

USING RESISTANCE MOISTURE METERS

Alan Dlugasch Sales/Customer Service
Delmhorst Instrument Co.
Towaco, New Jersey

Introduction

I would like to begin by thanking the members of the Western Dry Kiln Association for inviting someone from Delmhorst Instruments to speak today. I am aware that most of you are professionals in this industry and have been working with kilns and drying lumber for a long time. As a result some of what I say to you today you may already know or feel is kind of basic information. I can assure you that from the many phone calls that we receive at Delmhorst, there are still many people working in this industry and also related industries, who know what a moisture meter is but are not sure of what, why and how it works. My goal today is to try and make some of these questions about moisture meters clearer and better understood by you.

First Some General Information about Moisture Meters

One of the most dramatic changes in the lumber and wood products processing industries over the last decade has been the increased emphasis on quality. The accelerated demand for high quality lumber products has probably never been greater. Everybody, both domestically and abroad is demanding a higher quality product at the right moisture content.

The goal of your drying operation should be to produce a consistent, high quality product, at a profit, that meets or exceeds customer requirements. The moisture meter is a tool that, when used with proper techniques can help you do your part in this process. Some wood experts have found that up to $\frac{3}{4}$ of problems they find are typically related to moisture content. Either the person drying the lumber did not know the MC requirements of the customer or the problem can be traced to faulty drying practices.

Since moisture content is a key to quality, moisture meters, already in widespread use, have become an essential tool in the sawmill, dry kiln, planer mill and right on through to the finishing rooms in furniture plants. We emphasize the word *tool* because moisture meters are just that. Meters in use today have many valuable and obvious advantages, especially when used with the knowledge of how water moves in the wood. They also have some limitations. Meters, like most tools, are most effective when the user understands their capabilities.

The Moisture Meter as a Measuring Tool

There are two basic families of meters on the market today: the resistance or "pin meter", which is the focus of this presentation, and the capacitance or "pin-less meter", also known as the electromagnetic wave meter. Both types are an indirect, electronic method of measuring a property of the wood. The oven test is still the primary method by which all electrical systems are calibrated.

Pin-less or capacitance meters operate on the relation between the dielectric properties and the moisture content of the wood. When the meter is placed on the board surface, an electric field penetrates into the board anywhere from $\frac{1}{2}$ " to 1". The moisture content

nearest the electrode or surface moisture has the greatest effect on the reading. This is due to the fact that the sensor is closest to moisture at this location and the signal tends to weaken the farther it travels. The result is a reading that reflects a biased average MC, independent of moisture distribution. Pin-less meters are convenient to use. They work well on boards of known uniform MC. They can be useful when spot checking for wet pockets, and in sorting applications. Pin-less meters can not discriminate between surface and core MC and therefore do not provide information on distribution throughout the thickness.

The oven test is the most accurate way to measure MC if executed properly and under ideal conditions. The sample size, the quality of the equipment and the technician's skill all play a role in the end result. The oven test can produce accuracy to within 1/10 of 1% on a single sample, but this method has limited value in practice.

Why Should You Use a Meter?

First- The User Gets Immediate Results. The oven test can take up to 24 hours to complete. When checking a load, the user can go right to the slower drying quarter-sawn boards for a quick determination of the overall MC condition.

Second- There Is less Labor Involved. There is no need to cut and weigh sample specimens.

Third- You Have a Larger Sample. This makes it possible to use the whole board to take many readings which give a more significant average and an indication of the uniformity or non-uniformity throughout a board and of the entire load.

Fourth- You Can Locate Wet Spots. Much lumber is ripped into strips for flooring and furniture so it becomes desirable to know the MC of a ripping, rather than the average cross section of the whole board.

And the *Fifth Reason* to Use a Meter Is They Are Easy to Use. They are fast, accurate and corrections are made easily through the meter's firmware.

All considered, the resistance moisture meter can be the most practical and effective tool to measure MC, especially in applications where a moisture gradient, the difference in MC between the inner and outer portion of a board, may be present.

Next Some Important Information about the Pin Meter

The Pin Meters Principle of Operation – Pin meters indicate MC as a % of the oven-dry weight of the wood. They use the relationship between the DC resistance and the moisture content of the wood. The meter uses the wood as an element in the circuit, by driving a set of pins or electrodes into it. This method works well because moisture is an excellent conductor of electricity and dry wood is an effective insulator.

The relationship between the electrical resistance of the wood and its moisture content is not in a one to one proportion and here lies the advantage: for a small change in MC, there is a tremendous change in resistance. For example, at 8% MC in Douglas Fir, the resistance is approximately 5000 megohms, while at 10% the resistance is only 600 megohms.

