Logging - Saw Milling - Forest Products

1/ Air drying lumber

From the Horses Mouth - Air Drying Lumber - by Chris Lincoln
S&W Report / Summer / Fall 1998, Volume 12

The longer I work with wood, the more I marvel at its versatility, and the more I realize that, the quality of the final product is directly related to the quality of care given stacking and stickering the lumber for drying. The following information is taken from a handout I give customers before sawing their logs. There have been piles of quarter sawn and high quality boards turned to garbage by stacking an uneven ground, using green stickers, or orienting the pile in a manner that does not encourage air circulation. There are just a few tricks I have discovered along the way.

If you know of a better/different way to do something, please let me know. The goal of "From the Horses' Mouth" is to encourage the exchange of information amongst our membership.

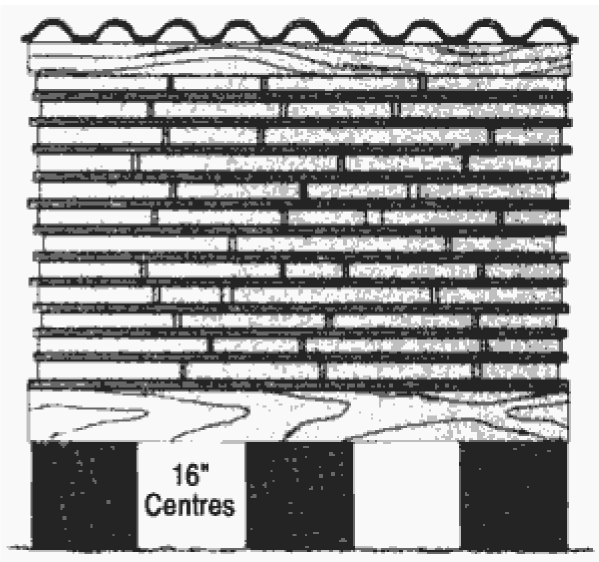
Before You Begin Stacking:

- Make sure that you have more than enough dry, insect, fungus and bark free stickers. The ideal wood to use is dry 1" x 2" cedar since it doesn't seem to react with other woods.
- Paint log ends and colour code them for species and year.

Preparing the Site:

- Make sure the ground is level, then create a base that will keep the lumber at least 12" off the ground.
- The ideal site for drying lumber is in a clearing, on high ground, with a gravelly base.
- Cut or spray all vegetation around the base of the stack.
- Orient the piles in a north south direction so that the air will move easily through them. If stacks are grouped, orient them northeast to southwest so that a west wind hits the end of the stacks and air is forced along all of the rows.

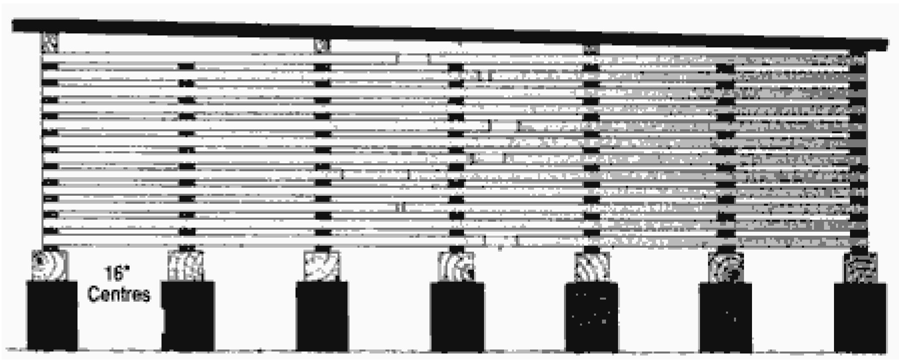
End view of stickered pile:



Stacking and Stickering:

- Sort your lumber, your longest boards and boards taken from reaction wood go on bottom.
- Make sure that all bark is off the planks.
- When stickering, the maximum sticker spacing is 16" for hardwood and 24" for softwood
- After your boards have been stacked; cover them with material that extends at least 12" over all sides. Old roofing tin works well, and can be easily tilted to facilitate runoff.
- As your wood dries, keep vegetation cut around the piles so that there is always good air movement.

