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Quality Control in Lumber Purchasing: Lumber Storage

by
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Once lumber is kiln dried to the specified moisture content, it must be properly stored or it will continue to gain or lose moisture in response to the relative humidity of the surrounding air. The wood is attempting to come to equilibrium with the moisture in the surrounding air; this is called the "equilibrium moisture content" or EMC of the wood. The moisture content to which lumber is kiln dried should be the same as the average moisture content it will equalize to in service. For woods used indoors in most parts of the United States, this is 6 to 8 percent. In the dry desert regions of the southwest the figure is somewhat lower, while it is higher in the damp coastal areas.

If lumber is kiln dried to the 6 to 8 percent moisture content suitable for interior applications and then exposed to the outdoor atmosphere, it will gain excessive moisture and swell in most regions and seasons of the United States. If manufactured into a product and exposed to conditions inside a plant or house, for example, it will again lose moisture and shrink. End splits, open glue joints, and warping will likely result. These problems are particularly severe during the heating season because indoor relative humidities are reduced.

To further complicate the situation, lumber is normally stored in bundles. In this case the outside boards and especially the ends will be the first to pick up or lose moisture, while the interior of the bundle will be slow to change. The moisture content between and within boards will no longer be uniform, and end-use problems are nearly certain.

Table 1 shows the equilibrium moisture content by month for wood exposed to outdoor atmospheric conditions for selected areas of the United States. To illustrate the significance of these numbers, Table 2 presents the equilibrium wood moisture content for different relative humidities at 70°F. The dimensional changes for a six-inch-wide northern red oak board with an initial moisture content of 7.1 percent are also given. Note that as the board dries from 7.1 to 4.5 percent, it shrinks 0.05 inches or well over 1/32 inch. If the moisture content of the six-inch-wide board increases to 11.8 percent, it will have expanded in width by 0.08 inches or well over a 1/16 inch. Light-weight woods generally do not shrink and swell as much, whereas heavier ones, such as hickory and beech, will generally shrink and swell more.

The point is that if kiln-dried lumber is to be maintained at the desired 6-8 percent moisture content level, it must be stored in an enclosed heated shed for all of the United States except the dry southwestern states.

Heated Sheds

The efficiency of a closed shed in maintaining a low moisture content in lumber is enhanced if the air can be heated as required to maintain the desired EMC. Only a small amount of heat is needed to raise the temperature enough above the average outdoor temperature to lower the relative humidity and to keep the EMC in an acceptable range. Table 3 shows typical temperature increase values.

Table 1. Equilibrium moisture content of wood exposed to the outdoor atmosphere in the United States.[1]

