# OUTLINE FOR THE DRYING OF SOFTWOOD LUMBER TO MEET NEW SPECIFICATIONS

by

John M. McMillen, Forest Products Technologist
Forest Products Laboratory,[1] Forest Service
U.S. Department of Agriculture

---

## Introduction

The first consideration in discussion of this subject is to know what the new specifications are or will be. Until a new commercial standard is adopted, no specification is fully established. Some associations, however, have published new grading rules that specify two drying levels: "dry" with 19 percent maximum moisture content; "kiln dry" or "MC 15" with 15 percent maximum. For special items, a lower level can be set up, for instance, 12 percent maximum for paneling.

Sizes specified in the new grading rules are standard and alternate. The standard dimensions correspond to the present commercial standard; the alternate sizes, for "dry" or "kiln dry" stock, are thinner without being reduced in width.

The "dry" specification can be met by:

1. Air drying,
2. Forced-air drying, or
3. Kiln drying.

Good storage and protection during shipment are needed to retain "dry" or drier moisture content values.

## Air Drying and Forced-Air Drying

In northern climates, air drying is effective only during the months of April through October. The same must be said for fan-shed drying, unless some heat is used; but drying time within this period is greatly shortened by use of the fans. Some general information on air drying is available in Forest Products Laboratory Report 1657. No general publication is available for forced-air drying, but information can be obtained from the University of Massachusetts, Amherst; the Southeastern Forest Experiment Station, Asheville, N.C.; or the dry kiln companies.

---

[1]Maintained at Madison, Wisconsin, in cooperation with the University of Wisconsin.

Excerpt from Proceedings, Forest Products Research and Dry Kiln Operators Meetings, Orono, Me., October 1968.

## Basics of Kiln Drying

Softwoods are dried rapidly in a kiln if proper schedules of dry-bulb temperatures and wet-bulb depressions are used. Air velocity through the load should be in the range of 350 to 450 feet per minute, or higher if economically feasible. Direction of air travel should be reversed every 6 hours or less. Conventional kiln schedules for eastern softwoods, on either the moisture content or time basis, are given in the Dry Kiln Operator's Manual and publications of the Canadian Forest Products Laboratory, Ottawa. The results of drying of studs from two species of western softwoods with a high-temperature schedule (over 212° F.) were published by Kimball and Lowery (Forest Products Journal, April and Sept. 1967). Additional information on high-temperature schedules is available from Ottawa.

In spite of rapid circulation of air and periodic reversal of air direction in a modern kiln, the lumber in the center of a kiln charge is considerably wetter than that on the outside during the early and intermediate stages of drying. For example, southern pine studs on the entering-air side of a 4-foot pile dried to 19 percent moisture content in 72 hours but on the leaving-air side took 112 hours. The leaving-air side of a 4-foot-wide load is equivalent to the center of an 8-foot load with air direction periodically reversed. Another 24 hours of equalizing could be used to advantage in attaining a good degree of moisture uniformity at the "kiln dry" moisture level with this uniformly drying species.

## Reaction of Softwoods to Kiln-Drying Conditions

Information on moisture distribution and internal strain during drying of sapwood, heartwood, and the combination of these two types of wood in the easy-drying softwood, ponderosa pine, is given in Forest Service Research Paper FPL 83. High moisture concentrations in sapwood are readily drawn toward the surface by capillary forces and there the moisture is easily evaporated. High moisture concentrations in sapwood of white pine react similarly, but those in the heartwood tend to remain centrally located thicknesswise. They do, however, continuously drop in moisture content as long as kiln drying proceeds. In other words, if white pine is kept in the kiln long enough, with high enough temperature, all wet spots disappear. Observation on several wet boards in a recent kiln-drying course demonstrated this. Although some eastern hemlock sapwood and lodgepole pine sapwood have been found to be greatly reduced in permeability by drying, a similar reaction is unlikely in white pine heartwood. The best procedure, however, is to keep the pine in the kiln until the wet spots are gone.

## Final Moisture Content Uniformity for Eastern Hemlock

A study on 2 by 4 specimens has shown that eastern hemlock can be satisfactorily dried for studs that can compete well with precision-dried western stud species. Hemlock has two major problems--shake and highly variable initial moisture content. To overcome shake, it is necessary to hand sort out the studs having enough shake in the green condition to cause serious degrade. The shaky material can be air dried for local use. The rest of the stock can be kiln dried with schedules that do not aggravate shake.

