SCHEDULES FOR THE KILN DRYING OF WOOD

Slightly Revised

November 1957

(Report)

No. 1791

FOREST PRODUCTS LABORATORY
MADISON 5, WISCONSIN

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

SCHEDULES FOR THE KILN DRYING OF WOOD[1]

By

O. W. TORGESON, Technologist

Forest Products Laboratory,[2] Forest Service
U. S. Department of Agriculture

General Considerations in the Development and Application of Standardized Kiln-Drying Schedules

A proper schedule for the kiln drying of wood green from the saw is a series of temperature and relative humidity conditions that guides the operator efficiently through each stage of the drying process. The desired objective is to produce a drying rate that is satisfactory without causing objectionable drying defects. This objective, however, cannot be fully realized by the use of a standardized set of kiln schedules because of differences in the characteristics of the wood, in local production and selling practices, in the degree of care in kiln operation, and in kiln characteristics. In these schedules the Forest Products Laboratory has attempted to use the available information on this subject and to incorporate new ideas as to methods of accelerating the drying rate and of reducing drying defects. In many individual cases modifications of these schedules will be desirable and necessary to take care of the many variables involved. In spite of the modifications that may be necessary, it is felt that these schedules will be useful to the industry as a guide and as a reference base for the formulation of schedules best suited for the species, thicknesses, items, and available kiln equipment.

New Versus Old Forest Products Laboratory Schedules

It is intended that the schedules presented here shall replace the standard schedule recommendations of the Forest Products Laboratory previously published. New data have shown that previous recommendations can be improved by certain changes, consisting mainly of: (1) making the first change in relative humidity when the wood loses about one-third of its original green moisture content, (2) dropping the intermediate relative humidities more rapidly, and (3) using higher final temperatures. In addition to these changes, the initial relative humidities were adjusted to prevent surface checking in the more refractory species.

---

[1] Original report dated February 1951.

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

Need for a Moisture Content Basis

It has been found that, in general, drying defects can be controlled best by the use of safe initial drying conditions and that drying rates can be accelerated with greatest safety during the intermediate and, especially, the final stages of drying. Since temperatures are most critical with respect to collapse and honeycomb, particularly in oak, while the wood is wet, the maximum safe initial temperature should not be increased appreciably until after all wood is well below 30 percent moisture content (the fiber-saturation point of wood). Relative humidities are most critical with respect to surface checking and, in drying green wood, the minimum safe initial relative humidity can be dropped gradually, but at a progressively greater rate, during the time the wood is losing, approximately, the second one-third of the original green moisture content.

These rather general guides in designing a schedule are mentioned to show the need for a knowledge of current moisture content during the entire kiln-drying operation. For this reason, the kiln schedules presented here are based on the moisture content of the stock and on the use of adequate kiln samples as the best method of following the moisture condition of the stock through the entire kiln-drying process.

Need for a Good Sampling Method

The moisture content of green wood varies greatly between species and to some extent, within species. There is some difference between the moisture content of the heartwood and of the sapwood of almost any hardwood, while in most softwoods the moisture content of the sapwood is much greater than that of the heartwood. In general, sapwood dries faster and checks less than the heartwood. Between the mill and the kiln, some stock may dry considerably and some may not. Because of these and other variables, such as position in the kiln, a number of representative samples are necessary to represent properly the entire kiln charge. A desired minimum is one sample to each truckload on each side of the kiln and not less than six in each kiln charge. A sufficiently safe operating procedure is to use the average moisture content of the wettest one-half of the total number of samples to govern the scheduled changes in kiln conditions.

To use schedules as intended, therefore, it is necessary that such variables in each kiln charge be discovered and provided for by the careful selection and use of suitable samples.[3]

Need for the Proper Locating of the Control Bulbs

The various conditions given in the schedules are intended to be those of the air as it enters the load. If control bulbs in a forced-air kiln are placed

---

[3]Forest Products Laboratory Report No. R1607. Use of Kiln Samples in Operating a Lumber Dry Kiln. 1954.

on the leaving-air side of a load, the drying conditions on the entering-air side may be excessively severe. The safest general rule is to place such bulbs within the hottest zone of the kiln and to control drying on entering-air temperatures at all times.

