

No. 89

June, 1998

## Guide for Using the Oven-Dry Method for Determining the Moisture Content of Wood

R.S. Boone and E.M. Wengert

### INTRODUCTION

The oven-dry method is the most accurate and reliable method of determining the moisture content (MC) of wood at any moisture content. Because of this accuracy and reliability, the oven-dry method of determining MC of wood is the method against which all other methods are judged. The oven-dry method is also the recommended way of determining initial MC when using moisture content based kiln schedules.

When speaking of MC of lumber, furniture parts, molding, poles and most solid wood products, the MC of the wood is expressed as the ratio of the amount of water in a piece of wood compared to the oven-dry weight of wood. This is called the "moisture content on the oven-dry basis." For lumber and most solid wood products, MC is always expressed in percent so the ratio is multiplied by 100.

Specifically,

$$\%MC = \frac{\text{(Amount of water in the wood)}}{\text{(Oven-dry weight of wood)}} \times 100$$

The amount of water in the wood is the difference between the original weight and the oven-dry weight so,

$$\% MC = \frac{\text{(Original weigh - Oven-dry weight)}}{\text{(Oven-dry weight)}} \times 100$$

The 'original weight' in the above formula is the weight of the piece at the unknown MC. It could be the weight

when green, partly dried, air dried, kiln dried or in use. The original weight may also be called the wet weight, the green weight, the current weight, or the present weight. The oven-dry weight is the weight of the wood substance after all the moisture (water) has been evaporated from the wood in the oven. In oven-drying, ALL of the water must be evaporated, but none of the wood substance must be destroyed. Therefore, very close control of the temperature in the oven, very exact weighing of the wood samples, and careful attention to calculations are vital in arriving at the most accurate MC values.

Following the suggestions in this guide will help achieve the most accurate MC values when using the oven-dry method to determine MC of lumber or other solid wood products.

### SELECTING AND CUTTING SAMPLES FOR MOISTURE TESTING

**SPECIAL NOTE:** Always use a sharp saw for cutting moisture sections. Using a dull saw will heat, if not burn, the wood and cause some drying or evaporation of water, thereby offering an opportunity for error.

For best results, cut moisture sections that will weigh a minimum of 100 grams when oven-dry (OD). This may not always be possible with smaller items, but it should be the target size.

**MC of Lumber.** When measuring the MC in a piece of lumber, the entire piece cannot be put into the oven and oven-dried. So, the MC of the lumber is estimated by

cutting a small piece from the lumber. We call this small piece a moisture section.

- 1) Select a location on the lumber that is at least 12 inches (18 inches is probably better) from the end, and free of knots, decay, and bark. If possible, avoid pitch pockets, and mineral streak.
- 2) Cut the moisture section at this location, using a sharp saw. Moisture sections should be at least 1 inch along the grain and the full width and full thickness of the board.
- 3) Number the moisture section.
- 4) Brush or scrape off any splinters and/or sawdust from the section.
- 5) If the moisture section cannot be weighed immediately, then immediately put section in a plastic bag to prevent any drying before weighing.

**MC of Items, such as Moldings, Turnings, Picture Frames, Dowels.** As with lumber, a moisture section is prepared.

- 1) Cut the moisture section at least 2 inches along the grain and at least 3 inches from the end of the piece to produce a piece that weighs about 100 grams (4 oz). Cut the section the full width and thickness of the item, avoiding knots, decay, and bark. For dowels or other round pieces, use the full diameter of the item.

As these are partially manufactured products, we would expect MC's to be below 30%. Therefore, the need to avoid cutting moisture sections from very near the end of the piece is lessened.

- 2) Follow Steps 3 through 5 above.

## **WEIGHING OF MOISTURE SECTIONS**

Using balances or scales that weigh in grams to at least 0.05 grams is recommended. The decimal system of grams or kilograms also lends itself to calculations more readily than ounces and pounds.

**Types of Balances Suggested.** Electronic top-loading balances are available in a wide range of weighing capacities, precision, styles, and price ranges. When buying a new balance, we suggest a digital electronic top-loading balance with a maximum capacity of at least 1,000 grams (g) capable of weighing to the nearest 0.01 g. This will typically result in an accuracy of better than 0.1% MC. With top-loading electronic balances a large

number of moisture sections can be weighed quickly and accurately. If the moisture sections weigh less than 50 g, they should be weighed on a balance capable of weighing to the nearest 0.01 g.

