FORESTRY EXTENSION NOTES

AIR AND SOLAR DRYING OF HARDWOOD LUMBER

Wood from native hardwoods may be used for construction and other home uses. Hardwood lumber may offer substantial savings in material costs compared with shipped-in lumber. However, for most uses, lumber must be dried to remove a substantial amount of the water. Dry lumber is stronger, lighter, more durable, more stable, a better insulator, more easily finished and glued, and more effectively fastened with nails and screws.

Air drying and solar drying are the most economical ways to remove much of the water from green lumber. Correct exposure of the lumber to the outside air can reduce moisture content down to 14 to 19 percent; lumber at this moisture content is suitable for many construction uses and exterior applications. Solar drying can reduce the moisture content of lumber to 7 to 8 percent so it can be used in furniture and other applications within a heated building. Further drying beyond air and solar drying is usually accomplished in a dry kiln where temperature, humidity, and air circulation can be carefully controlled.

AIR DRYING

Proper Piling of Lumber

Locate the lumber pile on a site that is level, has good drainage, and is exposed to the prevailing winds. Clear the selected area of vegetation and any debris, and then keep it clean.

Proper piling of lumber for air drying involves building a suitable foundation, careful placement and spacing of the boards in the pile, and providing roof protection.

Various methods of building a foundation may be used. For example, treated wood sleepers or concrete blocks could be used as a base to support the lumber pile. Restrict the width of the pile to six feet or less. The length should be determined by the maximum length of the lumber to be dried.

Stack the lumber in neat layers as soon after sawing as possible. Leave a 1 or 2 inch space between boards within a layer. Do not mix lumber of different thickness within a single layer. Separate the layers with spacers called stickers positioned 12 to 18 inches apart. These stickers run perpendicular to the length of the lumber. The strips of wood used should be at least 3/4-inch thick, 1 to 1 1/2 inches wide, uniform in size, and dry. Place the stickers directly above the supports and above each other. Do not leave the ends of the lumber unsupported.

Roof the finished pile to protect the lumber from direct exposure to sunlight and rain or snow. Boards, slabs, plywood, or other materials may be used for the roof. Alternatively, lumber may be piled under cover in an open shed.

Drying Rate

The rate at which green lumber dries, after proper stacking for air seasoning, depends upon the characteristics of the wood, the thickness of the lumber, and the climatic conditions.

Heavier hardwoods require longer drying periods than lighter woods. Some species of wood have higher green moisture content than others; sapwood and heartwood may have quite different drying characteristics.

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Drying time required increases rapidly with increase in lumber thickness; for example, 2-inch thick lumber may take from two to four times longer than 1-inch lumber. Do not saw lumber any thicker than is necessary for the intended use (after allowing for shrinkage and surfacing), if speed of drying is important.

The climate and the particular season in which green lumber is exposed has a major influence on time required to air-dry lumber. Temperature is perhaps the most influential factor, but rainfall and humidity are also important. Green lumber piled during the warm months will typically dry much faster than lumber exposed during the late fall and winter. Native hardwood lumber that is 1 inch thick may require from 50 to 200 calendar days to dry to 15 to 20 percent moisture content depending upon when drying begins.

The U.S. Forest Products Laboratory has developed the concept of "effective air-drying days" for the upper Midwest. The following tabulation shows the average number of effective air-drying days for each month; the total for the year is 215.

EFFECTIVE AIR-DRYING DAYS PER MONTH FOR UPPER MIDWEST

Month	Effective Air-Drying Days
January	5
February	5
March	10
April	20
May	25
June	30
July	30
August	30
September	25
October	20
November	10
December	5

Approximately 60 effective air-drying days are required to bring most 1-inch hardwood lumber down to 15 to 20 percent moisture content. For example, lumber exposed June 1 may only require two months to dry while lumber piled on November 1 may take six months or more.

Minimizing Degrade during Drying

Stresses develop in lumber as moisture is lost during drying. Shrinkage in width and thickness will occur; warp, checks, or other defects may develop. The potential for occurrence of drying defects such as checking and warping also increases with greater lumber thickness. Warping can be minimized through proper piling techniques; adding weight to the top of the pile (about 40 pounds per square foot) can help keep the lumber flat during drying.

