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Quality Drying of Hardwood Lumber

Guidebook-Checklist

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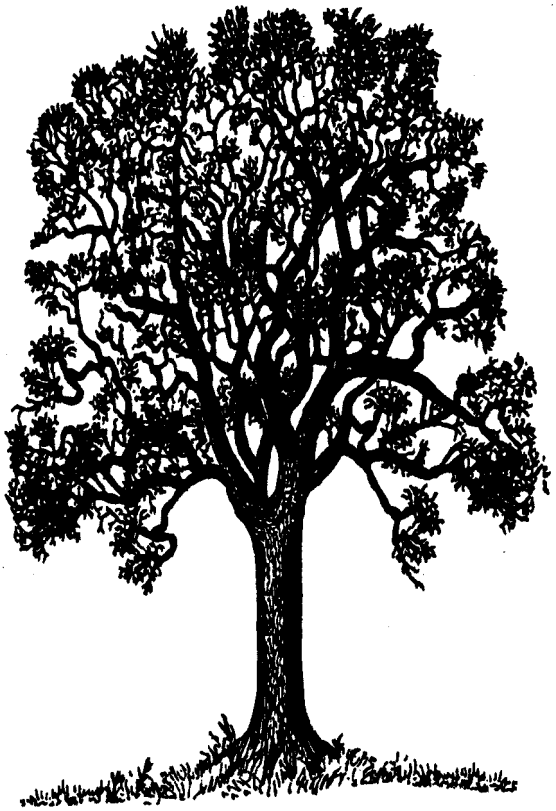

IMPROVE

Lumber Drying Program

Abstract

The IMPROVE Lumber Drying Program is intended to increase awareness of the lumber drying system as a critical component in the manufacture of quality lumber. One objective of the program is to provide easy-to-use tools that **a kiln** operator can use to maintain an efficient kiln operation and therefore improve lumber drying quality. This report is one component of the IMPROVE Program. It contains a Guidebook-Checklist for Quality Drying of Hardwood Lumber that kiln operators or owners can use to readily evaluate how well their operations rate on those factors that most strongly affect drying quality, with particular emphasis on kiln operation and maintenance and lumber handling. Appendix 1 contains a shortened version of the checklist for easy duplication and filing. Appendix 2 contains the same checklist items; however, the information is arranged by drying system components for convenience in checking individual components.

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Introduction

The IMPROVE Lumber Drying Program is intended to increase awareness of the lumber drying system as a critical component in the manufacture of quality lumber. The goals of the program are to help sawmill, furniture, flooring, molding, and cabinet plant personnel improve lumber drying quality by identifying sources of drying losses, both grade and volume. Operation of the dry kiln is only one factor that determines lumber drying quality. Each step of the lumber manufacturing process affects lumber drying quality-from the time logs are felled in the woods until the lumber leaves the unstacker after drying. The IMPROVE Lumber Drying Program is designed to systematically evaluate the drying operation and identify areas contributing to poor lumber product quality, both in the drying operation stage and at every prior stage of lumber manufacture. Therefore, causes of drying quality losses can be corrected at their source, rather than trying to compensate for them in the kiln.

A package of analytical tools for the IMPROVE program is under development. These tools will measure and improve processing efficiency and product quality in sawmills, veneer mills, and plywood plants. Methods will be provided to evaluate how effectively logs are being converted into end products, to identify opportunities to increase product yield and value, and to predict the results of proposed improvements.

One objective of the IMPROVE Lumber Drying Program is to provide easy-to-use tools that a kiln operator can use routinely in daily work around the kilns without having to perform special studies or interfering with production. To help fulfill this objective, this report contains a complete guidebook-checklist for drying quality hardwood lumber. The guidebook explains the importance of each item on the checklist and describes how to evaluate it. if questions arise while using the checklist, you can refer to the guidebook for a detailed explanation. The guidebook also provides a quick reference on drying quality. Kiln operators can use the checklist to readily evaluate how well their operations rate on those factors that most strongly affect drying quality. Particular emphasis is given to kiln operation as well as maintenance and lumber handling. In addition to the guidebook and checklist, Appendix 1 contains a summary checklist for easy duplication and filing. Appendix 2 contains the same checklist items but listed according to drying system components for convenience in checking individual components.

The guidebook-checklist is intended to be used with either steam-heated or dehumidification kilns. It is not practical or our intent to cover all the detailed components of the lumber drying system. We encourage you to use the guidebook-checklist and adapt them to your individual situations. Many other maintenance and operating factors are also important, but these do not have as direct a bearing on drying quality, although they should not be neglected. Chapter 4 of the "Dry Kiln Operator's Manual" (DKOM)[1] contains maintenance checklists and discusses many factors of kiln maintenance. Kiln manufacturers can also supply maintenance checklists and additional information.

[1]US Department of Agriculture, Forest Service. 1991. Dry kiln operator's manual. Agric. Handb. 188. Washington, DC: U.S. Department of Agriculture, Forest Service. 274 p.

Guidebook-Checklist

The guidebook-checklist can be used three ways: (1) to make an overview of the entire kiln operation; (2) to closely check or monitor a particular kiln that is suspected of causing drying problems; and (3) to monitor the effects of improvements by providing a "baseline" for later comparison.

The checklist is a working tool and to get the most value from it, you must physically examine various equipment and systems around the kiln. Only by actually observing the items on the checklist can you accurately assess your kiln operation, The checklist is arranged so that items located near each other can be checked together. For example, all observations of values and controls normally found in the control room are listed together on the checklist, and checks of stacking and snickering are done at the dry end. A shortened version or summary of the checklist (without the rating key) is given in Appendix 1. We suggest you make copies of this shortened version to write on and keep with your kiln records.

For convenience in checking individual systems, such as air circulation or heating, a summary of the checklist items arranged by drying system components is given in Appendix 2.

Rating System

Each item on the checklist has a rating key based on a scale from 4 (high) to 1 (low). Each level of rating is further described in the guidebook. The high rating of 4 is intended to be attainable, but challenging, for most of the industry. The low score of 1 indicates a strong need for improvement. In a well-maintained and well-operated kiln, most of the ratings should be 4 and 3.

Overviewing the Kilns

When using the checklist as an overview, it is not necessary to look at all items in the same kiln. You may complete the checklist items relating to an empty kiln in one kiln, then do the ones related to a running kiln at a second kiln, and check the dry end as a third kiln is being unloaded. This overview can be completed in several hours or less.

Studying One Kiln

Past experience or the overview checklist may suggest one particular kiln is causing drying quality problems. You can also use the checklist to evaluate that one kiln for all steps from loading through unloading. You will have to keep the checklist for each step of the drying cycle as it is completed.

Monitoring the Effects of Changes

If changes are made that affect the drying operation, either at the kiln or in the prior lumber handling, you can use the checklist to monitor how these changes affected drying quality. Rate the kiln or operation before the changes are made and save the checklist. Repeat the checklist rating after the changes have been made. You can then compare the before and after ratings for the effect of these changes.

How to Follow the Checklist

The checklist is arranged so that items are grouped together by the area of the kiln or yard where they are checked. Begin in the kiln control room. The first series of questions ask about standard operating procedures. These relate to maintenance procedures and maintenance schedules, recordkeeping, and communications. These items should be checked regularly to prevent problems or correct them before they become serious.

In the control room, you will be asked to check the steam valves and controls to see that these are in working order and that the desired schedule is actually followed.

From the control room, go to the fan deck and the kiln roof. Here, you will check the fans, heating coils, and vents.

In the kiln yard area, accurately measure the stickers and bolsters for uniform size. Use dial calipers or a micrometer, if possible, to check sticker and bolster thickness.

Then, find an empty kiln and check for condensation, clean reheat coils, and a good water supply to the wet-bulb. Next, turn on the steam to check the steam pipes and heating coils, and turn on the steam spray to check it for leaks and uniform distribution of steam.

From the empty kiln, move to a kiln that is being loaded. Check the loading practices as packages are loaded on the kiln trucks or load supports. After that kiln is loaded, check that the package loading and use of baffles will ensure proper airflow through the packages. During startup, check the traps and the airflow across the wet-bulb. While the kiln is operating, check for drainage or leaks, and confirm that the fan reversals actually are occurring.

Finally, go to a kiln that is ready to be unloaded and check the baffles to see if they were properly placed to direct airflow through the load and remained securely in place during drying. Then, spot check the moisture

content (MC) of the load. Before the load is broken down, check the sticker placement and stacking and also check for drying defects. At this time, you can see how the sticker placement and stacking affect warp and other drying defects. It maybe difficult to see drying defects in boards that are away from the package sides. If the checklist review points to problems with drying defects, watch the packages being broken down and talk with the operators and/or supervisors of the rough mill or cut-up operations to get more information.

Safety Precautions

Be extremely careful and observe safety precautions as you use this checklist. It is not possible to list all the potential hazards; some are listed below.

(1) Be careful of burns from live steam when checking traps, steam valves, and steam spray lines.

(2) LOCK OUT fan switches when checking items on the fan deck. DO NOT go on the fan deck when the fans are turning.

(3) Tell someone in the immediate area that you are entering a loaded kiln and preferably have that person nearby, especially if the kiln is operating. Know how to move the end baffles and operate the door latches in the dark. Watch where you step when walking in the kiln.

(4) DO NOT enter a kiln when the wet-bulb temperature is greater than 120°F.

(5) Use a handkerchief or rag to check air direction on fan reversals. This same technique should be used when looking for leaks at vents or around doors as air from exhaust vents and leaks can be extremely hot when high-temperature schedules are used.

(6) Watch for unstable lumber piles or loose boards and for protruding kiln stickers.

For each item in the checklist section, the following descriptions summarize how that item affects drying quality and why it is important. Additional descriptions are provided in the "Dry Kiln Operator's Manual" (DKOM). The DKOM is referenced throughout this guidebook when it contains additional helpful information. Also refer to DKOM for needed definitions of terms.

