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Air Seasoning

Native Hardwood Lumber

by Robert H. Perkins

Department of Forestry and Conservation

Cooperative Extension Service  PURDUE UNIVERSITY  Lafayette, Indiana
PREFACE

The information presented in this publication is based upon results of research on air-seasoning of native hardwoods by the Purdue Agricultural Experiment Station and upon existing knowledge found in any number of published references. However, source acknowledgment has been given for use of specific material or data.

Although the more important points involved in the procedural aspects of seasoning lumber by the air-drying method have been covered, an excellent general publication for those persons desiring more complete information in all phases of air-drying of lumber is the USDA Forest Products Laboratory Report 1657, entitled Air Drying of Lumber. Single copies of this report may be obtained without charge from the Education and Information Department of the Forest Products Laboratory at Madison, Wisconsin.

Cooperative Extension Work in Agriculture and Home Economics
State of Indiana, Purdue University
and the United States Department of Agriculture Cooperating
H. G. Diesslin, Director, Lafayette, Indiana
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Introduction

Lumber in use will fluctuate in moisture content according to surrounding atmospheric conditions, but best service will be obtained if lumber is first dried to the approximate average moisture content of its in-service environment. Considerable shrinkage and most of the natural tendency of wood to warp, twist, check and distort in cross-section will have occurred if wood is dried prior to use. Green lumber and timber have only limited uses.

The drying of green lumber by exposure to the outdoor air, although simple in concept, can increase profits for sawmill operators by upgrading rough-sawn lumber for expanded markets and save money for farmers and builders by cutting losses caused by use of green or improperly dried lumber. The minimum wood moisture content that can be achieved by air-drying will range from 10 to 15 percent depending upon the season of the year and section of the country. Lumber in this moisture content range is suitable for sheds, barns, fences, crates, wagon and truck bodies, bridges and other general rough-construction uses.

Air-drying is also used for initial drying of wood that must be kiln-dried to a lower moisture content for such uses as paneling, flooring, and furniture.

The purpose of this report is to present some of the problems and principles involved in the air-drying of lumber and to provide a guide for sawmill operators, wood products manufacturers, farmers, builders, and others for use in providing facilities for the efficient air-drying of rough-cut lumber. Some of the information presented will be of limited value to those desiring to dry only one or two stacks of material, i.e., yard layout, machine stacking, etc., but information of this sort has been listed so as to be easily passed-over by the reader for which it has no application.

General

Lumber stacked out-of-doors is dependent upon temperature and relative humidity of the air and the circulation of this air within the pile—for loss of moisture. The temperature and relative humidity depend upon the region of the country and the season of the year; air circulation depends upon wind and natural horizontal and vertical movement of air within the pile. The vertical movement, greatly aided by correct pile construction, is generally downward because the air becomes heavier as it gains moisture from the wood. The horizontal movement, also favored by correct pile construction, is caused by the vertical air movement and the difference in air pressure between the two sides of the pile caused by winds. ¹

The rapidity of loss of moisture in wood being air-dried will generally vary according to season of the year and region of the country. The most rapid drying period in the Central States Region is in the spring when atmospheric humidity is lowest and becomes progressively slower during the summer and fall as the atmosphere becomes more humid. Winter is the most unfavorable period of all because of the higher relative humidity and the adverse effect of low temperatures on the movement of moisture in wood. In some cases lumber which has become air-dry during the active drying period will absorb moisture during the winter months. Direct wetting of the lumber by precipitation will also retard drying. Covers or roofs

¹ Rate of air circulation can be increased by use of fans. However, forced-air drying entails particular considerations which are beyond the scope of this publication. Complete information on this specialized air-drying technique may be obtained from the USDA Forest Products Laboratory, Madison, Wisconsin.
on piles will help minimize direct wetting but will not stop penetration of wind-blown precipitation. Rate of drying is also dependent upon site conditions, pile height, species, thickness of material and other factors. It is thus not possible to accurately predict the length of time to air-dry a stack of lumber. Table 1 presents approximate drying periods for 1-inch thick green lumber of some species common to Indiana. The estimates are for hand-stacked piles for widths of up to 16 feet. Machine piled lumber in unit packages are usually not as wide and would probably dry somewhat faster. The range of listed periods of the respective species reflects the influence of seasonal variations. Lumber stacked in the spring would require the shorter period.