The Pin Meters Range – They work best in the range of the fiber saturation point (25-30%) down to about 6%. Fiber saturation is the MC at which the cell walls are saturated with "bound water" but no "free water" remains in the cell cavities. As you know a wood cell will not shrink until it reaches fiber saturation, when large changes in many physical and mechanical properties of wood begin to take place.

It is difficult to make accurate, repeatable readings below 6% because of the high resistance in very dry wood. Due to the presence of "free moisture", readings above 30% are only qualitative indications that the wood is gaining or losing moisture over time. These readings are valid if, at elevated wood temperatures, the temperature-corrected reading falls below 30%.

What is the Accuracy of a Pin Meter?: The electrical accuracy of the meters is +/- 0.2 of the indicated reading. The secondary calibration is better than 0.5% between 6 and 12% MC, better than 1.0% at 20% and better than 2% at fiber saturation point. The user should check the accuracy of his meter periodically either through an internal calibration check if the meter has this feature, or with an external resistance standard supplied by the manufacturer.

Origin of the Original Calibration of the Pin Meter: The original USDA calibration was made on a very large number of rather thin samples of Douglas-fir, which were conditioned at various levels of temperature and relative humidity to achieve uniform moisture distribution. The electrode used was fitted with four non-insulated pins that penetrated a maximum of 5/16th". These optimum laboratory conditions are certainly not often found in the field. Here is where a big part of the challenge comes into play when using a pin meter. You as the kiln operator must develop the skills and knowledge in the use of a moisture meter to obtain the best MC readings.

Primary Factors That Affect the Moisture Meter Readings Besides the MC

First, The Moisture Gradient and Thickness – This is most critical during drying. If the MC of a board could be guaranteed to be uniform throughout, thickness would not be a factor in accuracy. But because of the normal variations and gradients that exist when drying lumber, we must consider thickness and pin penetration in order for the reading to be an accurate estimate of the average MC. A normal gradient develops from the wetter core to the drier surface. Two or three quick readings at different levels of penetration, with pins that have insulated shanks, will give a good idea of the gradient and how the wood is drying. Any changes in these "shell" and "core" readings are a true indication of a change in MC. One of the main challenges of the kiln operator is to relieve the board stresses by carefully bringing these readings close together by the end of the charge.

Where is the best place to take readings on a board? Start with three readings: one at each end, about 12-18" in from the end, and one in the center of the board. All readings should be taken in the middle 1/3rd portion. Depending on the variation among the initial readings, you may have to take more in order to have reliable info on the board's uniformity.

How far do we drive the pins into the wood? The famous "1/5th rule" states that the average moisture content of a 12 inch board section is located at 1/4 to 1/5th the thickness on boards that are dried below the fiber saturation point, even at the core. It's easy to prove this rule. Simply drive an electrode with insulated pins into a small sample at 1/4" increments and average the four readings. Do an oven test on the sample. The result should be within 1/2 of 1% of the meter's average.

When making "hot checks" in the kiln following these rules will produce a better and more accurate reading. First, when sampling hot lumber a deeper pinning depth provides a better estimate of final MC. As a result, be sure to drive pins as close to the center of the board as possible. Remember the 1/5th rule does not apply to edge readings. Second, remember on thick lumber or when a significant moisture gradient is present, the pinning depth is even more critical.

Next, The Effect of Wood Temperature – After MC and gradient, temperature has the most impact on the accuracy of the meter readings. As the wood temperature increases, its electrical resistance decreases and the indicated MC rises. The lower the temperature, the lower the indicated MC. Meters are generally calibrated at 70°F. We usually apply a correction if the wood temperature is outside of the 50°F-90°F range. This correction is made through the digital meter's firmware. If you are using an analog meter, a chart or slide rule is supplied by the meter manufacturer.

When taking a moisture meter from room temperature into a hot kiln remember the following:

- One-If the meter is colder than the dew pt. temperature of the warm air; the moisture will condense on the cold equipment.
- Two-The condensation may cause an erratic reading.
- Three-Low MC's cannot be measured until the moisture is evaporated from the meter, it may take several hours to evaporate.
- And four, the recommendation is don't take the meters into a hot kiln and expect to take accurate readings, unless the meter is warmed to approximately the temperature of the kiln.

