Wood Moves, Get Over It

October 21, 2011 By Shannon Rogers 3 Comments

As if it were some kind of perpetual motion machine, wood will never stop moving. No matter how old it is, what has been done to seal it, fasten it, or restrain it, the wood will move. Accept it, and move on. Understanding how and why your wood moves is necessary if you are going to work with this wonderful medium. Understanding how a particular species and cut moves is even more important when it comes to figuring out the tolerances you have to work with.

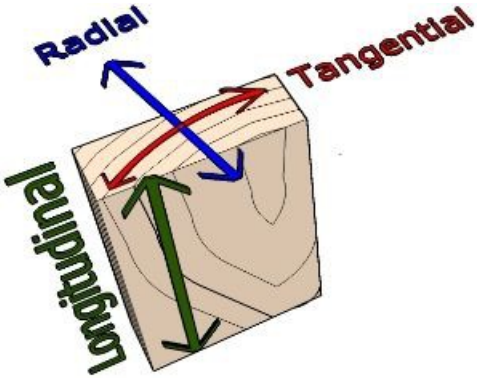


Image courtesy of Iverswoodshop.com

Think of wood as a bundle of straws. While it grows,

Image courtesy of Iverswoodshop.com

Think of wood as a bundle of straws. While it grows, trees suck up moisture from the ground into these straws and transports the water and nutrients throughout the tree to help it grow. When a tree is cut down and sawn into lumber these straws are still full of water but will start to shed that water from the ends of the straws. As the straws lose water they shrink and become narrower. Conversely they grow as they take on moisture. This process will continue until the wood comes into equilibrium with the surrounding humidity. Loss and absorption of moisture can be controlled and slowed through end sealing, finishing, kiln drying, and more but nothing can stop it entirely. This expansion and contraction of the straws is what causes wood movement. The only way to deal with it is to anticipate the movement and build accordingly.

Each and every wood species page on our site has a chart with technical data in it that can help you decipher how a species will perform in a variety of condition. The most important data in those charts when it comes to movement is tangential shrinkage and radial shrinkage.

Tangential shrinkage is the amount the wood moves along the growth rings. Imagine this as the side to side swelling of those straws. This is the greatest amount of movement lumber experiences.

Radial shrinkage is the amount the wood moves perpendicular to the growth rings or along the radial or medullary rays that transport nutrients into the interior of the tree. This is a small amount of movement but still should be accounted for.

It should be noted that wood will move along the length of the board but this is very minimal and for the most part can be discounted.

If you take the ratio of tangential versus radial movement or T/R ratio you can get a good feel for how stable a species is. The closer these numbers the less the board will have a tendency to warp and cup.

As the outer layers dry and shrink, the inner layers are still moist and the differences force cracks to open in the end grain.

Now we understand that wood moves, why it moves, and that different species move different amounts. Knowing this we can allow for the movement and make sure our decks, windows, siding, flooring, etc don't explode as the humidity rises and falls throughout the year. The real rub is that the wood we use does not expand and contract uniformly. Going back to the straw analogy: if the moisture is lost from the ends then obviously the ends will dry out faster than the middle. It is this differential that causes wood to bow, cup, twist, and warp. To avoid this time must be allowed for the slower parts of the board to catch up with the faster parts. Every time a pack of lumber is moved from one part of the country to the other or even as simple as from the cool shade into bright sunlight, the lumber goes through an adjustment period where warpage can occur. Eventually the entire board will reach equilibrium and the exchange of moisture will slow (not stop).

Our job is to lessen these wide swings of moisture. Don't leave your lumber in direct sunlight where the heat will accelerate this moisture loss. Stack your lumber in a well ventilated area and perhaps even sticker the wood (insert small pieces between the boards that allow air to flow through a pack) so that even drying can occur. Most important is to simply give your lumber time to acclimate to it's new surroundings. Preferably also following the above advice and letting that acclimatization happen in a friendly environment.