Need for Accurate Instruments

A very common fault in kiln operation is failure to provide clean wicks on the wet bulb and to calibrate and to adjust the control indicators and recording pens on the recorder-controller. Without such attention, the drying conditions may be quite different from those intended and, in the drying of some items, such differences may result in considerable drying defects or else in a considerable loss of drying time.

Need for Good Air Circulation

These schedules are intended primarily for use in compartment kilns with fast air circulation where conditions on the wood surface are most nearly those of the conditioned air. Air velocities of 200 to 350 feet per minute through the load are quite common in forced-air-circulation kilns. For air velocities much less than these, the initial wet-bulb depressions can be increased somewhat. For natural-circulation kilns, the wet-bulb depressions can be increased as much as 4° F.

Description and Use of Schedules

General Composition

As temperature and relative humidity do not bear the same relationship to the moisture content of the wood with respect to their effect in causing seasoning defects, the temperature and humidity schedules have been made up separately and are shown independently of each other in the schedules at the end of the text.

There are 14 temperature schedules, ranging from the mildest (T1) to the most severe (T14). For instance, T1 has been found suitable for hickory handle stock to prevent pinking, and T14 is commonly used to accelerate the drying of such species as southern pine lumber. The initial temperature is maintained until the moisture content of the stock dries to 30 percent. The final temperature is reached in five steps during the time the moisture content changes from 30 to 15 percent.

The humidity schedules are given in terms of the wet-bulb depression and consist of eight sets of values, identified by numbers from 1 to 8. Each schedule, or set, has a different initial value, but the same final value of

50° F. In each, the final value is reached in six steps, at progressively greater rates that have been found safe and desirable. Another phase of the humidity schedules is the moisture content at which the various wet-bulb depressions are used. As mentioned before, it has been found that the first change in humidity can be made at a moisture content that bears some relationship to the original green moisture content of the wood. For that reason, six classes of moisture content steps have been made, identified by the letters A to F, any one of which can be used with any one of the eight wet-bulb-depression sets to make up a humidity schedule that is best suited to the wood being dried. A total of 48 combinations is possible.

General Lumber Schedules

Suggested schedules for hardwoods are listed in the hardwood index (table 1) at the end of the text. Using 4/4 red oak as an example, the complete schedule is given as T4-D2, which means that temperature schedule T4 must be used in combination with humidity schedule D2. This combination in conventional form would appear as shown in table 2 at the end of the text.

Although the same schedule is recommended for 4/4, 5/4, and 6/4 material, it does not mean that they should be dried in the same kiln charge. Thick lumber dries slower and tends to check more than 4/4 material. For that reason a milder schedule is recommended for 8/4 lumber.

Schedules for softwoods are listed in the softwood index (table 3) at the end of the text. As the drying periods for softwoods are relatively short, the schedules as given may have more steps than are practical to use. For instance, if, after one day of drying, the moisture content is below the minimum value given in the succeeding step, then that step can be omitted and drying conditions that are called for by the moisture condition of the stock as given in the schedule can be established immediately.

Schedules for Special Items

Certain special items are listed that differ from lumber in size or shape. The fact that a different schedule is used may be due to use requirements as well as to differences in seasoning characteristics. In short items end checking must be controlled, and in others color or complete freedom from checks must be considered. For these reasons a schedule for some special item may differ in certain respects from that needed for lumber of the same species.

Final Moisture Content

The moisture content to which lumber should be dried is based primarily upon use requirements. In the northern part of this country an average of about 8 percent represents the indoor equilibrium moisture content conditions, and 12

percent, the outdoor conditions. In the damp southern coastal states, the average values are 11 and 12, respectively, and in the dry southwestern states, 6 and 9 percent.[4]

Items such as flooring and furniture wood are usually dried to a somewhat lower moisture content than the values given to take care of the moisture regain that may occur during storage and manufacturing periods.

Modifications

1. Drying Previously Air-Dried Lumber

During the kiln drying of lumber green from the saw a moisture gradient is established within the wood that permits the use of the intermediate and final temperatures and relative humidities that are shown in the schedules. In air-dried lumber at the same moisture content, however, the moisture gradient may be relatively flat, and it is desirable to start with higher relative humidities until a definite moisture gradient has been established before using the scheduled conditions.