Before electronic balances were available, the triple-beam balance was commonly used for weighing moisture sections. If used properly and carefully, triple-beam balances can be used when only a few sections are weighed every day. Like the electronic balances, the triple-beam should have a maximum capacity of 1,000 g and weigh to an accuracy of at least 0.1 g (0.01 g is preferable).

**Preferred Procedure For Weighing.** For accurate MC results, following these procedures exactly.

- 1) Turn balance on. Check that the weighing pan or tray is free of sawdust and debris, and that the weight indicator reads '0'.
- 2) Remove one moisture section from the plastic bag, place on balance, and read weight.
- 3) Remove moisture section from balance, write weight on the section with a permanent marker. Also record the reading on a data form. This is the 'original', 'green', or 'wet' weight to be used later in calculating the MC of the section. The section is now ready to go in the oven.
- 4) Check that balance returns to '0' reading.
- 5) Repeat steps 2 through 4 for each moisture section.
- 6) Turn balance off when all moisture sections have been weighed. Place dust cover over balance.

**SPECIAL NOTE:** Balances should be located in a clean, dust free environment, with no air drafts to affect readings. Follow maintenance instructions provided by manufacturer. (Rule-of-thumb tip for checking calibration of balance; a U.S. \$1 bill weighs 1 g.)

## **OVEN DRYING OF MOISTURE SECTIONS**

**Types of Ovens Suggested.** Electrically heated laboratory type ovens with a fan to circulate the air and speed up drying are recommended for drying the moisture sections, especially if large numbers of moisture sections are dried frequently. Natural draft ovens, those depending on the heat rising to create air circulation, are usually less efficient and require more time to remove all the moisture from the sections. Ovens should have a thermostat capable of controlling the temperature to within about 2°F of the setting. Ovens

should have ventilators on the top or sides and bottom to allow the evaporating moisture to escape. Electric forced-circulation ovens are available in several sizes, including large floor models and several sizes of table models. The choke of oven size depends on how many sections must be dried at one time and the typical size of the moisture sections. Ovens should also have various safety features including automatic overheating protection.

**Preferred Procedure for Oven Drying.** Follow these procedures exactly.

1) Achieve an oven temperature at 215 to 217°F With OVEN EMPTY. Excessive temperatures will char or start to break down the wood substance and thus give us erroneous results. Temperatures below 215°F may not drive off all the water in the sections, thereby giving incorrect MC values.

2) Place moisture sections in oven, allowing space for good air circulation around all sections. Wet sections should not be put in an oven with other sections that are partially or nearly fully dry. DO NOT RESET the thermostat higher after placing the wet wood in the oven, even though temperature may drop at first.

3) After 18 to 24 hours in the oven, weigh 3 or 4 sections (separately, not together), record the weight of each section, and calculate the MC of each section as directed in the "Calculation of MC" section below. Return the sections to the oven promptly.

4) Reweigh these same 3 or 4 sections 1 to 2 hours later and recalculate the MC for each. If there is a change in MC of 0.1% or more, return sections to oven for an additional 1 to 2 hours of drying. If the change in MC is less than 0.1%, all sections can be considered oven-dry.

5) When judged to be oven-dry, remove each moisture section from the oven, weigh to nearest 0.01 g. Write weight on the section and also on a data form. This is the oven-dry or OD weight to be used in the calculation.

6) Save moisture sections, at least until MC is calculated. If a permanent record is needed, make photocopies of sections with the numbers showing.

### CALCULATION OF MOISTURE CONTENT

Moisture content of the moisture section is calculated by dividing the weight of the removed water by the oven-dry weight of the sections and multiplying that number by 100 to have the answer as a percent. Since the weight of the water equals the original weight of the section minus its oven-dry weight, the formula for this

calculation is :

$$MC = \frac{[\text{Original weight} - \text{Oven-dry weight (OD)}]}{\text{Oven-dry (OD) weight}} \times 100$$

When using a calculator to calculate MC, use the following equivalent formula.

$$MC (\%) = \frac{(\text{Original weight})}{(\text{OD weight})} \times 100$$

Do not round any intermediate answers. The final answer should typically be reported to 0.01% accuracy.

