

A SUMMARY OF WESTERN SOFTWOOD KILN SCHEDULES¹

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In 1954, when plans were made to revise the Forest Products Laboratory kiln schedules, it was decided to try to arrive at softwood kiln schedules in keeping with the time schedules used by the industry. Laboratory and Forest Utilization Service representatives in the major softwood-producing regions decided that a thorough study of the kiln schedules used by the industry was the most important first step of the overall job. Accordingly, information was obtained from industry on the northeastern pines, the southern pines, and western softwoods.

This report is just an introduction to the large amount of information obtained on the western softwood species. The major purpose in presenting it to the joint annual meeting of the Western Dry Kiln Clubs is to get suggestions as to how to set up softwood schedule recommendations that will be of the greatest benefit to industry and the utilization of our national forest resources.

Just getting time-temperature data from the industry would not fully serve this joint purpose. Not only should we know what is being done now--we need to understand why it is successful, if it is as successful as it should be, and, if not, how can it be improved. So, for each segregation of species, thickness, width, type of wood (sapwood or heartwood), grain, grade, and general moisture condition, we obtained information on the locality of growth, moisture content of the wood when it went into and came out of the kiln, the ultimate use, any defects and their causes, type and make of kiln, final conditioning treatment, and, last but not least, the total kiln time.

Mills visited were selected almost entirely from those with modern fully automatically controlled dry kilns of average or better quality. There are many more such mills than could be visited. Schedules suitable for these kilns can be applied to other kilns with generally minor modifications.

The method of study was to visit the mill to observe actual as well as prescribed conditions and get as much of the supplemental information as possible. We could not make tests of drying results; all we could do was obtain the opinion of the kiln operators and the management as to whether the results were commercially satisfactory. In some cases, schedules with which the mills themselves were not satisfied were omitted from the compilation. In a few other cases, limitations of the equipment made it impossible for the kilns to be operated at the schedules the operators would have liked to use. By and large, however, all the data collected were used in arriving at the average schedules.

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Accurate data on drying time and moisture content were not available. In summarizing the data, therefore, all we could do was tabulate the dry-bulb temperatures and wet-bulb depressions at the various mills by 12- or 24-hour intervals. The shorter intervals were generally used for items that dried in 5 days or less and the longer intervals for other items. A few mills make changes at shorter intervals, probably saving some drying time by so doing, but they were so few that their data were transformed to the 12- or 24-hour basis for summarization. Tabulation generally was separated by moisture class and regions and sometimes by type of wood. Final results, however, were often combined if there seemed to be no consistent reason for separating them. As a first step in arriving at the final series of schedules, the numerical averages of dry-bulb temperature and wet-bulb depression for each time interval, as well as for the conditioning treatment, and the conditioning time, total kiln time, and average moisture control were calculated.

Table 1 on 8/4 Douglas-fir shows that there are some differences between regions and grades for the same thickness. The difference between the West Coast and the Inland Empire on lower grades is not of any consequence so far as temperature is concerned, but is significant as far as wet-bulb depression, total drying time, and final moisture content are concerned. These differences may have some connection with differences in density. There also may be some differences in drying standards.

The schedule for laminating stock is interesting, in that the final moisture content must be brought as low as that of the clears. While the stock contains knots, they can check badly or even drop out--but, of course, the grade excludes knots from the edges of the boards. The schedule is more severe temperature-wise, but less severe humidity-wise, than those of the common grades. To complete drying to 10 per cent in a practical length of time, final temperatures are very high and final humidity is quite low. Perhaps these same final conditions could be used for the upper grades, saving 10 to 20 hours' kiln time.

Joe Steel, Ed Knight, and other old-timer western kiln-drying authorities have strongly promoted as much segregation as possible. Douglas-fir 8/4 stock of the upper grades, segregated by width, gives a good example of the savings possible. Four mills that segregate their 4-inch, or 4- and 6-inch, from their wider stock take 168 hours to dry the narrow stock compared with 213 hours for the wider stock to the same degree of dryness. This 20 per cent saving is partly due to the use of more severe schedules with narrow stock and partly to a shorter drying time when the same schedule is used. Of course, the Weyerhaeuser mills with their large volume can give many examples of savings from such segregations.

In spite of the above differences, it is striking how similar different regions can be for some items. Table 2 gives average schedules for three distinct regions in 4/4 upper grade ponderosa pine. Exact average temperature and wet-bulb depression values are given to show how small the differences are. On the basis of drying stress results for easy-drying softwoods, the smaller first and second wet-bulb depressions in the Central California region may not be necessary. Note that the difference in time between this and the Northern California-Southern Oregon mills is only equivalent to the difference in conditioning time. The final moisture content is stated to be slightly lower, however. This is attained by a 5° F. higher dry-bulb temperature during the last 30 hours of drying. The similarity of these schedules is probably largely

due to the excellent service given member mills by the Western Pine Association. The shorter time in the Inland Empire mills is probably due in part to the fact that the stock dries more in green storage before it enters the kilns and possibly to some further drying after it is out of the kiln. There is less conditioning also.

Data for these mills, however, can be used to show the variation that exists between mills for the same item in the same region (Table 3). Almost the same amount of variation existed in the other regions.

Of course, there are segregations of sinker stock and light stock in redwood and sugar pine and of sapwood and heartwood in some other species. Perhaps the least sensible segregation--or so it seemed until the reason was explained--was that for the 4-inch width of 4/4 ponderosa pine, which took longer to dry than the wider widths. The 4-inch stock, it turned out, was all sapwood, wringing wet; the wider 4/4 was mostly heartwood and considerably drier before it went into the kiln.