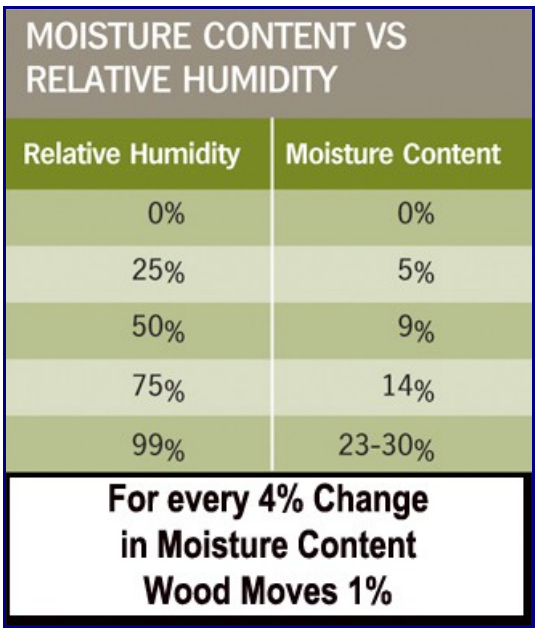
As a woodworker, builder, manufacturer or whatever, you will mostly be using kiln dried lumber; so much of the work is already done for you by us. The wood will be more stable once it is kiln dried to a uniform moisture content, but it will still move if mistreated. J. Gibson McIlvain ships our lumber nationwide and when we move kiln dried Mahogany from the humid summer months here in Maryland to the dry and hot desert of Arizona, that Mahogany is going to move. Should it be cut up and moulded or built into a fixed position before that movement has had time to equalize, it can get ugly very quickly.

In summary, wood is an organic material that will always move as long as the humidity changes. There is nothing you can do to stop it so understanding is a must to be able to work with it. Accept it, respect it, and deal with it and love it.

Moisture Content & Wood Movement – Toolbox

by Carl Hagstrom *on* September 15, 2008

Wood is hygroscopic, which means its **moisture content (MC)** will fluctuate based on the **relative humidity (RH)** of the surrounding air. As humidity increases, the MC increases, and the wood expands, and as the humidity decreases, MC decreases, and the wood shrinks. This relationship is referred to as **equilibrium moisture content (EMC)**, and can be accurately predicted.



Woodworkers and carpenters should tattoo this chart on their chests! If you want to know how much wood is going to move, this chart, and a moisture meter, is all you need.

Understanding Equilibrium Moisture Content

The moisture content of wood is tied directly to the relative humidity of the surrounding air. The higher the relative humidity, the higher the MC of the wood. Period. If you're installing wood that's recently been transported, or installed on a job, it might take a little while for the material to reach its EMC with the air—in other words, for the wood to accommodate to the humidity level for the climate around the wood: the wood may take on more moisture or it may dry out. For example, if wood at 10% MC is exposed to 25% RH, the wood will dry to 5% MC (and shrink as it dries).

The EMC helps us understand the response wood will have to relative humidity, whether it will shrink or expand. For woodworkers and carpenters, the EMC is more helpful than RH. The simplified chart above shows the EMC values of wood when stored at the humidity and temperatures indicated.

Regional Equilibrium Moisture Content

Knowing the regional EMC for *exterior wood application* in your area of the country—and the time of year of your installation, is also critical if you want to ensure durable joinery and long-lasting woodwork. Click on/download the following chart! Find the nearest location to your area and identify the time of year you're installing exterior material.

Regional_EMC.pdf

If you can't acclimate your materials to the suggested EMC, at the very least you'll be able to predict

the movement *after* the material is installed. Using that prediction, you can calculate exactly how much to space your material for future expansion.

Understanding Moisture Content and Wood Movement

by Carl Hagstrom *on* September 3, 2010

(with Gene Wengert, The Wood Doctor.)

Expected movement can be accurately predicted, which means avoiding potential problems down the road.

In this article, we'll explain the importance of understanding wood movement, how to use a moisture meter to measure the **moisture content (MC)** of trim, how to decide when a load of trim should be rejected, and how to accurately estimate how much trim will move after it's installed.

