

Wood Moisture Problems, Helpful Hints and Moisture Meters.

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Wood is an ideal raw material; long-lasting and sturdy, easy to shape, join or glue and continuously replenished. Above all, wood is beautiful - everybody likes its texture, looks, touch, coloring and unique patterns.

Wood is used in many different applications - from structural building compo-

nents to hardwood flooring, from furniture to toys for kids, from cabinets to musical instruments.

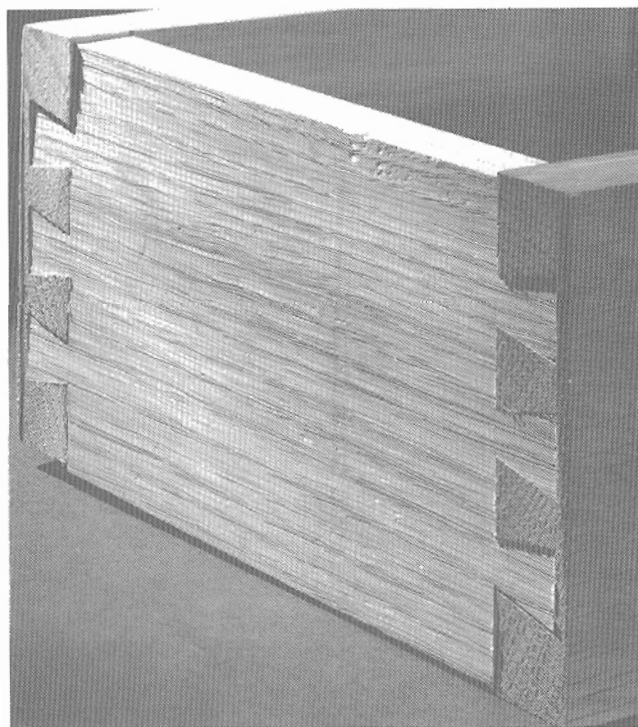
The challenge of woodworking starts with choosing the right lumber. If the wood is not right for the application, the best tools and excellence in craftsmanship cannot guarantee a high quality product. Species, grade and moisture content determine quality and usefulness of wood.

Common Moisture Problems are...

A chair with loose joints. A cabinet door that will not close or a drawer that doesn't open. A butcher-block table with a big crack down the middle. A veneered surface that shows surface checks. Edgebanding applications where the glue line fails. A jewelry box with crooked joints. Cupped floors. Foggy finishes, etc.

During air or kiln drying moisture defects such as case hardening, honeycombing, split ends or surface checks can occur. If wood is not properly stress-relieved, internal stress can be suddenly released when a board is cut.

Moisture defects are irreversible. Immense stress within the wood deforms (warping and shrinking) or destroys the structure of wood (crack, check, honeycombing).



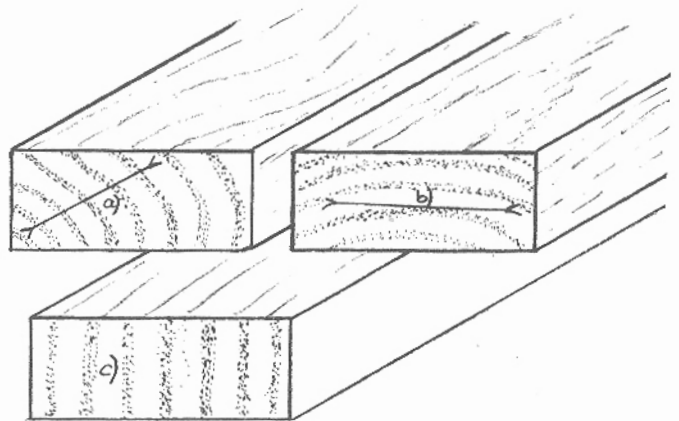
What once was a perfect joint is now ruined by warpage and shrinkage.

Why Moisture Problems Occur

Wood is not a homogenous material, but structured by year rings, which form a series of more or less concentric cylinders. These cylinders consist of irregular tubes that transport nutrients and support the tree.