Side View of Stickered Pile:



Moisture Content:
The difference between free water and bound water - even though it is self explanatory, it is useful to think of the wood as a sponge. Once the sponge is squeezed out (free water) the sponge is still damp and needs to dry (bound water)

Average Green Moisture Content of Selected Hardwoods: By properly positioning the wettest lumber in the pile, you can take advantage of the greater air movement on the west side of the stack :

Average Green Moisture Content

	%Heartwood	%Sapwood
White Ash	46	44
Aspen	96	113
Basswood	81	133
Beech	55	72
Birch, Yellow	74	72
Cherry, Black	58	
Hickory	80	54
Maple, Hard	65	72
Oak, Red	80	69
Oak, White	64	78
Sycamore	114	130
Walnut, Black	90	73
Yellow Poplar	83	106

Table 2 shows the approximate time to air dry lumber to 20% moisture content. The lower figure is spring / summer (good drying weather) and the higher figure is lumber stacked over the winter

Hardwood Drying Times

Hardwoods	Days
Ash, White	60-200
Aspen	50-150
Basswood	40-150
Beech	70-200
Birch, Yellow	70-200
Butternut	60-200
Cherry, Black	70-200
Elm	50-150
Hickory	60-200
Maple, Red	30-120
Maple, Hard	50-200
Oak, Red	70-200
Oak, White	80-250
Sycamore	30-150
Walnut, Black	70-200
Yellow Poplar	40-150

Sawmilling Concepts - Part IV: Introduction to Drying Lumber

This is Part IV of our series about sawmilling concepts. The purpose of the series is twofold. It provides some useful tips to those who own a portable sawmill. It will also assist landowners, who may want to purchase a mill or hire a sawyer, gain a better understanding of proper sawing techniques.

Topics covered in the series include: sawing lumber, using the quarter scale, saw blade maintenance, introduction to drying lumber, determining moisture content of wood, wood drying defects, methods of drying lumber and dry kilns.

In Part IV, we examine the reasons for drying lumber.

What is lumber drying?
Lumber drying is the process of systematically removing excessive moisture from boards to a point where they will remain dimensionally stable.

Why is it necessary to dry lumber?
Logs (green wood) contain huge amounts of water when first cut. If wood is not properly dried it will shrink or swell. Lumber loses water by evaporation into air. It will eventually become stable when it reaches its final equilibrium moisture content or EMC. This depends on the surrounding environmental conditions, relative humidity and temperature.

Softwoods with more than 20% moisture content are considered green. Hardwoods are considered green until they reach the desired moisture content for the intended purpose of the wood. If left outside in most areas of North America, the minimum EMC that can be attained will be 11% to 12%. **This is 4% to 5% higher than the average EMC needed for wood furniture or other interior woodwork**.

	Moisture Content (%)			Moisture Content (%)	
Species Hardwoods	Heartwood	Sapwood	Species Softwoods	Heartwood	Sapwood
Ash, white	46	44	Cedar, eastern red	33	---
Aspen	96	113	Cedar, Port-Orland	50	96
Basswood	81	133	Cedar, western red	58	249
Beech, American	55	72	Fir, balsam	88	173
Birch, paper	89	72	Fir, coast-type Douglas	37	115
Cherry, black	58	---	Hemlock, eastern	97	119
Cottonwood	162	146	Hemlock, western	85	170
Elm, American	95	92	Larch, western	54	119
Hackberry	61	65	Pine, lodgepole	41	120
Hickory	80	54	Pine, ponderosa	40	148
Maple, sugar	65	72	Pine, sugar	96	219
Oaks, northern red	80	69	Pine, western white	62	148
Oaks, white	64	78	Redwood, old growth	86	210
Poplar, yellow	83	106	Spruce, Engelmann	51	173
Sycamore, American	114	130	Spruce, Sitka	41	142
Walnut, black	90	73	Tamarack	49	---

Forest Products Laboratory

Figure 1: This table shows the average green moisture content for the heartwood and sapwood by species.

The average interior EMC in most of North America is between 6% and 8%. Therefore, it is necessary to dry the lumber to the end use moisture content conditions by artificial means (kiln drying) to keep the wood from shrinking after it is manufactured into a wood product.

Moisture in Wood and Wood Shrinkage

Free water - is the liquid water found in the interior of the wood cell. It makes up the majority of the moisture content of the wood when the tree is first cut into a log.