Standard Operating Practices

1. Maintenance and Inspection

1a. Equipment above fan deck inspected regularly

Identifying maintenance problems so that repairs can be scheduled is preferable to having equipment failures. Small repairs are usually less costly, particularly in the fan system where vibrations and breakage can cause major damage. Regular inspection of fans and motors will help identify problems leading to nonuniform airflow. This, in turn, will help control MC variability.

Rating
4 - Fans, motors, bearings, shafts, and other equipment inspected monthly
3 - Inspected quarterly
2 - Inspected annually
1 - Inspections are not made regularly

1b. Air velocity checks made regularly

Air velocity must be sufficient to bring heat to the lumber and remove evaporated moisture. It should also be uniform throughout the kiln so that drying occurs as equally as possible in all packages. Regular air velocity checks help identify obstructions to airflow and fan maintenance problems that lead to uneven drying. Air velocity should be measured in the sticker spaces and bolster openings at the edge of the stack on the leaving-air side (Ch 3, DKOM). Air velocity should also be checked where it passes around the ends of the load and through any major opening in the load.

Rating

4 - Checked at least semiannually and when unusual lumber load configuration or package arrangement exists
3 - Air velocity is checked when there is a problem
2 - Air velocity was checked when the kiln was new or rebuilt
1 - Air velocity has never been checked

1 c. Traps checked for proper operation and plumbed for ease of checking

Traps are vital in separating condensed water from the steam in the heating system. Traps should be sized large enough to handle the peak load during kiln start-up, but not pass excessive steam late in the drying schedule when steam demand is low. Even a properly designed and installed trap can malfunction due to dirt. Installing screens just upstream of the traps and flushing them every 30 days can help prevent malfunctions.

If condensate is not removed from the heating coils, they will fill with condensed water, keeping steam from entering. To ensure even heating throughout the kiln, the traps should be checked frequently. Good kiln design calls for placing traps where they are readily accessible (but as close to the coils as practical) for ease of checking while the kiln is running.

Rating

4 - Traps are checked for condensate backup and passing steam weekly; traps are properly sized for the load
3 - Traps are checked at least every 30 days, or traps are not quite large enough to handle condensate during startup
2 - Traps are checked at least every 6 months, or traps are very undersized
1 - Traps are rarely checked, inaccessible, not plumbed for regular checks

1d. Air supply to control instruments and operating valves checked at regular intervals

Compressed air is used to operate many kiln controllers and/or valves. Many pneumatic controller problems can be traced to dirt or moisture in the air supply. It is estimated that anywhere from 25% to as much as 40% of controller problems originate from poor air supply quality. Water should be drained from the compressor daily. Each instrument should have a filter/water trap in the compressed air line just before the air enters the instrument. This should be checked and drained daily.

Rating
4 - Air filters and compressors are checked and drained daily
3 - Inspected on some other schedule but at least monthly
2 - Inspected only when a problem is suspected
1 - Inspected only when the controller or air supply does not work

1e. Regular maintenance program for steam valves

Faulty valves can prevent steam from entering the coils when it is needed or allow steam to enter when it is not needed. Regular inspection of the valves is one way to prevent problems or identify them while they are small, instead of waiting for wet or ovendried lumber to indicate a problem exists. Inspection should check that valves open and close completely and, if applicable, that they open in proportion to the signal from the controller.

Rating
4 - Valves are inspected at least every 90 days
3 - Inspected at least annually
1 - Inspected only when a problem is suspected

1f. Regular calibration of temperature sensing devices and indicators

Accurate sensing of temperature is essential to maintaining the scheduled temperature in the kiln. It is frequently necessary to maintain wet-bulb depression of 3°F or 4°F when drying completely green lumber or when equalizing and/or conditioning lumber. If either the dry bulb or wet bulb sensors are out of calibration by >2°, good control cannot be maintained and this can lead to problems ranging from surface checking and stain to inadequately equalized and conditioned lumber.

The simplest way to check the operation of the temperature sensors is to attach a thermocouple to each sensor and see how closely the thermocouple reading agrees with the kiln's recorder. When doing this, the bare end of the thermocouple wire should not touch metal, such as the sensor bulb, but should be located as close to the sensor as possible. On the wet-bulb, the thermocouple should be located under the wick at the tip of the sensor. It is good practice to coat the tip of this thermocouple with silicone to electrically isolate it from the bulb and the water. The thermocouple wires should be routed so that it is easy to compare the thermocouple readings to the temperature indicated on the recorder/controller. Some mills permanently install the wires to facilitate regular checks.

Another way to check the operation of the temperature sensors and the recording device is to use a stirred hot water bath (bucket) as described in Chapter 4 of the DKOM. An accurate glass thermometer is used to measure the bath temperature. The sensors are submerged in the bath. One person stirs the bath while another reads the recorder. At least 5 to 10 minutes of stirring are needed for the system to come to a steady temperature. For vapor or liquid-vapor bulbs, the height of the bucket should be the same as the bulb location in the kiln. This check of the calibration is usually done throughout the range of the instrument and is considerably more thorough, but is also more difficult than the thermocouple method. In addition, the kiln must be shut down.

The calibration procedure is the same for both dry- and wet-bulb sensors. Chapters 3 and 4 of the DKOM give additional information about calibrating sensors.

Rating
4 - Calibration checks are made at least every 6 months; results are recorded and filed
3 - Calibration checks are made more than 6 months apart but at least every 2 years
2 - Calibration is checked when a problem is suspected
1 - Not calibrated since installation

1g. Wet-bulb wicks changed on a regular schedule

If the wet-bulb wick is not clean, it will not give the true wet-bulb temperature. The dirt can be from dust, sawdust, volatiles from the wood, or salts and minerals in the water. For best wet-bulb control, the wick should be changed with every new charge of lumber or possibly more often for charges in the kiln for more than 10 to 14 days. Consider which is more expensive-a new wet-bulb wick or a ruined charge of lumber.

Rating
4 - New wick(s) used every charge
3 - Wick(s) changed on some other regular schedule
2 - Wick(s) changed when they are dirty, feel crusty, or falling apart
1 - Wick(s) changed rarely

1h. EMC wafers changed on a regular schedule

In some kiln control systems, equilibrium moisture content (EMC) is estimated based on electric resistance measurements across a small cellulose pad (EMC wafer). The pad is held by electrodes mounted in the kiln. This system of measurement maybe used instead of the more traditional wet-bulb systems. Like the wet-bulb wick, the cellulose wafer or pad becomes dirty and must be changed at specified intervals for the EMC measurements to be accurate. For best performance and accurate readings, we suggest following the manufacturer's replacement schedule "to the letter."

Rating
4 - Equipment manufacturer's replacement schedule followed exactly
3 - Equipment manufacturer's replacement schedule usually followed
1 - Wafers changed only when EMC readings are obviously in error

1i. Regular maintenance program for dehumidification kilns

Dehumidification kilns have a somewhat different list of items that require routine attention than steam heated systems. Many points are similar, such as valves, controls, air velocities, and fans. Others are different, usually relating to the compressor and evaporator/condenser. Such items as compressor operating pressures, evaporator and exhaust dampers, and refrigerant levels require regular, periodic checking. For best performance of your equipment, we suggest following the manufacturer's maintenance checklist "to the letter."

Rating
4 - Equipment manufacturer's maintenance checklist followed exactly
3 - Equipment manufacturer's maintenance checklist usually followed
1 - Little attention paid to equipment manufacturer's checklist

2. *Moisture Content Monitoring and Recordkeeping*

2a. Knowledge of history of lumber before going into kiln

Knowing the history of the lumber to be dried in your kiln is important in drying hardwoods. In many cases, a furniture or cabinet plant will dry rough green lumber produced at several different sawmills. Purchase may be through a broker or directly from the sawmill. With woods prone to surface checking (oak and beech) and those prone to stain (maple, hackberry, gum), it is quite helpful to know what has happened to the lumber since it was sawn. How long was it solid piled before being put on stickers? Was it trucked a considerable distance untarped? Was it rained on? Is there or has there been ice and/or snow on the lumber? Has it been partially dried in an air-drying yard or in a predrier? What is the current MC? In common usage, the term "green" lumber may refer to any MC above about 30%. It is important to know more precisely what is the current MC, rather than just know that it is green. Oak lumber just off the saw, and thus "green green" or "grass green," will commonly have a MC of 65% to 80%, depending on species. If the lumber has dried to 55% or 50%, surface checking may have already started, even though by the more common usage it is still green. If you know the lumber is partly dried or can see surface checking, then start up procedures for the kiln may be different than if the lumber is truly green from the saw.

If you suspect that the lumber you expect to load into your kiln came from several sources or some packages are drier than others, choose your sample boards to give you a representative sample of MC variation.

Rating
4 - The history of the lumber going into the kiln is known
3 - You can reconstruct the history by asking a few questions or making a phone call or two
2 - You do not know the history
1 - No effort was made or did not know the history was important

2b. Use of sample boards (kiln samples) to monitor moisture content

Using sample boards (kiln samples) to monitor the changing MC in a charge of lumber during drying has traditionally been considered the preferred method for drying hardwoods. This technique, using short carefully chosen boards placed at selected locations in the kiln charge, is used to determine when to make appropriate schedule changes and to obtain the best results during equalizing and conditioning the lumber.

Rating
4 - Sample boards are always selected, prepared, placed, and used as recommended in Chapter 6 of the DKOM.
3 - Sample boards are usually used, with minimal attention to selection and usually only two or three boards used
2 - Sample boards are used only when drying an unfamiliar species or a thickness not commonly dried
1 - Sample boards never used

2c. In-kiln moisture content monitoring equipment is used when available

Equipment that tells the operator some information about the moisture content of the lumber in the kiln is valuable in achieving the target MC. The equipment for this technique usually consists of sensors placed in or adjacent to the stack of lumber, resistance pins placed in selected boards or metal strips placed in sticker openings and connected to control devices, or some feedback from the control system such as temperature drop across the load or steam demand. Resistance pins are the most commonly used sensors in hardwood drying.