Most finish carpenters are aware that seasonal changes in humidity cause trim and flooring to shrink in the winter and expand in the summer. But few realize that the expected movement can be accurately predicted and potential problems avoided. It's our premise that with a moisture meter and an understanding of wood movement, most wood movement problems can be avoided. Plus, with this data, finish carpenters can accurately predict how trim and flooring will behave after it's installed.

Wood Movement — You Can't Stop It

Wood is hygroscopic, which means its MC will fluctuate based on the **relative humidity (RH)** of the surrounding air. As humidity increases, the MC increases, and the wood expands, and as the humidity decreases, MC decreases, and the wood shrinks. This relationship is referred to as **Equilibrium Moisture Content (EMC)**, and can be accurately predicted.

Understanding Equilibrium Moisture Content

MOISTURE CONTENT VS RELATIVE HUMIDITY	
Relative Humidity	**Moisture Content**
0%	0%
25%	5%
50%	9%
75%	14%
99%	23-30%

Share this chart with your customers so they'll understand what moisture meter readings mean (http://www.forestprod.org/cdromdemo/wd/wd4.html)

FIG 3 ABOVE: According to test data from WindsorONE, for every 4% change in moisture content, flat-grain boards with two layers of primer will change size approximately 1%. That means 1/16 in. in a 1x6 board!

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The EMC helps us understand the response wood will have to relative humidity, whether it will shrink or expand. For woodworkers and carpenters, the EMC is more helpful than RH. The simplified chart to the right shows the EMC values of wood when stored at the humidity and temperatures indicated.

Complete EMC levels for wood stored in unheated structures in your area of the country can be found HERE.

How Wood Moves

If the MC of the wood you install is too high, excessive shrinkage may occur, along with the risk of problems of unacceptable gaps and cracks in the wood itself. When the MC is too low, the wood may expand, and may buckle, bow, and distort surrounding material.

There are six key areas finish carpenters should be aware of when it comes to wood movement.

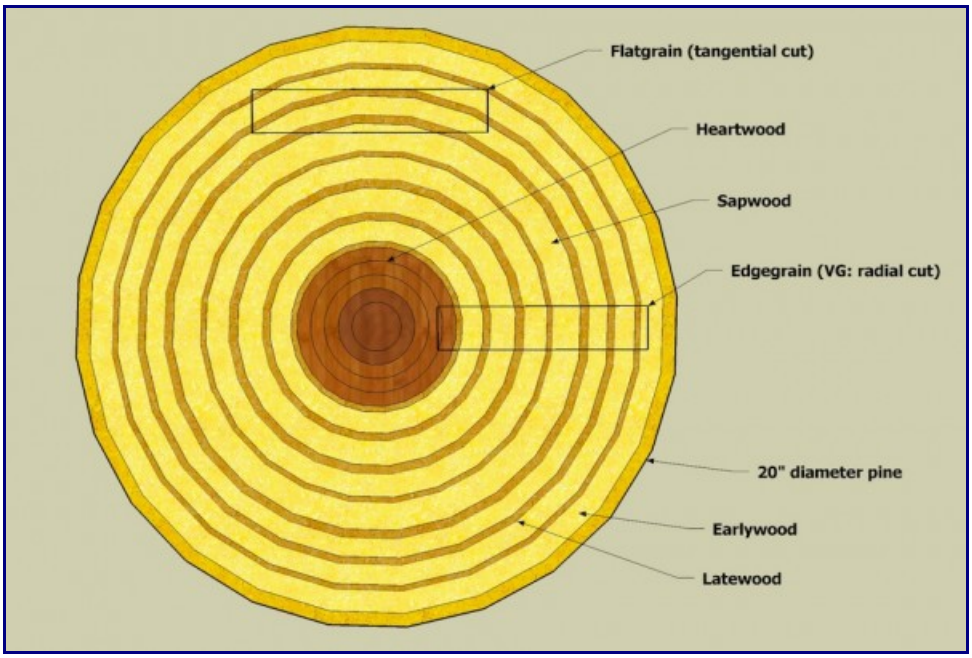
1. Width of material

The wider the board, the more movement will occur (the term "board" technically refers to wood 1 1/2 in. thick or less, but for this article its use will refer to wood typically used by finish carpenters). It's a direct proportion: an 8-in. board will move twice as much as a 4-in. board, and a 12-in. board will

move 3 times the amount as a 4-in. board. And it's important to keep in mind that a glued-up panel behaves basically as one wide piece of lumber.