To conform to this general idea, stock that has been previously air dried to 30 percent, then suffered a surface moisture regain, should be run on an 8° or 10° F. wet-bulb depression for 24 hours before being shifted to the regular humidity schedule. The shift can be abrupt for 6/4 or thinner stock but should be gradual for 8/4 and thicker. Air-dried stock that has not suffered moisture regain can be started directly at the proper step of the regular humidity schedule. In either case, the regular temperature schedule should be used.

2. Final Humidities in Low-Temperature Schedules

A final wet-bulb depression of 50° F. at low temperatures, such as 120° or 130° F., represents relative humidities that are often lower than can be attained in commercial kilns. Consequently, smaller wet-bulb depressions may have to be used until sufficiently high temperatures are called for by the schedule. The point to remember is that low final relative humidities are conducive to fast drying and that no harm can be done to the wood by using the 50° F. depression when called for by the schedule, except that some fast-drying boards may become excessively dry before the wetter boards have dried down to the desired moisture content. Such a condition, however, can be corrected by the use of an equalization treatment.

---

[4] Forest Products Laboratory Report No. R1655. Moisture Content of Wood in Use. 1955.

3. Final Humidities for Commons to Prevent the Development of Loose Knots

A rather low-temperature schedule is given for Douglas-fir commons so as not to melt the resin around the knots. The humidity schedule is rather mild so as to reduce the differential between the shrinkage of the knots and that of the wood surrounding them. To prevent excessive dryness and shrinkage, the conditions given in step 3 of both temperature and relative humidity schedules should be maintained as final conditions until the desired dryness is reached.

4. Final Conditions for Sound Knotty Pine Finishing Lumber

This problem differs from the loose-knot problem in common lumber in that this lumber is used for finish and should be dried to a moisture content of about 7 or 8 percent by the use of lower final relative humidities, and the pitch should be "set" to prevent subsequent exudation by using final temperatures above 160° F. In this case also, excessive dryness should be avoided to minimize checking in the knots.

5. The Material and Other Variables and Quality of Drying

Standardized schedules serve very well as a guide, but they cannot be expected to take care of all local variables. They serve best when used with some adjustments, based on careful observations of the stock during drying and on the quality of drying desired. It should be understood that there is some variation in seasoning characteristics within each species and identical results cannot always be obtained. Even the kilns may have individual characteristics that affect the results. For some of the less refractory species more severe temperatures or relative humidities can be used to reduce drying time without causing excessive increases in the amount of checking. For instance, quarter-sawed material has less tendency to surface check than plain-sawed and, consequently, lower initial relative humidities can be used. Without reliable information on data, however, radical departures from these schedules should not be made. Small changes can be made in successive steps, based upon close observations of the behavior of the stock in each run.

Equalizing and Conditioning Treatments[5]

If precise drying is required, the stock should be given an equalizing and conditioning treatment in the final stages of the drying process. The equalizing treatment precedes the conditioning treatment. Its purpose is to reduce the variation in moisture content between individual boards or items in the charge. The conditioning treatment serves two purposes; it establishes a more uniform moisture content throughout the thickness of each board or item and it relieves case-hardening.

---

[5]Some additional information on conditioning is given in Forest Products Laboratory Technical Note No. 213. The Detection and Relief of Case-Hardening. 1952.

A general guide for equalizing and conditioning lumber to any desired final average moisture content is as follows:

(1) Dry the driest sample in the kiln charge to a moisture content 2 percent below the desired final average moisture content.

Example: If this is 8 percent, dry the driest sample to 6 percent.

(2) As soon as the driest sample reaches the moisture value stated in (1), establish an equalizing equilibrium moisture content condition in the kiln equal to that value. The required equilibrium moisture content conditions can be obtained from figure 1 under several combinations of various dry-bulb and wet-bulb temperatures. For the example given in (1), the equalizing equilibrium moisture content would be 6 percent.

(3) Allow the kiln charge to remain on equalization until the wettest sample reaches the desired final average moisture content. If this is 8 percent, then the moisture content of the wettest sample should reach 8 percent before stopping the equalization treatment.