The Effect of Species – Because the electrical characteristics of different wood species vary, all species read differently at given moisture content. A correction is required when using the meter on species other than the calibration standard - Douglas-fir. Correction factors for other species are either programmed individually in to the meter or, can be found in a chart that is supplied with the meter. Group species corrections, while not as accurate as individual ones, are useful, especially in cases where it may be difficult to identify specific species for marketing purposes. The SPF correction is a good example. This group correction was adopted because of the difficulty to "distinguish visually between Spruce and Balsam Fir lumber." The group SPF correction is strongly impacted by the correction for Spruce which "makes up the largest portion of this mixture and happens to have the largest correction factors".

You may come across a species for which a correction is simply not available. Depending on the level of accuracy required, take most readings below 10% at face value as the correction is usually small. But you can also use the meter to establish the EMC of the species in a particular environment. Knowing the actual MC itself is not always as important as allowing the wood to attain its EMC level to where it won't change dimension, crack or split. The "equilibrium moisture content" is numerically equal to the MC that wood will eventually achieve when exposed to a given humidity

What is meant by 2-Pin/ 4-Pin Electrode? – As stated earlier, the original calibration was developed with a 4-pin electrode whose pins were not insulated. Reference to a "4-pin correction" means 2 or 4 pins that are *not insulated*; the 2-pin correction refers to 2 *insulated* pins. Most measurements today are either taken with 2 insulated pins that are fitted to a hammer-type electrode and driven into the board, or with 2 non-insulated pins that are built into the top of the hand-held meter. The insulated pins read lower than the than the non-insulated ones. Most meters can make the necessary corrections through firmware.

The Effect of Grain Direction - The electrode pins must be oriented parallel to the grain since this is how the original calibration was made. The resistance of the wood is greater across the grain, and a lower reading will result if the pins are driven into the board across the grain. This difference is slight at 10% and below, but around 20%, the reading can be as much as 2% lower.

Basic Care of Your Meter – The meter is a precision instrument and so some maintenance is necessary to keep it in good working condition. Keep the batteries fresh and charged, store the meter in its case and in a clean, dry room. Tighten the pins' retainers to insure good contact, and replace pins whose insulation has worn. Have it factory checked at least every 2-3 years.

The Knowledgeable User – Moisture meters are simple to use and with the electronics available to us today, will become even easier. It is still up to the user to maximize the meter for best accuracy. Check the calibration. Input the proper settings for temperature, species, and pins. Align the pins parallel to the grain. Be aware of possible surface moisture. Drive insulated pins to the desired depth, non-insulated pins to their full penetration.

The Meter as a Data Acquisition Tool

While the basic measuring principles have not changed much over the years, the bells and whistles available with meters certainly have. These changes are probably most significant in the area of data storage and reporting. The use of statistics and predictive techniques with moisture meters is really a topic that requires its own time slot. I'll touch on this area briefly since it is such an integral part of meters in use today. We can use the meter to collect and process a large number of data in a very short time. Either as a stand-alone device, or in combination with a PC, the meter allows us to obtain more and more information on a population of boards and to process it efficiently, thereby increasing the value of the equipment.

The meter does all of the number crunching but the user must know how to properly use and interpret the basic statistical functions that some meters offer. For example, the estimated average of a board or load is most useful when compared against standard deviation of the same batch. The standard deviation is a statistical parameter which gives the user, in one single figure, an indication of the range of readings which make up the average. The lower the standard deviation, the closer all readings are to the average, indicating a uniform distribution of MC throughout the batch or load. Two loads of lumber may have the same average, but if the values for standard deviation of each load are not close, it may be an indication that one load is far more uniform in MC than the other. Keep this in mind if, for ex. comparing kiln performance or evaluating a new drying schedule.

Once the average and standard deviation are known, one can estimate the average of an entire population of boards or predict whether a charge meets a specific standard. This can be made within a certain "degree of confidence" by using the confidence interval function. Its values are between 0.0 and 1.0 and again, a low number would indicate a more uniform distribution of moisture.

The use of a data collection type meter, a PC, and a spreadsheet program certainly make us all smarter by the numbers and can serve as a good management tool. Rather than fall to the initial tendency of over processing and analyzing computer generated numbers and reports, we can make best use of this capability by using this information in conjunction with the other basic elements of the wood/moisture relationship.

Conclusion

The resistance moisture meter is a proven, indispensable tool in all phases of lumber production and wood processing. It is a precision instrument that provides fast, accurate readings. Optimize its effectiveness by following the manufacturer's procedures, know the meter's capabilities, as well as its limitations, and use it with your knowledge and experience.

Thank you for your attention and I hope that some of this information about moisture meters will prove useful in your goal to produce the best possible product.