Interaction with Air: When wood absorbs or loses moisture below the Fiber Saturation Point *, the tubes expand or contract, causing wood to swell or shrink. To the woodworkers dismay shrinking and swelling is often accompanied by warping. Shrinkage does not occur lengthwise along the tubes. Imagine building a house with wood that would shrink lengthwise!

Changes in moisture content occur until an equilibrium with the surrounding air has been reached: The EMC of air (equilibrium moisture content) and the wood moisture are the same. For offices, houses, or other heated live-in areas, the ideal conditions are 70° F at 35% RH with a corresponding wood moisture of 6-8%. Furniture lumber is dimensionally stable at 6-8%, unless exposed to extreme air conditions. See "Proper Storage", page 3.



1a) Arrows indicate radial shrinkage 1c) Quartersawn board with straight
1b) Arrows indicate tangential shrinkage year rings parallel to the edges

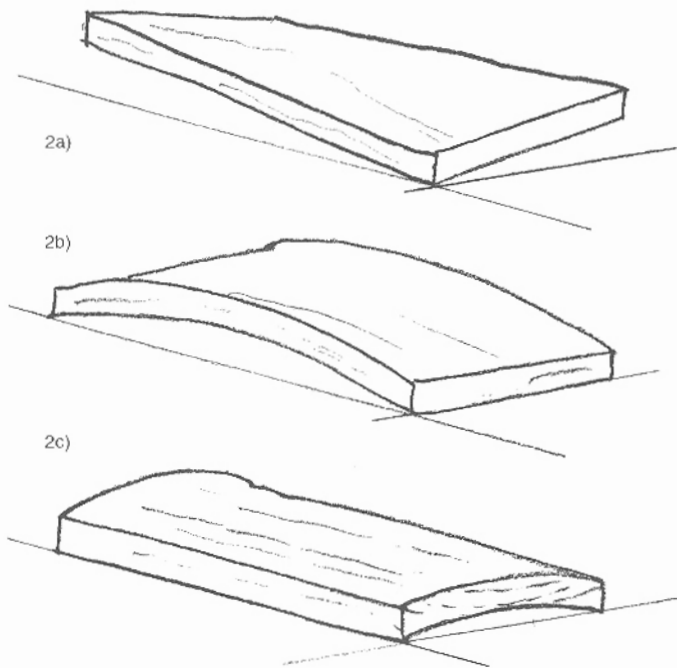
Shrinking and Warping

Year Rings: After logs are cut into lumber, each board - dependent upon its position in the log - has a unique year ring pattern (grain). Shrinkage and Warpage depends upon the changes in wood moisture and the arrangement of year rings. See also "The Perfect Board" page 2 and "Selecting Wood" page 3.

Shrinkage: Whenever wood below 30%* loses moisture it shrinks. By actually measuring the shrinkage in a block of wood, it has been found that shrinkage is not uniformly the same in all directions, but differs following the grain. Tangential shrinkage along the year rings is twice as much as radial shrinkage across the year rings. The different shrinkage factors within the same board cause warpage by pulling the boards in different directions.

Warpage: Dependent upon the year ring pattern within the board, shrinking is accompanied by warping. Warpage deforms boards by cupping, bowing, twisting or a combination of the three. See drawings on next page.

*FPS - Fiber Saturation Point for Wood at 28-38% Moisture Content.



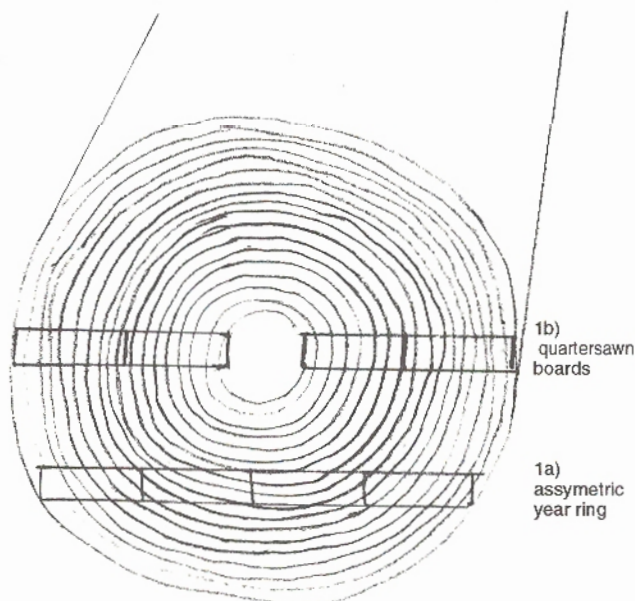
2a) Twisting, curved diagonally across the board
2b) Bowing, curved lengthwise 2c) Cupping, curved widthwise