(4) As soon as the wettest sample has reached the moisture content value stated in (3), place the kiln charge on conditioning. The conditioning equilibrium moisture content values should be 2 to 3 percent above the desired final average moisture content for softwoods, and 3 to 4 percent above the desired final average moisture content for hardwoods. Referring again to the example given in (3), if the charge were composed of softwoods, it would be conditioned at an equilibrium moisture content of 10 or 11 percent; if composed of hardwoods, at an equilibrium moisture content of 11 or 12 percent.

(5) Allow the charge to condition until the stock is free of case-hardening.

Table 4 at the end of the text gives equalizing and conditioning recommendations for other final average moisture content values.

Time Required for Conditioning Treatment

The time required for relieving case-hardening in lumber will depend upon the species, thickness, moisture content, and degree of stress present. It may vary from 4 hours for some 4/4 softwoods to 48 hours or more for some 8/4 hardwoods.

Temperature at Which Conditioning Treatment Should be Given

The higher the temperatures that can be used during the conditioning treatment, the faster and better will be the relief of case-hardening. It is sometimes impossible, however, to obtain the equilibrium moisture content required for this treatment at very high temperatures. Generally, in most commercial kilns, the required equilibrium moisture content can be obtained at a dry-bulb temperature of about 180° F. If, however, the required equilibrium moisture content cannot be obtained at this temperature, the temperature should be reduced to a point where the required equilibrium moisture content can be obtained and controlled.

Relief of Case-Hardening at a High Equilibrium Moisture Content

To reduce the time required for conditioning, many kiln operators use a very high equilibrium moisture content during the treatment. This approach can be used if the treatment is not continued for too long a time. If the treatment is too long, reverse case-hardening will result, a condition that may be equally as serious as case-hardening.

It has also been found that the relief of case-hardening through the use of a relatively high equilibrium moisture content during a very short conditioning treatment gives only superficial relief of the drying stresses, with the relief being confined more to the fibers near the surface.

Cooling of Lumber Before Pulling

There are many operators who prefer to cool the kiln charge gradually within the kiln before pulling it outside during cold weather. The snapping or creaking noise that is usually heard when hot lumber is pulled into a cold atmosphere may be due, however, to the slippage of the boards across the stickers as thermal contraction takes place, rather than to checking or splitting of the wood. Another action that takes place when this is done is that the heat from the lumber greatly increases the temperature of the air next to the wood surface and thus lowers its relative humidity. It is believed that this has no harmful effect on dry lumber with a moisture content of 7 or 8 percent.

Use of Schedules in Progressive Kilns

In a progressive kiln, the green end is usually operated at a rather low temperature and a high relative humidity as compared to the conditions at the dry end. In some progressive kilns, only the dry end is under temperature and humidity control. The initial and final conditions in these schedules can be used as a guide in selecting the proper conditions for the green and dry ends of the kiln. For refractory items, there would be a danger in using the schedules in this way because the intermediate conditions are likely to be more severe in the progressive kilns. In such cases, a somewhat more conservative temperature and relative humidity schedule may be required, instead of the one recommended for compartment kilns.

Time Schedules

In a time schedule, the moisture content steps are replaced by time-interval steps. For that reason they must be based on a knowledge of the moisture content-time relationship acquired by the use of kiln samples. Their use

should be confined to easy-drying items where the kilns used and where the successive kiln charges are very nearly identical. Time schedules, in general, are a practical method of operation, and the recommended schedules can be used as a basis for their development.

Drying Time[6]

It would be misleading to give a definite drying time for each of the schedules listed in this report. Under the same schedule, but at different plants, the drying time for any item may vary greatly depending upon such factors as original and final moisture content, rate and uniformity of air circulation, uniformity of drying conditions, piling methods, accuracy of control equipment, efficiency of operating technique, and even the individual peculiarity of the material being dried.

Schedules for Aircraft Lumber

Certain limitations have been placed on the temperatures to be used in kiln drying lumber for military aircraft. The purpose of this is to preserve the maximum strength of the wood. Permissible temperature values are given in Military Specification MIL-W-6109, copies of which can be obtained from either the Commanding Officer, U. S. Naval Air Station, Johnsville, Pa., or the Commanding General, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio.

