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# Kiln-drying Oregon Maple Paper Roll Plugs

By

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**OREGON FOREST PRODUCTS LABORATORY**

State Board of Forestry and School of Forestry,  
Oregon State College, Cooperating  
Corvallis

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SUMMARY

Four charges of 5-inch paper roll plugs of Oregon maple were kiln-dried at various temperatures and humidities. The charge with the most desirable combination of short drying time and low degrade was dried to 12 per cent moisture content in 14 hours, using a dry-bulb temperature of 160 degrees F and a wet-bulb temperature of 122 degrees F. Pieces in the charge suffering degrade in an empirical test amounted to 10 per cent of the total pieces in the charge.

At a final average moisture content of 8 per cent, 80 per cent of the plugs dried with the best schedule were within plus or minus 2 per cent of the average. The average of the tangential and radial shrinkage was 4 per cent.

With the best schedule used, boiler horsepower requirement for drying a charge of 2300 five-inch plugs was calculated to be 9 hp with kiln efficiency of  $33 \frac{1}{3}$  per cent, and 6 hp with kiln efficiency of 50 per cent.

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# Kiln-drying Oregon Maple Paper Roll Plugs

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## INTRODUCTION

Oregon, or bigleaf maple, Acer macrophyllum, Pursh., is a pinkish-brown, moderately heavy and strong wood, used at present largely for furniture, with figured-grain logs and burls made into face veneer. Use for paper roll plugs could provide an outlet for some lower quality lumber from this tree (Figure 1).

Little information is available on kiln-drying of paper roll plugs, although there are some articles on drying square and round blank stock for turning.<sup>1, 2</sup>

Four charges of Oregon maple paper roll plugs of 5-inch diameter and 2-inch thickness with 1 1/8-inch hole were kiln-dried at the Oregon Forest Products Laboratory in cooperation with a manufacturer in Lebanon, Oregon, to investigate the drying characteristics of the product.

Information desired included:

- . Drying time from green to 12 per cent moisture content without excessive degrade.
- . Effect of humidity control on degrade.
- . Uniformity of moisture content in dried plugs.
- . Shrinkage from green to various moisture contents.
- . Steam required for daily output of 2300 paper roll plugs.

Constant drying conditions were used because of the desirability of simplicity in controls and operation.

A major aim was to develop a schedule by which the plugs could be dried satisfactorily in less than a day.

## EXPERIMENTAL PROCEDURE

Four charges of about sixty Oregon maple paper plugs each were dried in a small high-circulation steam-heated dry kiln. Two charges had similar dry-bulb temperatures with different humidities to study the effect on degrade of humidity control. A third charge was dried with high humidity and high temperature and the fourth charge was dried under intermediate conditions.

The moisture contents and shrinkage values were recorded for 15 plugs from each charge, and all plugs in each charge were given an empirical test for defect.

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\* In charge Lumber Seasoning, Oregon Forest Products Laboratory, Corvallis, Oregon.

In the test, the end-grain surface of each plug was struck a sharp blow with the side-grain surface of another plug (one plug in either hand). The test was intended to simulate the impact of a mallet in driving a plug into a paper roll. Defective plugs (such as those with excessive honeycomb or split knots) fractured when struck. The degrade figure reported (Table 1) is the number of fractured plugs expressed as a percentage of the number of plugs in a charge.

Conditions in the kiln during drying are summarized in Table 1.

Table 1. Kiln Conditions and Degrade During Drying of Oregon Maple Paper Roll Plugs.

Charge	Temperature		Equilibrium moisture content	Relative humidity	Drying time to 12% MC <sup>1</sup>	Degrade	Average MC at test
	Dry bulb	Wet bulb					
	Deg F	Deg F	Per cent	Per cent	Hours	Per cent	Per cent
1	160	148	10.5	80	30 <sup>2</sup>	8	18
2	185	110	1.5	12	8.5	28	8
3	202	190	10.0	77	23	10	12
4	160	122	4.5	42	14	10	8

<sup>1</sup> Moisture content, dry-weight basis.

<sup>2</sup> Estimated; drying was stopped after 24 hours.

## RESULTS AND DISCUSSION

### Kiln schedules and degrade

Two important features are indicated in Table 1: (1) humidity control appeared necessary, since high degrade percentage was found in charge 2 dried with 1.5 per cent equilibrium moisture content conditions, and (2) the shortest drying time to 12 per cent MC (moisture content) without serious degrade was about 14 hours.