As stated above, the drying of lumber prior to use is desirable and necessary for satisfactory service in most applications but is not without some element of hazard. As in kiln-drying, losses are sometimes incurred in air-drying from staining, warping, and checking. These losses can be largely eliminated, however, by good technique in all phases of air-drying.

Pile or Yard Location

The drying location should be selected for good drainage. Soil on poorly drained sites does not dry quickly and causes high relative humidity under the pile which in turn retards drying and promotes stain and decay.

The site should be high relative to surrounding objects and level. A high site promotes rapid drying from the standpoint of good drainage and unobstructed wind flow.

Levelness of site reduces cost of pile foundations and facilitates ease of stacking and movement of trucks and forklifts.

Vegetation restricts the movement of air and must be kept from under and around the pile. The most efficient way to control

<table>
<thead>
<tr>
<th>Species</th>
<th>Days in drying period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ash:</td>
<td>60-200</td>
</tr>
<tr>
<td>Black</td>
<td>60-200</td>
</tr>
<tr>
<td>White</td>
<td>60-200</td>
</tr>
<tr>
<td>Basswood</td>
<td>40-150</td>
</tr>
<tr>
<td>Beech</td>
<td>70-200</td>
</tr>
<tr>
<td>Cherry, black</td>
<td>70-200</td>
</tr>
<tr>
<td>Elm, American</td>
<td>50-150</td>
</tr>
<tr>
<td>Hickory</td>
<td>60-200</td>
</tr>
<tr>
<td>Maple, hard</td>
<td>50-200</td>
</tr>
<tr>
<td>Oak:</td>
<td></td>
</tr>
<tr>
<td>Red</td>
<td>70-200</td>
</tr>
<tr>
<td>White</td>
<td>80-250</td>
</tr>
<tr>
<td>Sweetgum:</td>
<td></td>
</tr>
<tr>
<td>Heartwood</td>
<td>70-300</td>
</tr>
<tr>
<td>Sapwood</td>
<td>60-200</td>
</tr>
<tr>
<td>Walnut, black</td>
<td>70-200</td>
</tr>
<tr>
<td>Yellow-poplar</td>
<td>40-150</td>
</tr>
</tbody>
</table>

Source: USDA Forest Products Laboratory Technical Note. No. 233.

vegetation is by spraying with herbicides. Ideally, the ground surface should be covered with gravel, crushed stone or other firm covering. This retards growth of vegetation and aids in the operation of lumber-hauling and piling equipment.

The area around the pile must also be kept free of such debris as old boards, discarded stickers and bark. Such trash provides excellent accommodations for development of stain and decay organisms which are easily transferred to the stacked lumber.

Yard Layout

For operations requiring the use of more than one or two stacks, consideration must also be given to the physical arrangement of the piles. The main points concerning drying yard layout have been abstracted
from the USDA Forest Products Laboratory Report No. 1657, entitled "Air-Drying of Lumber".

Hand-stacked Piles

The three types of alleys in a hand-stacked air-drying yard are main, cross and rear (Figure 1a). Rear alleys, 6 feet wide or more, serve as passageways for the movement of air and can also contain ditches to drain surface water. The main and cross alleys are for access to the piles. In addition to the alleys, hand-stacked yards have spaces 2 to 6 feet wide between the piles that may also form long straight passages through the yard. For hand stacking, main alleys are usually 16 to 20 feet wide and cross alleys spaced every 200 or 300 feet for transportation and fire protection are usually 60 feet or wider.

Machine-stacked Piles

In yards where stacking consists primarily of pre-assembled packages piled by fork-lift truck, the main alleys are 24-30 feet wide to provide room for vehicle maneuvering. Rear alleys are not a rule used in yards consisting of packaged piles, the rows of which run from main alley to main alley (Figure 1b). The width and spacing of the cross alleys are the same as for hand-stacked yards.