Assymmetric year rings give wood its character and beauty, but cause the woodworker a lot of trouble with shrinking and warping.

The drawings above indicate the main deformations of a board. For instance, when a wood floor dries out, warpage deforms the planks - the floor cups.

The Perfect Board has straight year rings parallel to its edges. See page 1, quartersawn boards fig.1c. When changes in moisture occur, these boards swell or shrink the least and do not warp. Ideal for applications such as a solid front door, where humidity and temperature changes year-round.

Trees grow crooked and year rings are often distorted. These natural irregularities make it hard to find the "perfect tree". In addition, only a small number of **quartersawn** boards can be cut out of the perfect tree. Therefore; perfect boards are rare and expensive.



Drying and Drying Defects

Drying: Moisture from the core of a board is gradually transported to the surface and absorbed by the surrounding air. Three values describe the drying conditions - relative humidity, air temperature and moisture content of wood. Drying stops when the air cannot absorb any more moisture.

Honeycombing: When the temperature in a dry kiln is too hot, lumber can crack internally. Once lumber is cut, the defects become visible.

Casehardening occurs when wet lumber is exposed to very dry air. The surface shrinks fast and the pores close. Moisture is trapped and cannot evaporate, slowing the drying process.

Surface Checking: When the outside of a board dries faster than the core can follow, the outside shrinks more than the inside. Small checks and split ends appear.

Uneven drying: When only one side of a board is exposed to air and dries out, the board cups. When you place a board that has been stored in a damp area on your worktable, the next morning the board is crooked.

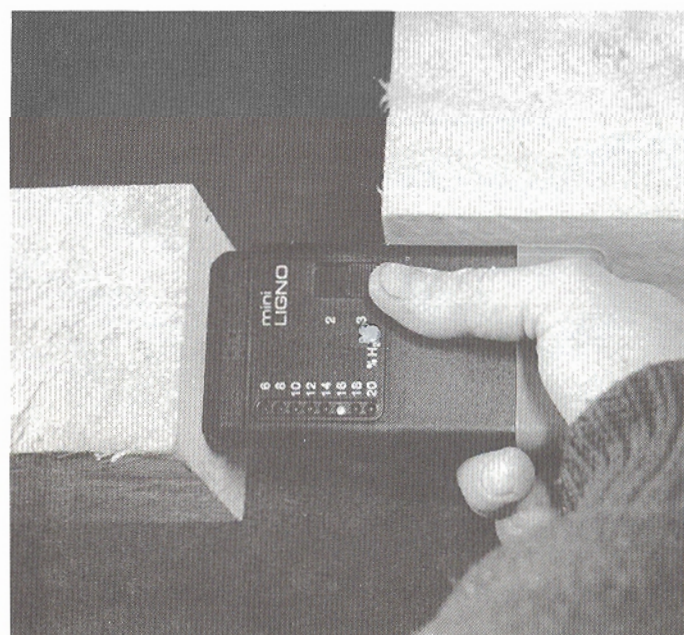
A Cure? Prevention!

Since moisture defects are permanent deformations of the wood structure, **there is no cure**. Moisture problems have to be **avoided before they occur**. A moisture meter can measure the moisture in a board and the woodworker has to know whether or not the moisture value is acceptable for the job. Lignomat offers a complete line of moisture meters for everybody from the serious hobbyist to the plant manager.

What if Lumber is too wet? Don't waste time and money on wet wood. It is better to buy dry lumber than to risk moisture defects. One wrong board can be enough to ruin the entire job, and you end up with an unhappy customer.

