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An Overview of Drying Hardwood Lumber

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Freshly sawn hardwood lumber is perishable, with delays or improper handling often resulting in lost revenues for producers. Green boards are usually dried as a first step in their utilization, making this process critical to value retention and addition. Two or three months of air drying followed by several days in a steam heated kiln has been the traditional procedure used by wood product manufacturers.

Recent years have seen an increased use of the pre-dryer and the dehumidifier kiln. The same attention to details from promptly stacking the lumber to proper dry-end storage is required by all methods. Lighter weight, increased strength, better gluing, and a reduced chance for deterioration are just some of the many benefits proper drying provides the end user.

Many residents may also wish to dry small quantities of hardwood lumber for their use; therefore, they need to understand basic wood-drying principles. This fact sheet provides local producers with key terms, the different methods available for drying hardwood lumber, and suggestions for implementing each.

Some Basic Definitions

Moisture content (MC): The weight of water contained in a board, expressed as a percentage of the

oven-dry weight of the board. Fifty percent moisture content means the weight of the water is half the weight of dry wood. This can be measured by an electric meter.

Oven dry weight (OD): The weight of a wood sample that has been dried to a constant weight (all of the moisture has evaporated) in a drying oven at 215°F.

Equilibrium moisture content (EMC): The moisture content at which wood will neither gain moisture from the air nor give off moisture. Wood furniture in the home reaches equilibrium with the air at 6–8% MC.

Fiber saturation point (FSP): The stage in drying wood when cell cavities contain no water but cell walls are still saturated. In most wood species this is 28–30% MC. Wood begins to shrink below this point as water continues to evaporate from the cell walls. This can only occur once all water is removed from the cell cavities.

Dry bulb temperature: The temperature of the air indicated by a thermometer that does not have a wet cloth covering.

Wet bulb temperature: This is measured with a second thermometer (identical to the dry bulb) covered by a smooth, clean, soft, water-saturated cloth. The

evaporation of water from the wet cloth lowers the indicated temperature. This evaporation and lowering is directly related to the air's relative humidity.

Wet bulb depression: This is determined by subtracting the wet bulb temperature reading from the dry bulb temperature (Wet bulb depression = Dry bulb – Wet bulb). The air's relative humidity can be determined from a humidity diagram given the dry bulb temperature and wet bulb depression.

Relative humidity: A ratio describing the amount of water in air compared to the maximum amount of water the air can hold at the same temperature, expressed as a percent. Relative humidity influences the drying rate of wood as lowering relative humidity results in faster drying. The final moisture content of a lumber stack is also dependent upon this measure.

Check: A defect in which wood fibers separate as a result of non-uniform drying in the early stages. **Surface checks** appear along the flat faces of a board while **end checks** develop on the edge faces.

Honeycomb: The occurrence of checking in the interior of a piece of wood, normally across the annual ring, as a consequence of accelerated initial drying.

Casehardening: A condition of stress and set in dry wood in which the outer fibers are forced inward and the inner fibers are pulled outward.

Air Drying

Air drying is less expensive from an energy standpoint because it depends on the wind and outside air temperature. It does not require elaborate buildings, electric fans, electronic control, or sources of heat. Hardwood lumber must be dried slowly to prevent seasoning defects such as checking and honeycombing. The longer drying schedule inherent with this method may be compatible with the goals of those who wish to season small quantities of lumber.

Hot, dry conditions of July and August may cause freshly sawn lumber from refractory species to dry too fast. The outer shell of oak and hickory boards may dry and shrink faster than the inner core, causing excessive checks and casehardening. They may also discolor rather quickly. Yellow-poplar and soft maple are less likely to be damaged by rapid drying. Other

species are intermediate in their drying characteristics. End coating the boards of species that easily check and split with a wax-based solution, which can be applied by brush or spray, can help minimize degrade.

Air drying does demand the same care in stacking the lumber because careless handling may diminish the value of high quality boards. Boards should be stacked within a few hours of sawing. Stickers must only be machined from kiln-dried lumber and properly aligned throughout the stack. Please refer to the Ohio State University Extension fact sheet *Stacking Lumber for Drying*, F-8-02 (<http://ohioline.osu.edu/for-fact/0008.html>), for detailed information regarding proper stickering and stacking techniques. Separation of species is not essential when air drying but is recommended, especially if kiln drying will later take place.

To prevent discoloration, stacks of lumber for air drying must be placed on a solid foundation that provides ample space between the soil and the bottom layer of the boards (Figure 1). At least 12 inches of air space beneath the drying lumber must be maintained free of vegetation and surface water. The supporting foundation must be level and built on solid footings. Uneven settling of the foundation during the drying period will cause warp and twist in the lumber. Dried wood timbers are typically used for foundations, but care to prevent decay is essential. Stacked rows should be a minimum of 4.5 feet apart.