Location by State	Equilibrium moisture in different months (percent)[2]											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Albuquerque, NM	09.2	08.1	08.0	06.9	06.3	05.7	07.9	07.7	07.1	06.9	10.5	11.1
Baltimore, MD	13.7	10.8	12.5	11.7	12.9	12.2	11.8	13.3	13.3	12.3	13.6	13.0
Bismark, ND	17.2	17.6	17.0	12.4	11.9	12.9	11.6	11.6	11.2	11.0	14.3	16.1
Boise, ID	15.8	14.3	12.1	10.3	10.9	10.5	07.3	07.3	07.6	08.6	10.3	18.0
Boston, MA	13.0	12.3	12.3	12.0	12.3	10.9	11.7	12.6	12.9	12.7	13.0	11.9
Bridgeport, CT	14.8	12.3	13.4	12.9	13.0	12.6	13.2	14.1	14.3	13.6	14.5	13.2
Burlington, VT	14.9	14.3	14.9	13.1	13.0	11.7	11.8	13.1	14.7	14.5	14.6	14.9
Casper, WY	11.0	12.3	11.5	10.3	11.2	08.4	08.6	08.1	07.0	08.2	11.0	12.8
Charleston, SC	14.8	15.1	13.2	13.4	14.1	15.5	16.2	16.8	17.3	16.1	15.6	16.0
Charleston, WV	14.3	12.1	12.0	11.9	12.7	13.8	14.1	13.8	12.6	11.7	12.2	13.4
Chicago, IL	16.1	13.7	14.2	11.8	12.4	11.9	11.9	12.5	11.6	10.9	10.3	15.2
Cleveland, OH	16.9	14.9	15.0	13.6	13.0	11.8	11.6	12.6	12.2	10.0	13.3	15.2
Concord, NH	14.9	14.0	14.3	13.0	13.0	11.7	12.6	14.1	14.2	14.2	15.4	14.6
Denver, CO	08.4	08.3	09.3	10.3	09.8	07.6	08.2	08.9	06.9	07.2	09.9	10.4
Des Moines, IA	16.9	16.0	14.9	12.4	12.8	13.6	13.5	13.3	11.6	10.1	12.4	16.4
Detroit, MI	17.5	14.3	15.2	12.2	12.2	11.4	11.5	12.4	12.5	11.9	14.0	15.8
Duluth, MN	15.5	15.2	16.0	12.8	12.7	14.9	14.8	16.1	16.5	13.9	15.9	16.9
Galveston, TX	18.2	18.2	18.1	15.8	16.9	15.7	15.4	15.7	15.5	14.2	16.6	15.9
Honolulu, HI	13.8	13.5	13.2	12.6	12.0	12.1	12.3	12.6	11.9	12.8	12.9	13.5
Huron, SD	17.0	18.0	16.0	12.7	12.1	13.0	11.8	12.2	10.1	10.2	13.4	17.6
Jackson, MS	14.7	14.5	12.6	12.7	13.5	11.9	12.7	12.5	11.4	10.3	11.5	13.9
Juneau, AK	19.8	20.2	17.9	15.8	16.3	14.8	16.2	18.2	21.4	----	22.0	18.6
Kansas City, MO	14.3	13.1	13.4	12.0	12.5	10.3	10.9	11.1	09.5	09.3	11.2	13.7
Key West, FL	14.7	14.7	14.3	12.9	13.7	14.0	14.0	13.0	14.5	16.3	15.9	14.8
Little Rock, AK	15.7	13.6	12.7	12.5	13.6	11.7	12.0	12.5	11.2	10.6	11.8	13.7
Louisville, KY	15.4	12.8	12.9	12.3	12.8	12.2	12.0	11.8	11.3	11.5	11.9	14.3
Milwaukee, WI	15.8	14.6	14.9	12.4	13.0	13.7	13.2	14.2	13.0	11.8	13.2	15.8
Missoula, MT	16.1	15.1	12.5	10.2	11.6	11.5	08.2	08.7	09.3	10.5	14.6	16.4
Mobile, AL	15.8	16.2	14.6	13.3	15.0	14.2	15.4	16.7	14.3	12.0	13.0	14.9
Nashville, TN	15.4	14.0	12.9	12.1	12.3	11.4	11.8	11.9	11.8	11.7	12.0	14.8
Newark, NJ	14.0	11.9	13.2	12.0	12.4	11.4	11.5	12.9	13.0	12.3	13.3	13.4
New Orleans, LA	16.2	15.6	14.0	13.4	14.6	14.5	15.7	17.1	16.8	13.1	14.5	15.3
New York, NY	13.7	11.7	12.7	11.7	12.6	11.2	11.3	12.2	12.0	11.9	12.6	12.5
Norfolk, VA	13.9	12.7	13.0	12.4	13.0	13.2	13.4	14.9	14.5	14.7	14.5	14.0
Omaha, NE	18.0	15.5	15.2	12.2	12.6	11.3	12.1	12.9	11.3	10.4	12.4	15.7
Philadelphia, PA	14.3	11.3	12.4	11.9	12.7	12.0	11.7	13.5	13.3	12.3	13.0	12.9
Portland, ME	16.9	15.5	15.8	14.8	15.0	13.4	13.9	15.5	17.2	15.4	16.3	14.9
Portland, OR	19.6	16.8	14.7	13.0	14.1	14.5	12.1	13.4	13.1	15.9	18.5	20.0
Providence, RI	13.7	12.4	13.1	12.4	12.9	12.1	12.6	14.5	14.6	14.2	13.6	11.8
Reno, NV	13.2	11.3	11.0	09.4	09.0	08.6	08.0	07.8	08.9	09.6	11.3	13.4
Salt Lake City, UT	14.3	12.5	12.4	10.8	09.3	07.8	07.8	07.4	07.5	09.1	12.1	15.8
San Francisco, CA	18.5	14.8	14.7	16.0	14.7	15.6	15.8	16.6	15.5	15.9	16.0	16.3
San Juan, PR	14.7	15.3	14.4	15.2	14.6	15.7	16.2	15.7	15.7	15.7	15.5	14.7
Savannah, GA	14.3	14.7	12.5	12.9	12.9	13.9	14.5	15.4	15.6	14.3	14.6	15.4
Seattle-Tacoma, WA	21.0	18.9	16.8	14.8	14.2	15.3	13.7	14.6	14.7	17.2	18.9	18.9
South Bend, IN	18.9	15.4	15.2	13.3	14.1	13.0	12.9	14.5	13.7	13.3	14.3	17.4
Tulsa, OK	14.0	12.2	12.2	12.6	12.6	11.0	12.4	11.2	09.7	09.7	12.0	12.7
Tuscon, AZ	08.8	07.0	07.9	06.8	05.3	04.6	08.1	08.0	05.2	05.2	07.7	08.0
Wichita, KS	13.7	12.4	13.0	12.0	11.9	09.9	11.0	10.5	08.3	08.5	11.9	15.5
Wilmington, DE	15.1	12.1	13.4	12.3	13.4	12.7	12.6	12.9	14.5	13.9	14.6	13.7
Wilmington, NC	15.7	15.4	15.0	13.7	13.5	13.5	15.4	16.7	16.8	15.8	15.9	16.3