Rating
4 - In-kiln sensors are used according to the manufacturer's instructions
2 - In-kiln sensors are used but some of the operators do not pay attention to the readings or not all sensor locations are operating
1 - In-kiln sensors are available but not used

2d. Moisture content control practices for each charge

Rating
4 - Sample boards always used, every charge spot checked with moisture meter, and all records are kept with the kiln charts
3 - Sample boards usually used, meter spot checks are infrequent, but records are kept with kiln charts
2 - Sample boards seldom used, no meter spot checks, no moisture records kept
1 - Sample boards never used, no meter spot checks, no records kept

2e. Dry storage of lumber

Largely because of the final product for which it is used, hardwood lumber is typically dried to MC of 6% to 8%, significantly less than most softwood dimension and shop lumber. Most hardwood lumber is dried in areas of the country where outdoor EMCS vary from 13% to 15% over the course of a year. Lumber that is kiln dried to around 7% and then exposed to these outdoor conditions without protection will experience moisture regain, and if left long enough will increase in moisture up to 13% to 15%—too high for use as furniture, flooring, interior paneling, moulding, etc.

Short-term storage in a covered cooling shed is usually satisfactory. To minimize moisture pickup for long-term storage, closed sheds or heated closed sheds are suggested.

Rating
4 - Dry lumber is always moved to and stored in closed shed
3 - Dry lumber is always moved to and stored in covered shed
2 - Dry lumber maybe left out in weather for several days
1 - No protection from weather for lumber after removal from kiln

2f. Control charts labeled and filed for reference

Good records should be maintained in any production operation. They are valuable in tracing problems that arise slowly over time. It is a good idea to also record and store moisture information with the control charts, thus giving a complete history of drying for a particular kiln. At least the date and time in, date and time out, product, species, and other information that may be historically important should be recorded on each control chart. This might include unusual weather, maintenance problems, unusual loading of the kiln, or a new schedule. Reports of defects or degrade should be saved with the control charts as an aid to identifying their cause. These should be filed so they can be easily retrieved, for example, by kiln number or by product.

Rating
4 - Complete set of records is kept and retrieval is easy
3 - Available information is kept for a while in a manner that allows retrieval
2 - Charts are kept but finding records for a charge of lumber dried 6 months ago is difficult
1 - No information is kept

2g. Records of moisture content checks are kept with control charts

It is a good idea to also record and store moisture information with the control charts, thus giving a complete history of drying for a particular kiln. This history can be particularly useful in tracking moisture variation problems that affect one kiln or part of a kiln.

Rating
4 - Complete records are filed together for easy retrieval
3 - Records of MC checks are kept but not filed with control charts
1 - Records are not kept

3. Discussions and feedback from rough mill or glue room supervisors

3a. Communications with rough mill and/or glue room supervisors

The rough mill and glue room supervisors are good sources to learn about drying quality problems. Many problems such as checks, honeycomb, stain, and drying stresses are not obvious in the piled lumber when it leaves the kiln but are readily seen as the lumber moves through the surfacing and cutup stages in the rough mill. Variations in MC between pieces and drying stress problems maybe more evident in the glue room than in the rough mill.

Rating
4 - Communicate regularly, at least weekly
3 - Communicate only at scheduled production meetings
2 - Communicate only when there are problems
1 - Communicate rarely

4. Learning Opportunities

4a. Opportunities to visit other sites and meet other operators

Meeting with other kiln operators and visiting their operations provides a chance to discuss common problems and learn how others may do things differently.

Rating
4 - Visit other kiln drying sites three or more times per year
3 - Visit other kiln drying sites twice a year
2 - Visit other kiln drying sites once a year
1 - Never visit other kiln drying sites

4b. Attend Dry Kiln Association meetings and drying workshops

Dry Kiln Association meetings and drying workshops are one of the best sources of up-to-date information on the latest techniques and equipment. Attending them also gives you a chance to meet other operators and equipment suppliers and to learn more about their approaches to similar situations.

Rating
4 - Attend Dry Kiln Association meetings yearly and have attended at least one workshop
3 - Regularly attend meetings but have never been to a workshop
2 - Attend meetings every 2 or 3 years
1 - Never attend meetings or workshops

Control Room

5. *Valves Operate Properly*

5a. Steam heat valves operate properly

It is important for the heat valves to open and close properly to the position signaled by the controller. This is particularly important for the fully closed position so that part or all of the kiln does not heat above set-point. Also, steam leaking under the valve seat will cause erosion and permanent damage to valve parts. It is important for the valve to move to the fully open position so that maximum steam flow can be achieved when it is needed.

Listen to the valve when it should be in the fully closed position. If steam can be heard passing through it, then the valve is not fully closed. A mechanic's stethoscope can be helpful for this, particularly on low-pressure systems. A way to check for fully closed valves during downtime is to make sure that the valves are receiving the appropriate air pressure for the fully closed position. Then, after sufficient time has elapsed (2 hours), check the pipes leading from the valves to the heating coils to see if they are hot. Heat indicates that the valve is leaking steam because the valve is not fully closed. The recorder chart can also give an indication that the valve is leaking. Late in the drying schedule when the lumber is hot and heat demand is low, the controller will signal the valve to close when it senses the temperature is above setpoint. A leaking steam valve (not fully closed) will allow steam to enter the kiln. Therefore, the recorder chart will show a slow rise in dry-bulb temperature above the setpoint. The correction for leaking steam valves is usually an adjustment on the valve stem, provided the appropriate springs are used and the valve seat is in good repair.

To check for the fully open position, measure the stroke of the valve from the fully closed position to the fully open position and compare it with the manufacturer's specifications. Another way is to set the signal to place the valve in the fully open position, then increase the signal and listen for an increase in the steam flow and look for additional travel of the valve stem. Some valves have an indicator along the side of the stem to indicate valve position. If the indicator is set properly, it can also be used to check the fully open valve position.

Rating
4 - No steam passes when valves close; valves open fully during full-steam demand
2 - Bypassing steam is barely detectable by sound; valves open more than 90% during full-steam demand
1 - Bypassing steam is easily detected when valves are closed or valves open less than 90% during full-steam demand

5b. Steam spray valve fully opens and closes

The same considerations discussed in 5a. apply to the steam spray valve.

Rating
4 - No steam passes when valve closes and valve opens fully
1 - Steam enters spray line when valve is closed or valve opens less than 90% when steam spray demand is high

5c. Gauges are working and readable

Gauges found around dry kiln operations generally measure the pressure in steam lines or in compressed air lines. Ail gauges should be working properly, have a clean glass, and be readable.

Rating
4 - All gauges are working and easily readable
1 - Any gauges nonfunctioning or unreadable

6. ***Controls Operate Properly***

6a. Vents and spray are not on together

Humidity in the kiln is controlled by two opposing systems. Vents are used to decrease the humidity in the kiln; steam spray is used to increase the humidity. If both are under automatic control, they should never be on at the same time. They should rarely alternate off and on during the schedule. The vents should be modulating or the spray should be modulating, but they should not cycle rapidly between vent-spray-vent-spray, etc. If they are doing this, either the dead band is too narrow or a tuning parameter may be set incorrectly in a computer-controlled system.

Rating
4 - Steam spray and vent opening never alternate off and on during any part of the drying schedule
3 - Steam spray and vent opening occasionally alternate during some part of the schedule
2 - Steam spray and vent opening alternate rapidly during some part of the schedule
1 - Steam spray is on and vents are open simultaneously

6b. Recent control charts show fan reversals occur

The ability to reverse the direction of the fans provides the ability to reverse the flow of air through the load. When the air flow is always in the same direction, the lumber on the entering-air side of the load is always exposed to more severe drying conditions than that in the middle or on the leaving-air side of the load. By reversing the air flow every few hours, the hot or entering-air side of the load alternates and a more even drying of all the lumber will occur. For best results, the reversing cycle should always work properly and the air velocity (as measured through the load on the leaving-air side) should be approximately the same in both directions.

Look at recent control charts for an indication of fan reversal, such as a spike in the dry-bulb temperature. Fan reversals probably occur on schedule for kilns with automatic reversing relays; however, check the charts to be sure that there are actually indications of fan reversal. A later Checklist question will ask you to check the air-flow direction before and after fan reversal (feel or look for leakage on one side of the kiln before reversal, then the other side after reversal) to make sure that the airflow actually reverses.

The ratings pertain primarily to manual systems. With an automatic system, the rating will probably be either 1 or 4. With systems where the fan reversal is computer optimized, give a rating of 1 if the reversals are not occurring.

Rating
4 - Fan reversals all occurred on schedule according to recent charts
3 - At least 9 out of 10 fan reversals occurred on schedule
2 - At least 7 out of 10 fan reversals occurred on schedule
1 - Less than 7 out of 10 scheduled fan reversals were actually made

6c. Recent charts show setpoint changes are made according to the schedule

Most hardwood lumber is dried by kiln schedules in which changes in setpoints are based on the MC of the wood, rather than on how many hours the lumber has been in the kiln. This is because both drying rate and susceptibility to drying defects are related to the MC of the lumber. If changes in the schedule are made before the MC of the lumber has dried to the appropriate level, i.e., too early, one or more types of drying defects are likely to occur. If changes in the schedule are substantially delayed, then the drying time for the charge is unnecessarily lengthened, thereby wasting energy and time. It is usually recommended that sample boards be used and that schedule changes be made based on the average MC of the wettest half of the sample boards. A typical kiln charge will have 10 to 12 sample boards, so the average MC of the wettest 5 or 6 boards is used to determine change points in the schedule. Constructing a drying-time curve (plotting MC over time) will help in estimating the approximate time to weigh sample boards and calculate the current MC. Use recent kiln records (control charts and kiln sample records) to evaluate schedule changes.

Rating
4 - Setpoint changes are made within 2 hours of reaching the appropriate MC indicating a change is needed, according to recent charts and records
3 - Setpoint changes are made within 5 hours of reaching the appropriate MC indicating a change is needed, according to recent charts and records
1 - Changes in setpoint are only loosely associated with MC of lumber at time of change

6d. Correct instrument charts are used

To assure proper calibration and operation, it is very important that the paper charts on the recorder are correct for the model. All recorders do not have the same temperature range and the spacing between lines on the chart may be different. Check the manufacturer's information and compare this to the charts.