To overcome initial moisture content and drying-rate variations, the studs are sawn to a precise rough size and then sorted into three weight classes. This can be done automatically. The weight-class boundaries are set so that one-sixth of the studs fall into each of the light and the heavy classes and two-thirds in the medium.

The lightweight studs can be kiln dried separately in 6 days by themselves or with pine or balsam fir. The medium-weight studs can be dried to meet a 19 percent moisture content maximum in 11 days by the schedule given in table 1. Results with this schedule were favorable enough to indicate that this sort could be dried in 9 days with a slightly more severe schedule. The heavy studs can be air dried or forced-air-dried to a medium moisture content or weight and then kiln dried with medium-weight stock. Limited tests indicate that a 4-hour preliminary steaming of heavy pieces will permit at least half of the steamed studs to be kiln dried successfully with medium-weight stock.

To meet a moisture content specification requires procedures such as indicated above, plus some means of testing the wood for moisture content as the end of the drying run approaches. One method is to use a resistance-type moisture meter with long, insulated-pin electrodes. The pins are driven into the edges of a number of boards along the length of the kiln charge. The depth of penetration, 2 to 3 inches, is sufficient to show the general moisture content of the wood in the charge, even though the boards on the edges of the load have a somewhat faster drying rate. If temperature and species corrections are needed, they are made on an empirical basis that may encompass factors other than the basic temperature influence on the resistance of the wood.

In making final moisture tests on the 2 by 4 hemlock specimens 1 day after the end of drying, the short-pin electrode gave results closer to the moisture content by oven test than did insulated pins driven to a 7/l6-inch depth. The average moisture content obtained by the meter still was slightly higher than that found by oven test, probably because of the moisture gradients in recently dried wood. Where this type of metering is used for quality control, development of locally applicable, empirical species-correction curves is advisable.

If the light- and heavyweight pieces of eastern hemlock are sorted out before drying starts, the frequency of final moisture content values for the kiln-dried stock can be plotted as a straight line on a special graph paper. All that is necessary for moisture content quality control is to determine total drying times for the different initial weight classes, so that in the plotting 95 percent or more of the values fall at or below the 19 percent MC level, or any other specified maximum value. The actual moisture content of the very wettest piece is of no practical consequence if the moisture content of the rest of the stock is well distributed.

## Storage and Shipment

To meet the specifications for moisture content at the point of delivery, properly dried stock should be banded in solid piles and stored under a shed roof. It can be shipped on open trucks or flatcars, provided it is covered during periods of precipitation. Reinforced asphalt-laminated

paper shrouds or wrappings are an effective alternate but should not be used for lumber not completely dried. Weather-resistant spray coatings will prevent water pickup by lumber dried to the fully air-dry level but will not prevent moisture reabsorption by stock dried to less than 12 percent moisture content.

## References


Kimball, K. E., and Lowery, D. P.
1967. High temperature and conventional temperature methods for drying lodgepole pine and western larch studs. Forest Products J. 17(4): 32-40.

Kimball, K. E., and Lowery, D. P.
1967. Quality of studs kiln dried by high and conventional temperatures. Forest Products J. 17(9): 81-85.

McMillen, J. M.
1968. Transverse strains during drying of 2-inch ponderosa pine. U.S. Forest Service Research Paper FPL 83, 26 p., illus. Forest Products Lab., Madison, Wisconsin.

Millett, R. S.
1961. Kiln drying of lumber in eastern Canada. Forest Products Research Branch (Ottawa) Tech. Note No. 21, 37 p., illus.

Peck, E. C.
1956. Air drying of lumber. Forest Products Laboratory Report No. 1657, 21 p., illus.