1.5-16

---

[6] Forest Products Laboratory Technical Note No. 233. Approximate Air-Drying and Kiln-Drying Periods for Inch Lumber. 1953.

FOREST PRODUCTS LABORATORY SCHEDULES FOR THE KILN DRYING OF WOOD (1951)

Temperature schedules (dry bulb temperatures)

Step number	Moisture content		Temperature schedule number --												
	From	To	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
	Percent	Percent	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1	Initial	30	100	100	110	110	120	120	130	130	140	140	150	160	170	180
2	30	25	105	110	120	120	130	130	140	140	150	150	160	170	180	190
3	25	20	105	120	130	130	140	140	150	150	160	160	160	170	180	190
4	20	15	115	130	140	140	150	150	160	160	160	170	180	180	190	200
5	15	Final	120	150	160	180	160	180	160	180	160	180	180	180	190	200

Humidity schedules (wet bulb depressions)

"A" schedules

Step number	Moisture content		Humidity schedule number --							
	From	To	A1	A2	A3	A4	A5	A6	A7	A8
	Percent	Percent	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1	Initial	30	3	4	5	7	10	15	20	25
2	30	25	4	5	7	10	14	20	30	35
3	25	20	6	8	11	15	20	30	40	50
4	20	15	10	14	19	25	35	50	50	50
5	15	10	25	30	35	40	50	50	50	50
6	10	Final	50	50	50	50	50	50	50	50

"B" schedules

Step number	Moisture content		Humidity schedule number --							
	From	To	B1	B2	B3	B4	B5	B6	B7	B8
	Percent	Percent	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1	Initial	35	3	4	5	7	10	15	20	25
2	35	30	4	5	7	10	14	20	30	35
3	30	25	6	8	11	15	20	30	40	50
4	25	20	10	14	19	25	35	50	50	50
5	20	15	25	30	35	40	50	50	50	50
6	15	Final	50	50	50	50	50	50	50	50

"C" schedules

Step number	Moisture content		Humidity schedule number --							
	From	To	C1	C2	C3	C4	C5	C6	C7	C8
	Percent	Percent	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1	Initial	40	3	4	5	7	10	15	20	25
2	40	35	4	5	7	10	14	20	30	35
3	35	30	6	8	11	15	20	30	40	50
4	30	25	10	14	19	25	35	50	50	50
5	25	20	25	30	35	40	50	50	50	50
6	20	Final	50	50	50	50	50	50	50	50

"D" schedules

Step number	Moisture content		Humidity schedule number --							
	From	To	D1	D2	D3	D4	D5	D6	D7	D8
	Percent	Percent	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1	Initial	50	3	4	5	7	10	15	20	25
2	50	40	4	5	7	10	14	20	30	35
3	40	35	6	8	11	15	20	30	40	50
4	35	30	10	14	19	25	35	50	50	50
5	30	25	25	30	35	40	50	50	50	50
6	25	Final	50	50	50	50	50	50	50	50

"E" schedules

Step number	Moisture content		Humidity schedule number --							
	From	To	E1	E2	E3	E4	E5	E6	E7	E8
	Percent	Percent	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1	Initial	60	3	4	5	7	10	15	20	25
2	60	50	4	5	7	10	14	20	30	35
3	50	40	6	8	11	15	20	30	40	50
4	40	35	10	14	19	25	35	50	50	50
5	35	30	25	30	35	40	50	50	50	50
6	30	Final	50	50	50	50	50	50	50	50

"F" schedules

Step number	Moisture content		Humidity schedule number --							
	From	To	F1	F2	F3	F4	F5	F6	F7	F8
	Percent	Percent	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1	Initial	70	3	4	5	7	10	15	20	25
2	70	60	4	5	7	10	14	20	30	35
3	60	50	6	8	11	15	20	30	40	50
4	50	40	10	14	19	25	35	50	50	50
5	40	35	25	30	35	40	50	50	50	50
6	35	Final	50	50	50	50	50	50	50	50