Rating
4 - Chart paper matches recording instrument
1 - Wrong paper is used

Fan Deck and Kiln Roof

7. *Fans*

7a. Fans and shrouds are well maintained

To dry lumber, air of controlled temperature and humidity must be passed uniformly over the surface of the lumber. This circulating air is the "workhorse" of the dry kiln. As such, the air performs two tasks: it carries heat to the wood to evaporate the water and it removes the evaporated water vapor. An adequate volume of air must pass uniformly through the courses of lumber to accomplish these two tasks.

To get the best air circulation in the kiln, all fans, fan blades, and fan motors must operate properly and as designed. Missing or bent fan blades will cause the fan to be out of balance, and if bad enough, can damage the motor or cause the motor and/or motor mount to vibrate excessively.

Fan blades that are loose on the shaft are not doing their share of the work. Air velocities will be lower in a portion of the kiln. if a fan is quite loose on the shaft, it may turn in the opposite direction from the others. For maximum fan efficiency, the fan should be centered in its shroud, both axially and radially.

While the kiln is not operating, LOCK OUT the electrical fan switches so that they cannot be turned on. Check each fan for (1) tightness on the shaft, (2) blade damage, and (3) fit in the shroud. Be **extremely careful when doing this inspection.**

Rating
4 - All fans are tight on the shaft, centered in the shroud both radially and axially, and there is no blade damage
2 - One of the above is not correct
1 - More than one problem is found

7b. Fans turning for proper airflow

In line-shaft kilns, fans may be made as “right-hand” or “left-hand” fans. If a right-hand fan is installed where a left-hand fan should be, it will push air in the wrong direction, disrupt the airflow, and work against the other fans on the shaft. With the fan switches still LOCKED OUT, check the fans for proper handedness (right or left).

In cross-shaft kilns, all fans should turn in the same direction. Sometimes the three-phase wiring is reversed during installation, so one or more fans turn in the opposite direction. This disrupts uniform airflow through the kiln. Check to see that all fans are turning the same direction. This can be done by having one person turn the fans off as you watch the fan blades “wind down.” Depending on the kiln design, it maybe possible to see the fans from the access door to the fan deck or it might be necessary to stand on a ladder and look through the heating coils from underneath.

The blades on each adjustable pitch fan (most 66 and 72 in. propeller-type fans) should be adjusted to the same pitch. The correct pitch is that which causes the amperage draw to equal the rating for the motor. If the pitch varies between fans, the amperage draw will not be the same on each motor (in cross-shaft systems). If the pitch varies between blades on a single hub, vibration and bearing problems will occur. In either case, airflow will not be as uniform as possible.

Angle graduations are marked on the hub-often from “left 40°” to “right 40°” on either side of a 0° reference. An index mark is located on each blade shank. Check to see that the index mark for each blade shank relative to the angle graduations on the hub is within ±1° of the correct pitch. Left- and right-handed blades should be set to the left or right side of the 0° reference, respectively. If you do not know the correct pitch, see if all blades are within 2° of each other.

Line-shaft kilns

Rating
4 - All fans proper “handedness” and pitch set correctly
3 - All fans proper “handedness” but pitch not set correctly
1 - One or more fans wrong “handedness” or not turning

Cross-shaft kilns

Rating
4 - All fan motors turn the same direction and pitch set correctly
3 - All fan motors turn the same direction but pitch not set correctly
1 - One or more fan motors turning the wrong direction or fan not turning

7c. Fan deck (fan floor) in good repair

The fan deck serves two purposes—to direct the air to the plenum chamber and thus to the lumber and to provide a surface for servicing the fans, motors, and vents (in some designs). When the fan deck becomes corroded, rusty, or is otherwise in disrepair, it does not do an adequate job of directing air and does not provide a safe surface from which to perform maintenance or repairs.

Rating
4 - Fan floor extends to the edge of the lumber piles and can support personnel during maintenance
3 - Fan floor extends to the edge of the lumber piles but minor corrosion, rust, or small holes are visible
1 - Fan floor does not extend to the edge of the lumber pile and/or rust and holes in the floor make it unsafe for walking

7d. Easy access to fan deck and roof vents

Unless there is easy access to the fan deck and roof vents, it is easy to put off regular inspections and maintenance of the fans, vents, and roof structure. A stairway or permanently mounted ladder with a safety cage around it provides the best access to the roof. Access doors to the fan floor make it easier to reach this area than does a ladder around the heating coils.

Rating
4 - Stairway or permanent ladder to roof and easy access to fan deck are available
2 - Ladders are available for reaching roof and fan floor
1 - Only access to roof and fan floor is by being lifted by fork lift and climbing through the vents to the roof

8. *Heat Distribution System*

8a. Heating coils clean and free of debris

Kiln air must pass between the fins of the fin pipe, if the kiln is so equipped, to transfer energy from the coil to the air. If the spaces between the fins are obstructed or plain pipe is covered with dirt or debris, the surface area available for heat transfer is greatly reduced. Kiln coating that has been sprayed onto the heating coils and dust mixed with oil or grease from the bearings can foul the pipe's surface or fill the spaces between fins. Rust will also reduce the heat transfer capability. As a result, the kiln may be slow in coming up to the setpoint or may be unable to maintain the setpoint. Any debris (such as coating that has peeled off the roof) that falls onto the coils will block air movement through the coils and reduce heat transfer.

Kilns with fin pipe

Rating
4 - Can see space between fins; coils look clean
3 - Some dirt, ruts, or coating on coils or between fins
2 - Moderate dirt, rust, or coating; difficult to see pipe
1 - Cannot see pipe in places or foreign material on coils

Kilns with plain (nonfinned) pipe

Rating
4 - Coils are clean
3 - Small amounts of dirt, rust, or coating on coils
2 - Moderate dirt, rust, or coating on coils
1 - Heavy dirt, rust, coating, or foreign material on coils

9. ***Vents***

9a. Vent lids open and close fully

The design of a dry kiln assumes uniform humidity along the length of the kiln on the entering-air side of the kiln load. When a vent does not seat, the leakage can cause localized areas of low humidity and/or low temperature. This can lead to nonuniform drying and possible stain or checking problems in some species. Cool air leaking into the kiln can cause condensation leading to corrosion on steel surfaces. In addition, vents that do not seat tightly will increase the steam spray required during periods of high relative humidity (small wet-bulb depression). Failure to seat tightly can be the result of a bent or broken lid, a misset or loose linkage to a vent, or the entire vent mechanism not set correctly relative to the actuator.

Vent leakage should be checked from outside the kiln with the vents closed while the fans are running in the forward direction, and then checked again after reversal. Early in the morning when relative humidity is high and the ambient air temperature is low is the best time of day to observe leakage by observing the vapor plume that escapes through leaks. If some vent leakage is noted, go inside the kiln (when it is not operating) and look for light around the closed vents.

Rating
4 - All vent lids open to the same height; no vent leakage can be seen or felt with vents closed
3 - Slight leakage of vent lids; a little vapor can be seen from outside but light cannot be seen around vents from inside the kiln
2 - Major leakage of vent lids or light can be easily seen around vents when they are closed
1 - Vent lids do not close and leak significantly; one or more vent lids are bent or broken

9b. Vent actuators and linkages operate properly

A mechanical linkage connects the vent actuators to the connecting linkage that opens and closes the vent lids. If the mechanical linkage is worn, it maybe incapable of moving the connecting linkage properly. If the fitting on the connecting linkage to the vent lid works loose, the fitting slides on the linkage and does not open the lid. Also, the lid hinges may break, causing the lid to open at an angle across the vent opening rather than straight upward from the opening. When the vents are open, check to see that all lids open to the desired height. Leaking or malfunctioning vents affect both dry-bulb and wet-bulb control, increasing drying degrade.

Rating
4 - Vent actuators and mechanical linkages open vent lids to proper height
3 - Mechanical linkage is worn so vents only partially open or desired vent opening height cannot be achieved for other reasons
2 - One or more vent lids disconnected from connecting linkage
1 - Vents inoperative, vent activators not functioning or linkages disconnected

Yard and Stacker Area

10. Sticker and Bolster Thickness

10a. Sticker thickness uniformity

Stickers are usually 5/8 to 1 in. thick. Regardless of size or thickness, all stickers within a kiln charge should be surfaced to a uniform thickness. Variation in sticker thickness can cause nonuniformity of drying, and if variation is large enough, can contribute to kink or other forms of warp. Stickers that are too thick should be resurfaced, and if they are too thin, broken, or kinked, they should be discarded.

Measure and record the thickness near the center of 20 stickers. Since stickers tend to compress after a few times through the kiln, try to measure those stickers that are currently in use, selecting them either at the stacker or the unstacker. Use a dial caliper or micrometer for the measurements, if possible.

Subtract the smallest of the 20 measurements from the largest. This gives a value called the range. It is a measure of the sticker thickness variation.

Rating
4 - Range of sticker thickness is 1/32 in. (0.031 in.) or less
3 - Range of sticker thickness is 1/16 in. (0.063 in.) or less
2 - Range of sticker thickness is 1/8 in. (0.125 in.) or less
1 - Range of sticker thickness is greater than 1/8 in. (0.125 in.)

10b. Bolster thickness uniformity

Different bolster thickness can cause warp and kink in boards as they bend over the bolster. Also, two different bolster thicknesses under side-by-side packages can raise one package enough that the sticker spaces are no longer aligned. This can block horizontal airflow through the packages. If the bolsters are not square, make sure they are positioned so the bolster space is the same thickness for all packages.

Measure and record the thickness of 20 bolsters. Bolsters tend to become compressed the first few times in use and damaged from dropping and being hit by forklift tines. Try to use bolsters that have been used several times as well as some that have only been used a few times so they represent the typical mix of bolsters. Measure more than 3 in. in from the end of the bolster to avoid thin spots where the ends are broken or compressed.

