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ELECTRICAL MOISTURE METERS FOR WOOD

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The measurement of moisture in wood by rapid electrical methods is now fairly well established in the United States; about seven or eight years have elapsed since electrical moisture meters for wood first made their appearance in a practical form. The Forest Products Laboratory has developed several types of electrical moisture meters, including the "blinker", which has been on the market for a number of years; a capacity-type machine, which has never been commercialized; and a recently patented resistance type employing a novel Wheatstone bridge balancing circuit (see list of references at end of article).

Electrical moisture meters have an advantage over other methods for determining the moisture content of wood because of their convenience and speed, the time required to determine the amount of moisture in any piece of wood being only a few seconds. They are therefore adaptable for sorting lumber and veneers on the basis of moisture content. Furthermore, they offer the only practical means thus far developed of determining the moisture content of finished woodwork in place without serious injury to the wood.

Two general types of instruments are available, one evaluating the moisture content by measuring the electrical resistance of the wood and the other by measuring the electrical capacity of the wood (see list of makers at end of article).

Resistance Meters

Below the fiber-saturation point (about 25 percent moisture content) the electrical resistance of wood varies widely with changes in moisture content, the resistance increasing as the moisture content decreases. This enables one to evaluate the moisture content by measuring the electrical resistance of wood. The resistance increases with a falling temperature and decreases as the temperature rises. Furthermore, there are variations among different species that must also be taken into account. Fortunately, reasonably accurate corrections for temperature and species variations can be rather easily made. Makers usually furnish correction data with their instruments.

Electrical contact is generally made by driving four needle points into the wood to be tested so that the flow of current is parallel to the grain. The two points of like polarity are usually spaced one-half inch apart, and the points of unlike polarity about 1-1/4 inches apart in

the direction of current flow. All the points are usually mounted in a block of insulating material and arranged so that they can be readily driven into the wood and withdrawn again after testing. Several different designs are available. Contact may also be made by clamping surface plates to the opposite faces of lumber, veneer, etc. The needle-point type of electrode is thought to be preferable to the surface contact type in making resistance measurements where a drying moisture gradient is present, which is usually the case in lumber passing through industrial processes.

A study of moisture gradients in drying boards and planks has shown that, after the entire piece has passed the fiber-saturation point, the moisture content in a plane located at one-fifth of the thickness of the material from its surface is usually very near the average moisture of the piece. When using a needle-point type of electrode in wood containing a drying gradient the moisture meter indicates the moisture content at or near the points of the needles, since the wood becomes a better conductor as the moisture content increases. Because of these facts it is possible to estimate the average moisture content by driving the needles to a depth of one-fifth the thickness of the piece. Further, it is possible, by driving electrodes to any desired depth, to evaluate the moisture content at that particular distance from the surface. This is of great importance in the treatment of timber with wood preservatives, in the use of heavy timbers for many structural purposes, and, in fact, wherever moisture content is a vital factor. Nails may be used for this purpose to advantage, in place of the regular electrode.

Surface plate electrodes, which make contact with opposite surfaces of a board, indicate the moisture content of the surface of the board under and near the plates and are specially suitable for thin material, like veneers, and for material that has practically no moisture gradient, such as thoroughly seasoned lumber.

The moisture content of veneer ranging from about 3.5 or 4 percent up to 16 or 17 percent may be also measured by the resistance method by merely increasing the electrode area. This has been accomplished by setting a large number of contact points in the wood simultaneously. Points of positive polarity are driven from one side and those of negative polarity from the opposite side.

The range of most resistance-type moisture meters for lumber lies between 7 and 25 percent moisture content. Two instruments may be had which are calibrated from 7 to 60 percent moisture. In the 7-25 percent moisture range the accuracy of resistance-type instruments, when properly calibrated and used for testing relatively thin samples or on heavier material that is known to be of uniform moisture content, should be with $\pm$ 1 percent of moisture content in the majority of cases. It is not to be expected that readings of moisture content above 25 percent will be as accurate as those in the lower range; nor do they ordinarily need to be.

Resistance-type meters will not give satisfactory readings on lumber wet by rain or fog, since only the surface moisture content will be

shown. Further, when used in wet weather, the surfaces of the instrument itself may become damp and prevent readings at low moisture content values.

In the meters measuring moisture content by resistance methods, the actual measurement is made by balancing the resistance between the electrodes by known resistances, or, in the case of the blinker type, by adjusting the rate of flash of a neon tube to that of another, flashing at a standard rate, by introducing into the electrode circuit calibrated condensers having a greater or less capacity. Both types of instruments are easy to use and the choice in the selection of a meter rests largely in cost and personal preference.

Capacity Meters

The electrical capacity of wood varies directly with the amount of moisture in it, throughout the entire range of moisture content from green to oven dry. Therefore, the moisture content may be evaluated by measuring the electrical capacity. Temperature effects are so small as to be negligible for ordinary use, and there are no errors introduced into the readings by variations in properties inherent among different species.

