumber degrades, most of it drops to Utility rather than to Standard. In both studies it was found that Standard drops to Utility with only a very small proportion going to Economy. In this study, a significant proportion of the Select Structural also degraded to Utility. In view of the price differential, the effect on value is substantial when a significant volume of Standard and Better degrades to Utility.

Seasoning and Surfacing Degrade

The types of seasoning and surfacing defects and the proportion of degrade caused by each are shown in Table 4. In the Finish grades warp and torn grain accounted for most of the remaining degrade. The effect of width on planer split is also apparent in the 1-inch thickness. The effect of warp appears to be constant on all widths of the 1-inch Finish, although in the 2-inch Dimension warp decreases as width increases.

Warp was a source of degrade in the 2-inch Dimension in the 4- and 6-inch widths. Thereafter, it was of only minor importance. Season check, however, was a continual and significant cause of degrade in all widths in the Standard and Better grades. In Utility, season check was only a small proportion of total degrade. This is a reflection of the grading rules which do not specify any limits on the amount of season checks in Utility grade lumber. Those pieces that were degraded from Utility were, in the opinion of the grader, considered too severely checked to remain in the grade.

End check in Dimension was of minor importance but did cause most of the cull-and-trim loss. Planer split, machine burn, torn grain, planer gouge, and stain were defects that did not cause any degrade in this study. One reason for the absence of planer split in the Dimension versus its occurrence in the Finish was, no doubt, the much better piling practice for Dimension. All Dimension was stacked with no more than two lengths per package and the 16-foot lengths were piled separately. The resultant absence of degrade because of planer split points out the value of this piling practice.

Knotholes and broken knots were a cause of degrade through all widths and all grades of Dimension. Considering the type of timber (understory from an old-growth Douglas-fir stand) from which the lumber was manufactured, the amount of this degrade is understandable.

Shake in western hemlock occurs as two types: ring shake, a separation between the annual rings; and heart shake, which appears as short splits or checks radiating from and extending along the heart pith. Both types were found in this study and were classified under the seasoning defect of shake. At times it was difficult to make a positive identification between season checks and shake. When this occurred the defect was tallied as shake. It was not the intention of anyone connected with the study to place the blame for degrade by shake on the kiln operator. Shake is inherent in the piece and will open up whether air-dried, kiln-dried, or dried in place after use. The company was, however, interested in knowing their total costs of kiln-drying. These total drying costs would include the degrade caused by shake since lumber had been shipped surfaced green and any shake that subsequently opened was not a loss to the mill.

[2] Knauss, A. C., and Clarke, E. H. Seasoning and surfacing degrade in kiln-drying western hemlock in western Oregon. Pacific Northwest Forest and Range Experiment Station. Research note 207, 11 pp. illus. 1961.

Manufacturing Degrade

This type of degrade includes those defects not chargeable to kiln-drying or surfacing but which do contribute to part of the total loss in value and volume. Mismanufacture in the sawmill, resulting in pieces too thin or too narrow, is usually the major source of degrade. This study showed the same pattern as the other hemlock degrade study differing only in degree of intensity. Thin and narrow pieces accounted for most of the degrade in both the 1-inch Finish and the 2-inch Dimension. In the 1-inch Finish the losses from mismanufacture in the sawmill were more severe, accounting for far over one-half the total degrade. In the Dimension, the loss due to thin and narrow, while significant, does not appear disproportionate.

Mechanical damage included all those defects caused by handling equipment such as log turners, forklift trucks, cranes, etc. Considering the innumerable times that a piece of lumber is handled, the losses reported do not seem unreasonable. The cull-and-trim losses were mostly the result of 2-foot end trims due to damaged or mismanufactured ends.

Loss in Value

Table 5 shows the loss in dollars per thousand board feet by defect. Although none of the values in the table should be considered absolute, i.e., total loss for Construction 2 x 4 for any given period of time may never be exactly $6.01, they should be important and useful when considered as relative values. In this respect, then, examination of the table should be helpful to management in determining areas in the manufacturing process that could be improved. Management should be in a position to weigh the gain in product value against increased manufacturing cost, if any.

It should also be pointed out that these degrade losses must be added to investment and drying costs to determine the total cost of kiln-drying. Studies such as this one help to determine where the major defects in seasoning and surfacing are occurring. Management then has the information it needs to decide where improvements in equipment or practices are needed.