Write down the 20 measurements and subtract the smallest from the largest to get the range of thicknesses.

Rating
4 - Range of bolster thickness is 1/8 in. (0.125 in.) or less
3 - Range of bolster thickness is 1/4 in. (0.250 in.) or less
2 - Range of bolster thickness is 3/8 in. (0.375 in.) or less
1 - Range of bolster thickness is greater than 3/8 in. (0.375 in.)

10c. Uniformity of sticker straightness

In hardwood plants using semiautomatic stackers and stickers up to 7 or 8 ft in length, it is likely that a significant number of stickers will develop a noticeable amount of crook and/or kink after repeated use. Stickers with more than 3 in. of crook or side kink (usually resulting from abnormal shrinkage around or near a knot), as measured by an imaginary line drawn from one end to the other, should not be used. If the plant also uses shorter stickers in other stackers or kilns, excessively crooked or kinked stickers can be cut back to shorter lengths and utilized. If not, they should be discarded. Stickers with broken ends that are shorter than the width of the package by 3 in. or more should not be used.

Measure and record the departure from straightness of about 20 stickers having noticeable amounts of crook or kink.

Rating
4 - All stickers have less than 2 in. of crook or kink
3 - No more than 3 of these stickers have 2 in. or more of crook or kink
2 - No more than 5 of these stickers have 2 in. or more of crook or kink
1 - More than 5 of these stickers have 2 in. or more of crook or kink

Inside an Empty Kiln

11. Inside a Cold Kiln

11a. Condensation or other water inside of kiln

Condensation will occur wherever the surface temperature is below the dewpoint. Proper kiln design and operation should minimize this. Well-insulated walls reduce condensation as does modulated venting when compared to on-off venting. Water can also enter the kiln through leaks in the roof or around doors. Evidence of condensation and leaks include water spots on the lumber, signs of running water in the kiln, corrosion problems, especially at the base of the walls and around the vents, and pitting of the concrete, especially below the vents and at the base of the columns.

Rating
4 - No evidence of condensation or water in kiln
3 - Some evidence of condensation near walls, at the base of structural members, or under vents, or small water leaks
2 - Much evidence of condensation, corrosion problems, or water leaks
1 - Kiln damage as a result of condensation or large amounts of water entering kiln

11 b. Drainage from kiln floor

Water that has condensed on vent lids or near vent openings runs or drips down to the floor of the kiln. As standing water evaporates, it can affect the humidity control in the kiln. Also, it can cause corrosion problems. Leaking steam and/or condensate return lines can also contribute to water on the floor. The kiln floor should be properly drained so that condensed or accumulated water can run out of the kiln.

Evaluating whether water is draining from the kiln floor must be done after the kiln has been operating at a humid condition (small wet-bulb depression), such as early in some schedules or after conditioning, At the end of a drying kiln charge done without conditioning, standing water would have been evaporated or drained away during the latter part of the schedule while the wet-bulb depression was large.

Rating
4 - No water standing on kiln floor
3 - Small amounts of water present
2 - Small puddles covering less than one-fourth of kiln floor
1 - Drains are plugged; water standing in kiln

11 c. Proper wet-bulb wick is used

The wick used for wet-bulb measurements must be made from a material that wicks water well; 10O% cotton is the best fabric. In addition, the wick must be thick enough so that more water can wick up to the bulb than can actually evaporate. This way the entire wick will always be very wet.

Rating
4 - Wick is thick, 100% cotton, and feels very wet to the touch
3 - Wick feels soft but is only damp, not wet
2 - Wick feels crusted on top and only damp, not wet
1 - Wick is crusted and dry

11 d. Adequate water flowing to wet-bulb

The wet-bulb thermometer gives a lower temperature than the dry-bulb thermometer because of the cooling effect of evaporating water from the wick. An inadequate water supply will slow the rate of evaporation, cause the bulb to give a temperature higher than the true wet-bulb temperature, and cause the kiln air to be drier than expected. If the water supplied to the wick is too cool, then the bulb temperature will be lower than the actual wet-bulb temperature causing the kiln environment to be too humid. Similarly, supply water that is

too hot will cause the kiln air to be too dry. If the water flow rate is properly adjusted, it is probably safe to assume that the temperature is also all right. Ideally the wet-bulb pan should be supplied with exactly the amount of water that is evaporated (there are systems that do this). However, because of changes in the evaporation rate and fluctuations in the water supply, it is common to supply slightly more water than evaporates. The excess overflows a weir and is piped out of the kiln.

Rating
4 - Water runs out of wet-bulb pan at a rate between 1/8 and 1/2 cup in 3 minutes
2 - Wick is wet but there is less than 1/8 cup of water or more than 1/2 cup overflowing the pan in 3 minutes
1 - Wick is barely damp or dry or pan is empty

12. Kiln Operational Checks

12a. Heating coils and steam pipe free of steam or water leaks

Even small leaks in the steam heating system can cause zones of high humidity, resulting in uneven drying. These leaks can be caused by internal pipe damage caused by erosion or corrosion, poor or loose fittings, or external damage to the piping. If there is insufficient slope to the heating coils, condensate can pool in one spot, contributing to poor heat transfer and internal corrosion.

A large leak is one similar in size to the water/steam that would come out of one hole in the steam spray line. To test for steam leaks, adjust the instrument controller so heat is called for and the steam valves open fully.

Rating
4 - No leaks present
3- Small leaks around fittings, in coils, or in steam pipes
2 - Several small leaks or one medium leak
1 - Several medium or large leaks

12b. Steam spray free of liquid water

The piping for steam spray in the kiln should be sloped so condensate drains out of the kiln. Check the drainage point for the steam spray line and make sure it is open. If condensate is in the spray line, it will spray onto the lumber, staining it, or onto the kiln structure, which encourages corrosion. The most serious evidence of water in the steam spray is water spots on the lumber. Liquid condensate or steam spray on temperature sensors can also cause the control system to function erratically. Condensate in the piping can also lead to corrosion in the pipe.

Rating
4 - No liquid water comes out when steam spray comes on, drain line is open, no water spots on lumber
2 - Improper slope on line or drainage point is blocked
1 - Water spots on lumber that can be traced to the steam spray line or spray line not draining to outside of kiln

12c. Steam spray uniformly distributed

Just as proper vent operation is necessary to maintain good humidity control along the length of the kiln, the steam spray needs to be uniform along the length of the kiln. When the kiln is empty and cool inside, turn on the spray line and observe each nozzle (drilled hole) on the steam spray line.

Rating
4 - All nozzles appear to produce equal amounts of steam
2 - Steam spray appears not uniform or one nozzle plugged
1 - More than one nozzle plugged

While Preparing Charges and Loading the Kiln

13. Lumber Quality and Package Loading

13a. Lumber thickness variation

Some variation in lumber thickness is to be expected from normal sawing conditions. However, thickness variation greater than about 1/32 in. (0.031 in.) is usually a result of sawblade or feed problems in the sawmill. Thickness variation greater than this can have a major effect on kiln drying. Thick lumber dries more slowly than thin lumber, so mixing thick and thin lumber in a kiln charge increases MC variation. When thick and thin pieces are mixed across a course, the thinner pieces are not restrained by the stickers. Thin lumber is then free to cup, twist, and bow.

Look at the ends of 15 packages of green lumber. All the boards should appear the same thickness with the stickers straight and touching all boards. Note gaps where thin boards are not restrained by the stickers. Also look for stickers bent over thicker boards. Figure 1 illustrates how to evaluate thickness variation.

Rating
4 - All boards are uniform and touching stickers; stickers are not bent
3 - Fewer than 10 boards per package do not touch stickers or stickers bend slightly over thick or thin lumber
2 - Thickness variation is sufficient to bend stickers or show gaps more than 1/8 in. wide above boards
1 - Thickness variation is great enough to make stacking visibly irregular

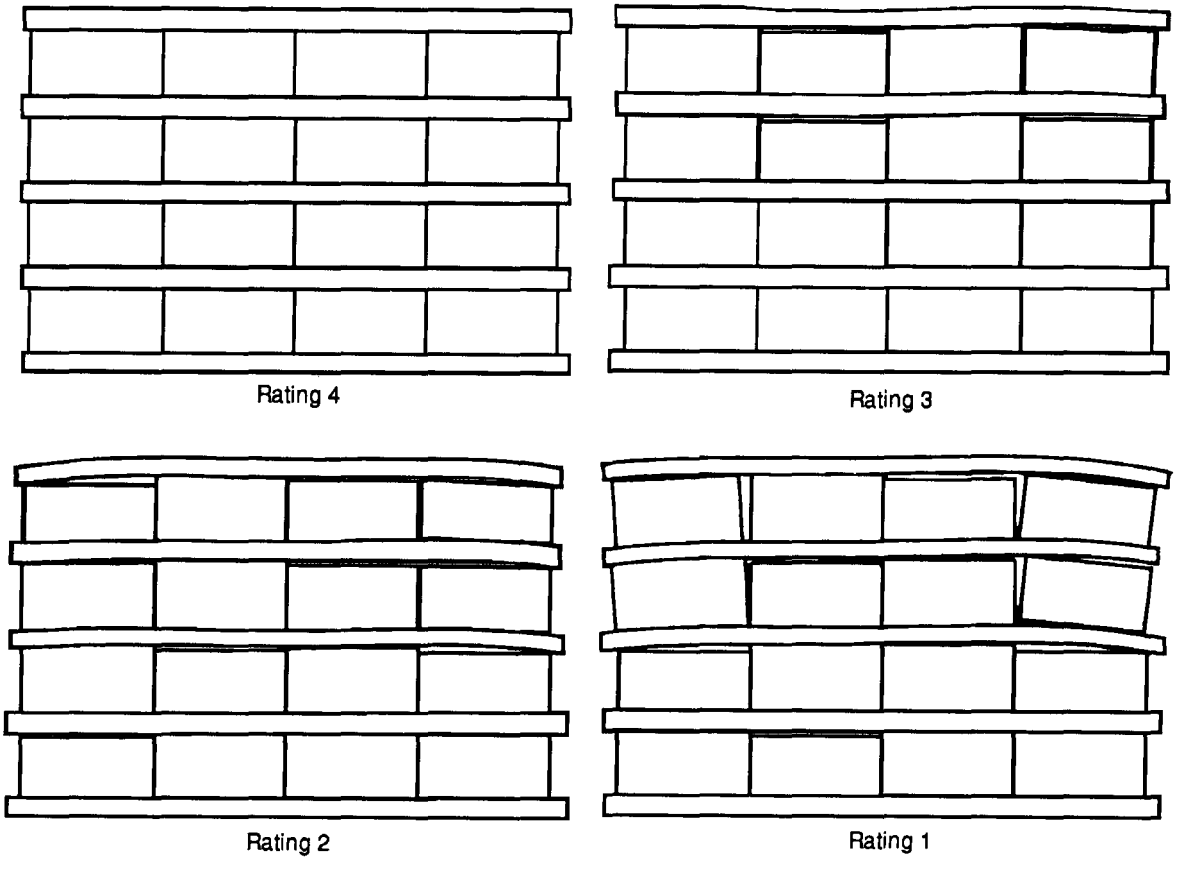


Figure 1. Evaluating lumber thickness variation.