Pile Foundations

Hand-stacked Piles

Piles must be provided with well-built, sturdy foundations of decay resistant material. Green lumber of most species will weigh 40-60 pounds per cubic foot. A moderate sized stack thus represents considerable weight which will cause poorly built foundations to settle unevenly and in some cases fail, resulting in lumber degrade and loss. Concrete piers or treated posts set in the ground below the frost line make a most satisfactory support for stringers. A suggested spacing of the support piers or posts is 4 feet along the length and across the pile. In no case should the supports be spaced more than 5 feet along the pile and 5 feet apart across the pile. With the 4-foot spacing, stringers 4 by 6 inches in dimension placed on edge on the piers or posts along the length of the pile may be used for small stacks not more than 15 feet high. Cross-beams, 4 by 4 inches are placed on top of the 4- by 6-inch stringers across the width of the pile and spaced 2 feet apart. If the piers or posts have a 5-foot spacing, or if piles are expected to be 20-25 feet high, 6- by 8-inch stringers placed on edge must be used. Cross-beams 4 by 6 inches are placed on edge across the 6- by 8-inch stringers and spaced 2 feet apart. Preferably, material for stringers and cross-beams should be pressure treated and stress rated for a minimum allowable fiber stress in bending of 1500 psi. When stress-rated material is not available preservative treated, rough-sawed stringers and cross-beams of one of the more dense hardwoods such as oak or hickory will also be satisfactory if the pieces are free of large knots, shake, pith, bark and areas of decay. The foundation should be sloped from front to rear about 1 inch for every foot of length to insure water run-off. It is generally recommended the ends of the stringers at the rear of the pile be at least 12 inches from the ground. The clearance between the stringers and the ground at the front of the pile will thus be about 2 to 2-1/2 feet for piles 12-18 feet long which provides ample space for air movement under the stack.

Timbers are sometimes placed directly on the ground, instead of on posts or piers, to support the stringers and cross-beams. This type of foundation is undesirable because it reduces movement of air under the pile.

Machine-stacked Piles

Foundations for piles made of packages of lumber put in place with fork-lift
trucks differ from those of hand-stacked piles because provision must be made for access to the piles by the lift-truck. Since the rows of piles are laid out perpendicular to the main alleys (Figure 1b), the usual arrangement is to have removable supports in the center of the pile foundation which are removed when necessary to provide a roadway through unloaded supports to a pile. The last pile to be stacked in any row is the one closest to the main alley. It follows then, that the first pile will be located within

![Diagram](image)

(a) Suggested layout for hand-stacked yard.

![Diagram](image)

(b) Suggested layout for machine-stacked yard.

Figure 1. Pile arrangement in air-drying yards.
the row a predetermined distance from the alley. If alleys are on both ends of a row the pile in the center is usually the first to be stacked. In building a pile the fork-lift turns at right angles to the alley and carries the package of lumber to be stacked along the path through the center of the unloaded foundations until it reaches the pile being built. When a stack is finished the center supports are replaced in the unloaded foundation of the next pile closer to the main alley that is to be stacked.

Perhaps the easiest way to provide for removable supports is to pour concrete piers so that their tops are level with the ground and use blocking between the piers and support stringers. The roadway through the foundations has to be level and have a firm surface of gravel, crushed stone or other surfacing material. The more elaborate installations use roadways paved with asphalt.

The foundations may not be sloped, depending upon the ability of the fork-lift to orient the bottom of the package to the same slope as the pile when lifting packages into place. Bolsters that are placed between individual packages in a pile, usually 4 by 4 inches in cross-section, do not provide enough clearance in a sloped pile for the lift-forks of the truck to slide between the packages. If the lift-forks cannot be tilted to conform to the pile slope, the pile foundation will have to be kept essentially level. Sloped roofs or covers on level piles are used to help drain away water from rain and melting snow. Materials, spacing of supports, and size of support members should be the same as those specified for hand-stacked piles.