2. Grain orientation matters

Boards are characterized as being either "flat sawn" or "quarter sawn." Quarter sawn lumber (also referred to as "rift sawn" or "vertical grain") shrinks and expands roughly half as much as flat sawn. Most over-the-counter finish material is flat sawn, and you should assume flat sawn values unless you're sure your material is quarter sawn. Quarter sawn lumber has annular rings that are oriented between 45 and 90 degrees to the board's face. Flat sawn grain orientation falls between 0 and 45 degrees to the board's face.



Wood Grain (Note: Click any image to enlarge. Hit "back" button to return to article")

3. Moisture content of the wood at delivery

The only way to accurately predict wood movement is to know the MC of the material when you receive it. Moisture content is measured using a **moisture meter**. Failure to check your delivered material means you have no chance of anticipating movement problems. Furthermore, material that measures outside of the acceptable MC level should be rejected.

4. Humidity inside and outside the structure

Homes in most of the U.S. that lack humidity control typically experience interior levels of humidity from 25% RH to 65% RH. This range of humidity will cause a 6% change in the MC of the wood. This change in MC will cause a 12-in. wide maple board to change 1/4 in.

When material is installed that was delivered at an unacceptable MC, or the humidity range in the structure exceeds typical values, the amount of wood movement increases—and can cause problems even in well-designed trim details. It's worth noting that panel material (plywood, MDF, composite materials) move at about 1/10th the rate of solid wood.

In most of North America, exterior humidity levels range from 60% RH to 70% RH in summer and winter, but are lower in the Southwest, and higher near large bodies of water. If the material is

delivered at 6 to 8% MC, it can experience more than a 2% change in size as it adjusts to the EMC.

5. Species affects the amount of movement

Wood movement depends in part on the species. A 12-in. wide western red cedar board will fluctuate 1/8 in. while the same size maple board will fluctuate 1/4 in. The formula for calculating wood movement is complex and extremely accurate, but tedious.

One simple rule of thumb serves as an approximate guide to predicting wood movement: “Most species of flat grain material will change size 1% for every 4% change in MC.” Applying this formula to a situation where the seasonal EMC ranges from 6% to 10%, a 12-in. wide board will change dimension 1/8 in.

I’ve put together a rough chart (see below, click to enlarge) that offers approximate movement values for various widths and commonly used species of wood. These values are based on flat sawn lumber, and offer a general idea of anticipated annual in-service movement. The movement values for quarter sawn lumber are approximately 1/2 the flat sawn values.

	Board Width in Inches						
Species	**4**	**6**	**8**	**10**	**12**	**16**	**24**
Most Cedars & Redwood	- 1/16"	1/16"	1/8"	1/8"	1/8"	3/16"	1/4"
Most Pines, Alder, Ash, Walnut, Fir	1/16"	1/8"	1/8"	3/16"	3/16"	1/4"	3/8"
Red Oak, Hickory/Pecan, Beech, Sugar Maple, White Oak	1/8"	1/8"	3/16"	1/4"	1/4"	3/8"	1/2"

If you want to know exactly how much the material you’re using is going to shrink or expand, use this online shrinkage calculator. Simply enter the high and low MC values and the width and species of the board.

6. Applied finish does not stop movement

While it’s true a high quality finish will slow the rate of moisture exchange, it will not stop it. Material finished on all surfaces will expand or contract at a slower rate than raw wood, but make no mistake—finished wood will eventually acclimate to EMC levels.

Events That Increase Movement Risks

There are many events that can contribute to excessive wood movement issues. Nearly all of them can be prevented before they cause a problem if—and only if—you measure the MC of the wood as soon as it’s delivered, and avoid using wood that is too wet or too dry for the expected in-use EMC. The moment the wood is delivered, it begins to acclimate to the surrounding environment. At the very least, it’s important that you document the delivered MC, just in case wood movement becomes an issue. But responsible carpentry can’t be accomplished without reading the delivered moisture content of the wood and planning for wood movement during and after acclimation.