The combination of short drying time (14 hours to 12 per cent moisture content) and comparatively low degrade (10 per cent at 8 per cent moisture content) indicated that charge 4 was dried with the most favorable kiln schedule used (Figure 2).

### Uniformity of moisture content

Charges 3 and 4 were most uniform in final MC since both had over 80 per cent of the dried plugs within plus or minus 2 per cent of the average MC for the charge (Table 2, Figure 3). However, charges 3 and 4 also had less variation in green MC than was found in charges 1 and 2. Charge 4 might have shown more uniform and lower MC had not one of the fifteen sampled plugs contained a large knot, and dried to only 15 per cent MC.

Table 2. Uniformity in Moisture Content in Dried Paper Roll Plugs.

Charge	Final average MC	Percentage of paper roll plugs	
		Below avg MC	At avg MC $\pm$ 2%
	Per cent	Per cent	Per cent
1	18	38	10
2	8	38	50
3	12	40	88
4	8	85	83

Shrinkage

Shrinkage was rather uniform in all charges. Charge 4, however, showed the greatest uniformity, with 77 per cent of the plugs being within plus or minus 0.5 per cent of the average value (Table 3, Figure 4). The high shrinkage value obtained in Charge 3 (Figure 5) may have been caused by the use of a high dry-bulb temperature and relatively high relative humidity during the drying schedule.<sup>3</sup>

Table 3. Uniformity of Shrinkage in Drying Paper Roll Plugs.

Charge	MC at test	Average shrinkage	Percentage of paper roll plugs	
			Below avg shrinkage at avg $\pm$ 0.5%	
	Per cent	Per cent <sup>1</sup>	Per cent <sup>2</sup>	Per cent
1	18	3.2	69	59
2	8	3.9	63	53
3	12	4.5	66	53
4	8	4.0	65	77

<sup>1</sup>Based on green measurements; average of radial and tangential values.

<sup>2</sup>Based on number of pieces tested.

Steam requirements

The rate of water removal was high during the early hours of drying in each charge. Charge 2 showed the most rapid rate of water removal, so the maximum heat requirements were calculated using data from this charge. Charge 4, with low degrade, had lower heat requirements, as shown in Table 4.

The steam requirements were based on an output of 2300 plugs daily, since that was the output of the producer who suggested the study.

Table 4. Boiler Horsepower Requirements for Kiln-drying 5-inch Oregon Maple Paper Roll Plugs.

Kiln efficiency	Power requirements	
	Maximum (charge 2)	Best schedule (charge 4)
Per cent	Horsepower	Horsepower
33 1/3	15	9
50	10	6

The boiler horsepower requirement for the best schedule (charge 4), with an assumed kiln efficiency of 33 1/3 per cent, was calculated as follows:

Grams of water lost per plug per hour:

$$\frac{39}{2} = 19.5 \text{ (from Figure 2) (avg of first two hours)}$$

Grams of water lost per 2300 plugs per hour:

$$2300 \times 19.5 = 4490$$

Pounds of water lost per 2300 plugs per hour:

$$\frac{4490 \times 2.205}{1000} = 99$$

Steam required to evaporate 99 pounds water per hour:

$$99 \times 3 = 297 \text{ (33 1/3 per cent efficiency)}$$

Boiler horsepower required (at 35 pounds steam per boiler hp):

$$\frac{297}{35} = 9 \text{ horsepower}$$

#### REFERENCES

1. Torgeson, O. W. Technique of Developing a Drying Process for Small Stock. Report No. R 1263, U.S. Forest Products Laboratory, Madison, Wisconsin, Sept. 1940.
2. Baker, Gregory. Economies in Seasoning. Bulletin 23, Page 47, Northeastern Wood Utilization Council, Inc., New Haven 6, Connecticut. August, 1948.
3. Stevens, W. C. "The Effect of Temperature and Drying Rate on the Shrinkage of Beech." Timber Technology and Machine Woodworking, 154 Fleet Street, London. December 1952 and January 1953.