13b. Plenum width adequate

Adequate width of the plenum chamber is necessary for uniform airflow through all the sticker spaces. If the plenum chamber is too narrow, airflow will drop off at the top of the load. The plenum width should equal the sum of the sticker and bolster openings.

In package loaded kilns, operators are sometimes tempted to add an extra row of packages near the door to increase kiln capacity. This narrows the plenum space from the design width and causes nonuniform airflow through the load. This is poor practice and not recommended. Plenum space in the front (near doors) should be the same as in the rear of the kiln.

Rating
4 - Plenum width equals the sum of the sticker and bolster openings
3 - Plenum width is between 3/4 and 1-1/4 times the sum of the sticker and bolster openings
2 - Plenum width is between 1/2 and 1-1/2 times the sum of the sticker and bolster openings
1 - Plenum width is less than 1/2 or more than 1-1/2 times the sum of the sticker and bolster openings

13c. Package arrangement to accommodate short packages

If possible, all packages stacked on top of each other should be the same length. In package kilns, it is best to place the shorter packages in the middle row, and as a next choice, in a row that is not under a top baffle. That way, the top baffle will be in contact with lumber the entire length of the kiln. In track kilns, side-by-side packages should also be the same length. When this is not possible, the shorter packages should be placed on the top of the longer packages and on the side away from the top baffle. If two shorter packages have to be positioned side by side in a track kiln, they should be staggered so that no voids are left to permit the air to short circuit. If the void is left at the end of the charge, air can pass around the end baffle. Examples of placement in track kilns are shown in Figure 2.

See Chapter 5 of the DKOM for additional information about package placement. Baffling voids, as recommended in Chapter 5, will further help prevent short circuiting the airflow.

Rating
4 - Shorter length packages are always on the top and away from the top and end baffles so there are no voids
2 - Voids are next to the top or end baffles but these do not go through the load
1 - Openings go through the load

13d. Package placement in package kilns

Careful placement of packages and baffles is particularly important in package-loaded kilns to prevent short circuiting of airflow. Short circuiting is more critical in a package-loaded kiln than in track-loaded kilns because of the generally longer distance air must travel from the entering-air to the leaving-air side of the load. In general, the greater the capacity of package loaded kilns, the more difficult it is to prevent short circuiting. When loading a package kiln, the initial back row of packages *should* be placed tight against *one* wall. The second row should be side shifted so it is tight against the opposite wall. The placement of packages should be alternated from one wall to the other until all rows have been loaded (Fig. 3). This will leave a minimum of air space along either side wall for short circuiting of air.

Rating
4 - Initial or back row is tight against one wall; next row side shifted tight against the opposite wall
3 - Rows staggered but package ends are more than 2 ft from walls
2 - No effort made in positioning packages to avoid short circuiting of air
1 - Extra or additional row of packages placed in plenum space next to loading door

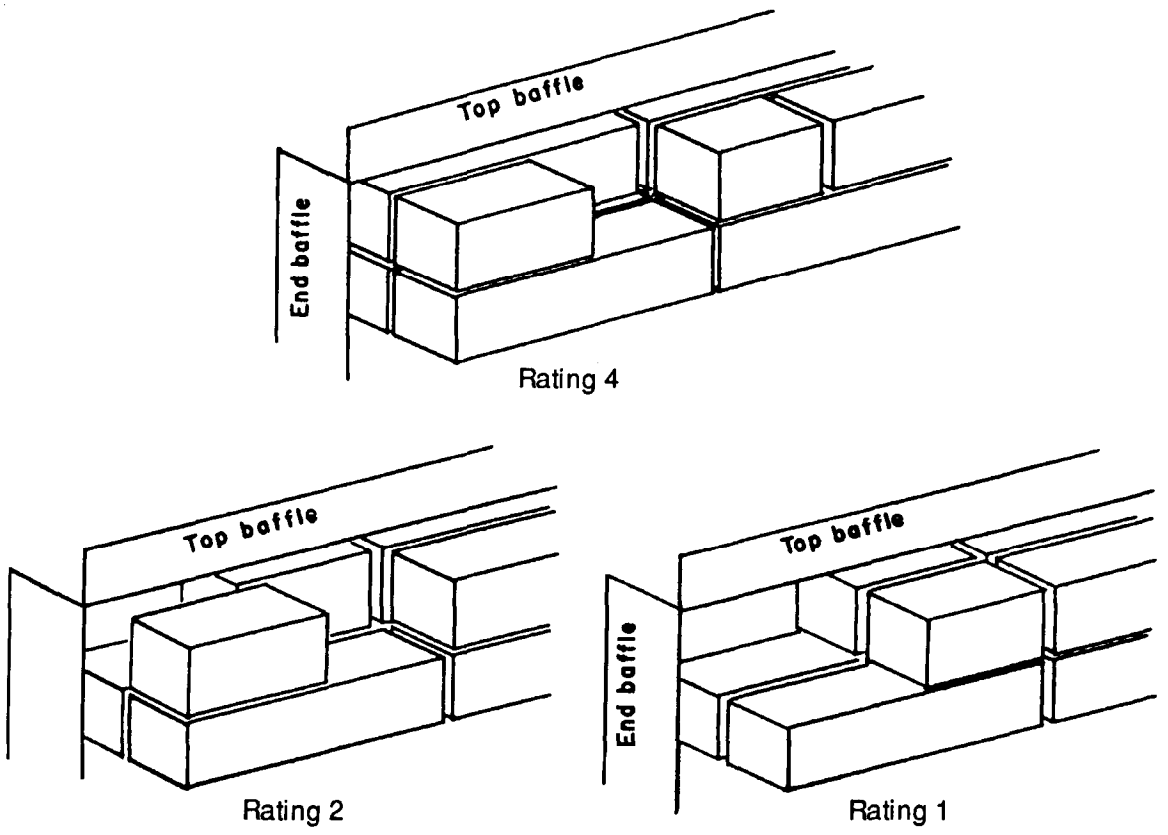


Figure 2. Evaluating package placement.

13e. Package placement on kiln trucks in track kilns

The main idea in stacking is to have good vertical alignment of stickers, bolsters, and kiln truck supports. Careful, exact placement of packages on the kiln truck and aligning the vertical tiers of stickers and bolsters with the supports on the kiln truck is strongly encouraged. Lack of attention to this detail will likely cause losses in the lower courses of lumber as a result of kink or warp. Make sure that kiln trucks have supports properly spaced to correspond to the sticker spacing used. Having some kiln trucks with a load support in the center rather than only at both ends will make it simpler to get load supports under each sticker column when the packages have an odd number of stickers. Figure 4 shows proper alignment with stickers.

Rating
4 - All truck load supports are vertically aligned under the columns of stickers
3 - No more than one truck is not in vertical alignment
2 - No more than two trucks are not in alignment
1 - More than two trucks are not in alignment

13f. Rails in track kilns

Rails need to be supported by a level, immobile foundation. When the rails are uneven, the kiln trucks are not all in the same plane. This, in turn, can cause lumber to bow or twist. Watch the rails as the loaded kiln trucks are rolled across them. If they deflect, they may not be securely fastened to the foundation or the foundation may have weakened or settled. Be careful while you are watching the trucks move in case the lumber shifts.

Rating
4 - All rails level and well supported with no sign of deflection
3 - Rails settle or move slightly in one or two places
2 - Dips in rails or more than 1/2 in. deflection when loaded
1 - Rails visibly out of level or have a large amount of deflection

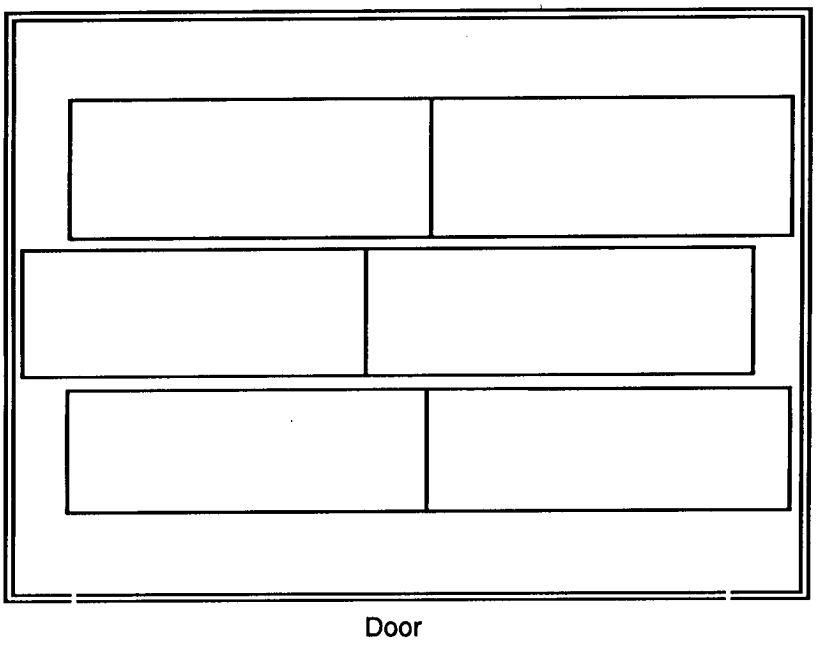


Figure 3. Top view of proper package placement in a package kiln.