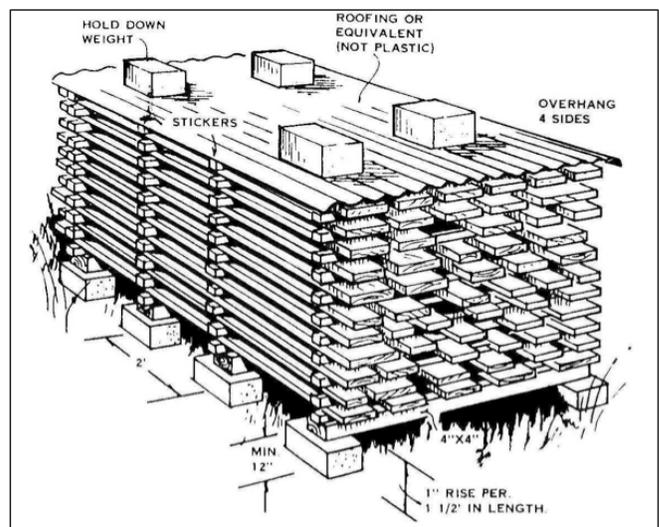


Figure 1. A properly stickered, raised, and covered lumber stack for air drying.

Valuable boards must be protected from the sun while drying. Shelter from rain and snow will also help shorten the drying time. A roof, temporary or permanent, is recommended. This roof may be built directly on top of the lumber and removed when drying is complete. If the location is to be used year after year, a lumber drying shed without sidewalls may be desirable. Ensure air flow is adequate through the shed to prevent mold buildup on the backside and bottom of a stack. Monitoring bird and rodent activity is also advised to minimize degrade due to droppings.

Pre-Dryer

The pre-dryer looks like a large barn in a commercial operation but can be sized to fit the small producer. It is equipped with steam heat, several fans, and vents to maintain ideal air drying conditions year-round. Automatic controls monitor dry bulb and wet bulb temperatures. These controls open roof vents to exhaust humid air and side wall vents to admit fresh air. Fans direct the air down between the stacks of lumber.

A pre-dryer is typically used for hard-to-dry species. This building represents a large capital investment but does reduce the energy consumption of the dry kiln. It is used by furniture manufacturers and their suppliers to prepare lumber for kiln drying. Lumber bundles are usually built by a stacking machine and placed in the pre-dryer by lift trucks. An average schedule for drying green oak lumber to 20% MC might be 60 days.

Conventional Dry Kiln

Several manufacturers offer these commercial units in a range of sizes with all the necessary engineering services (Figure 2). Conventional dry kilns run at temperatures between 100–200°F. While the usual heat source is a steam boiler, some receive hot air directly from a furnace. Bark and sawdust are common fuels. Automatic controls maintain the desired combination of air velocity, dry bulb temperature, and wet bulb temperature to optimize drying time and minimize degrade.

Hardwood lumber is usually dried below the fiber saturation point before kiln drying, but occasionally green lumber from hard-to-dry species is placed



Figure 2. An industrial-scale kiln can dry large volumes of hardwood lumber.

directly into the kiln. Lumber drying begins at mild conditions followed by a series of species-specific temperature increases and lowering of relative humidity, termed the **kiln schedule**. A later stage in the hardwood kiln schedule is the equalization of the moisture content of all boards at 6–8%. The last step requires a short period of high humidity to relieve the drying stresses in the boards. Different species should not be loaded simultaneously into the kiln due to often differing kiln schedules.

Dehumidification Kilns

Dehumidifier drying is slow and suitable for the hardwood industry. The principal difference from the conventional dry kiln is that water is removed from air inside the dehumidification kiln. As the entire dehumidifier is inside the kiln, heat from the machine is used to warm the circulating air. These units are energy efficient because the heat is retained rather than exhausted as in the conventional kiln. Maximum temperature is typically 150°F, and drying times are similar to a conventional kiln. The quality of lumber dried in dehumidifiers can also equal conventional kilns, given both are operated properly.

A dehumidification kiln is an economical alternative for the small hardwood lumber producer (Figure 3). Capital investment is much less with this type of kiln, and small units can be built for home use. Plywood and fiberglass insulation are the usual building materials. Cold winters may require additional electric heaters to maintain drying temperatures. Careful use of moisture content samples is recommended.



Figure 3. A dehumidification kiln provides a low-cost option for small, hardwood lumber firms.

Solar Kilns

Several designs for solar-heated dry kilns have been tested by universities and the Forest Products Laboratory at Madison, Wisconsin. Most are small, easy to build, and well suited for home use. A solar kiln can dry lumber three times faster than air drying. However, temperatures and drying rates in the solar kiln are often capable of causing serious drying defects. Careful monitoring and use of moisture content samples are required to avoid this problem.

Dry End Storage

Hardwood lumber is still subject to degrading factors following kiln drying. Proper storage is necessary to retain board quality. Storing dried lumber in an environment of high moisture will cause swelling and can make it susceptible to fungal activity. Insects can infest air-dried lumber as well as kiln-dried lumber where excessive debris is present.

Dried lumber should be stored away from the sun and precipitation (Figure 4). Open T-sheds are a short-term option. They should be free of debris and away from green, partially dried, and degraded logs and lumber. Animal activity should be monitored. Stacks may also be covered with a mesh-like, breathable material to lessen the occurrence of outside sources of deterioration.



Figure 4. Dry-end storage using a T-shed and mesh covered stacks (photos courtesy of Dr. Kevin Ragon, Quality Pole Inspection and Maintenance, Inc.).

More Information

Air Drying of Lumber, *Drying Hardwood Lumber*, and *Dry Kiln Operator's Manual* are comprehensive instruction booklets from the United States Forest Service; these publications provide information about drying wood. If you need further study, you may search Ohio State University Extension's Forest Operations and Products website at www.ohiowood.osu.edu for

these publications as well as contact information for The Ohio State University School of Environment and Natural Resources.

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