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R. W. COWLIN, DIRECTOR

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SEASONING AND SURFACING DEGRADE IN KILN-DRYING DOUGLAS-FIR IN EASTERN WASHINGTON

by

A. C. Knauss and E. H. Clarke

This report presents the results of a study to determine the degrade (loss in volume and grade) of Douglas-fir lumber when kiln-dried and surfaced in accordance with commercial practice in eastern Washington. The study measured (1) loss in volume due to culling and trimming surfaced dry lumber because of sawing, seasoning, and surfacing defects; (2) reduction in grade due to seasoning and surfacing defects; and (3) reduction in grade due to incomplete manufacture or the development of manufacturing defects. Degrade is expressed as a percentage of the rough green lumber volume and also as a loss in value per thousand board feet of lumber.

The study was made at the Ardenvoir, Wash., sawmill of C. A. Harris & Son, Inc., in June and July 1957, on approximately 28,000 board feet of lumber cut from logs representative of Douglas-fir timber in this area. A volume of at least 700 board feet was included in each grade-thickness item to help insure that the analysis of degrade would be representative.

STUDY PROCEDURE

In making this degrade study, the lumber was first graded, marked, and tallied in the rough green condition at the sawmill to establish its potential grade[1/] and value. It was then kiln-dried

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

according to industry practice. Finally, it was planed, regraded, and tallied for shipment. At the time of regrading, the original grade designation was corrected to reflect defects that were present but not discernible in the rough green condition. The difference between the potential grade and volume (as indicated by the corrected tally of unseasoned lumber) and the final grade and volume of surfaced dry lumber is represented as degrade.

Initial Grading

The rough green lumber was graded at the green chain according to Western Pine Association's 1956 Standard Grading Rules by an association grade supervisor. The grade was marked on each piece of lumber, and pieces which had not been adequately trimmed in the sawmill were pencil-trimmed by the grader. The lumber was then sorted into the following two thickness groups for kiln-drying: (1) 1-inch, containing random-width Selects and Shops, and Commons 4 to 12 inches wide; and (2) 2-inch Dimension 4 to 12 inches wide.

Kiln-Drying

The unseasoned lumber was stacked immediately following sawing, and was loaded promptly into the kiln where it was dried under the schedules shown in table 1.

Drying was done in a battery of side-loading, steam-heated, internal-fan, cross-circulation kilns equipped with automatic temperature and humidity controls. The lumber was flat-piled, using 3/4-inch-thick stickers, into unit packages 4 feet wide. The packages, each containing two lumber lengths, were loaded into the kilns by a forklift truck. In these kilns, circulating air passed transversely through 12 feet of piled lumber (three unit packages) through reheating coils in the center of the kiln, and then through another 12 feet of piled lumber before returning to the main heating coils and fans overhead. The kilns are operated as compartment units and circulation was reversed at 3-hour intervals. The kilns operated satisfactorily throughout the study.

Under sawing practices followed at this mill, the volume of 1-inch Selects and Commons produced was small. Therefore, as a matter of economy, all grades of 1-inch boards were dried in the same kiln charge to a final moisture content of 10 to 12 percent. The 2-inch Dimension was kiln-dried in separate charges to an average

moisture content of 15 percent. A short high-humidity treatment was given at the end of the drying to equalize moisture contents.

Table 1.--Kiln-drying schedule for Douglas-fir; 1957 study at C. A. Harris & Sons, Inc.

Thickness and grade	Time from start of drying	Temperature	
		Dry bulb	Wet bulb
	Hours	Degrees F.	
1-inch Common	0	140	124
	33	144	124
	66	Out	--
2-inch Dimension	0	140	130
	28	145	130
	48	150	130
	78	145	130
	93	148	144
	95	Out	--

Surfacing

The dry lumber was allowed to stand for a day or more before it was unstacked, retrimmed (in accordance with the pencil-trim indicated at the time of original grading), and sorted into planing units. Each planing unit consisted of a single thickness and green grade. The lumber was then surfaced with conventional planing equipment, using a feed rate of 250 feet per minute.

Following surfacing, the lumber was graded by the same Western Pine Association supervisor who had previously graded it in the rough green condition. The authors tallied the surfaced lumber by grade and recorded the volume culled or trimmed. In tallying, notation was made of the specific cause of degrade and trim. This information was used to compile degrade values shown in tables 2 and 3.