Excessive MC in delivered material

Optimum MC for interior millwork is 6-8%. In the real world, your material may arrive around 9-10%. For installations in unheated areas, the preferred readings are in the 12-14% range, assuming an area is protected from the weather. In most cases, you can deal with material that’s a couple of points high, but keep in mind that the wider the stock, the greater the movement. Ideally, the moisture content of wood should not change more than 2% when put into use.

Think through your trim details and consider how they will react when the wider assemblies shrink. With wide glued-up material, slightly higher MC levels may not be acceptable. If you’ll be installing wide material, it’s a good idea to be upfront with your supplier and let them know that the material’s MC must be within the range you specify. As a last resort, you may choose to dry the wood in your

shop if the shop's EMC is low, and have any shrinkage problems show up before the wood is installed.

Delivered material that's too dry

This is seldom an issue for interior trim, but can be a real issue for exterior trim. Material delivered at 6% MC, and installed outside, will acclimate at 12% in the more humid months, resulting in a 6 point MC change. This swelling of the material can cause significant problems in situations where installation creates accumulated movement (more on this below).

Long-term storage of trim material

If you plan on storing trim material for any length of time in an unheated area, keep in mind that, in most parts of the US, the material will acclimate to roughly 11-12% MC. (See the humidity moisture content chart at the beginning of this article.)

If MC is too high, lower readings can be achieved by moving the material into a heated area. The amount will depend on the temperature and humidity of the storage area. The change in MC won't happen immediately, and the material in the center of a pile will change at a slower rate than the material at the edges. Spacing the material so all surfaces are exposed to the air helps, as does good air circulation throughout the pile. You'll need to take sample readings with your moisture meter to determine when the material reaches your intended MC.

Higher temperatures result in a more rapid change in MC when the humidity remains constant (roughly speaking, moisture moves twice as quickly for every increase in temperature of 20 degrees). And despite what you may think, moisture gain or loss does not stop when temperatures fall below freezing. The moisture in wood is chemically bound in the walls of the wood cells and cannot freeze.

Typical on-site humidity

At certain points during construction, such as when pouring concrete, plastering or drywalling, tremendous amounts of moisture are often added to the air, causing humidity spikes as high as 80-85% RH. If you are storing finish material on-site during these periods, be sure to keep them wrapped in a vapor impermeable material (like plastic) with as few gaps as possible. Wood stored in this manner will not pick up any appreciable moisture.

Interior trim should not be installed until the temporary construction humidity has subsided. Use an accurate digital hygrometer to measure RH (under $40). Generally speaking, interior trim should not be installed when the humidity is above 60%, or the material may climb above acceptable MC levels.

Humidity in un-heated areas fluctuates about 10%; therefore dry material (6% to 8% MC) installed in un-heated areas will swell significantly. It's important that the MC of exterior trim be within 2-3 points of the EMC values for the area before it is installed.

In-service low humidity issues

In heating climates, older, drafty homes may see humidity drop, measuring 20% RH in the winter. The EMC in this environment will vary nearly 8% wintertime to summertime. Homes with wood stoves and no humidity control can see EMC swings of up to 11%. In extreme environments, consider using cabinet grade plywood for wide panel application instead of solid wood.

In-service high humidity issues

Typically, high humidity (constant levels above 60%) is not an issue. But if you find yourself working on a project that includes a room with a spa, heated pool, or damp crawl space, proceed with serious caution—85% RH means an 18% EMC. A 12-in. wide piece of birch installed at 8% MC in such a room will swell in width over 3/8 in. Letting your material acclimate to the high MC levels before installing is one approach, but keep in mind that if there is ever a period where the pool is drained for a significant time, and the humidity drops to typical levels, the trim material will experience severe shrinkage. A carefully-worded disclaimer regarding wood movement would seem to be in order.