Surface checking may be minimized by protecting the lumber from direct exposure to the weather; a properly constructed roof can provide this protection. End checking and splitting can be reduced by sealing the ends of the green boards with aluminum paint, asphalt, or paraffin. However, end-coating the lumber will slow down drying rate and is only appropriate for higher quality lumber.

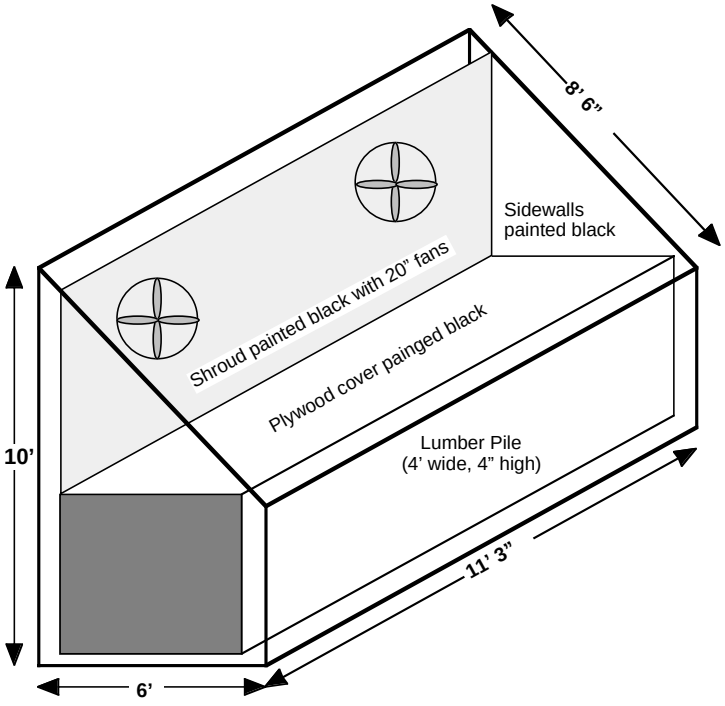
SOLAR DRYING

There has been increasing interest in using solar energy for quickly drying lumber to low moisture content. For small businesses and hobbyists solar dryers are now recognized as a viable alternative to more expensive, conventional lumber dry kilns. The U.S. Forest Service and several state universities have developed several different models of solar heated kilns. In 1980, the Virginia Cooperative Extension Service published information on a "Solar Heated Lumber Dryer for the Small Business." In 1982, Iowa State University and the Forestry Section, Iowa Conservation Commission, constructed a solar heated lumber dryer at the State Forest Nursery in Ames, Iowa (fig. 1). This dryer was patterned after the Virginia model. Results from the Iowa solar dryer can be obtained from Forestry Extension, 253 Bessey Hall, Iowa State University, Ames, IA 50011.

Basic Design Fundamentals

The Iowa solar heated lumber dryer basically consists of a sloped passive solar collector which directly heats the interior of an insulated, tight, wood-frame building. A single or double layer of translucent plastic sloped at a 45° angle to the south functions as the collecting surface. The solar energy enters through the fiberglass, is incident on one of the black painted interior

surfaces, and is converted to heat. Warmed air is circulated through the lumber pile by fans. The fans are turned on during the day when the interior temperature reaches a specific temperature level. Vents located at the top and bottom of the north wall are opened manually as needed to reduce temperature and humidity levels and to bring in fresh air. Solar drying is dependent on day to day changes in temperature and humidity. During bright sunny days the temperature may be high, but during the night, temperatures will decrease, especially in non-insulated kilns. Fig. 1 is a transparent view of the solar lumber dryer showing basic components and interior dimensions.



Operation of the Solar Dryer

Locate the solar dryer on a site that is level, has good drainage, and is exposed to unobstructed, full south sunlight.

Lumber is stacked in the kiln using the same procedure as for other types of lumber drying. Stickers (or spacers) 3/4-inch thick and 1 1/4-inch wide are located every 18 inches along the length of the pile to separate the different layers of lumber.