During Kiln Startup and Operation

14. During Kiln Startup

14a. Adequate air flow across the wet bulb

Airflow must be adequate over the wet bulb for the correct wet-bulb temperature to be measured. Air velocity should be more than 300 ft/min. If the air velocity is less than 150 ft/min, the bulb will definitely give a reading higher than the actual wet-bulb temperature. Thus, a wet-bulb sensor with a low velocity airflow across it may indicate a 4° depression from the dry-bulb reading when the true conditions in the kiln could well be a 6° or 7° depression. The wood, of course, dries in response to the actual or true conditions in the kiln, which in this example is drier than the sensor indicates. Sometimes airflow to the wet bulb is blocked by a baffle, wall, or other object. If the airflow rate is too low, it is sometimes possible to move the wet bulb to a place where there is more airflow (further from the wall or higher in the plenum) or construct a device to blow air over the wick. See Chapter 4 of the DKOM for more information.

Rating

When airflow is measured at the wet-bulb sensor

4 - Measured airflow 300 ft/min or greater
3 - Measured airflow is 150 to 300 ft/mi
2 - Measured airflow is less than 150 ft/min
1 - Wet bulb is blocked from airflow

When airflow is estimated at the wet-bulb sensor

4 - Can easily feel air moving across wick
3 - Airflow is not easy to feel, but a handkerchief can be blown by the air
2 - Cannot feel air movement or see handkerchief move
1 - Wet bulb is blocked from airflow

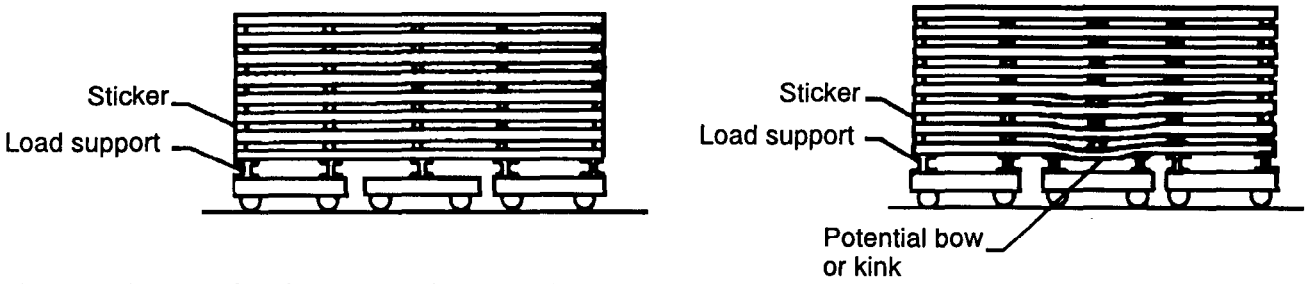


Figure 4. Alignment of truck supports or bottom load supports with stickers.

14b. Confirm that traps are tunctioning

Checking traps regularly is part of the standard kiln operating procedures. When the kiln is starting up, check the traps to confirm that they are working properly and are capable of handling the startup load. For example, a properly sized trap will discharge condensate intermittently. A continuous discharge of steam indicates a problem. Large amounts of condensate behind the trap may indicate a problem. Chapter 2 of the DKOM contains more information on traps.

Rating
4 - All traps are working
3 - Traps do not quite handle condensate during startup
2 - Traps are very undersized for startup and hold back a large amount of condensate
1 - One or more traps are not working

15. While Kiln Is Operating

15a. Doors, walls, and roof are free of leaks

Leaks in the kiln structure cause areas of low humidity and/or low temperature. This can lead to nonuniform drying and possible stain problems on some species. In addition, leaks are evidence of a structure that is in need of repair. Cool air leaking into the kiln can cause condensation leading to corrosion problems. During parts of the cycle in which the steam spray is used, leaks in the kiln structure increase the steam required.

Leaks show up as water vapor leaving the kiln on the entering-air side of the load. On the other side, air is being drawn into the kiln so the leaks are not visible. Check for leakage with the fans running first in one direction, then the other. Carefully check doors for leaks-door leaks can be the most common type of leak. A small leak means that vapor is visible or can be felt while the kiln is operating, but no daylight can be seen to identify the opening from inside the kiln. Large leaks are identified by large amounts of vapor and by daylight being visible from inside the kiln.

Rating
4 - No leaks are visible or only slight leaks around rails
3 - Slight leaks around doors or other small leaks
2 - Large leaks
1 - Holes visible in the kiln structure

15b. Confirm fan reversal by feeling airflow direction

The control charts give an indication that fan reversals were occurring in previous kiln runs. During initial startup, confirm that the fans actually reverse by feeling the airflow direction before and after fan reversal.

Rating
4 - Airflow actually reverses
1 - Airflow does not actually reverse when timer or control chart indicates it should

Moisture Content Control and Equalizing and Conditioning Treatments

16. Control of Moisture Content

16a. Proper selection and use of kiln sample boards

Using kiln sample boards or kiln samples is a method of estimating the MC of the lumber in the kiln as it is drying. This method uses short, carefully chosen sample boards sawn from larger pieces of lumber. These sample boards are placed in pockets constructed in the load and weighed periodically, and their MC is calculated. Sample boards should be chosen to represent all the lumber in the dryer-the slowest drying and the fastest drying. This means cutting sample boards from lumber that represents the driest and wettest, widest and narrowest boards, flatsawn and quartersawn, thickest and thinnest. For the best job of equalizing and conditioning, it is necessary to have the narrowest, driest lumber represented among the sample boards. See Chapter 6 of the DKOM for detailed discussion.

Rating

4 - Sample boards are always selected, prepared, placed, and used as recommended in the DKOM, with at least six samples per charge
3 - Sample boards are usually sampled and prepared well with at least six samples used per charge
2 - Sample board selection is poor, samples placed in bolster spaces, or there are fewer than six samples per charge
1 - No real thought is given to sample selection, samples poorly placed in the kiln or only one to three samples per charge

16b. Moisture content variation using kiln sample boards

Moisture content after equalizing and conditioning must show little variation from the target MC when the intended product is furniture, cabinetry, or flooring. Target MCs are frequently around 7% or 8%. Allowable variation around this target is typically only plus or minus 2% MC. The use of properly selected and placed sample boards that are weighed periodically to determine MC values in the kiln at any given time is still the best recommended practice. It should be noted again that hardwood lumber grades do not imply any specified MC or relief of drying stresses. These points are specified and/or agreed on by buyer and seller.

Rating
4 - All sample boards are within 1% MC of target when kiln run is completed
3 - No sample board more than 2% MC off target
2 - No sample board more than 3% MC off target
1 - Sample boards not used

16c. Moisture content variation measured by in-kiln monitors.

The objective of in-kiln monitoring equipment is to provide the same information provided by the sample board technique, but to do it remotely without the necessity of entering a hot kiln, retrieving sample boards, weighing them, and returning them to their position in the load for future weighings and monitoring.

To be a successful tool, equipment must be maintained and operated according to the manufacturer's specifications. Some operators augment their in-kiln monitors with a limited number of sample boards, because currently available in-kiln monitors are not highly accurate when wood is above the fiber saturation point.

Rating
4 - All readings of sensors in monitored boards are within 1% MC of target when kiln run is completed
3 - No reading is more than 2% MC off target
2 - No reading is more than 3% MC off target
1 - Readings of monitored boards off target by 4% MC or more

16d. Moisture content variation measured by electric moisture meter

Spot checking with an electric moisture meter at the conclusion of the kiln run is a suggested method for determining the MC spread. The readings from electric moisture meters usually require a correction for species. In addition, there is a temperature correction if the lumber is hot. These correction factors are listed in the manual supplied with the meter. Remember to apply them to your readings. Check 10 boards in each package with the meter.

Rating
4 - All values are within 2% MC of target
3 - All values are within 3% MC of target
2 - All values are within 4% MC of target
1 - Some values are greater than 4% MC off target

17. Equalizing and Conditioning Treatments

17a. Equalizing and conditioning treatments used correctly and used when needed

Equalizing treatments are used to reduce the MC spread within boards as well as between the wettest and driest boards in a kiln charge. An equalizing treatment is suggested when the spread between the driest and the wettest kiln sample boards exceeds about 2% MC in the final stages of drying. Begin the equalizing treatment when the driest sample is 2% below the final target MC and continue until the wettest piece has dried to the target MC. For more details on the equalizing procedure, see Chapter 7 of the DKOM.

Conditioning treatments are used to relieve the drying stresses and tension set (often called casehardening) that are present at the end of kiln drying and equalizing. Any lumber that will be resawn, ripped, or machined nonuniformly should be conditioned to relieve stresses. The conditioning treatment should be the final step in kiln drying after reaching the target MC and completing the equalizing treatment. For more details on the conditioning procedure, see Chapter 7 of the DKOM.

