ELECTRICALLY OPERATED WOOD-ELEMENT HYGROSTATS
FOR CONTROL OF MOISTURE FLUCTUATIONS IN LUMBER
STORED IN CLOSED SHEDS
Revised March 1953

INFORMATION REVIEWED AND REAFFIRMED 1959

No. R1140

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY
Madison 5, Wisconsin
In Cooperation with the University of Wisconsin
Tests at the Forest Products Laboratory indicate that undesirable changes in the moisture content of lumber within closed storage sheds can be largely eliminated by means of an electrically operated wood-element hygrostat and electrical heating units. Although heating by electricity is usually more costly than heating by steam, there are some circumstances under which the use of electricity is highly desirable. This is particularly true where the shed is in a remote location. Also a temperature considerably lower than freezing point of water, but adequate to maintain an equilibrium moisture content of 7 or 8 percent in a lumber storage shed, can be had with electricity.

A hygrostat, such as that used in the tests, can be constructed in an ordinary workshop. It consists of a 1-1/8- by 13/16- by 7/32-inch rectangular piece of western white pine sapwood between an adjustable spring and a commercial microswitch. The first dimension mentioned is tangential, the second radial, and the third longitudinal. The shrinking and swelling of the wood with atmospheric conditions opens and closes the switch (fig. 1). A 14-ounce pressure causes a 0.001-inch movement of the switch lever, which is capable of controlling a heating load of 10 amperes at 110 volts.

The shed used in the tests was 10 feet wide, 20 feet long, and 10 feet high. Twelve 150-watt lamps were installed on one wall of the shed at a height of 1 foot above the floor. A guard of wallboard was placed in front of the lamps. Because the microswitch can directly control only 1,100 watts and the load is 1,800 watts, a relay was connected in the circuit with the microswitch. When the hygrostat causes the switch to close, the lights are turned on, the temperature rises, and the relative humidity is reduced so as to maintain the desired equilibrium moisture content.

A three-pen recorder was used to measure the temperature at three points: one near the northeast corner about 1 foot below the ceiling and directly over the electric lights used for heating; one about 3 feet north of the south wall and 6 inches above the floor; and one outdoors on the north side of the shed.
Small strips of wood of known oven-dry weight were used to measure the variations in equilibrium moisture content within and outside the shed. A special method was used to make these strips each with a calculated oven-dry weight of 100 grams; they were not oven-dried, however, because oven drying would have made them less sensitive to fluctuating temperatures and relative humidities than they would otherwise be. Six of the strips were placed at various points within the shed, and one hung outside under the shed roof so as to be protected from sun and rain but exposed to free air movement. Each strip was weighed twice daily, with the percentage increase or decrease in moisture content of each strip being calculated from the weighings.

Five groups of 40 boards each were piled in the shed. Three of the groups were 1- by 8-inch by 12-foot ponderosa pine shiplap, two of which were solid piled and one open piled. The two other groups were 2- by 8-inch by 12-foot ponderosa pine joists, one of which was solid piled and the other open piled. Each group was weighed once a month. In addition an electrical moisture-meter was used to determine the moisture content at three points; one about 2 inches from each end and one in the middle of the length of each board. The three moisture content values were averaged and used to compute the oven-dry weight of each board. This oven-dry weight was used in computing the moisture content values plotted in figure 2. The averages of the moisture content values of the strip of wood outside the shed and of the six strips inside the shed are also shown in figure 2.

Figures 3 and 4 are charts showing very dissimilar shapes of temperature curves, although they correspond to about the same equilibrium moisture content, 7 percent, during different weeks. The first chart is for the period January 27 to February 3, 1936, and the second chart is for the period April 13 to 20, 1936. Factors affecting the shapes and inter-relationship of these curves are: (1) Heat and moisture absorption and loss by the shed structure and by the stored lumber; and (2) lag in the dimension change in the wood element of the hygrostat as the temperature and relative humidity fluctuate inside and outside the shed.

On January 27, 1936, the outdoor temperature was 4° F. below zero, the inside temperature was 2° below zero, and the equilibrium moisture content about 7 percent. The observed minimum temperature inside the shed was 4° below zero, which occurred on January 24, 1936, when the outdoor temperature was 22° below zero.

The method of piling and the initial and final moisture content values of each group of shiplap and of joists are indicated in table 1.

From table 1 and figure 2 it is apparent that with the aid of the electrically operated wood-element hygrostat it was possible to maintain the moisture content of stored open-piled shiplap and joists between 7 and 8 percent during a period of 11 months. The maximum difference in equilibrium moisture content in different parts of the shed was usually about 1-1/2 percent. To attain this result in a large storage shed would probably require mechanical circulation.

It is practicable to use the hygrostat to start and stop motors on unit heaters for maintaining any desired equilibrium moisture content in a large
storage shed. Constant-duty fans may be required for auxiliary air circulation. Careful consideration is required in deciding upon the proper size, number, and location of unit heaters; also upon the number and location of hygrostats. In some cases a combination of wall coils and fans or unit heaters may prove most advantageous.

Since the hygrostat described above was made, another form\textsuperscript{2} has been designed and used successfully at the Forest Products Laboratory. This type of hygrostat has a somewhat similar type of microswitch and a longer wood element, as shown in figures 5 and 6. The microswitch is designed so that a 9-ounce pressure causes a 0.002-inch movement of the switch lever and permits 7/32-inch over-travel. The 1/8-inch brass plate to which the microswitch is screwed has three mounting holes, as shown in figures 5 and 6. The wood element shown is about 4 inches long. If greater sensitivity is desired, this length may be increased to 6 or 8 inches, and the 5-inch dimension shown in figure 6 may be correspondingly increased to 7 or 9 inches.

The wood element should be free of defects and have as flat a grain as possible because the flatter the grain parallel to the long dimension of the element, the greater will be the dimensional change lengthwise of the element with a given change in relative humidity. The sapwood of maple or of birch is satisfactory for this use. The relative humidity to be maintained is controlled by the proximity of the lower end of the wood element to the switch contact pin. The distance between the element and pin is adjusted by turning the knob shown in the two illustrations.

\textsuperscript{2}Similar to one originally designed by O. W. Torgeson, formerly engineer, U. S. Forest Products Laboratory, for controlling the operation of dampers in a furnace-type dry kiln.
<table>
<thead>
<tr>
<th>Group number</th>
<th>Item</th>
<th>Method of piling</th>
<th>Moisture content</th>
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</tr>
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<td></td>
<td></td>
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<td>7.8</td>
</tr>
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1Boards were piled on 1-inch stickers and were spaced about 1 inch apart.

Rept. No. R1140, revised
Figure 1. -- Forest Products Laboratory wood-element hygrostat.
Figure 2.—Moisture content of stored shiplap and joists maintained at approximately 8 percent for 11 months by means of electricity and a wood-element hygrostat.
Figure 3.—Temperature chart, January 27 to February 3, 1936.
Figure 4.—Temperature chart, April 13 to 20, 1936.
Figure 5. --New type of wood-element hygrostat.
Figure 6. --Details of new type of wood-element hygrostat.