Selecting a Moisture Meter: The main criterias are moisture range (dry or green wood) and measuring depth (thin or thick boards). Microprocessor Technology is available in some instruments to increase accuracy and convenience, see page 4.

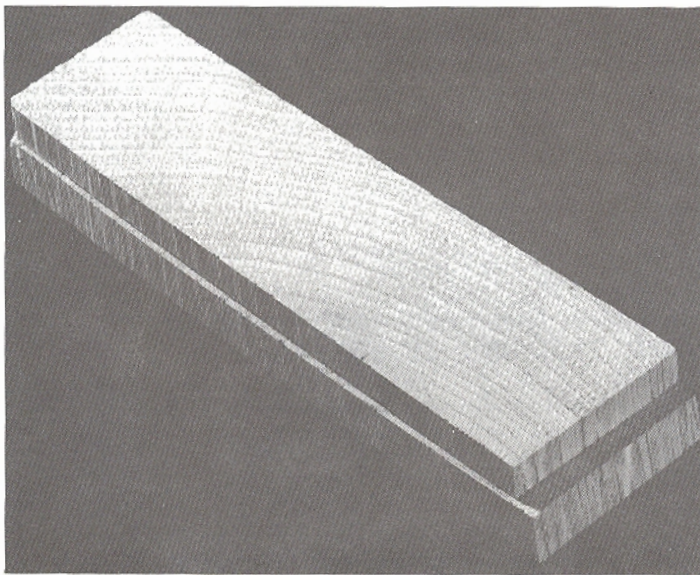
Using a Moisture Meter: The surface and the core of a board should be checked thoroughly. A dry surface does not automatically mean that the core is dry. Whenever a moisture meter with short needles is used for thick boards, core readings should be taken on a fresh cut (see photo below). If it is not feasible to cut the board, the depth electrode E12 should be used (photo on page 4).



Hints to Help

Buying Lumber: Be sure to specify the wood moisture, when you order lumber. Upon delivery, check the moisture content with a moisture meter. In case the lumber is too wet, the supplier should be notified **promptly**. If you wait too long, the supplier may not accept the blame.

Selecting Wood: Not all woods shrink the same. Teak, mahogany, cedar, sugar pine and redwood are dimensionally stable woods. Oak, hickory and beech shrink and warp considerably more. (See photo below.) And not all woods warp the same. The more parallel the grain runs to the edges of a board, the less warpage can be expected.



Difference in size between a board (1 1/4" by 4") at 6% and at 18% moisture.

Woodworkers Expertise: Since wood movement due to changes in ambient conditions cannot always be avoided, the woodworker can counteract by building overlaid or offset panels, by placing boards with reversed warpage tendencies side by side, etc. Nevertheless, using dry lumber is a basic requirement to reduce the possibility of moisture related problems.

Proper Storage: Dry lumber should be stored in a closed-in area with a controlled climate. If stored in a damp area or outside, lumber will adapt to the surrounding air and absorb moisture. Lignomat offers a Thermo-Hygrometer to measure temperature and relative humidity in a warehouse, workshop or other storage areas.

A complete diagram for the relationship between Temperature, Relative Humidity, Wet-Bulb Temperature and EMC is available from Lignomat. See paragraph "Interaction with Air", page 1.

at 70° F and 35% rel. humidity the EMC is 7% ideal condition
at 85° F and 75% rel. humidity the EMC is 14% moist summer
at 32° F and 20% rel. humidity the EMC is 5% dry winter
at 50° F and 90% rel. humidity the EMC is 21% wet winter

Different Ambient Conditions: You may wonder what the right moisture content for a new project should be. Determine the moisture content of a piece of furniture now located where the new piece will be. "Old" furniture has reached an equilibrium with the surrounding air. Match this moisture content to avoid moisture problems.

Are you concerned about climate changes throughout the year? Measure several pieces of furniture in different areas of your house, shop or office once every month. After 12 months you will have a series of moisture values that reflect seasonal changes. You may be amazed at

how little the moisture in wood furniture or cabinets changes inside your home.