Stacking

Hand-stacked Piles

Equally important with proper foundations for piles is correct selection and placement of stickers between succeeding layers of lumber. The stickers should be straight, of uniform thickness, free from bark, decay and stain, and seasoned before use if possible. Stickers of green wood reduce rate of drying and increase chances for stain in the lumber. It is poor practice to use board edgings and other sawmill waste for stickers. It is much more economical in the long-run to use stickers specially cut for that purpose. Recommended dimensions are 1 inch thick and 1 to 1-1/4 inches wide. Sometimes stickers up to 2 inches wide are used at the front of the pile with the edge of the sticker projecting slightly beyond the end of the boards to slow the drying and reduce the splitting and checking of the board ends. Since stickers retard drying in the immediate vicinity of contact with the board surface, the proper number of stickers to use constitutes a compromise. Use only enough to restrain warping of the lumber as it dries. A recommended spacing of stickers for hardwoods is every 2 feet. The stickers must be placed directly over the foundation cross-beams, with the ends in good vertical alignment so that each tier of stickers is supported by a cross-beam. In cases of occasional short boards where the ends do not occur over a cross-beam, place a short sticker under the board end. The full-length sticker over the cross-beam that wasn't reached by the short board will fill in the space and support the next layer of boards. Do not allow short board ends to occur directly over each other.

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2 End checking may also be reduced by coating the board ends with commercially developed products readily available from any dry kiln company.
Figure 2. An example of very poor lumber stacking. Note the inadequate ground clearance and slope in the pile foundation. In addition, the lack of proper sticker placement and alignment is contributing to the lumber warpage easily seen in the photograph.

in succeeding layers. Stacking boards too long for the foundation is a common error. The 2- or 3-foot-long over-hanging board end has no support and will be severely warped during drying. Figure 2 is an illustration of very poor technique in regard to pile foundation, sticker placement, and over-hanging and unsupported board ends. Serious degrade will occur during drying under the conditions imposed in such stacking.

In sloped piles the front row of stickers of each board layer should protrude slightly beyond the board ends in the previous layer so that the front of the pile remains vertical or pitched slightly forward. Figure 3 illustrates proper placement of stickers and pitch in a correctly stacked pile.

Segregate lumber before stacking according to species, thickness and grade.

Species segregation is important because of the differences in drying rate among species. Stacking according to uniform thickness is important because of differences in drying rate and warpage occurring in the thinner pieces that are not held down by contact with the stickers. All things being equal, 2-inch thick lumber will require 3 to 5 times longer to air-dry than 1-inch thick lumber. Separation by species, grade and thickness promotes accessibility for use and is essential to efficient merchandising in commercial yards. Width of spacing to use between edges of boards in the pile depends upon species, board width, pile height and the season of the year the lumber is first stacked. Spaces are necessary for the vertical downward movement of air within the pile which promotes the horizontal movement of air between the layers of boards for drying. The wider the board-edge spacing, the more

Figure 3. Correct alignment and placement of stickers directly over the cross-beams which have the suggested spacing of 2 feet on center across the main stringers of a sloped foundation. A slight forward pitch of the front of the pile is also shown.
vertical air movement. The correct spacing for any given situation can only be determined by experience. A good starting point would be a 1-inch spacing. For piles over 12 feet wide or consisting mainly of wide boards, or 20-25 feet high, the spacing would need to be increased to a minimum of about 1-1/2 to 2 inches as a beginning point. In such instances, the 1-inch spacing might also be used if a double thickness of stickers is used in the lower layers of the pile. In piles of random-width lumber, where vertical alignment of the spaces between board edges is continuously interrupted, the effective width of the pile may be reduced by leaving a wider space, 6 to 18 inches wide, in the center of the pile for the entire pile height.

Spacing of piles within a row can vary, but a minimum of 4 feet is recommended to insure good air movement.

Pile width will also vary, with 16 feet being the widest for efficient drying under optimum conditions. Maximum pile height is generally about 16-18 feet; above this, hand-stacking becomes too laborious.

**Machine-stacked Piles**

Recommendations for stickers, their placement, separation of lumber prior to stacking, etc., that have been listed for hand-stacked piles generally apply to machine-made piles. The main difference is that the packages that are stacked to form a pile are usually pre-assembled at a spot away from the drying yard. Pile heights may also be higher than the hand-made piles, but they are somewhat dependent upon the fork-lift being used. Twenty-five feet is probably maximum from the standpoint of efficient drying and stability of the pile against tipping.