Table 2.--Grade recovery of Douglas-fir lumber following kiln-drying and surfacing; 1957 study at C. A. Harris & Son, Inc.

Rough green lumber input			Grade recovery of dry surfaced lumber as percent of input						
Thickness and grade	Width	Corrected volume tested	No. 1	No. 2	No. 3	No. 4	No. 5	Cull and trim loss	Total degrade
	Inches	Board feet	Percent						
1-inch Common:									
No. 2	4-12	739	--	60.0	28.0	11.0	0	1.0	40.0
No. 3	4-12	1,422	--	--	63.3	35.1	.7	.9	36.7
No. 4	4-12	1,261	--	--	--	91.0	8.7	.3	9.0
No. 5	4-12	650	--	--	--	--	99.6	.4	.4
2-inch Dimension:									
No. 1	6	1,824	89.2	9.8	1.0	0	0	0	10.8
	8	3,114	90.7	7.5	0	1.3	0	.5	9.3
	10	2,981	92.5	6.3	0	.9	0	.3	7.5
	12	11,172	85.7	13.0	0	.8	0	.5	14.3
No. 2	8	1,383	--	98.4	1.5	0	0	.1	1.6
	10	1,455	--	97.3	1.4	0	0	1.3	2.7
	12	4,928	--	96.1	2.5	.6	0	.8	3.9
No. 3	12	1,644	--	--	100.0	0	0	0	0
No. 4	12	996	--	--	--	99.2	0	.8	.8

Table 3.--Seasoning, surfacing, and manufacturing degrade in kiln-dried Douglas-fir lumber; 1957 study at C. A. Harris & Son, Inc.

Thickness and grade	Rough green lumber input: Width	Rough green lumber input: Corrected volume tested	Proportion of input degraded during processing, by cause: Seasoning and surfacing defects: Season check	End split	Warp	Planer split	Broken grain	Loose knots	Broken knots	Knotholes	Cull and trim loss	Total	Manufacturing defects: Thin	Narrow	Mechanical damage	Cull and trim loss	Total	Total degrade
	Inches	Bd.ft.	Percent										Percent					Percent
1-inch Common:																		
No. 2	4-12	739	0.5	0	3.4	3.9	1.4	2.7	7.4	15.4	0.3	35.0	1.1	1.4	1.8	0.7	5.0	40.0
No. 3	4-12	1,422	0	.6	1.9	0	5.6	.4	2.0	24.6	.3	35.4	.3	0	.4	.6	1.3	36.7
No. 4	4-12	1,261	0	0	0	0	.7	0	1.5	4.0	.3	6.5	0	1.2	.9	.4	2.5	9.0
No. 5	4-12	650	0	0	0	0	0	0	0	0	.1	.1	0	0	0	.3	.3	.4
2-inch Dimension:																		
No. 1	6	1,824	0	.7	6.4	0	0	0	.9	1.9	0	9.9	.9	0	0	0	.9	10.8
	8	3,114	0	.7	1.4	.7	.7	0	.6	2.0	.4	6.5	.7	1.3	.7	.1	2.8	9.3
	10	2,981	.9	0	1.0	1.7	.9	0	0	1.0	0	5.5	.8	.9	0	.3	2.0	7.5
	12	11,172	1.4	0	.3	5.2	.3	.3	.3	2.0	.4	10.2	2.9	.5	.6	.1	4.1	14.3
No. 2	8	1,383	0	0	1.5	0	0	0	0	0	.1	1.6	0	0	0	0	0	1.6
	10	1,455	0	0	0	0	0	1.4	0	0	.4	1.8	0	0	0	.9	.9	2.7
	12	4,928	0	0	.7	0	0	0	0	.6	.3	1.6	.5	.6	.7	.5	2.3	3.9
No. 3	12	1,644	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
No. 4	12	996	0	0	0	0	0	0	0	0	0	0	0	0	0	.8	.8	.8

RESULTS AND DISCUSSION

General

Conforming to commercial practice, all lumber was measured and tallied in terms of its nominal thickness, width, and length. For tallying purposes, these nominal dimensions remained the same throughout the study, beginning with the rough green lumber and carrying through to the surfaced dry stage.

It is not always possible to accurately judge the extent of wane, shake, pitch, wormholes, felling defects, or the size of knots in rough lumber. It was obvious after surfacing that some study lumber had been misgraded in the unseasoned condition. Therefore, a corrected tally was made to transfer the misgraded lumber to its proper category. This adjusted green lumber tally provided the base from which all degrade was calculated.

