Measuring Moisture

Portable meters prevent guesswork and grief

by R. Bruce Hoadley

Problems that result from using wood at the wrong moisture content continue to be among the most common frustrations and failures plaguing the woodworker. Many of the symptoms are all too familiar—warp or dimensional change in parts, opened glue joints, raised grain, end checks, finish imperfections—all because the moisture content of the stock was inappropriate.

Perhaps the excuses are also quite familiar. The job just had to get started and there simply was no time to allow the material to come to equilibrium in the shop. Or, the boards were bought from a dealer's bin; the oven-drying of samples just wasn't possible. Such woes can be avoided by using modern moisture meters, which give immediate and highly accurate readings. These magical little meters use the electrical properties of wood, and their development has followed the usual trend in electronics toward portable and miniature units with simplified operation. A wide range of models is now available to suit virtually every situation, from the hobbyist's use to production operations, in the shop or in the field.

For typical woodworking applications two principal types of meters are available. One is based on the direct-current electrical resistance of the wood and involves driving small, pin-type electrodes into the wood surface; the other uses the dielectric properties of the wood and requires only surface contact of the meter with the board.

The resistance meter takes advantage of the fact that moisture is an excellent conductor of electricity but dry wood is an effective electrical insulator. The meter itself is simply a specialized ohmmeter which measures electrical resistance. The piece of wood is arranged as an element in an electrical circuit by driving the two pin electrodes into it. The current (usually supplied by a battery) flows from one electrode through the wood to the other, then back through the ohmmeter. Actually, by simply driving pairs of nails into a piece of wood for electrodes and taking resistance measurements with a standard ohmmeter, readings could be obtained that would indicate relative moisture content. Perhaps some useful values could be obtained this way, but resistance varies non-uniformly with moisture content and a mass of data would have to be accumulated to make a useful and versatile meter. Commercially manufactured meters have the meter scale printed directly in percent moisture content instead of ohms of resistance. Because electricity follows the path of least resistance, the wettest layer of wood penetrated by the electrodes will be measured. For boards that dry normally, a drying gradient usually develops from the wetter core to the drier surface with an average moisture content about 1/5 or 1/4 the board thickness from the surface. Thus for 1-in. lumber, the pins should penetrate only 1/4 in. to measure average moisture content. In the smallest models, the electrodes are a pair of pins extending from one end of the unit, which can be pushed into the wood by hand. More commonly the electrode pins are mounted in a separate handle, attached by plug-in cord to the meter box. Electrodes of various lengths, up to 2 in. or more, are available for measuring thick material so the same meter can be used for thin veneer and heavy planks. Electrodes should be insetted so current flow is parallel to the grain. Electrical resistance is greater across the grain than parallel to it, although the difference is minor at lower moisture-content levels.

Meters using the dielectric properties of wood have a surface electrode array which generates a radio-frequency field that extends for a prescribed distance when placed against the wood. Some meters measure the power-loss effect which varies according to moisture content, whereas others respond to changes in electrical capacitance. Different models have electrodes designed for field penetration to various depths. Field penetration to about half the stock thickness is usual. Where moisture content is uneven, a more or less average reading will be given.

Green wood may have an extremely high moisture content, but woodworkers are most concerned with moisture measurement of seasoned stock. Depending on geographic location, air-dried wood will reach moisture equilibrium levels in the 12% to 15% range. For interior products, stock must usually be kiln-dried or conditioned to the 6% to 8% range. Fortunately, the electrical properties of wood are most consistent at moisture levels below fiber saturation (25% to 30%), the range of most interest to woodworkers. Dielectric meters can indicate moisture contents down to zero. The electrical resistance of wood becomes extreme at low moisture contents, limiting the lower end of the range of resistance meters to about 5% or 6% . More elaborate meters sometimes have scales extending to 60% or 80% moisture content; however, electrical properties are less consistent above fiber saturation so readings in this range must be considered approximate.

Moisture meters usually give scale readings of percent moisture content that are correct for certain typical species at room temperature. Instruction manuals give correction factors for other species and different temperatures. Since density has little effect on electrical resistance, the species corrections are usually less than two percentage points for resistance meters; correction factors may be greater with power-loss meters. Resistance readings must also be corrected about one percentage point for every 20° F departure from the calibration standard. With dielectric meters the correction is more complicated,

but is well explained in the instruction manuals. For anyone using meters under regular conditions—with one or a few common species and always at room temperature—correction factors either are not applicable or become routine.