M 86439 F

Agriculture-Madison

Table 1.--Index of schedules for kiln drying hardwoods

Species	Schedule designation: For lumber: 4/4, 5/4, 6/4: Temperature	Humidity	8/4: Temperature	Humidity	For special items: Name	Temperature	Humidity
Alder, red	T10	D4	T8	D3			
Apple	T6	C3	T3	C2			
Ash, white	T8	B4	T5	B3			
Aspen	T12	E7	T10	E6			
Basswood	T12	E7	T10	E6			
Beech	T8	C2	T5	C1	1-inch squares	T8	C3
					2-inch squares	T5	C2
Birch, paper	T10	C4	T8	C3	1-inch squares	T10	C6
					2-inch squares	T8	C4
Birch, yellow	T8	C4	T5	C3	1-inch squares	T8	C5
					2-inch squares	T5	C4
Buckeye, yellow	T10	F4	T8	F3			
Butternut	T10	E4	T8	E3			
Cherry, black	T8	B4	T5	B3			
Chestnut	T10	E4	T8	E3			
Chinkapin	T4	F1	T2	E1			
Cottonwood	T10	F5	T8	F4			
Dogwood	T6	C3	T3	C2	Shuttles	T3	B2
Elm, American and slippery	T6	D4	T5	D3			
Hackberry	T8	C4	T6	C3			
Hickory	T8	D3	T6	D1	White handles, Small	T1	D2
					White handles, Large	T1	C2
					Pink or red handles, Small	T8	D1
					Pink or red handles, Large	T8	C1
Holly	T6	D4	T4	C3			
Hop-hornbeam (ironwood)	T6	B3	T3	B1			
Laurel (California Laurel, Oregon Myrtle)	T8	C4	T5	C3			
Locust, black	T6	A3	T3	A1			
Madrone	T6	D2	T3	D1			
Magnolia	T10	D4	T8	D3			
Mahogany	T6	C4	T4	C3			
Maple, silver	T8	D4	T6	C3			
Maple, sugar	T8	C3	T5	C2	Bowling pins (end coated)	T3	A3
					1-inch squares	T8	C4
					2-inch squares	T5	C3
Oak, California black	T4	E2	T3	E1			
Oak, red	T4	D2	T3	D1			
Oak, white	T4	C2	T3	C1			
Oak, southern lowland	T2	C1					
Oak, tan	T4	E1	T3	D1			
Osage-orange	T6	A2	T3	A1			
Persimmon	T6	C3	T3	C2	Shuttles	T3	B2
Sweetgum (sap gum)	T12	F5	T11	D4			
Sweetgum (red gum)	T8	C4	T5	C3			
Sycamore	T6	D2	T3	D1			
Tupelo, black	T12	E5	T11	D3			
Tupelo, water	T6	F2					
Walnut, black	T6	D4	T3	D3	Gunstock blanks	T3	D4
Willow, black	T10	F4	T8	F3			
Yellow-poplar	T11	D4	T10	D3			

Table 2.--Combined temperature and humidity schedules for kiln drying green 4/4 red oak

Temperature step number	Humidity step number	Moisture content: Moisture class D, From	Moisture content: Moisture class D, To	Temperature schedule T4, Dry bulb	Humidity schedule 2, Wet-bulb depression	Wet bulb	Relative humidity[1]	Equilibrium moisture content[1]
		Percent	Percent	°F.	°F.	°F.	Percent	Percent
1	1	Initial	50	110	4	106	87	17.5
1	2	50	40	110	5	105	84	16.2
1	3	40	35	110	8	102	75	13.3
1	4	35	30	110	14	96	60	9.9
2	5	30	25	120	30	90	31	5.4
3	6	25	20	130	50	80	10	2.0
4	6	20	15	140	50	90	14	2.6
5	6	15	Final	180	50	130	26	3.3

[1] Relative humidity and equilibrium moisture content values corresponding to the given dry-bulb temperatures and wet-bulb depressions are given in figure 1 at the end of the text. Equilibrium moisture content is that moisture content to which wood will come if exposed long enough to that particular set of conditions.