Understanding Accumulated Wood Movement

Glued-up solid wood panels behave as though they were one wide board—a 24-in. wide panel will shrink and swell four times as much as a 6-in. board. But what about a series of boards installed side by side (T&G flooring, for example)? While it's true that each board can move independently, accumulated movement can cause significant problems, typically when the newly installed material gains moisture. (See photo, right)

If the material in non-glued assemblies (flooring, for example) is installed "tight", and there's no gap to absorb expansion as the material gains moisture, the increase in width of each floor board becomes cumulative, and causes the entire floor to "grow" buy the sum of each piece's individual movement. In cases of excessive shrinkage, unacceptable gaps can result between each floorboard.

For example, random width oak flooring is delivered at 8% MC. The width of the room is 12 feet, and the floor acclimates to a high level of 11% MC, the cumulative movement is about 1 3/8 in. In the real world, a lot of this expansion is "lost" as the fit tightens up, but in some cases the wood fibers compress, and fiber compression can cause grain ridges. By using a moisture meter, and predicting the movement, you can decide whether you should install the material "tight" or "loose" to absorb what you know will be an increase in material width.

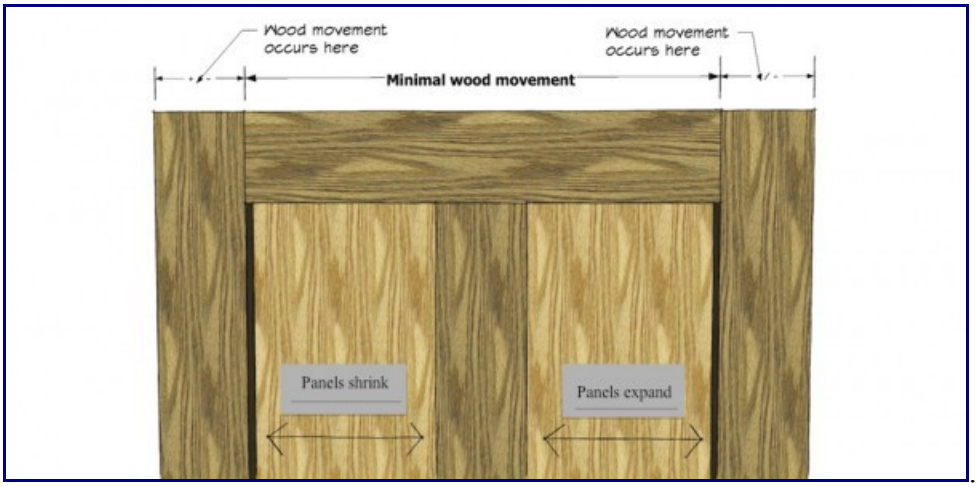
Moisture content on exterior trim can range from 12% to 16% depending on the region, time of year, and location of the material. (Click images to enlarge)

Common Movement Issues

Paneled Passage Doors

Experienced door hangers know that a paneled passage door with a tight reveal will shrink in the winter and possibly stick in the summer. (Remember, if you live in California, the winters may be more humid than the summers!). But basing your door gap on the time of year you hang the door can be a mistake if you don't know the MC of the door.

The seasonal width changes of a door are controlled by the MC change in the door's stiles.



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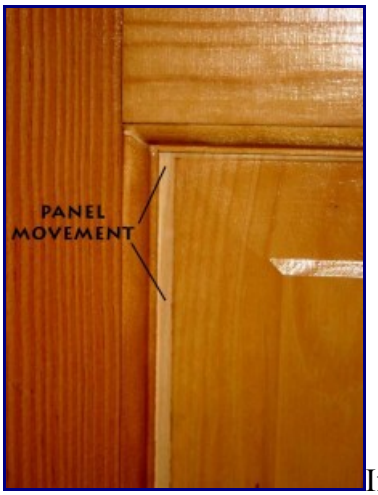