The values obtained with a resistance meter can be expected to agree within one-half a percentage point with those obtained by oven-testing for samples in the 6% to 12% range; within one point in the 12% to 20% moisture-content range, and within two percentage points in the range from 20% to fiber saturation.

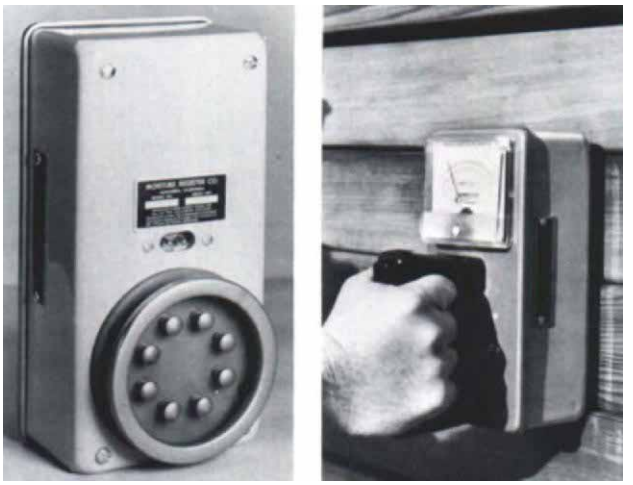
It is important to appreciate that a meter in good condition will faithfully and accurately measure the electrical properties of the wood being sampled. The operator must understand the vagaries of wood moisture and interpret accordingly. For example, a new owner of a meter might discover a variation of two or three percentage points up and down a given board. The common reaction is, "the meter is only accurate to within three percent" or, "it gives variable readings." But in fact the meter is properly measuring moisture variations that exist in the board. Thus one must measure average or typical areas of boards to avoid the ends or cross-grain around knots, which dry most rapidly.

Each type of meter has its strengths and weaknesses. Resistance meters have the disadvantage of leaving small pinholes wherever the electrodes were inserted, which might be unacceptable in exposed furniture parts, gunstocks and the like. On the other hand, a given meter can be used with a variety of electrodes in a wide range of situations. Resistance meters with a 6% to 30% range are available down to pocket size, with both built-in short pin electrodes and separate cord-attached electrodes, for about $150. Radio-frequency power-loss meters in compact hand-held models, with electrodes for one-inch field penetration and scaled from 0 to 25% moisture content, cost about $400. Their distinct advantage is the ability to take readings without marring surfaces, thereby allowing measurements of completed items, even after the finish has been applied. These meters are extremely quick to use, but are less versatile because a given electrode style works only for a particular area and depth of field.

The actual dollar value of moisture measurement is very difficult to assess. It should be given serious thought, however, as it is most commonly underestimated. Many woodworkers buy machinery costing hundreds of dollars to attain close dimensional tolerances that are later lost when parts shrink or swell because there was no way of measuring moisture. What is the real cost of a solid cherry dining table that is ruined because of the errant moisture content of just one edge-glued board in its top?

Nobody would buy meat without knowing the grade, or a used car without the mileage, and nobody should buy lumber without knowing its dryness. Yet some lumber dealers sell millions of board feet a year and don't own a moisture meter. A relatively tiny investment would allow them to provide this valuable service to their customers.

[Author's note: For more about moisture meters, see *Electric Moisture Meters for Wood* by William L. James (U. S. Forest Products Lab. Gen. Tech. Rpt. FPL-6, 1975), available from the Superintendent of Documents, U. S. Govt. Printing Office, Washington, D. C. Portable moisture meters are made by Delmhorst Instrument Co., 607 Cedar St., Boonton, N. J. 07005; Moisture Register Co., 1510 W. Chestnut St., Alhambra, Calif. 91802; Electrodyne Inc., 2126 Adams St., Milwaukee, Ore. 97222; and Valley Products and Design, Box 396, Milford, Pa. 18337.



Electrode array of dielectric meter, left, generates radio-frequency field when pressed against face of board, right. Strip arrays for edge measurement are also available.

Pin electrodes of resistance meter are pushed into board, parallel to grain. Center pin gauges penetration.

Electrodes are attached to case of pocket-size resistance meter.