Shipping or Moving Furniture: If you are moving furniture from one area to another, make sure that temperature and relative humidity are similar. (Lignomat offers a Thermo-Hygrometer to check air conditions). If your shop is damp and you move furniture to a dry, air-conditioned office, surface checks may appear. Cabinet doors may all of a sudden not close any more due to uneven drying. Some people have encountered severe moisture defects, when moving furniture within the US.

Special precaution is necessary when prefinished parts or furniture are shipped from outside the US. Often goods show cracks upon arrival. Maybe the wood was not dried correctly, or not packaged correctly.

Restoration: When you are restoring antiques or repairing furniture, new wood is added to existing woodwork. Make sure to match the moisture content. Otherwise, the different moisture contents equalize and may cause shrinking, warping, delamination and other defects, that make your work look sloppy.

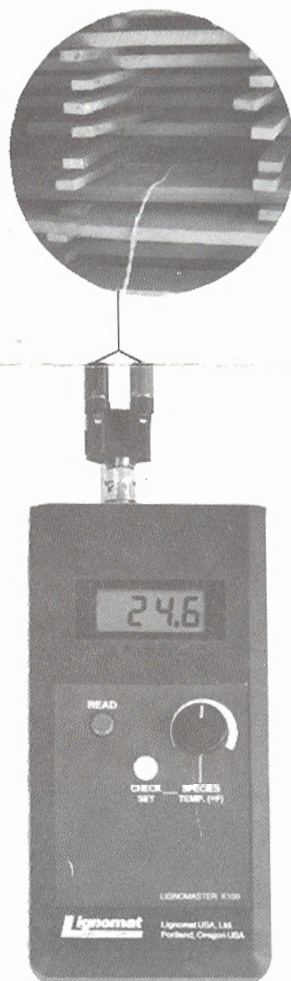
Air and Kiln Drying

Lumber: The great challenge of drying efficiently and without degrade is: finding the right temperatures and relative humidities for the constantly decreasing wood moisture content. One critical value is the FSP* at 28-30%. Above FSP free water between the cells evaporates, below FSP water evaporates from the cell wall and the lumber shrinks. Since the ends of a board reach the FSP faster, checks and cracks appear here first.

Drying conditions are obvious from different moisture levels within the same board. If the ends and the center of a board have the same moisture content, no further drying occurs. If the difference between end and core is too big, drying defects will degrade the lumber and the drying process has to be slowed down. (The critical difference depends upon species and moisture content). Many customers have found Lignomat's extension probe and cable system to be a helpful tool in determining drying conditions and drying lumber efficiently. We offer equipment for small and industrial-sized dry kilns.

Air drying: Wood will not dry further than 12-15% if stored outside. Once air dried lumber has been dried down to 6-8%, the wood can be used without a problem.

A good woodworker could probably give more helpful hints. It's part of his skill and experience to understand wood. The right moisture content is a basic requirement. If neglected, irreversible damage can reduce the value of the finished product - **don't waste time and money on wet wood.**



Lignomaster K100 with remote cable

Accuracy and Convenience in Moisture Meters with Microprocessor Technology

Lignomat USA, Ltd. manufactures a line of resistance-type moisture meters. The moisture meters indicate the wood moisture measured in a thin line between two metal pins.