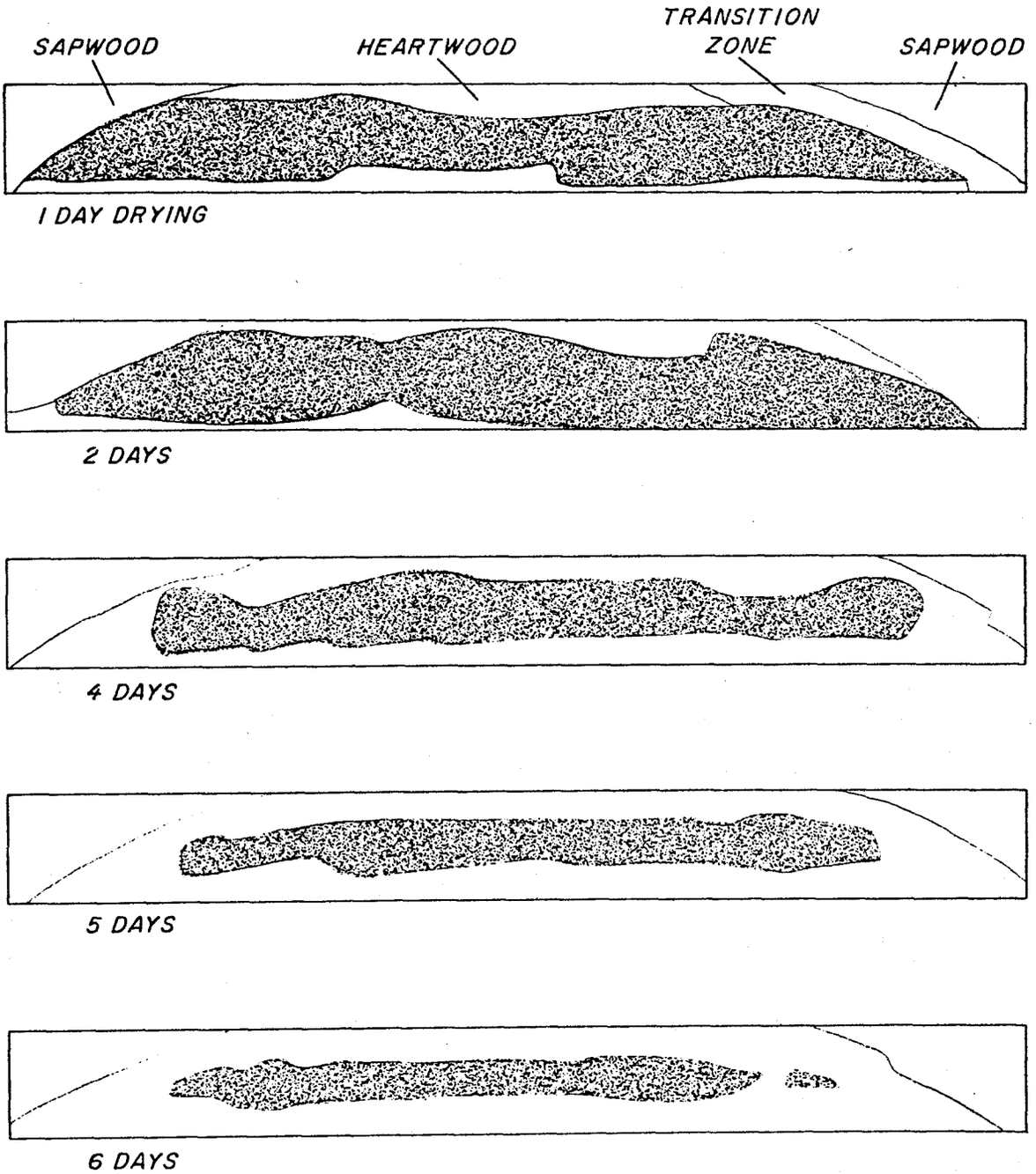
Rasmussen, E. F.
1961. Dry kiln operator's manual. U.S. Dept. Agri., Agri. Handbook No. 188, 197 p., illus.

Southern Pine Inspection Bureau
1968. 1968 Standard grading rules for southern pine lumber. 171 p., illus. So. Pine Inspect. Bur., New Orleans, La.