**Roofs and Covers**

Research findings of numerous organizations have shown the economic feasibility of using covers on all air-drying piles, except possibly, those of very low-grade material. Roofs protect the lumber from precipitation and sunshine which in some cases cause extensive degrade of the top layers of the pile. Precipitation can also more readily penetrate the uncovered pile from the top and seriously retard drying, thus contributing to possible infection of the lumber by stain and decay.

Covers may be fabricated of low-grade material and covered with roofing paper, plastic film or other waterproof material. The roof should be pitched from front to rear for water drainage. In sloped piles the pitch of the roof can follow that of the pile. Covers should be raised at least 4 inches above the top layer and extend about a foot over the front and sides of the pile and 2 to 3 feet over the rear. The added extension at the rear allows water draining from the roof to fall free of the pile. Covers made of a wood frame covered with sheet-metal roofing are durable and are relatively inexpensive if equipment is available to remove and replace them in one piece so that they may be re-used several times.

A simply constructed roof, which protects the top of the pile from direct sunshine but is not leak-proof, is made from a double layer of close-piled boards. The boards in the top layer are placed so that they cover the joint made by two adjoining boards in the bottom layer.

Two or three wire ties running from each side of the roof down to outriggers inserted between two layers of boards 2 or 3 feet from the top of the pile will be needed to keep the covers in place.

**Stain Control**

Generally speaking, lumber seasoning defects during air-drying can be effectively controlled by proper attention to pile foundations and stacking. In some species one defect not always subject to control by such measures is that of stain. However, the
Table 2. Products for the control of stain, mold, and decay in green lumber

<table>
<thead>
<tr>
<th>Product</th>
<th>Suggested concentration, pounds per 100 gallons of water</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>BORAX</td>
<td>32</td>
<td>Numerous sources</td>
</tr>
<tr>
<td>DOWICIDE G (technical sodium pentachlorophenate)</td>
<td>7</td>
<td>Chapman Chemical Co.</td>
</tr>
<tr>
<td>DOWICIDE H (technical sodium tetrachlorophenate)</td>
<td>6</td>
<td>Chapman Chemical Co.</td>
</tr>
<tr>
<td>LIGNASAN (6.25% ethylmercury phosphate)</td>
<td>2</td>
<td>E. I. du Pont de Nemours &amp; Co., Inc.</td>
</tr>
<tr>
<td>MELSAN (Lignasan and sodium pentachlorophenate)</td>
<td>4</td>
<td>E. I. du Pont de Nemours &amp; Co., Inc.</td>
</tr>
<tr>
<td>NOXTANE (sodium pentachlorophenate borax and soda)</td>
<td>10</td>
<td>Wood Treating Chemicals Co.</td>
</tr>
<tr>
<td>PERMATOX 10S (sodium pentachlorophenate and borax)</td>
<td>10</td>
<td>Chapman Chemical Co.</td>
</tr>
<tr>
<td>SANTOBRITE (technical sodium pentachlorophenate)</td>
<td>7</td>
<td>Monsanto Chemical Co.</td>
</tr>
<tr>
<td>Mixture 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lignasan + Dowicide G or Santobrite</td>
<td>1 + 4</td>
<td></td>
</tr>
<tr>
<td>Mixture 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lignasan + Dowicide G or Santobrite + Borax</td>
<td>1/2 + 2 + 6</td>
<td></td>
</tr>
</tbody>
</table>

Source: Toole, Richard E., 1969. Protection of Unseasoned Lumber from Damage by Fungi, Mississippi Forest Products Laboratory Information Series 9, State College of Mississippi.

Fungi which cause discoloration of lumber, thus detracting from its appearance, can usually be controlled by applying a toxic solution to the surfaces of the wood. To be effective, the freshly cut stock must be treated at once. Lumber is usually treated by passing the lumber through a dipping vat while it is still being processed on the sawmill green chain. On small mills, and other situations of low volume, the lumber may be dipped by hand. The solutions may also be applied with a hand sprayer, but complete immersion by dipping insures adequate coverage.

Table 2 presents several chemicals with suggested concentrations for use in control of fungi.