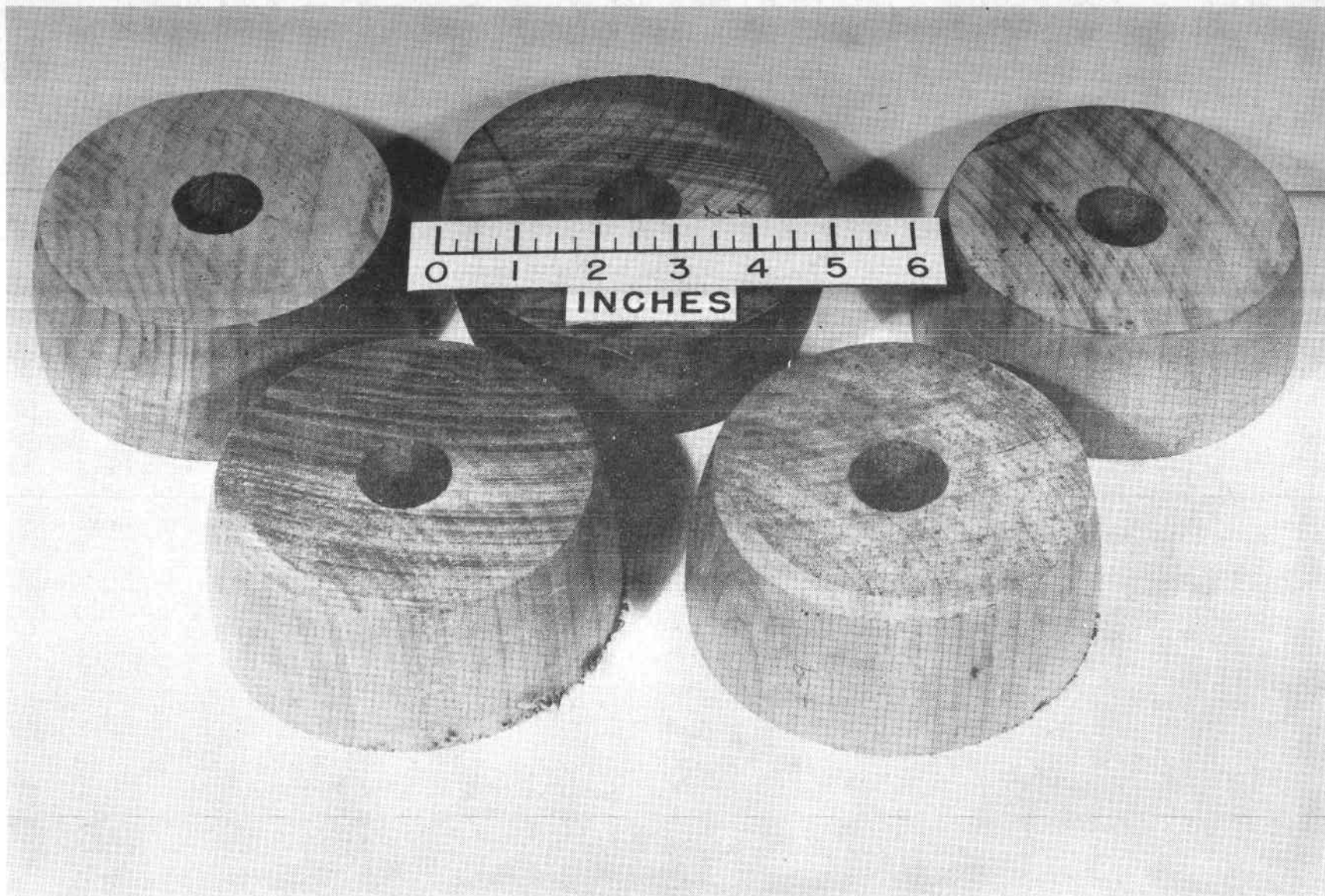


FIGURE 1. FIVE-INCH OREGON MAPLE PAPER ROLL PLUGS AFTER KILN-DRYING.