Bound water - is the water vapor molecules that are chemically bonded to the wood cell structure within the cell wall. When bound water begins to leave the cell wall the wood begins to shrink.

Fibre saturation point (fsp) - the point in the drying of wood when bound water first begins to leave the wood cell wall and the wood begins to shrink is called the fibre saturation point. The average fsp for most woods is when wood reaches approximately 28% moisture content (MC).

Desorption - refers to the loss of water vapor molecules at the hydrogen bonding sites. When this happens, wood shrinks.

Adsorption - refers to the taking on of water vapor molecules at the hydrogen bonding sites. When this happens, wood swells.

What effect does moisture have on wood?

When the moisture content of wood drops below the fibre saturation point, wood begins to shrink and will continue to shrink until the moisture content reaches 0%. If the conditions are right, the wood will also take on water vapor molecules and will swell back close to the original size (the size it was at fibre saturation point when it began to shrink). Once it reaches fibre saturation point, any additional moisture will not cause it to swell any more.

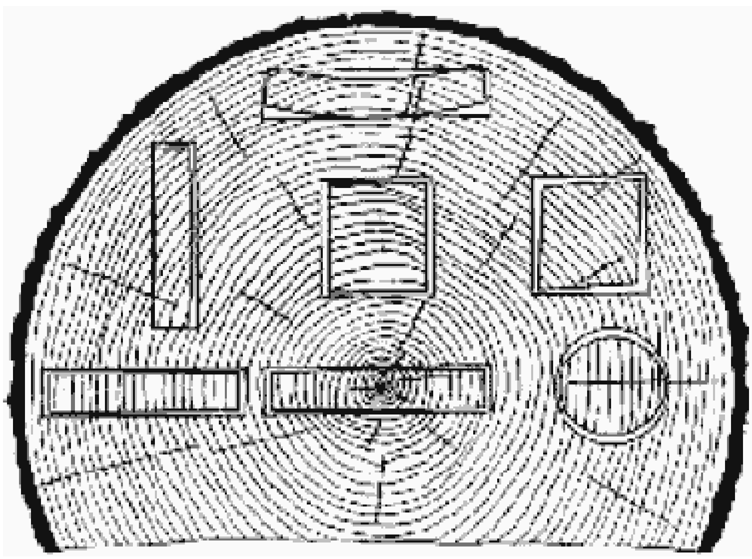


Figure 2:
Note the characteristic distortion and shrinkage of rectangular, round and square pieces as affected by orientation of growth rings. The tangential shrinkage is about twice as much as radial shrinkage

Wood shrinks and swells differently in different directions. Quarter sawn boards (radial shrinkage) will shrink and swell less than plain sawn (tangential shrinkage) boards. You should be aware that shrinkage in the longitudinal direction is very little

(from - 0.2% - or 0.002 times the longitudinal direction) and each different species of wood has different shrinkage values in different directions (tangential and radial).
For the most part, wood shrinkage from fsp (28% MC) to oven dry (0% MC) does not concern us. Changes in the size of wood product occur most often when interior equilibrium moisture content changes from summer to winter in most areas of the country. These changes are caused by drastic changes in temperature and relative humidity from summer to winter can range from 2% in Kansas to 7% in Maine. This causes doors that close nicely in winter to stick in summer. It can cause joints in wood to open up or crack.

Moisture Movement in Wood

In softwoods, as wood begins to dry, the liquid water begins to move from the cell lumen to the outside, by passing through the pits in the cell walls of softwoods. Also, water moves out the ends of the board through the cut longitudinal tracheids.

As the moisture content reaches fibre saturation point, movement of liquid molecules changes to movement of water vapor molecules that move by molecular action. This is a jumping action from one hydrogen-bonding (OH) site to another through the cell wall. They "jump" from one cell wall to another until they reach the outside environment. If a particular species has its pits aspirated (closed), then the liquid water in the cell lumen must first vaporize then move to the outside by molecular action also.

The hardwood structure is completely different than the softwood structure. Hardwoods have specialized cells called vessels or pores. Some hardwoods have huge pores while others have very small pores. These pores allow considerably easier movement of liquid moisture through hardwoods than softwoods. However, this doesn't mean hardwoods will kiln dry faster than softwoods. Most softwoods have considerably less water in them when they are first cut (green moisture content). Drying times are dependent on species' microstructure, green moisture content and pit aspiration changes.