Grade Recovery

The volume of rough green lumber tested and the grade recovery after kiln-drying and surfacing are shown in table 2 for each lumber item considered in the study. The amount of lumber that remained in the adjusted grade of green lumber, the amount dropping to lower grades, and the amount of cull and trim are shown for each grade-thickness item.

For equivalent grades, 1-inch boards suffered heavier degrade than did 2-inch Dimension. For example, 40 percent of the No. 2 Common board volume was degraded while less than 5 percent of the No. 2 Dimension was degraded. It is also apparent from table 2 that the amount of degrade was greatest in the better grades of boards and Dimension.

Seasoning and Surfacing Degrade

Types of seasoning and surfacing defects and the amount of degrade caused by each are shown in table 3. Knotholes were the major cause of degrade in Common boards, whereas warp and planer split were the major causes of degrade in Dimension lumber.

All of the lumber in this study was adequately dry, and there was no degrade for wet or insufficiently dry lumber. Surface checks due to seasoning were slight and did not cause serious loss.

Warp--including bow, crook, cup, and twist--was a relatively minor cause of degrade. Warping generally results from unequal longitudinal shrinkage in boards containing (1) cross and irregular grain (as found around large knots and in crooked logs), (2) spiral grain, (3) compression wood, or (4) juvenile wood.

Lumber shrinks as it dries below the fiber saturation point, and the amount of shrinkage increases as the lumber is dried to lower moisture contents. Consequently, with lumber that is inclined to warp, the kiln-drying is sometimes terminated at the relatively high moisture content of 16 to 20 percent to avoid this defect. In this study, terminating the drying of 1-inch Common at a 12-percent moisture-content level and 2-inch Dimension at 12- to 15-percent moisture content resulted in a relatively small amount of degrade. Of the 13 lumber items included in this study, only two suffered degrade of more than 2 percent due to warping; the maximum was 6.4 percent.

Broken grain was a minor source of degrade in a few items and serious only in No. 3 Common boards, where it caused a degrade of 5.6 percent. It occurs when the locally warped wood at areas of irregular grain, such as around large knots, breaks when flattened under the feed rolls of the planer. A higher moisture content will make the board more flexible at the planer and reduce broken grain.

Another defect, cupping, develops in flat-grain lumber when it is dried to a low moisture content. When cupped lumber is flattened to the bed of the planer as it is surfaced, it is subject to splitting--called roller check or planer split--along the midwidth of the board. Cupping can be minimized by providing adequate stickers to hold the boards flat during drying and by avoiding overdrying. Although the 1-inch Common boards were dried to a moisture content of 10 to 12 percent and 2-inch Dimension to 15 percent at this mill, planer split caused degrade only in the No. 2 Common boards and No. 1 Dimension.

The most serious degrade in the 1-inch Common was caused by loose and broken knots and by knotholes. Damage to knots results primarily from the fact that they shrink more than the surrounding wood due to their higher density. When knots become loose or check in drying, they are easily damaged in the surfacing operation. Dry, loose knots then often drop out leaving knotholes. The moisture content of the knot and board at the time of surfacing greatly influences the amount of degrade; low moisture contents contribute to greater damage. The Common boards in this study, which were dried to 12-percent moisture content or less because of being dried with Selects,

showed a degrade of 24.6 percent due to knotholes in No. 3 Common, with some additional degrade due to loose and broken knots. The only possibility of reducing this degrade in the seasoning operation is to separate the Common boards from the Selects for kiln-drying and, where acceptable, to terminate the drying of the Commons at a moisture content somewhat higher than 12 percent.

Degrade due to damaged knots was less in 2-inch Dimension because (1) drying was terminated at a higher moisture content and (2) irregularities in the knot perimeter helped to hold the knots in place in the thicker stock.

Cull and trim losses were minor in this study--varying from 1/2 to 1 percent in most items.

Manufacturing Degrade

Other factors that reduce the potential grade include inadequate manufacture in the sawmill and breakage due to rough handling. Typical examples of the former are pieces cut too thin or too narrow to surface to the required final size. Since thin or narrow pieces do not suffer degrade in seasoning and surfacing, the resulting losses are treated as manufacturing defects. Elimination of such loss must lie in examining and improving the sawing practice. Mechanical damage, such as dogholes, damaged faces or edges caused by log turners or forks on lift trucks, can be kept to a minimum by modifications in equipment and by care in handling.