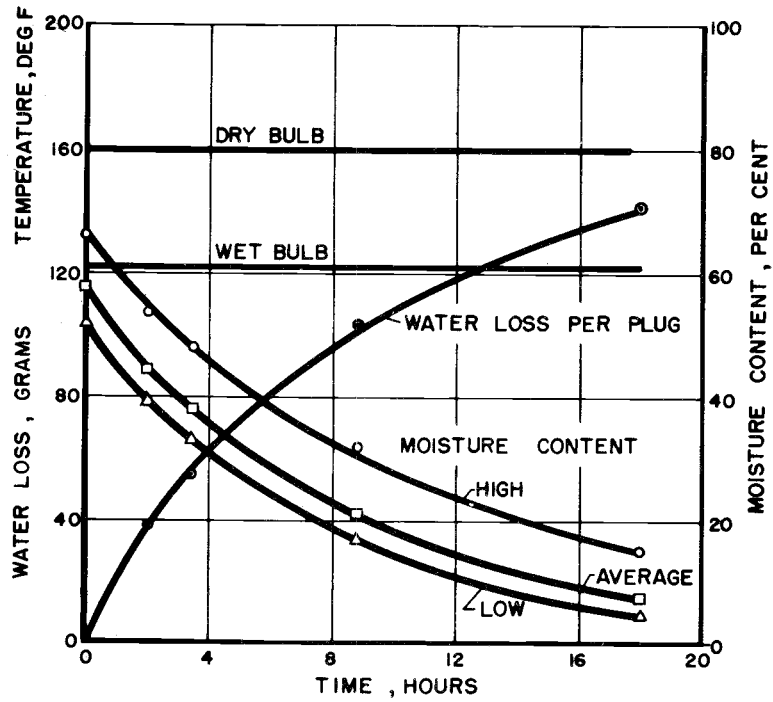


FIGURE 2. DRYING DATA AND KILN SCHEDULE FOR FIVE-INCH MAPLE PAPER PLUGS: CHARGE 4.

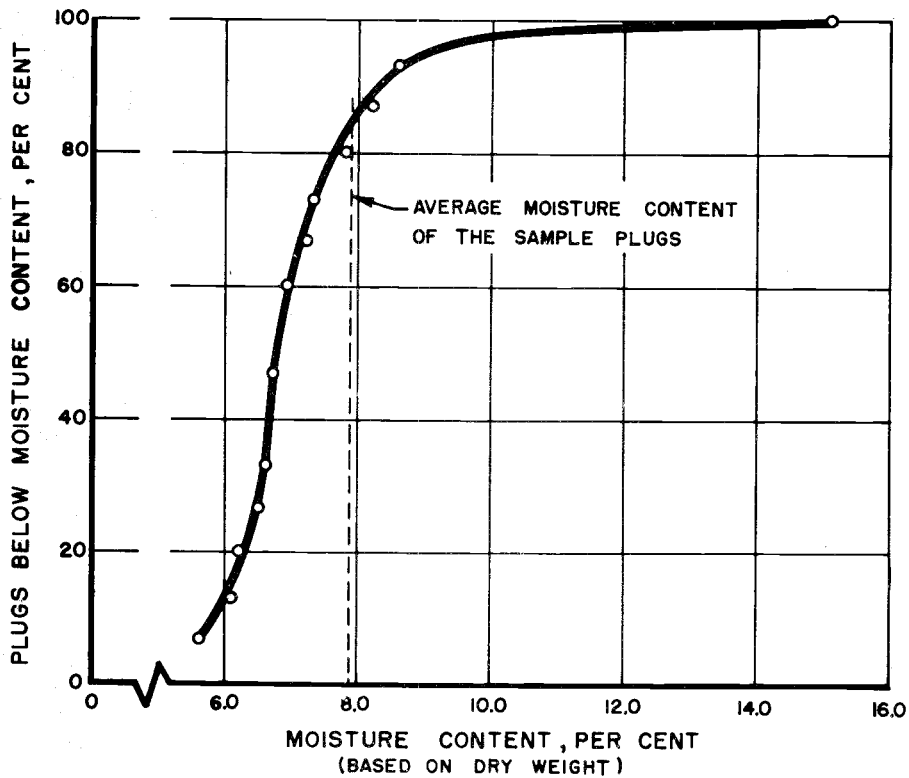


FIGURE 3. CUMULATIVE DISTRIBUTION OF MOISTURE CONTENT VALUES IN KILN-DRIED OREGON MAPLE PAPER-ROLL PLUGS; CHARGE 4.