Weight can be placed on top of the lumber pile to reduce tendency of the boards to cup while drying. At least 50 pounds per square foot is necessary; concrete blocks could be used as weight. If weight is added, the black plywood cover must be positioned on top of the blocks to promote solar absorption.

The solar energy comes through the fiberglass cover on the collector, strikes one of the black painted surfaces, and the resulting warm air is blown horizontally against the back of the collector and through the lumber stack. The air is continuously re-circulated with fresh air vented and introduced as needed. Maximum temperature and temperature rise (compared to outside temperature) must be limited during the early stages of drying of green hardwoods. As the lumber moisture content is reduced below 20 percent, the drying temperature may be increased substantially. For example, regular dry kiln schedules for green red oak lumber recommend a maximum temperature of 110°F until the lumber reaches 30 percent moisture content; below 20 percent, the temperatures may be increased to 140°F or more.

Drying Rate

The basic objective of lumber drying is to dry lumber as quickly as possible with the minimum amount of degrade (checks, splits, honeycomb, warp). Quality of drying is determined, in large part, by rate of moisture loss. Virginia has published a maximum safe rate of moisture loss per day for some hardwoods. The rates for 1-inch thick lumber for some common native species are shown in Table 1.

It is particularly important not to exceed these rates during early stages of drying green lumber. As the lumber dries below 20 percent moisture content, the risk of creating new drying defects is very low.

Table 1. Maximum rate of moisture loss per day for 1-inch thick lumber from selected hardwoods in a solar kiln.

Species	Maximum rate of moisture content loss per day (%)
cherry	5.8
elm, American	10.4
maple, soft	13.8
maple, hard	6.5
oak, red	3.8
oak, white	2.5
walnut	8.2

Monitoring Drying Rates for Air and Solar Drying

Samples of lumber are selected for use in measuring rate of moisture loss. These sample boards should represent the wettest and driest material in the load. At least two (preferably three or four) samples should be used. A section at least 30 inches long should be cut from the center of representative boards; these sections are used as sample boards. One inch wafers are cut from the ends of each kiln sample, weighed, dried at 220°F for at least 24 hours, and reweighed. Moisture content is then determined for each wafer using the following formula:

$$\text{Moisture content (\%)} = \frac{\text{original weight - ovendry weight} \times 100}{\text{ovendry weight}}$$

The ends of each sample board are sealed after the wafers are cut, and the sample boards are weighed. Individual sample boards are assumed to have the same original moisture content as the average of the wafers cut from each end. The estimated ovendry weight of each sample board is then calculated using the following formula:

$$\text{Ovendry weight} = \frac{\text{original weight} \times 100}{100 + \text{moisture content}}$$

The sample boards are placed in representative locations in the stack; for example, one in the middle of the south side, one near the bottom of the north side, and one near the top of the north side. As drying progresses, the samples are weighed periodically, and the moisture content is calculated using the current weight and the calculated oven-dry weight. Adjustments in the drying conditions are made by reducing or increasing the vent openings. Such adjustments may be needed on a daily basis during early stages of drying. Samples should be weighed daily during the first week of drying; less frequent weighing (weekly) may be appropriate during later stages of drying.

Summary

Air or solar drying is an economical way to dry native hardwood lumber to abut 15 percent moisture content which is suitable for may uses. However, proper piling techniques are essential to obtain good results. The objective of air drying lumber is to season the material as quickly as possible without excessive degrade due to drying defects. Remember, lumber used in furniture or other applications within a heated building must be dried further. Thoroughly air-dried lumber may have 19 percent moisture content or less and solar-dried lumber may have a moisture content of 7 to 8 percent.

Further information on characteristics of native woods is contained in extension pamphlet Pm-329, *"Properties and Uses of Iowa Hardwoods,"* available from your county extension office. Detailed discusion of air seasoning of lumber may be found in Air Drying of Lumber: A Guide to Industry Practices, Agriculture Handbook No. 402. The most effective current techniques for protecting the quality of stored lumber are surveyed in Storage of Lumber, Agriculture Handbook No. 531. Both of the handbooks are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Information on kiln drying of lumber is summarized in FORESTRY EXTENSION NOTE, F-328, available from Forestry Extension, 253 Bessey Hall, Iowa State University, Ames, IA 50011

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