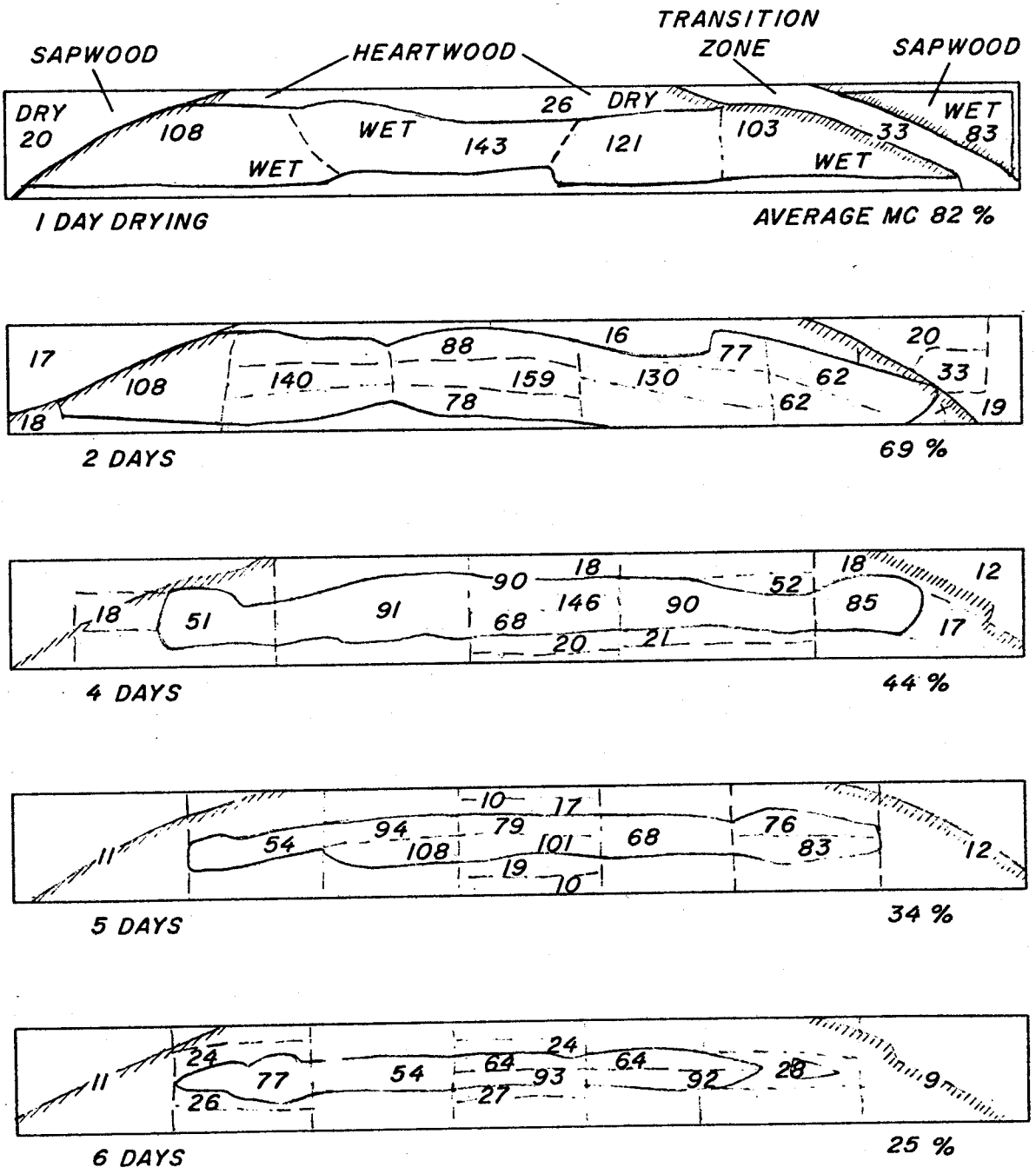
Western Wood Products Association
1968. Rules for grading western lumber. 188 p., illus. Western Wood Prod. Assoc., Portland, Oregon.

Table 1.--Kiln schedule found satisfactory for drying medium-weight eastern hemlock studs in 11 days

| Time | Dry-bulb temperature | Wet-bulb depression |
|---|---|---|
| Days | °F. | °F. |
| 0 - 2 | 150 | 7 |
| 2 - 4 | 155 | 10 |
| 4 - 6 | 160 | 15 |
| 6 - 8 | 165 | 20 |
| 8 - 9 | 170 | 25 |
| 9 - 10 | 180 | 30 |
| 10 - 11 | 180 | 35 |


SAPWOOD
HEARTWOOD
TRANSITION ZONE
SAPWOOD
1 DAY DRYING
2 DAYS
4 DAYS
5 DAYS
6 DAYS

M 139 173


SAPWOOD
HEARTWOOD
TRANSITION ZONE
SAPWOOD
DRY 20
108
WET
WET
143
26
DRY
121
103
33
WET
83
WET
I DAY DRYING
AVERAGE MC 82 %
17
108
18
140
88
78
159
16
130
77
62
62
20
33
19
2 DAYS
69 %
18
51
91
90
68
146
18
20
21
90
52
18
85
12
17
4 DAYS
44 %
11
54
94
108
10
79
101
19
17
10
68
76
83
12
5 DAYS
34 %
11
24
77
26
54
64
93
27
24
64
92
28
9
6 DAYS
25 %

M 139 172