[1]Dry Kiln Operator's Manual. Revised July 1988: USDA Forest Service, Forest Products Laboratory (Available from the Hardwood Research Council, Box 34518, Memphis, TN 38184-0518)

[2]The values were calculated by means of average monthly temperatures and relative humidites given in Climatological Data monthly reports of the Weather Bureau and the wood equilibrium moisture content to relative humidity relationship.

Table 2. Selected relative humidities, equilibrium moisture contents (EMC) at 70°F, and width variation for a northern red oak board.

R.H. (%)	EMC (%)	Width (in.)	Approximate Change Fractional Equivalent
20	4.5	5.95	- 3/64
35	7.1	6.00	
65	11.8	6.08	+ 5/64
90	20.6	6.24	+ 1/4

Heat can be supplied to a closed storage shed by steam coils, radiators, or unit heaters. The system need not have a large capacity, but it should be arranged so that the temperature throughout the shed is reasonably uniform. Fans to circulate the air are desirable. A minimum temperature of 35°F is suggested for a steam-heated storage area to prevent the return lines and traps from freezing. The heat supply may be controlled by an ordinary thermostat or by a more precise automatic device.

To use a thermostat, estimate or employ Weather Service data to obtain the expected mean outdoor temperature for the next 4 to 7 days. Then set the thermostat the number of degrees higher than that needed to maintain the desired EMC. Good air circulation is needed to maintain temperature and EMC uniformity. This necessitates the use of fans.

If the heat is to be controlled automatically, either a hygrostat or a differential thermostat may be used. A hygrostat maintains a given EMC by turning the heat on or off as needed. As the relative humidity in the shed increases, the hygroscopic element absorbs moisture and swells. The swelling activates a mechanism that turns on the heat. When the relative humidity decreases, the process is reversed.

Table 3. Typical temperature increase values to maintain desired EMC in a heated shed.[1]

Desired EMC	Amount above outside temperature
(Percent)	(°F)
6	25
7	20
8	15
9	12
10	8
11	5

[1]Drying Eastern Hardwood Lumber. Agr. Hbk. No. 528, USDA Forest Products Laboratory. 104 pp.

Differential thermostats can maintain a temperature in the shed that is a specific amount above the outside temperature. The differential thermostat is very dependable, economical, and easily installed, and the maintenance cost is low.

Calculating Shed Temperature

Figure 1 can be used to more precisely calculate the increase in temperature which is required to maintain wood at a particular EMC (Air Drying of Lumber. Agr. Hbk. No. 402, USDA Forest Product Laboratory. 110 pp). For example, if during the winter months the outdoor temperature averages 40°F and 75 percent relative humidity, the wood EMC is 15 percent. If the shed is to be heated so that the wood EMC is not less than 6 percent, what temperature should be maintained? The absolute humidity at 40°F and 75 percent relative humidity is about 2.2 grains per cubic foot. Parallel to the 2-grain line in Figure 1, follow an imaginary 2.2-grain line down and to the right until it intersects the 6 percent EMC line. Then read the temperature at the bottom of the chart at this intersection point. It is about 65°F. In this case, by heating the air to 65°F, the wood EMC is lowered from 15 percent to 6 percent.