How fast does wood dry?

How quickly moisture moves out of the wood is totally dependent on the wet-bulb depression. The wet-bulb depression is the difference between the dry-bulb temperature and the wet-bulb temperature. The dry-bulb temperature is the actual temperature measured with a typical thermometer.

The wet-bulb temperature is a little bit more difficult to understand. The thermometer is kept wet with a wick-like cover, from which water evaporates at a rate determined by the dryness of the air around it.

If the air is extremely humid (high relative humidity) the wet-bulb temperature will be close to the dry-bulb temperature. This creates a very small wet-bulb depression and very little moisture movement will occur from the wood to the surrounding air.

If the air is extremely dry (low relative humidity) the wet-bulb temperature will be considerably lower than the dry-bulb temperature. This creates a very high wet-bulb depression and a great deal of moisture movement will occur from the wood to the surrounding air.

If the wood is left in a constant environment (dry-bulb temperature and wet-bulb depression) for a reasonable length of time, the wood will attain a certain moisture content. Figure 3 provides the kiln operator with the information to determine that moisture content.

Moisture content of wood in equilibrium with stated temperature and relative humidity																				
Temperature		Moisture content (%) at various relative humidity values																		
(°C)	(°F)	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
-1.1	30	1.4	2.6	3.7	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.4	11.3	12.4	13.5	14.9	16.5	18.5	21.0	24.3
4.4	40	1.4	2.6	3.7	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.4	11.3	12.3	13.5	14.9	16.5	18.5	21.0	24.3
10.0	50	1.4	2.6	3.6	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.3	11.2	12.3	13.4	14.8	16.4	18.4	20.9	24.3
15.6	60	1.4	2.5	3.6	4.6	5.4	6.2	7.0	7.8	8.6	9.4	10.2	11.1	12.1	13.3	14.6	16.2	18.2	20.7	24.1
21.1	70	1.3	2.5	3.5	4.5	5.4	6.2	6.9	7.7	8.5	9.2	10.1	11.0	12.0	13.1	14.4	16.0	17.9	20.5	23.9
26.7	80	1.3	2.4	3.5	4.4	5.3	6.1	6.8	7.6	8.3	9.1	9.9	10.8	11.7	12.9	14.2	15.7	17.7	20.2	23.6
32.2	90	1.2	2.3	3.4	4.3	5.1	5.9	6.7	7.4	8.1	8.9	9.7	10.5	11.5	12.6	13.9	15.4	17.3	19.8	23.3
37.8	100	1.2	2.3	3.3	4.2	5.0	5.8	6.5	7.2	7.9	8.7	9.5	10.3	11.2	12.3	13.6	15.1	17.0	19.5	22.9
43.3	110	1.1	2.2	3.2	4.0	4.9	5.6	6.3	7.0	7.7	8.4	9.2	10.0	11.0	12.0	13.2	14.7	16.6	19.1	22.4
48.9	120	1.1	2.1	3.0	3.9	4.7	5.4	6.1	6.8	7.5	8.2	8.9	9.7	10.6	11.7	12.9	14.4	16.2	18.6	22.0
54.4	130	1.0	2.0	2.9	3.7	4.5	5.2	5.9	6.6	7.2	7.9	8.7	9.4	10.3	11.3	12.5	14.0	15.8	18.2	21.5
60.0	140	0.9	1.9	2.8	3.6	4.3	5.0	5.7	6.3	7.0	7.7	8.4	9.1	10.0	11.0	12.1	13.6	15.3	17.7	21.0
65.6	150	0.9	1.8	2.6	3.4	4.1	4.8	5.5	6.1	6.7	7.4	8.1	8.8	9.7	10.6	11.8	13.1	14.9	17.2	20.4
71.1	160	0.8	1.6	2.4	3.2	3.9	4.6	5.2	5.8	6.4	7.1	7.8	8.5	9.3	10.3	11.4	12.7	14.4	16.7	19.9
76.7	170	0.7	1.5	2.3	3.0	3.7	4.3	4.9	5.6	6.2	6.8	7.4	8.2	9.0	9.9	11.0	12.3	14.0	16.2	19.3
82.2	180	0.7	1.4	2.1	2.8	3.5	4.1	4.7	5.3	5.9	6.5	7.1	7.8	8.6	9.5	10.5	11.8	13.5	15.7	18.7
87.8	190	0.6	1.3	1.9	2.6	3.2	3.8	4.4	5.0	5.5	6.1	6.8	7.5	8.2	9.1	10.1	11.4	13.0	15.1	18.1
93.3	200	0.5	1.1	1.7	2.4	3.0	3.5	4.1	4.6	5.2	5.8	6.4	7.1	7.8	8.7	9.7	10.9	12.6	14.6	17.5
98.9	210	0.5	1.0	1.6	2.1	2.7	3.2	3.8	4.3	4.9	5.4	6.0	6.7	7.4	8.3	9.2	10.4	12.0	14.0	16.9
104.4	220	0.4	0.9	1.4	1.9	2.4	2.9	3.4	3.9	4.5	5.0	5.6	6.3	7.0	7.8	8.8	9.9			
110.0	230	0.3	0.8	1.2	1.6	2.1	2.6	3.1	3.6	4.2	4.7	5.3	6.0	6.7						
115.6	240	0.3	0.6	0.9	1.3	1.7	2.1	2.6	3.1	3.5	4.1	4.6								
121.1	250	0.2	0.4	0.7	1.0	1.3	1.7	2.1	2.5	2.9										
126.7	260	0.2	0.3	0.5	0.7	0.9	1.1	1.4												
132.2	270	0.1	0.1	0.2	0.3	0.4	0.4											Forest Products Lab		