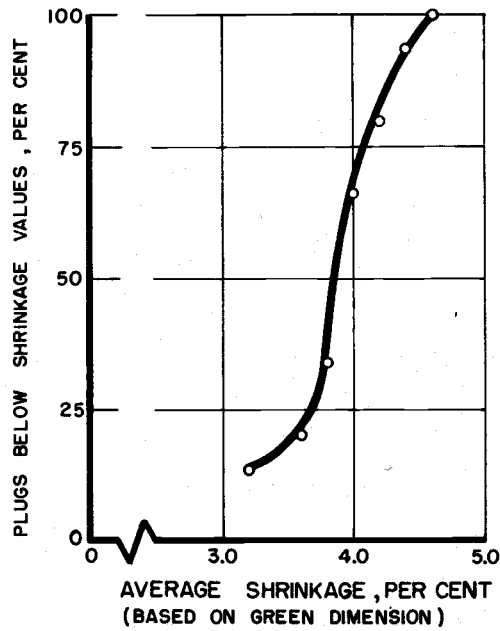


FIGURE 4. CUMULATIVE DISTRIBUTION OF SHRINKAGE VALUES FOR PLUGS; CHARGE 4, DRIED TO 8% AVERAGE MOISTURE CONTENT.

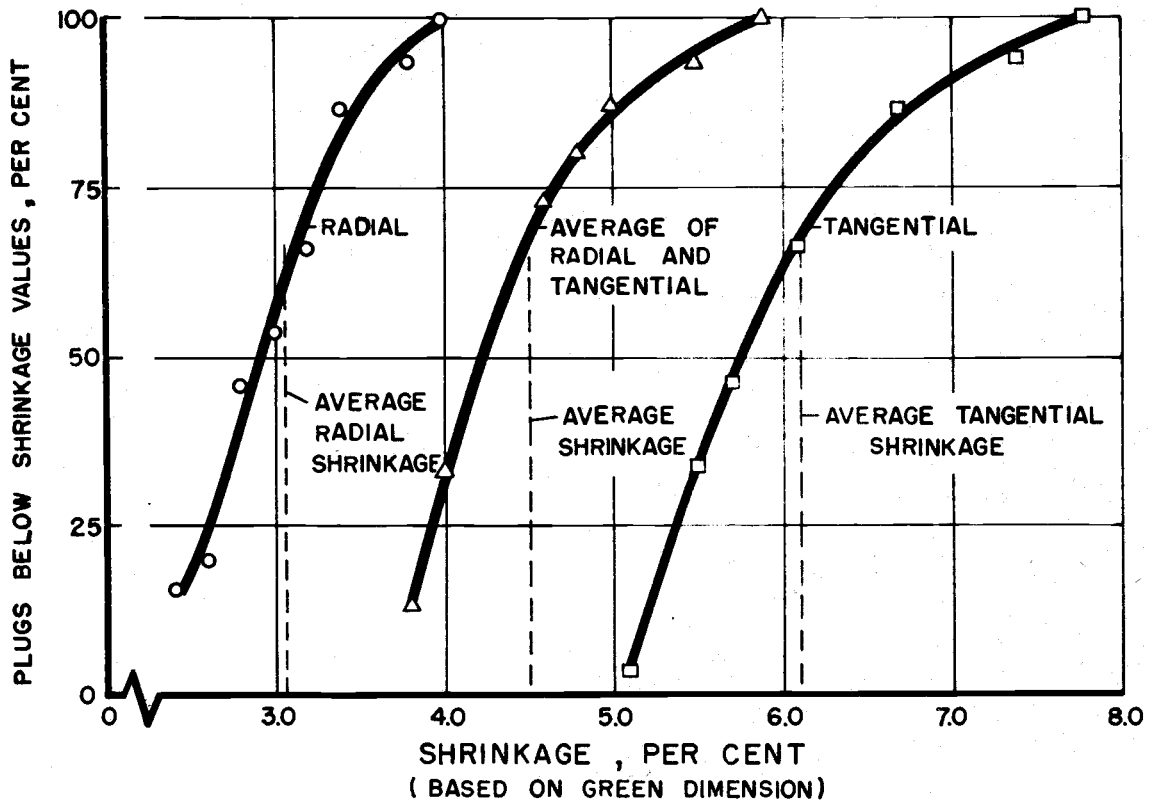


FIGURE 5. CUMULATIVE DISTRIBUTION OF SHRINKAGE VALUES FOR PLUGS; CHARGE 3, DRIED TO 12 PER CENT AVERAGE MOISTURE CONTENT.