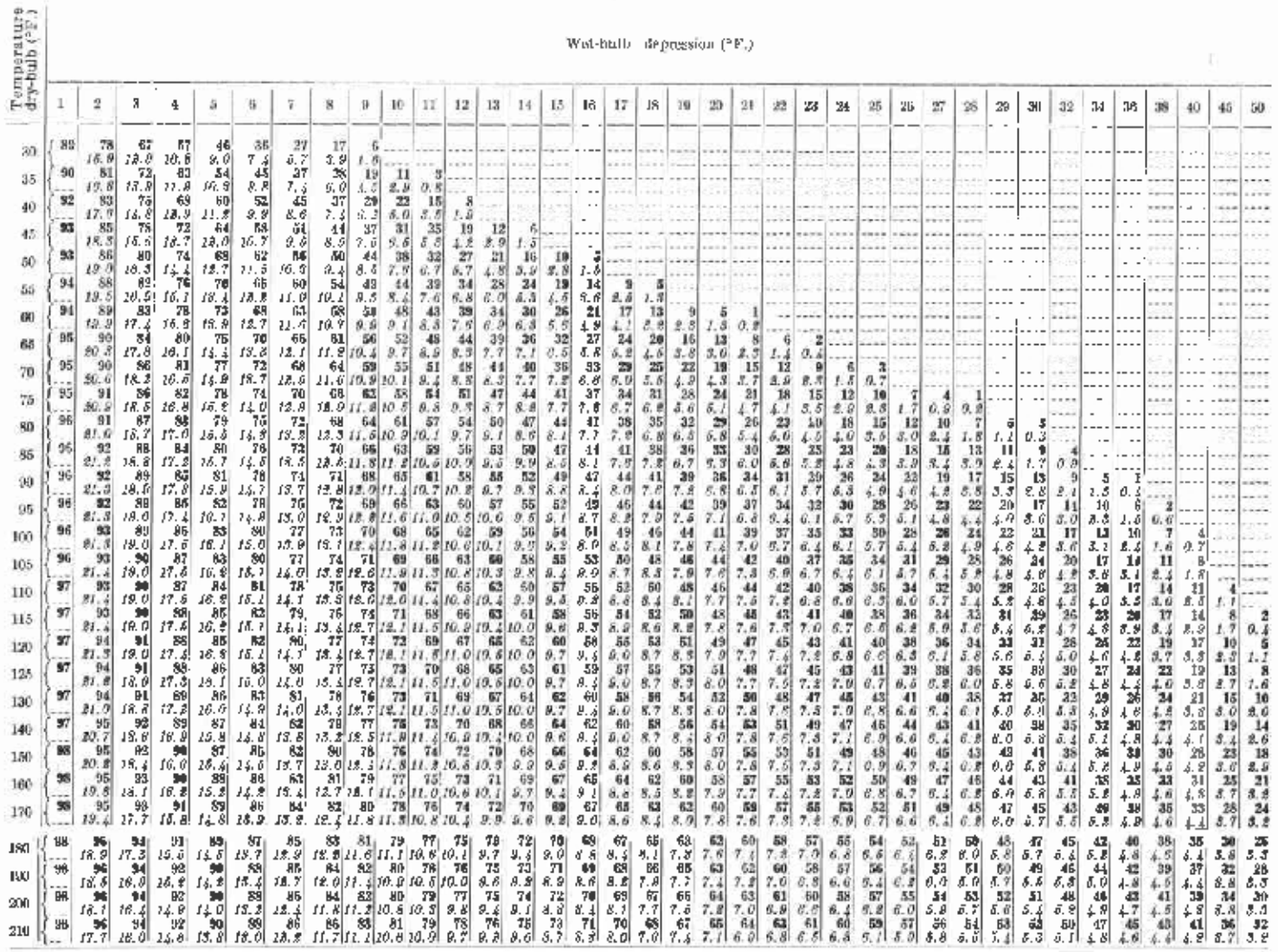
Table 3.--Index of schedules for kiln drying softwoods[1]