Successful commercial kiln schedules should have some relationship to the internal stresses that develop within softwoods as they dry. In the few woods tested for drying stresses, the data indicate that a permanent reversal of stresses does not occur until late in drying and that severe tensile stress can be developed in surface layers by abrupt lowering of relative humidity at moisture content values above 20 per cent. Thus, the generally universal practice of gradual humidity changes has some technological foundation. A few mills use very large wet-bulb depressions after stresses have really reversed, when it is necessary to go to very low final moisture content values.

To cover each of the major segregations for species, item, and moisture class would involve at least 90 separate schedules. When these are fully summarized, it is hoped that enough of them will be similar or identical to make a unified chart plan of presentation possible. It is also hoped that you kiln operators will have some suggestions for interpreting them so that a feasible way of publishing the data for your greatest benefit will be apparent.

Unfortunately, the time available for the study did not permit first-hand investigation of the quality factors: whether the desired average moisture content was attained, the uniformity of moisture content, or the effectiveness of stress-relief treatments. It is hoped that management will recognize the value of having kiln operators keep tab on these things and will give you greater opportunities to make practical studies and relieve you of less important duties. When given such opportunities, the kiln operators should keep careful records and present their findings to kiln club meetings for discussion. One quality factor that it was good to observe at the different mills was that so many were actually achieving good conditioning treatments.

Other expectations from the softwood schedule study, besides that of producing a unified basic series of schedules in keeping with drying stress and quality principles, are that places in greatest need of research will become self-evident. Then it is hoped that a sound program of general research in softwood schedules can be instituted and carried out. In such an extensive program, the work of many laboratories will be needed.

To get fundamental research done on the university level, industry should support fellowships in drying technology and then employ the graduates. They must be recognized as professionals. Industry then should work out ways for technologists and you, the experienced wood-drying technicians, to work together as a team to put the new developments into commercial practice. Such a procedure will pay off the research investments many, many fold.

Table 1. Differences in regional schedules, 8/4 Douglas-fir, lower and upper grades

Time	Lower grades				Laminating stock		Upper grades			
	West	Coast	Inland	Empire	West Coast		West Coast		Northern California	
	Dry-bulb temper- ature	Wet-bulb depres- sion	Dry-bulb temper- ature	Wet-bulb depres- sion	Dry-bulb temper- ature	Wet-bulb depres- sion	Dry-bulb temper- ature	Wet-bulb depres- sion	Dry-bulb temper- ature	Wet-bulb depres- sion
<u>Hr.</u>	<u>°F.</u>	<u>°F.</u>	<u>°F.</u>	<u>°F.</u>	<u>°F.</u>	<u>°F.</u>	<u>°F.</u>	<u>°F.</u>	<u>°F.</u>	<u>°F.</u>
AVERAGE SCHEDULES										
0-12	145	8	145	15	160	7	146	5	140	5
12-24	145	10	150	15	165	9				
24-36	150	15	155	15	170	14	152	9	146	8
36-48	150	20	160	20	170	15				
48-60	155	25	160	20	175	20	160	14	152	13
60-72	160	25			175	25				
72-96					175	25	165	18	157	16
96-120					180	30	172	25	160	18
120-final					190	40	175	30	165	23
Conditioning							180	9	165	5
RESULTS										
Drying time....Hr.	72			55		180		192		180
Conditioning...Hr.								10		10
Total time.....Hr.	72			55		180		202		190
Final moisture content..Percent	17			13		10		10		11
Number of mills	12			6		3		12		2

Table 2. Similarity of regional schedules, 4/4 Ponderosa pine, upper grades

Time	Central California		North-California-South Oregon		Inland Empire	
	Dry-bulb temperature	Wet-bulb depression	Dry-bulb temperature	Wet-bulb depression	Dry-bulb temperature	Wet-bulb depression
<u>Hr.</u>	<u>OF.</u>	<u>OF.</u>	<u>OF.</u>	<u>OF.</u>	<u>OF.</u>	<u>OF.</u>

AVERAGE SCHEDULES

0-12	136	13	138	19	137	17
12-24	141	16	141	20	139	20
24-36	151	26	148	25	144	24
36-48	152	27	153	27	149	27
48-60	160	32	156	34	155	30
60-72	160	34	155	33	155	30
72-84	161	36	156	32		
Conditioning	(1)	(1)	175	9	167	10

RESULTS

Drying time....Hr.	79	79	70
Conditioning...Hr.	9	6	4
Total time.....Hr.	88	85	74
Final moisture content...Percent	9	10	10
Number of mills	9	8	13

¹
No data.

Table 3. Variation between mills within the Central California region, 4/4
ponderosa pine, upper grades

Time	Average schedule		Closest actual schedule		Low-temperature schedule		High-temperature schedule	
	Dry-bulb temperature	Wet-bulb depression	Dry-bulb temperature	Wet-bulb depression	Dry-bulb temperature	Wet-bulb depression	Dry-bulb temperature	Wet-bulb depression
<u>Hr.</u>	<u>°F.</u>	<u>°F.</u>	<u>°F.</u>	<u>°F.</u>	<u>°F.</u>	<u>°F.</u>	<u>°F.</u>	<u>°F.</u>
SCHEDULES								
0-12	136	13	140	15	120	10	160	20
12-24	141	16	140	15	120	10	160	20
24-36	151	26	150	25	130	15	170	30
36-48	152	27	150	25	130	15	170	30
48-60	160	32	160	35	140	20	180	45
60-72	160	34	160	35	140	20	180	45
72-final	161	36	160	35	150	30	180	45
RESULTS								
Kiln time:.....Hr.	88		90		102		90	
Final moisture content.Percent	9		10		8		7.5	