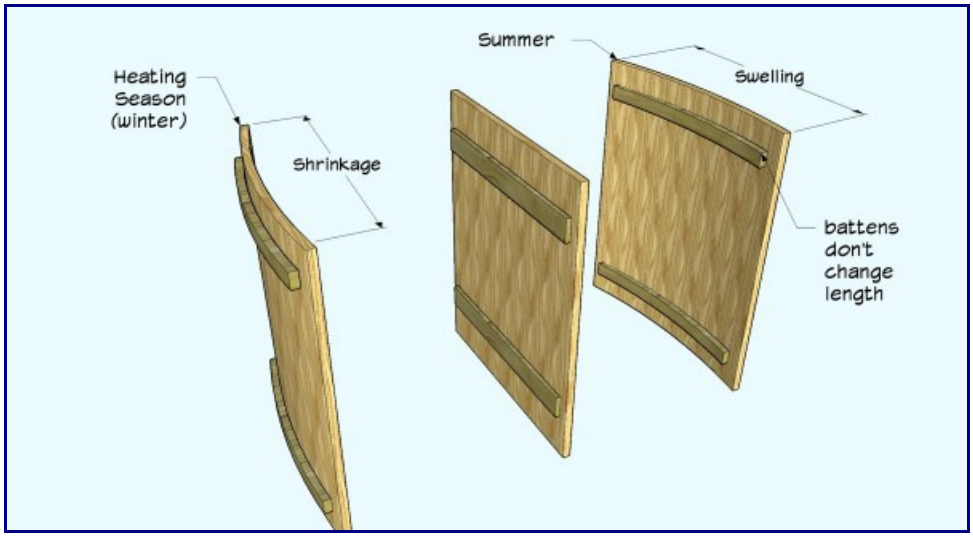
If that fir door you're getting ready to hang in the winter has been stored for six months in an unheated building, the moisture of the 5-in. stiles may easily measure 12-13% MC. After that door is hung, the MC of those stiles will drop to 6%, and the door can easily shrink 3/16 in. Knowing the MC at the time of installation provides the needed guidance.

And keep in mind that the door panels in this example will shrink significantly after installation. This won't affect the fit of the door, but if the door finish is applied at the MC noted, there will likely be unfinished wood exposed as the door panels shrink to their in-service width. (See photo, left) *This is particularly noticeable when a light wood is stained dark.*

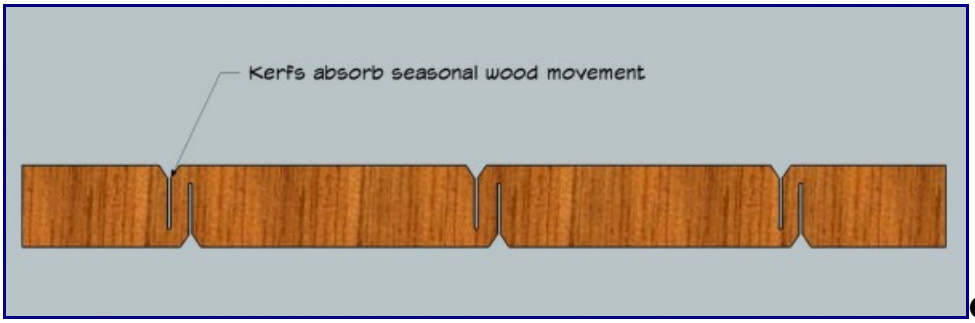
By measuring the MC of the door stiles, you can base your door gap on established movement values, not guesswork, and avoid callbacks when the fit becomes a problem.

Doors with horizontal battens

Unless you're setup to build these doors properly, avoid them. The typical horizontal batten door is built using T&G material for the door face, and then battens are fastened to the back of the door to hold things in place. As the seasonal MC of the T&G material rises and falls, the boards expand and contract, but the battens—with their grain running in the opposite direction—resist that movement, forcing the door to cup inward or outward depending on the direction of the movement.



The detail below is one method used for cabinet batten doors that successfully allows for seasonal wood movement.