Summary

Lumber is kiln dried to the moisture content consistent with its intended end use. This practice limits the amount of shrinkage and swelling which will occur under normal circumstances. Unfortunately, kiln-dried lumber, when exposed to unheated storage conditions, will regain moisture and swell. Defects will likely result in products manufactured from this material and exposed to indoor conditions. Thus, lumber once kiln dried must be properly stored while in inventory or during the manufacturing process.

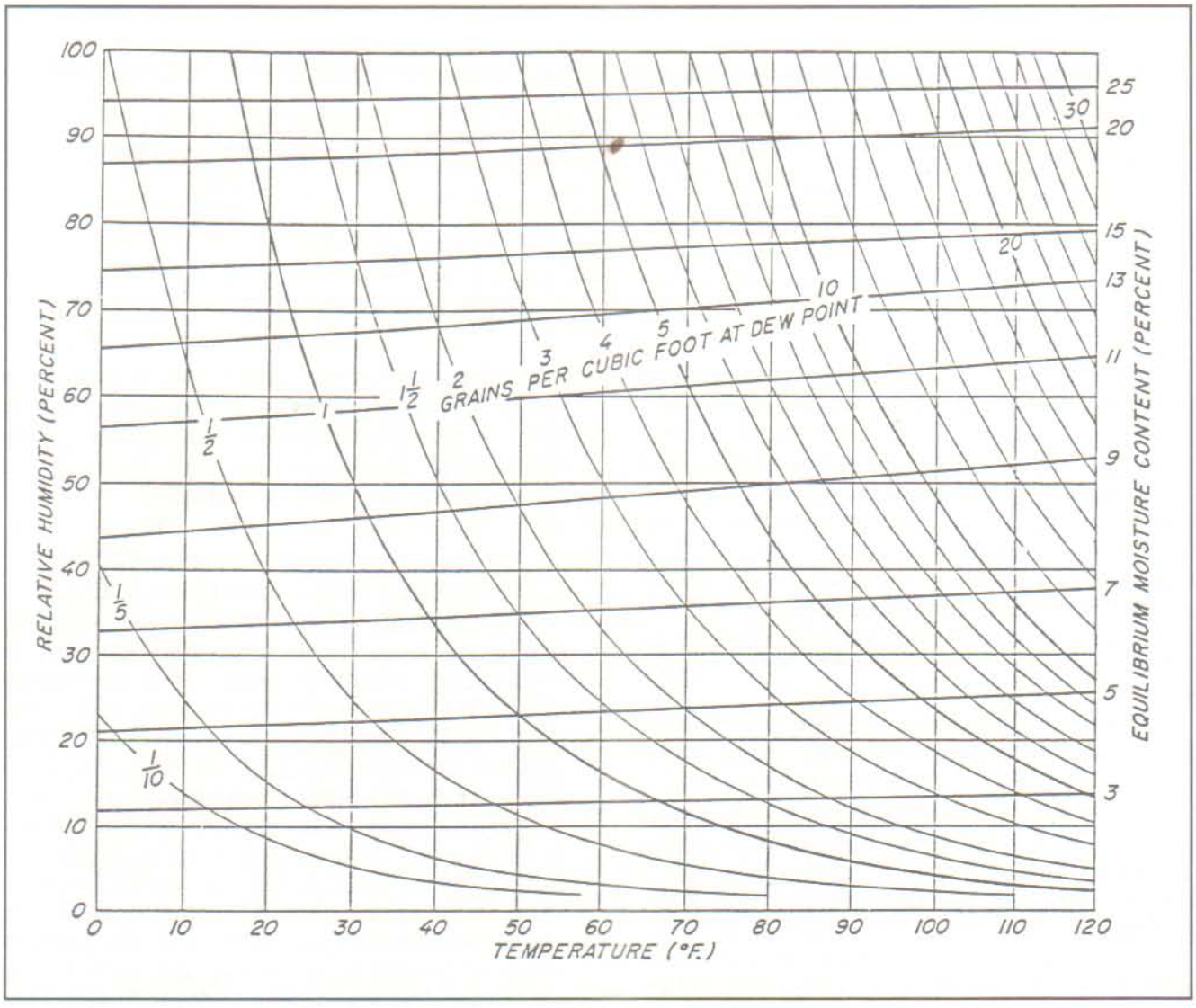

Figure 1. Equilibrium moisture content of wood as a function of temperature, relative humidity, and absolute humidity.

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