The capacity method is, in principle, an excellent means for evaluating the quantity, by weight, of water in wood. However, it is not possible to convert this weight into a percentage without knowing the weight or specific gravity of the wood. This property cannot be determined quickly enough by any method now available, and it is present practice to assume the specific gravity of the individual piece when dry to be the same as the average for the species and to calibrate the moisture meter accordingly. Each reading on a meter so calibrated carries an error proportional to the actual error in the assumed specific gravity of the piece.

Several specific forms of condenser plates for obtaining measurements on wood have been developed. One form consists of two suitably insulated plates that are placed on opposite faces of the piece under test. In another form, four quadrant-shaped plates are assembled in the shape of a flat circular disk several inches in diameter. In use this assembly of plates is pressed against one surface of the piece under test.

Meters using condensers with plates on opposite sides of the piece under tests evaluate the total quantity of water in the wood, irrespective of moisture gradient, and the readings are therefore inherently true averages. Moisture gradients may well affect the readings of meters using condenser plates on one side only of the piece under test. However, it is not feasible to actually determine moisture gradients or to measure moisture contents at various depths with any capacity-type meter.

The capacity-type meter now on the American market uses the quadrant-shaped condenser plates and is calibrated to read from 0 to about 25 percent moisture content.

Electrical Moisture Meter Makers and Dealers

Makers and dealers	Trade name	Type
Colloid Equipment Co., Inc. 50 Church St., New York City	Delmhorst Moisture Detector	Resistance
Hart Moisture Gauges, Inc. 126 Liberty St., New York City	Hart Moisture Gauge	Resistance
Raymond S. Hart 1950 Grand Central Terminal New York City	Moisture Meter	Resistance
Industrial Instruments, Inc. 156 Culver Ave. Jersey City, N. J.	Megohm Bridge	Resistance
Measurements, Inc. Boonton, N. J.	Delmhorst Moisture Meter	Resistance
Moisture Register Co., 133 N. Garfield Ave. Alhambra, Calif.	Moisture Register	Radio frequency power loss
Moore Dry Kiln Co., Jacksonville, Fla. also at North Portland, Oreg.	Tag-Heppenstall Moisture Meter	Resistance
C. M. Lovsted & Co. Seattle, Wash.	Moisture Register	Radio frequency power loss
Standard Dry Kiln Co., Indianapolis, Ind.	Moisture Register	Radio frequency power loss
	Tag-Heppenstall	Resistance
C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.	Tag-Heppenstall Moisture Meter	Resistance
Wilbur Instrument Co., 1123 N. W. Gilson St., Portland, Oreg.	Wilbur Moisture Indicator	Capacity
National Engineering Co. P. O. Box 1475 Indianapolis, Ind.	Tag-Heppenstall Moisture Meter	Resistance

References to Published Articles on Electrical Moisture Meters by the Forest Products Laboratory

The Electrical Resistance of Wood as a Measure of Its Moisture Content, by A. J. Stamm, p. 1021, Indus. & Eng. Chem., V.19, No. 9, Sept. 1927.

An Electrical Conductivity Method for Determining the Moisture Content of Wood, by A. J. Stamm. p. 240, Analytical Ed. Indus. & Eng. Chem., V.2, July 15, 1930.

Lessons in Kiln Drying (Nos. 18 to 24 and 30), by H. D. Tiemann. Published in the Southern Lumberman in 1936, 1937, and 1938. (Now available in book form from the Southern Lumberman, Nashville, Tenn.)

A Wide Range Vacuum Tube Resistance Bridge, by I. I. Davies. p. 261, Instruments, Oct. 1937.

A wide range vacuum tube resistance bridge - U. S. Patent 2088843 - assigned to U. S. Government for the free use of the public.

Articles describing the Blinker Moisture meter by Suits and Dunlap were published in the following periodicals. The most complete description will be found in the General Electric Review mentioned below:

South. Lbrman., July 1, 1930,
Wood Construction, July 1, 1930,
Amer. Lbrman., July 5, 1930,
Lbr. Trade Journal, July 15, 1930
Timberman, July 1930,
Barrel & Box & Packages, July 1930,
Furn. Mfr., Aug. 1930,
Wood Working Indus., Aug. 1930,
Instruments, Aug. 15, 1930,
Natl. Assn. of Commission Lbr. Salesmen Annual, 1930,
General Elec. Review, Dec. 1931 (p. 706-13 - Determination of the moisture content of wood by electrical means)

Blinker moisture meter - U. S. Patent 1875359 - assigned to the U. S. Government for the free use of the public.

Other Publications

Electronics Applied to Moisture Determinations in Lumber, Anonymous, Describes the Moisture Register, American Lumberman, p. 34, June 10, 1944.