Figure 3: Relative humidity and equilibrium moisture content values occurring at various dry-bulb temperature and wet-bulb depressions.

What happens if wood is not dried properly?

Before it is made into a final product, wood should be dried (as closely as possible) to the moisture content it will equalize to in the final environment (temperature and relative humidity) where it will be placed into service. For example, if the wood is to be made into a table in a house in Michigan at 7% EMC, the wood should be dried to 7% moisture content before the table is produced.
Module IV: Lumber Drying
If it is not properly dried, the wood will shrink or swell until it reaches its final EMC after the product is made. This may cause severe project deformation and possible product recall and loss of money.

Determining Moisture Content of Wood

The moisture content of wood is a ratio of the weight of the water in the wood, to the weight of the wood without any water in it. It is expressed as a percentage, and often the water in the wood can weigh more than the wood itself, making the moisture content greater than 100%.

Other key terms concerning weight are:

Specific gravity - the ratio of the weight of a material of a certain volume to the weight of an equal volume of water.

Density - the weight of a material per some unit volume, such as pounds per cubic foot, pounds per cubic yard, grams per cubic centimetre, etc.

Green weight - the weight of wood prior to drying process.

Oven Dry Weight (ODW) - the weight of wood after oven or microwave drying; all moisture has been driven out of the wood.

Moisture Meters

A variety of moisture meters are available to measure the moisture content of wood. The most common are those that measure either the electrical resistance between two points in the wood or those that measure the density of the wood with a magnetic field.

Electric Meters - require the penetration of two probes into the wood. They measure the electrical resistance between these two points. The problem is they can only measure moisture contents between 6% and fibre saturation point. They also leave two holes in the wood.

Density Meters - measure the density of the wood with the moisture in it. They require that the specific gravity of the wood be programmed into the meter to compensate for the differences in wood densities between species.

In the Next Edition

In Part V of this series, we will look at wood drying defects commonly seen in lumber operations.

Sawmilling Concepts – Part V: Wood Drying Defects and Warpage

This is Part V of our series about sawmilling concepts. The purpose of the series is twofold. It will provide some useful tips to those who own a portable sawmill. It will also assist landowners, who may want to purchase a mill or hire a sawyer, gain a better understanding of proper sawing techniques.

Topics covered in the series include: sawing lumber, using the quarter scale, saw blade maintenance, introduction to drying lumber, determining moisture content of wood, wood drying defects, methods of drying lumber and dry kilns.

In Part V, we will learn about wood drying defects and types of warpage commonly encountered in lumber operations.

Wood Drying Defects and Warpage Importance of Proper Drying Schedules

Each species of wood varies in its microstructure: size of pits between fibers, size of fibers, number and size of pores, presence of tyloses, aspirated pits and possible drastic variations in the extractive contents. The moisture movement during the drying process can vary drastically between species. Therefore, each species has been tested by experienced kiln operators, and drying schedules have been determined that are the best for each individual species. If these schedules are deviated from too much, severe drying defects can occur.