#### Examples:

**Example No. 1.** The original or wet weight of a moisture section of red oak is 167.43 g and the OD weight is 96.85 g.

$$\begin{aligned} MC \% &= \frac{(167.43)}{(96.85)} - 1 \times 100 \\ &= (1.7287 - 1) \times 100 \\ &= (.7287) \times 100 \\ &= 72.87\% \end{aligned}$$

**Example No. 2.** The original or green weight of a moisture section of cottonwood is 223.13 g and the OD weight of same section is 101.24 g.

$$\begin{aligned} MC \% &= \frac{(223.13)}{(101.24)} - 1 \times 100 \\ &= (2.20397 - 1) \times 100 \\ &= (1.20397) \times 100 \\ &= 120.40\% \end{aligned}$$

Note: We want the MC to two decimal places, so we round 120.397 to 120.40. Also note that the MC is over 100%, not uncommon with green sections of species such as cottonwood, aspen, Eastern white pine, and Southern yellow pine.

**Example No. 3.** The original weight of a kiln dried moisture section of cherry molding is 128.77 g and the OD weight is 121.52 g.

$$\begin{aligned} \text{MC \%} &= \frac{(128.77)}{(121.52)} - 1 \times 100 \\ &= (1.05966 - 1) \times 100 \\ &= (.05966) \times 100 \\ &= 5.97\% \end{aligned}$$

**Example No. 4.** The original weight of a moisture section from red oak lumber in a predryer is 156.38 g and the OD weight is 120.44 g.

$$\begin{aligned} \text{MC \%} &= \frac{(156.38)}{(120.44)} - 1 \times 100 \\ &= (1.29840 - 1) \times 100 \\ &= (.29840 \times 100) \\ &= 29.84\% \end{aligned}$$

**Example No. 5.** To illustrate how a small difference in oven-dry weight (that is, a small error) can affect final MC, assume from Example No. 4 that we didn't quite get all the moisture out of the section during oven-drying and the section weighed 122.44 g. This is only 2 gram difference, but look what it does to the MC.

$$\begin{aligned} \text{MC \%} &= \frac{(156.38)}{(122.44)} - 1 \times 100 \\ &= (1.277197 - 1) \times 100 \\ &= (.2772) \times 100 \\ &= 27.72\% \end{aligned}$$

A 2 g error has made a 2% MC error. With the error, the lumber appears to be drier than it really is.

## SUMMARY

Using the oven-dry method to determine MC of lumber or other solid wood products is the most accurate and reliable procedure available. However, to get accurate MC values, considerable care must be taken in preparing moisture sections, in proper weighing of sections, in

proper operation of the oven, and in careful attention to calculating MC values.

## APPENDIX:

### Using a Kitchen -Type Microwave Oven

A kitchen model microwave oven may be used in oven-drying moisture sections to shorten the drying time. It is best used in combination with the electrically heated forced circulation oven described above. Use the microwave to remove the liquid water present in moisture sections of green wood, then move the sections to the electric oven to remove the remaining moisture under the more tightly controlled conditions of the electric oven.

If a microwave oven is used, we recommend an oven with the following features; 1) must have a carousel tray, 2) must have a setting to run on medium low (360 watts) to low (200 watts) power. Considerable care must be taken to get good results using a microwave oven. It is a fairly labor intensive operation and we suggest training one or two operators, as experience and judgment are needed for best results. We also recommend a dedicated microwave to dry wood. Do not use the same oven to dry wood and to heat coffee or lunches.

### Preferred Procedure for Using Microwave Oven

1) Place moisture sections on outer edge of carousel tray. Several moisture sections can be placed on tray at one time, but they must not touch each other. It is best not to mix very green sections and partially dry sections. Determine the green/original weight of each moisture section before placing it in the oven.

2) Dry at medium low setting. Do not leave the room while the oven is operating. Green pieces will need about 20 to 30 minutes and drier pieces about 10 to 12 minutes. Be careful not to burn or over dry the sections as this will result in incorrect weights and MC values.

3) Move sections to electric, forced-circulation oven to dry down to oven-dry weight. (See Preferred Procedure for Oven Drying above.) Sections which are first microwaved should need about 2 to 8 hours in the electric oven before achieving oven-dryness.

Sidney Boone, Wood Drying Specialist, 2409 Ravenswood Rd., Madison, WI 53711. Phone: (608) 271-0768. Eugene Wengert, Extension Specialist in Wood Processing, Department of Forest Ecology and Management, 1630 Linden Drive, Madison, WI 53706. Phone (608) 262-3455.