Wood and Moisture

Perhaps the most important aspect of woodworking deals with the relationship between wood and moisture. A fundamental fact is that wood is **hygroscopic**. This means that wood, almost like a sponge, will gain or lose moisture from the air based upon the conditions of the surrounding environment.

But not only does wood gain or lose moisture, but it will also *expand or contract* according to the magnitude of such changes; and it is this swelling and shrinking in finished wood products—often referred to as the wood's **movement in service**—that is responsible for so much mischief and so many malfunctions in woodworking.

When a tree is first felled, it is considered to be in the **green** state, and contains a very large amount of moisture. This moisture exists in two different forms: as **free water** that is contained as liquid in the pores or vessels of the wood itself, and as **bound water** that is trapped within the cell walls.

Once a fresh log or piece of lumber is cut and exposed to the air, it will immediately begin losing free water. At this point, the wood does not contract or otherwise change in dimension since the fibers are still completely saturated with bound water. It is only once all the free water has been lost that the wood will reach what is called the **fiber saturation point,** or simply **FSP**.

Below the FSP, the wood will then begin to lose moisture in the form of bound water, and an accompanying reduction in the wood's volume will occur. At this point, the wood is no longer considered to be in the green state, but is now in a state of *drying*.

Just how much bound moisture is lost during the drying phase will ultimately depend upon the temperature and relative humidity (RH) of the surrounding air. At 100%?rh, no bound water will be lost. At 0% RH, all the bound water in the wood will be lost, a condition known as **ovendry**—so-called because a kiln or oven is typically required to completely drive out all moisture.

The amount of water in a given piece of wood is expressed as a percentage of the weight of the water as compared to its ovendry weight. Some species of trees, when they are initially felled, may contain more water by weight than actual wood fiber, resulting in a moisture content (MC) over 100%.

Moisture Content % = (weight of water / ovendry weight of wood) x 100

For instance, suppose that a freshly sawn piece of Eastern Cottonwood *(Populus deltoides)* weighed 50 lbs. in its initial green state, and ended up weighing only 20 lbs. when fully dried in an oven—this means that a total of 30 lbs. of water was lost in the drying process. So using the equation above: 30 lbs. (weight of water), divided by 20 lbs. (ovendry weight of wood), and multiplied by 100 to get the percentage, we arrive at 150% MC for a green section of Cottonwood.

Of course, the preceding moisture equation—though entirely factual—is mainly for illustrative purposes. In most practical circumstances, the easiest way to check the moisture content of a piece of wood is to simply use a moisture meter. But it's a good practice to understand what the moisture meter reading actually represents, and to recognize that readings above 100% MC are possible, (and in the case of many lightweight species in their green condition, are quite common).

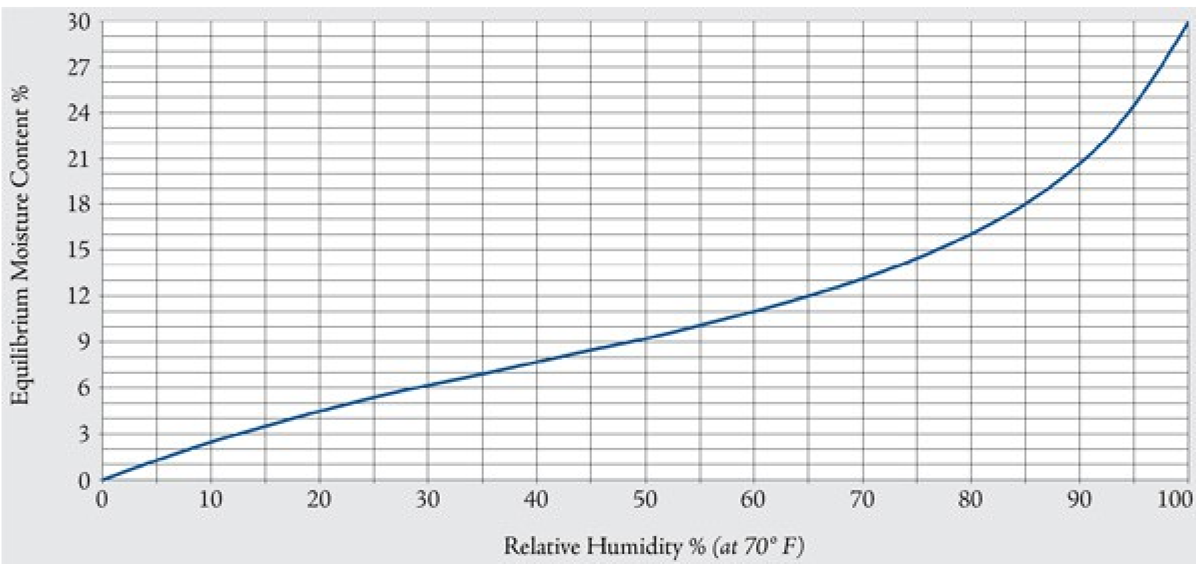
As a piece of wood dries, it first loses its free water and dips below the FSP (fiber saturation point). This FSP corresponds to roughly 30% MC in most wood species. (The FSP may be roughly ±3% MC depending on the wood species, but 30% MC is the commonly-accepted average.)