Wood Drying Defects

If wood was dried very slowly we would not have to worry about many drying defects. However, since most kiln drying is done to get the wood into service as quickly as possible, several of the following defects may occur:

Surface checking – surface checks are failures that occur in the wood rays on the flat sawed surface of the lumber. They normally occur in the initial stage of drying when relative humidity is too low.

End checks/end splitting – end checks are cracks at the end of the board that are caused by the water moving out the end of the board more quickly than from the sides or edges. It normally occurs in the initial stage of drying when relative humidity is too low. It is a common drying defect and can be somewhat controlled by end-coating boards before kiln drying. End splitting is an extension of end checks.

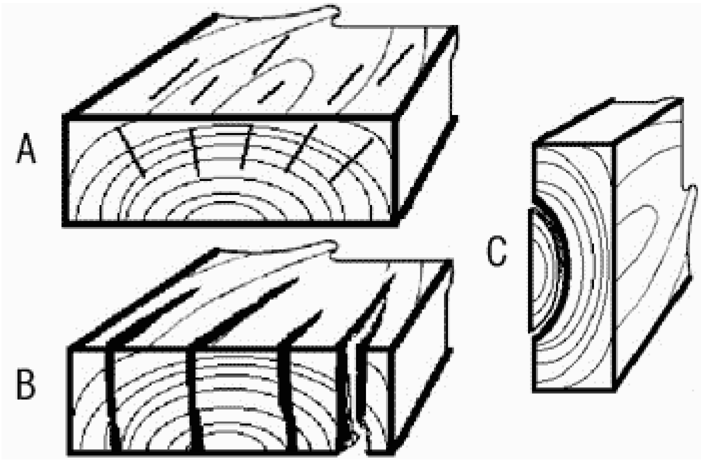


Figure 1: Several defects can occur due to improper drying, including (A) surface checking, (B) end checks and end splitting, wood cell collapse, honeycombing and (C) ring shake.

Wood cell collapse – cell collapse results from liquid (water) being removed too quickly during drying, causing the board to actually collapse into itself. Extremely high temperatures cause this defect in the early stages of drying.

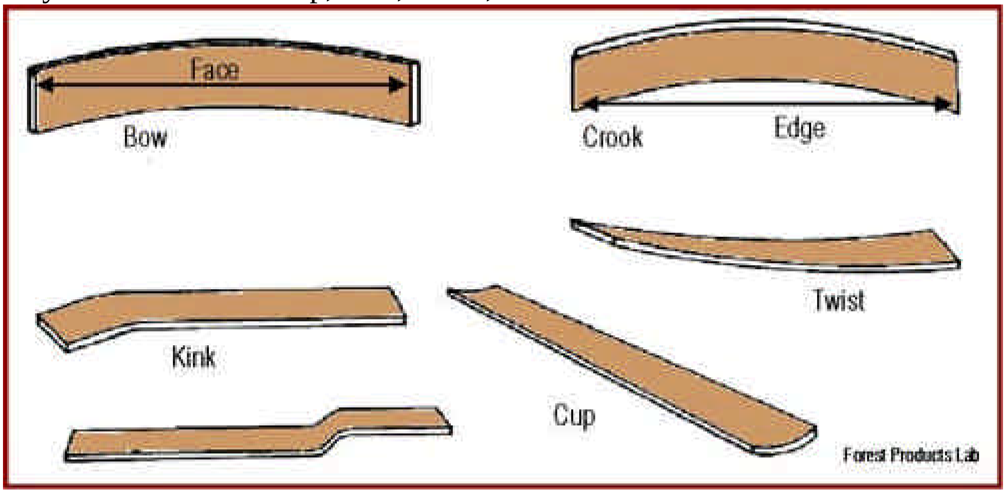
Ring shake – shake is the separation of the wood parallel to the grain along the growth rings. It can be caused by excessively high temperature in the early stage of the drying process or by felling the tree along uneven ground, causing the bole to bend and separate along the growth rings.

Warping

Warp is defined as any deviation from the true plane surface of the wood. Warping normally is caused by the shrinkage value differences in the different parts of the tree; for example, juvenile wood on one side and mature wood on the other, or domination of latewood growth in the grain pattern of the board.