Species	Schedule designation								
	For lumber				For special purposes				
	4/4, 5/4, 6/4		8/4		Purpose		Temperature	Humidity	
	Temperature	Humidity	Temperature	Humidity					
Baldcypress	T12	E4	T11	E3					
Cedar, Alaska	T12	A4	T11	A3					
eastern red	T10	A4	T8	A3	To preserve oil for chests	4/4, 5/4, 6/4, 8/4	T7 T5	A4 A3	
incense	T12	E5	T11	E4					
northern white	T12	B5	T11	B4					
Port Orford	T12	B4	T11	B3					
southern white	T12	A5	T11	A4					
western red (light)	T12	B5	T11	B4					
(sinker)	T8	F5	T6	F4					
Douglas-fir	T13	A4	T12	A3	Commons[1] Strips		T7 T14	A4 A6	
Fir, Alpine	T14	B5	T12	B4					
balsam	T14	E5	T12	E4					
grand	T14	E5	T12	E4					
Noble	T14	A5	T12	A4					
Pacific silver	T14	B5	T12	B3					
red (California)	T14	E5	T12	E4					
white	T14	E5	T12	E4					
Hemlock, eastern	T13	E5	T12	E4					
western	T13	C5	T12	C4					
Larch, eastern (Tamarack)	T12	B4	T11	B3					
western	T12	B4	T11	B3					
Pine, eastern white	T11	C5	T10	C4	To reduce brown stain	4/4, 5/4, 6/4, 8/4	T7 T7	E6 E5	
lodgepole	T12	C5	T11	C4					
ponderosa	T10	C6	T8	C5	To reduce brown stain	4/4, 5/4, 6/4, 8/4	T7 T7	E6 E5	
red	T12	B5	T11	B4					
southern yellow	T14	B5	T12	B4					
sugar	T10	E6	T8	E5	To reduce brown stain	4/4, 5/4, 6/4, 8/4	T7 T7	F6 F5	
western white (Idaho)	T10	B5	T8	B4					
Redwood, (light)	T6	D5	T6	D4					
(sinker)	T6	F5	T6	F4					
Spruce, eastern (black, red, white)	T14	B5	T12	B4					
Engelmann	T14	E5	T12	E4					
Sitka	T14	B5	T12	B4					

[1]The schedules given are based mainly on the moisture content of the heartwood and are intended for average stock and for all grades and items that do not have special drying requirements. One modification would be in the drying of commons to prevent the development of loose knots. In this case, the temperature schedule should be T7 and the conditions given in step 3 of both temperature and humidity schedules should be maintained as final conditions until the desired moisture content is reached. As trouble of this kind becomes somewhat less with increases in thickness, step 4 instead of step 3 in the humidity schedule can be used for final conditions, if desired, to accelerate the drying of 8/4 stock.

Table 4.--Recommendations for equalizing and conditioning a charge of lumber

Final desired average moisture content	Moisture content to which driest sample should be dried before equalizing	Equilibrium moisture content at which charge should be equalized	Desired moisture content of wettest sample at end of equalizing	Equilibrium moisture content values for conditioning treatment	
				For softwoods	For hardwoods
Percent	Percent	Percent	Percent	Percent	Percent
5	3	3	5	7-8	8-9
6	4	4	6	8-9	9-10
7	5	5	7	9-10	10-11
8	6	6	8	10-11	11-12
9	7	7	9	11-12	12-13
10	8	8	10	12-13	13-14
11	9	9	11	13-14	14-15



[1] Relative-humidity values in roman type.
[2] Equilibrium-moisture-content values in italic type.

Figure 1.--Relative humidity and equilibrium moisture content chart for use with dry-bulb temperatures and wet-bulb depressions.

Z M 87885 F

ORGANIZATIONAL DIRECTORY

of the

Forest Products Laboratory, Forest Service
U. S. Department of Agriculture

J. Alfred Hall.....Director

L. J. Markwardt.....Assistant Director

Florence Rose Steffes, In Charge.....Library (Madison Branch USDA)

Claude A. Brown, Chief.....Fiscal Control

Gardner H. Chidester, Chief.....Pulp and Paper

Donald G. Coleman, Chief.....Research Publications and Information

Herbert O. Fleischer, Chief.....Timber Processing

R. P. A. Johnson, Chief.....Physics and Engineering

Kenneth W. Kruger, Chief.....Packaging Research

Ralph M. Lindgren, Chief.....Wood Preservation

Edward G. Locke, Chief.....Wood Chemistry

Gordon D. Logan, Chief.....Administrative Management

Harold L. Mitchell, Chief.....Timber Growth and Utilization Relations