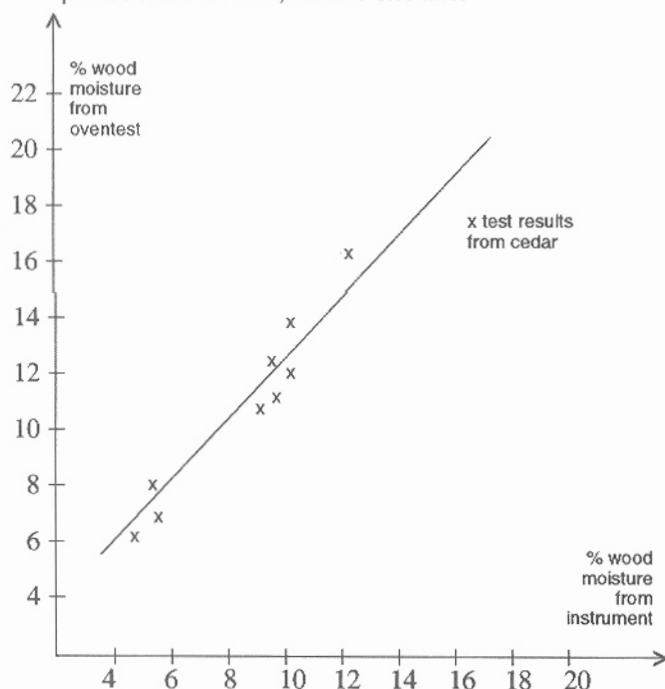
Mini-Master HT and Electrode E12

By taking moisture readings in many boards at different depth levels, you can find out, if all boards have a uniform moisture content from the surface to the core. It is important to know the moisture distribution throughout the board for quality control. The average moisture content is only important if the standard deviation is also known.

Accuracy :

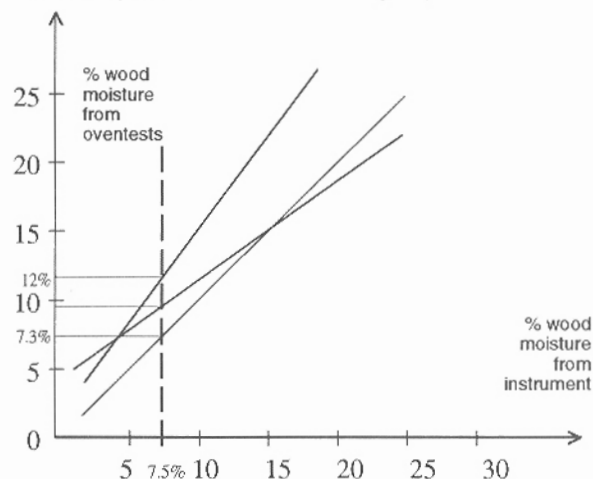
To determine the accuracy of a moisture meter, moisture readings are compared to oven tests.

Differences within the same Wood Species: Each piece of wood is different and the electrical characteristics differ too. Tests with sample boards of the same species show small deviations of moisture readings from oven tests. The deviations get larger for moisture readings above Fiber Saturation Point. Allowing for small deviations, each species nevertheless, follows one line:



Graph 1: Comparison between oven tests and moisture readings for one wood species.

Differences between Species: Further tests showed there are even more significant differences when comparing wood samples from different species. See graph 2. For each species a characteristic line or calibration curve can be determined. If the same calibration curve fits two different species, the same wood group number is assigned.



Graph2: 3 different calibration curves representing 3 different wood species. A moisture meter without species correction will read 7.5% for all three species, even though the oven test show the true moisture content to be 7.3%, 9.8% and 12%.

In order to obtain accurate moisture readings for different species, the readings have to be corrected. The most time-consuming method is using a chart, that lists correction factors for different species at different moisture levels. Often the chart has been misplaced or the operator does not use it, thus accepting less accurate readings.

More modern moisture testers have different calibration curves built-in; though the number of calibration curves is limited by the internal electronic hardware.

New Microprocessor Technology: These limitations do not exist for moisture meters with built in microprocessor technology. A large number of different calibration curves can be built into the software. A great advantage - since the additional calibration curves mean greater accuracy for more species. The Mini-Ligno XL is the first mini meter with built in microprocessor technology. A unique two-light LED read-out assures unsurpassed 1% reading accuracy over the entire range.

On-Off selector switch allows for selection of 20 different calibration curves.

Differences between different Wood Temperatures: Moisture readings in hot or cold lumber need further corrections. The resistance changes when the lumber is hot or cold. Outdoor temperatures between summer and winter can result in differences of up to 5%. High temperatures in a kiln affect moisture readings even more. Each moisture meter comes with a correction chart.

With the new Mini-Master, Lignomat introduced a temperature and species corrected moisture meter, available at a lower price than ever before. All corrections are built into the software and correction charts are obsolete. Set species and temperature and read the corrected wood moisture content in percent instantly.