That is to say, regardless of whatever MC the wood begins at when green, (anywhere from 35% MC to over 200% MC depending on the species), it begins to lose bound water (and dimensionally shrink) when the weight of the remaining water is at a ratio of approximately 30% to the theoretical weight of the ovendry wood.

It should be noted that in real-world situations, the FSP is never uniformly reached throughout the thickness of a piece of lumber. A moisture gradient develops where the outside (shell) is drier, with the interior (core) still wet and playing catch-up.

As the MC of wood drops below the FSP, it will continue to lose moisture until it eventually stabilizes at a value that is commensurate with the surrounding moisture in the air. This is known as the point of **equilibrium moisture content**, or simply **EMC**. The EMC will change based upon the fluctuating temperature and relative humidity of the surrounding air.

In addition to the fundamental fact that wood is hygroscopic, perhaps the most crucial concept to understand regarding wood and moisture is the link between relative humidity and equilibrium moisture content.



From studying the included chart, several important points pertaining to the relationship between relative humidity (RH) and equilibrium moisture content (EMC) emerge.

- The chart tops out at 30% EMC, which is equivalent to the FSP. Short of physically submerging a piece of wood underwater, it's not possible to go back and exceed the FSP once all the free water has been lost.
- The plotted line is not flat (linear), and 50% RH is *not* comparable to the midpoint value of 15% EMC. (50% RH actually equates to just over 9% EMC.)
- There is a noticeable increase in the slope of the line, especially in the 85% to 100%?rh range. This means that wood will swell to a significantly greater extent if it is exposed to prolonged humidity in excess of 85% RH.
- Conversely, the line is somewhat flatter in the range of 20% to 55% RH. Humidity changes that happen in this window have a slightly gentler effect on EMC, and hence results in smaller amounts of shrinking and swelling.

Although the values given in the preceding chart are for rh at 70° F, changes in temperature—assuming the same humidity level—only have a moderate effect on EMC, typically amounting to ±1% MC within a normal climatic range of 30° F to 110° F.

Most interior buildings are kept between 30 to 60% RH, corresponding to 6 to 11% EMC. Exterior values can be much more variable depending on locale and season, but averages typically range from

30% to 80% RH, corresponding to 6 to 16% EMC.

It can be very useful to make mental notes of common humidity levels and their corresponding EMC. For instance, furniture and other interior woodwork should usually be constructed with an intermediate target of 8% EMC, which is achieved by storing lumber at approximately 40 to 45% RH. For exterior projects, a target of about 12% EMC is a good compromise, which equates to lumber stored at 65% RH.

Using lumber that is within the median EMC range for a given locale prevents the *Goldilocks syndrome:* the wood is not too dry, (which might lead to subsequent swelling in the humid summer), and not too wet, (which might lead to checking and splitting in the dry winter). In this way, the wood is most likely to remain as close as possible to its intended size and shape.