Other warping may occur because of the natural grain direction of certain species. Warping is a natural occurrence in wood and cannot be completely controlled. However, the use of weights on the kiln charge will reduce some warping.

Figure 2: Warping is any deviation from the true plane surface of the wood. Warpage may take the form of cup, bow, crook, kink or twist.



Types of warps that commonly occur are:

Cup – is a deviation from edge-to-edge on the end of the board.

Bow – is a deviation from end-to-end on the flat surface of the board.

Crook – is a deviation from edge-to-edge along the long surface of the board.

Twist – is a distortion of the board so that the two end surfaces do not lie on the same plane.

Kink – is an abrupt deviation from flatness or straightness due to localized grain distortion (around knot); deformation caused by misplaced stickers in kiln.

Sawmilling Concepts – Part VI: Kiln Drying Lumber

In Part VI, we will examine the procedures for kiln drying, including the topics of stickering, stacking of wood in the kiln, end coating, kiln schedules and equalization and conditioning procedures that are used to eliminate stresses.

Kiln charge

The kiln charge is the load of lumber that is placed in the kiln to be dried. It is best if the charge is all of the same species and all the boards are at nearly the same moisture content. However, charges of several different species can be dried at the same time if the kiln schedule used is for the most sensitive species.

Drying lumber that has been air dried first

Lumber that has been air dried first requires 24 to 72 hours of conditioning before starting the kiln-drying schedule. This is required because the exterior of the board during the air drying process has set the exterior wood fibers in tension. These fibers probably have a lower moisture content than the wood fiber in the core of the board.

Conditioning is done by placing the kiln charge in the kiln and setting the dry-bulb temperature at or near 100° F (this temperature is species dependent). Leaving the charge in this manner for 24 to 72 hours allows the moisture in the core of the boards to move to the outside shell of the boards and to the air around it. This allows the fibers in the shell of the board to equalize in both stress levels and moisture content with the fibers in the core of the boards before the drying process begins.

Proper stickering and stacking

Stickers – are small boards similar to a lath that are used to separate wood stacked in kiln charges to allow movement of air equally across each layer. This allows for the uniform drying of the charge.

Kiln charges that are properly stickered and stacked allow for better movement of the airflow through the stack and less warping of the lumber due to the vertical placement of the stickers.

First-time stickering from the sawmill – the proper stickering and stacking of lumber immediately after the lumber is removed from the sawmill eliminates the redundancy of handling of lumber. A forklift or loading device can then be used to load and unload the kilns without restacking.

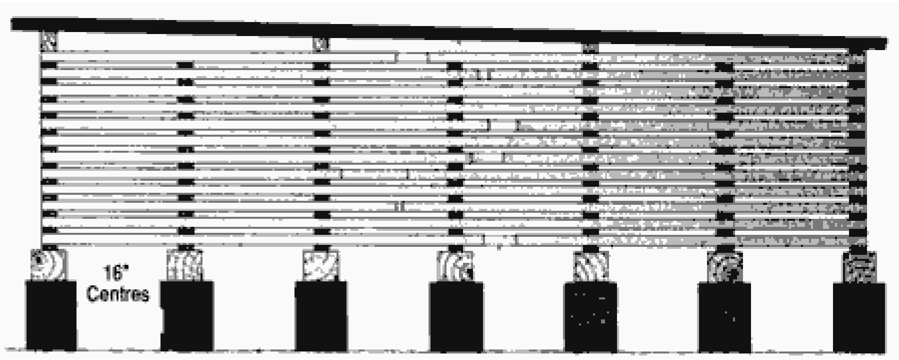


Figure 1: Simple stickering and stacking of lumber out in the air to allow natural wind currents and outside air conditions to dry lumber

Sizes of stickers – the sizes of stickers vary by the design of the kiln and kiln specifications. They range from 1/4" to 2" in width. They range from 3/4" to 4" in thickness.
Casehardening – is when the fibers in the shell of the board are set in tension more than the core of the board. This is checked for at the end of the drying schedule. Reverse casehardening – is when the fibers in the shell of the board are set in compression more than in the core of the board. This usually occurs after the conditioning process, when too much moisture has been added to the shell of the board.