The total degrade chargeable to manufacturing defects was relatively small, as shown in table 3. The cull and trim loss included under manufacturing defect resulted primarily from the need to trim thin or narrow ends.

Loss in Value

Reduced lumber sale values due to the degrade developed in seasoning and surfacing and losses due to manufacturing defects are summarized by cause in table 4. The volume of lumber degraded or lost because of such defects was listed in table 3, but table 4 more adequately reflects the severity of degrade by expressing the loss in potential sales value. A major portion of the degraded lumber dropped only one grade but some dropped two or more grades, and that which was lost in cull or trim was considered to have no sale value.

Table 4.--Loss in value of kiln-dried Douglas-fir lumber due to seasoning, surfacing, manufacturing degrade; 1957 study at C. A. Harris & Son, Inc.[1/]

Rough green lumber input				Cause of loss														
				Seasoning and surfacing defects										Manufacturing defects				
Thickness and grade	Width	Corrected volume tested	1959 price	Season check	End split	Warp	Planer split	Broken grain	Loose knots	Broken knots	Knotholes	Cull and trim	Total	Thin	Narrow	Mechanical damage	Cull and trim	Total	Total loss in value
	Inches	Bd. ft.	Dollars per M bd. ft.	Dollars per M bd. ft.										Dollars per M bd. ft.					Dollars per M bd. ft.
1-inch Common:																			
No. 2	4-12	739	86	0.07	0	0.55	0.55	0.29	0.48	1.23	3.16	0.23	6.56	0.15	0.19	0.24	0.47	1.05	7.61
No. 3	4-12	1,422	72	.10	0	.30	0	.89	.13	.36	3.94	.20	5.92	.04	0	.07	.41	.52	6.44
No. 4	4-12	1,261	56	0	0	0	0	.16	0	.34	.89	.18	1.57	0	.26	.19	.22	.67	2.24
No. 5	4-12	650	34	0	0	0	0	0	0	0	0	.05	.05	0	0	0	.10	.10	.15
2-inch Dimension:																			
No. 1	6	1,824	86	0	.08	1.01	0	0	0	.10	.21	0	1.40	.10	0	0	0	.10	1.50
	8	3,114	86	0	.08	.16	.08	.08	0	.07	.22	.34	1.03	.08	.77	.08	.17	1.10	2.13
	10	2,981	86	.10	0	.11	.19	.10	0	0	.11	0	.61	.09	.53	0	.26	.88	1.49
	12	11,172	86	.15	0	.03	.57	.18	.03	.03	.22	.34	1.55	.32	.30	.07	.09	.78	2.33
No. 2	8	1,383	75	0	0	.44	0	0	0	0	0	.07	.51	0	0	0	0	0	.51
	10	1,455	75	0	0	0	0	0	.41	0	0	.30	.71	0	0	0	.68	.68	1.39
	12	4,928	75	0	0	.20	0	0	0	0	.29	.22	.71	.14	.17	.20	.37	.88	1.59
No. 3	12	1,644	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
No. 4	12	996	27	0	0	0	0	0	0	0	0	0	0	0	0	0	.22	.22	.22

[1/] Based on average sale value of dry surfaced items, f.o.b. mill, 1959 WPA yearly Price Summary.

It is appreciated that it may never be practical and profitable to kiln-dry and surface Douglas-fir lumber so carefully that degrade and loss in value are eliminated entirely. The losses due to the seasoning, surfacing, and manufacturing defects shown in this study are not severe, but they do enable management to analyze them and consider opportunities to improve practice and increase realization. The losses due to manufacturing defects must be examined from the point of view of sawing practice. There seems to be opportunity for improving sawing practice to reduce the volume of thin and narrow lumber. The seasoning and surfacing practices might be improved somewhat by examining losses due to warp, roller check, and damage to knots. More extensive segregation of lumber for seasoning and the use of higher humidity during the latter stages of drying Common boards and Dimension might be considered with profit.

The total cost of kiln-drying lumber must include the degrade losses as well as the dry kiln investment and processing costs. This study and analysis was made to point out the major seasoning and surfacing defects now developing in commercial kiln-drying practice in order to indicate where improvement in equipment and practice might be profitable.