Captive panels

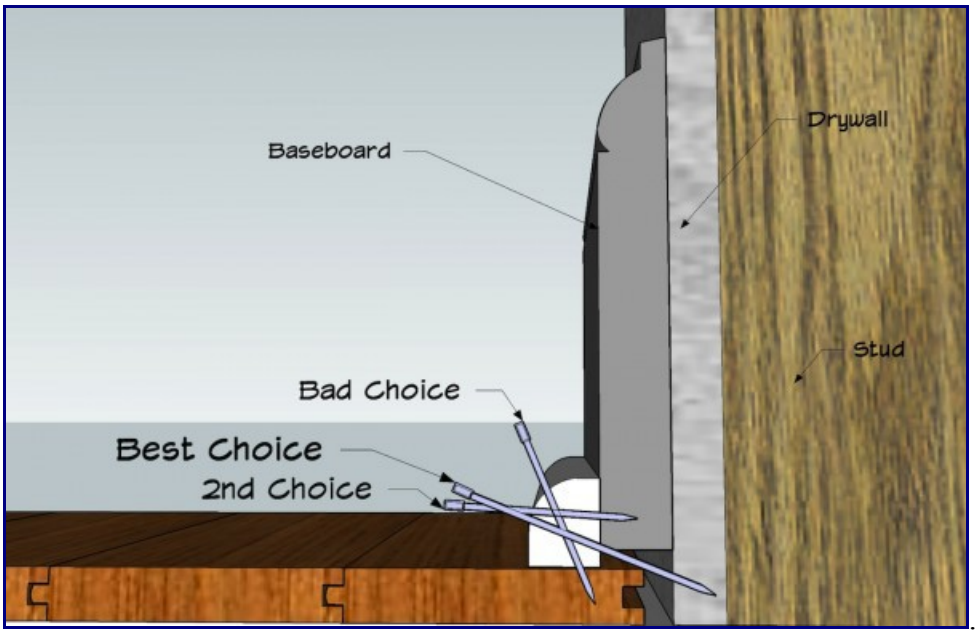
Resist the temptation to "picture frame" a solid wood panel—the way some woodworkers new to the craft miter a nosing or a frame around a tabletop. The miter joint will always fail when the panel expands and contracts. Instead, use a breadboard nosing design so that the wide panel can shrink or swell without destroying the surrounding joinery. (See below)

Inside corner trim

When installing trim that covers an inside corner, fasten the trim through the corner and into the

substrate so the adjoining finish material can move independently as its MC changes. A typical example is base shoe molding. The best practice is to nail base shoe to the plate, with a long nail that doesn't penetrate the baseboard or the flooring. But that's not practical on most jobs.

The second choice is to fasten the baseshoe to the baseboard. Yes, the baseboard will lift off the floor in the heating season, but rarely more than 1/16 in. A wide floor, on the other hand, moves more than a 6-in. piece of baseboard; if you nail the base shoe to the floor, the base shoe may separate significantly from the baseboard.



Common Myths

Wood is stable at below freezing temperatures.

The moisture in wood is chemically bound in the walls of the wood cells and cannot freeze, and expansion and contraction continues at below freezing temperatures. Wood does acclimate more slowly at lower temperatures.

Wood will expand on warmer days and contract on colder days.

For all practical purposes, thermal expansion and contraction of wood is not an issue. That said, warmer temperatures speed the exchange of moisture within the wood. Moisture exchange will happen more rapidly at warmer temperatures, but there is no thermal movement of wood worth measuring.

It doesn't matter if lumber is kiln-dried.

Kiln-dried hardwood lumber typically leaves the kiln near 6% MC (softwoods at 10-12%). But all kiln-dried material will acclimate to the surrounding EMC levels. The significant advantages of kiln-dried material is that it is typically heated to at least 130 degrees in the kiln, which will stop any insect activity, and also "set" the sap in resinous softwoods (sap in resinous air dried material can bleed from the board after it's installed, especially when interior temperatures rise in the summer).

They don’t make wood like they used to.

It’s true that most of the old growth timber is gone, but properly dried vertical grain material has highly desirable movement characteristics. If you’re seeking material that will move the least, choose one of the more stable species, and specify vertical grain (and be sure to check your wallet before ordering!).

But most importantly, *owning and using a moisture meter and knowing the in-use EMCs* is an inexpensive way for carpenters to predict and avoid wood movement problems that could require costly repairs.

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