Stickering – is the process of laying stickers in between the layers of boards as they are being stacked into a kiln charge. Placing the stickers in the right place is very important for the controlling of air movement and warping in the charge. The stickers should be placed at the end of each board, less than 4' apart for softwoods and less than 2' apart for hardwoods. Each sticker should be placed directly in a vertical row, as the layers of wood are stacked.

Stacking – the stacking of lumber for the kiln should be as uniform as possible. The lengths should all be the same, and the sides of the charge should be as vertical as possible. Equal spacing should be maintained between each layer.

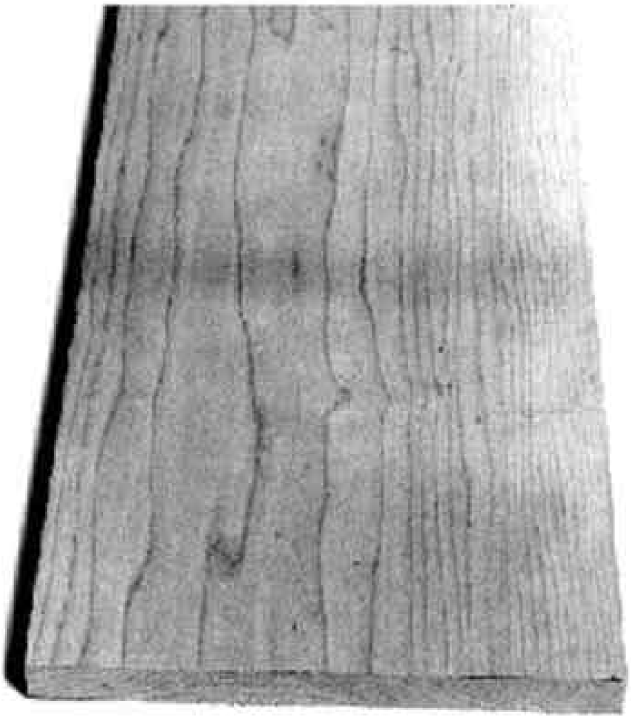


Figure 2: Note the dark narrow band across the width of this board at its mid point. It is sticker stain caused by using the wrong sticker material

End coating is the process of painting the ends of the boards of the kiln charge to prevent moisture from moving out of the lumber more quickly through the ends than the other surfaces of the boards. This helps reduce end checking and end splitting.

Kiln schedules are the schedules produced by kiln operators over a long period of time and experience that allow the wood of each species to be dried as quickly as possible with the least number of defects. A kiln schedule tells the operator at what temperature and what relative humidity to set the kiln when a certain species reaches a certain moisture content.

Equalization is the process at the end of the drying schedule that leaves the temperature and relative humidity at a certain condition, allowing the moisture content throughout the kiln charge to equalize to the same moisture content. During the drying cycle, some areas of the kiln may have dried more quickly than others. The equalization process allows the charge to equalize before the conditioning process.

Conditioning At the end of the drying process, stress samples are taken to test for casehardening of the boards. Almost always, casehardening occurs because of the nature of force drying lumber. After the equalizing process, the lumber is then conditioned by setting the temperature and relative humidity conditions to increase the moisture content in the shell of each board. This relieves the stresses caused by the force drying of lumber. If too much moisture is added to the shell of the boards, reverse casehardening occurs. This can be removed by raising the temperature of the kiln or reducing the relative humidity in the kiln.

Dressing and Edging After the kiln charge is dried and conditioned, the boards can be dressed and edged if desired. Most hardwoods are dressed (planed) to 13/16". However, if someone wants to glue this stock and it needs to be planed again, the stock should be left at 7/8" or greater. Edging allows the end user one straight edge to begin sawing the lumber on table saws in most small operations. Normally, a three- to four-cent charge is added to the board foot price for this additional operation.

“Theses articles (From the Horses Mouth – Air Drying Lumber and Sawmilling Concepts - Parts IV, V and VI) are re-printed with permission from the Ontario Woodlot Association (OWA). For more information about the OWA, visit www.ont-woodlot.assoc.org. The information (including illustrations) in the Sawmilling Concepts articles is from the Instructional Guide to Wood Technology and Sawmilling, 2000, a publication of Wood-Mizer Canada Co., 217 Salem Road, Manilla, Ontario K0M 2J0, www.woodmizer.ca.”