Rating
4 - Equalizing treatment used when MC spread is 2% or greater, conditioning used when stress relief is required, with close attention paid to achieving the correct wet-bulb depressions
3 - Equalizing treatment used when MC spread is 5% or greater, conditioning used when required, correct wet-bulb depressions usually achieved in a few hours
2 - Equalizing treatment seldom used, conditioning done if required, correct wet-bulb depressions not usually achieved until near the end
1 - Equalizing treatment not used, conditioning consists of steaming for a few hours, with no control of wet-bulb depression

17b. Check for drying stresses using prong test

Stress relief may be needed when the manufactured product requires stress-free lumber. Evaluation of stress relief achieved is made by cutting stress sections, sometimes known as the prong test. Several boards, both wide and narrow, should be checked from each kiln charge. If you are not familiar with this procedure, a complete discussion is given in Chapter 6 of the DKOM or in Appendix A of “Dry Kiln Schedules for Commercial Woods.”*

Rating
4 - Several boards, wide, narrow, and average width, are checked from each kiln charge and show no stress
3 - Only one or two boards checked from each kiln charge or several boards show slight stress
2 - Drying stresses are checked only when trouble is reported or regularly show severe drying stress
1 - Drying stresses are never checked

[2]Boone R. Sidney; Kozlik, Charles J.; Bois, Paul J.; Wengert, Eugene M. 1988. Dry kiln schedules for commercial woods—Temperate and tropical. FPL-GTR-57. Madison, Wl: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 158 p.

After Drying Is Completed

18. *Before Unloading Kiln*

18a. Baffles used properly

Baffles in the kiln direct the air through the courses of lumber rather than letting it go around the ends, over the top, or under the load. Overhead, end, and floor baffles should always be used on every load. Not to do so almost guarantees unevenly dried lumber, requires extra time in the kiln, and wastes energy.

Baffles should be placed flush against all sides of the load and be well secured, so they are not blown out of position during drying. As the lumber shrinks in drying, gaps maybe left between the baffles and the load, which also allows air to bypass the sticker openings. If this occurs, repositioning or enlarging the baffles may be necessary. When you open the kiln after drying, check the baffles to verify that they remained in place and were tight against the load throughout the cycle.

Rating
4 - Baffles are placed flush against the top, bottom, and ends of the load and were held securely during drying
3 - No spaces greater than 6 in. between baffles and the load, and baffles were held securely
2 - No spaces greater than 12 in. between baffles and the load, and baffles were held securely
1 - Baffles are missing, bent, or openings are greater than 12 in. between baffles and the load; any baffles were unsecured

18b. Package height uniform for good top baffle contact

All packages in a kiln charge should be of a uniform height. This allows the top baffles to continuously contact the lumber pile along the entire length of the charge. Low packages leave space under the baffle for air to bypass the load.

Rating
4 - All pile heights are the same
3 - Pile heights vary but are uniform under the baffle
2 - Pile heights vary by up to 1 ft and one pile does not reach baffle
1 - Pile heights vary by more than 1ft, and several packages do not reach baffles

Evaluate Stacking and Its Effect on Drying Quality

Proper stacking is important for preventing warp and ensuring proper kiln loading and adequate airflow through the kiln charge. The stacking operation may be remote from the kilns and the kiln operator; however, it is vital that the kiln operator pay close attention to how well the lumber is stacked and to provide feedback to the person supervising the stacking operation. By evaluating snickering and stacking practices after drying, you can see how they affected drying quality. Chapter 5 of the DKOM contains additional information about snickering and stacking.

19. Sticker Placement

19a. Sticker alignment

Stickers serve two main purposes. First, they separate the courses of lumber so that air can move through the stack to dry the lumber. Second, they distribute the weight of the lumber vertically from top to bottom—through the stickers and bolsters down to the kiln truck or load supports. Stickers out of alignment, stickers on edge, and stickers missing from their position can be costly to lumber quality by causing kink, twist, ski-tipped ends, and other forms of warp.

Ideally, all stickers in a column are vertically in line. In practice, however, the stickers are not perfectly positioned and may move after being placed by the stacker. For proper alignment, stickers should at least overlap the ones above and below.

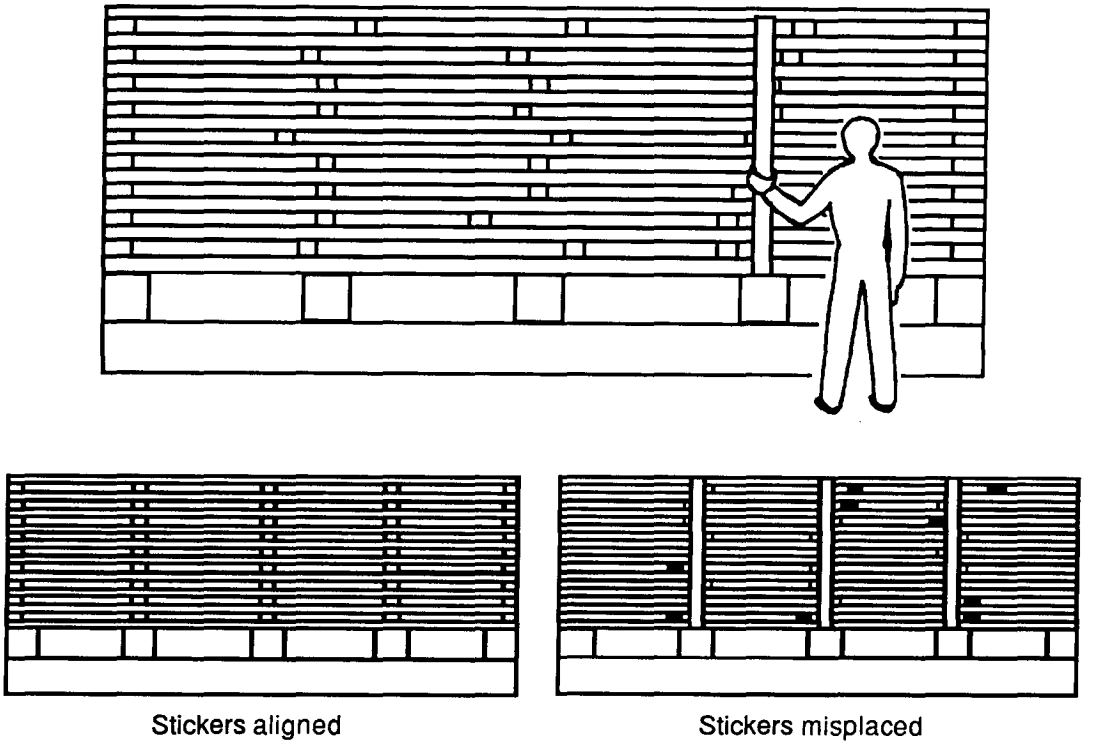


Figure 5. Examples of good sticker alignment and misplaced stickers. (Solid black stickers are misplaced.)

To test tor this, hold a straight sticker vertically in front of a column of stickers, covering as many as possible, as shown in Figure 5. Count the stickers that are not partially hidden behind the sticker that you are holding. Consider one column of stickers to be a vertical tier as high as one package (20 to 35 stickers, depending on the package height and board thickness). Select 15 columns from as many different packages as possible and from as many different positions in the package as possible. Count the total number of stickers that are not at least partially hidden from view, as shown in Figure 5. Try to observe if any patterns point to the cause, such as all the misaligned stickers are related to a certain position on the stacker.

Rating
4 - All stickers are vertically aligned or no more than 2 stickers are out of alignment
3 - No more than 5 stickers are out of alignment
2 - No more than 10 stickers are out of alignment
1 - More than 10 stickers are out of alignment

19b. Stickers missing

Missing stickers will result in bow, particularly in 4/4 and 5/4 lumber. Besides the degrade that can occur, airflow is restricted by the deformed boards, resulting in more variation in MC. Check 15 columns of stickers as described in 19a., and count how many stickers are missing.

Rating
4 - All stickers are present or no more than 2 stickers are missing
3 - No more than 5 stickers are missing
2 - No more than 10 stickers are missing
1 - More than 10 stickers are missing

19c. Stickers on edge

Stickers that are on edge cause warp problems and possible planer skip from a sticker indentation. They occasionally end upon edge by bouncing or by misplacement at the stacker. Check 15 columns of stickers as described in 19a., and count how many stickers are on edge.

Rating
4 - No more than 2 stickers are on edge
3 - No more than 5 stickers are on edge
2 - No more than 10 stickers are on edge
1 - More than 10 stickers are on edge

19d. Sticker placement at ends of packages

Ideally, the stickers at each end of the package should be within one sticker width of the board ends. If the stickers are exactly at the ends when the packages are built, they may fall out while the packages are transported and loaded in the kiln, particularly if the packages are carried by forklift and the yard is rough. When the stickers are more than 2 or 3 sticker widths further in, the unrestrained ends of the lumber tend to end split, twist, and warp. Check 15 columns of end stickers, and count the number that are more than 2 sticker widths in from the end.

Rating
4 - All stickers are within 1 sticker width of ends
3 - No more than 3 stickers are more than 2 sticker widths in from the end
2 - No more than 5 stickers are more than 2 sticker widths in from the end
1 - More than 5 stickers are more than 2 sticker widths in from the end

20. Board Placement In Packages

20a. Packages are square at both ends

Proper stacking practices call for both ends of the package to be even ended or squared up. At many hardwood plants, sorting of lumber by exact length is not practical. Double-end trimming is not common and lengths may vary in multiples of 6 in. to 1 ft, and boards may not be exactly square on the ends. To accommodate this variation, the box piling method of stacking is recommended (Fig. 6). Note that full length boards should be on each edge of the course, with shorter boards in the interior. Care should be taken that individual board ends do not extend beyond the nominal package end. When this extension exceeds about 5 to 6 in., it can cause problems in placing the package on the kiln trucks, when pushing the trucks into the kiln by pushing the board in the next package off the end sticker or when loading a package loaded kiln by misaligning the stickers, damaging board ends, or all of these.

One function of even-ending is to enable the stacker to place a sticker as close to the end of the board as practical. If the sticker is too close to the end, it may fall out in handling. If the sticker is too far away from the end of the board, the end is free to split and twist.

Check both ends of at least five packages for overhanging boards and boards that do not reach the end sticker.

Rating

4 - All boards in all packages reach and are supported by the end sticker; ends of packages are vertical
3 - Not more than 5 boards per package either do not reach the end sticker or extend beyond it by more than 3 in.
2 - No more than 10 boards per package either do not reach the end sticker or extend beyond it by more than 6 in.
1 - More than 10 boards per package either do not reach the end sticker or extend beyond it by more than 6 in.

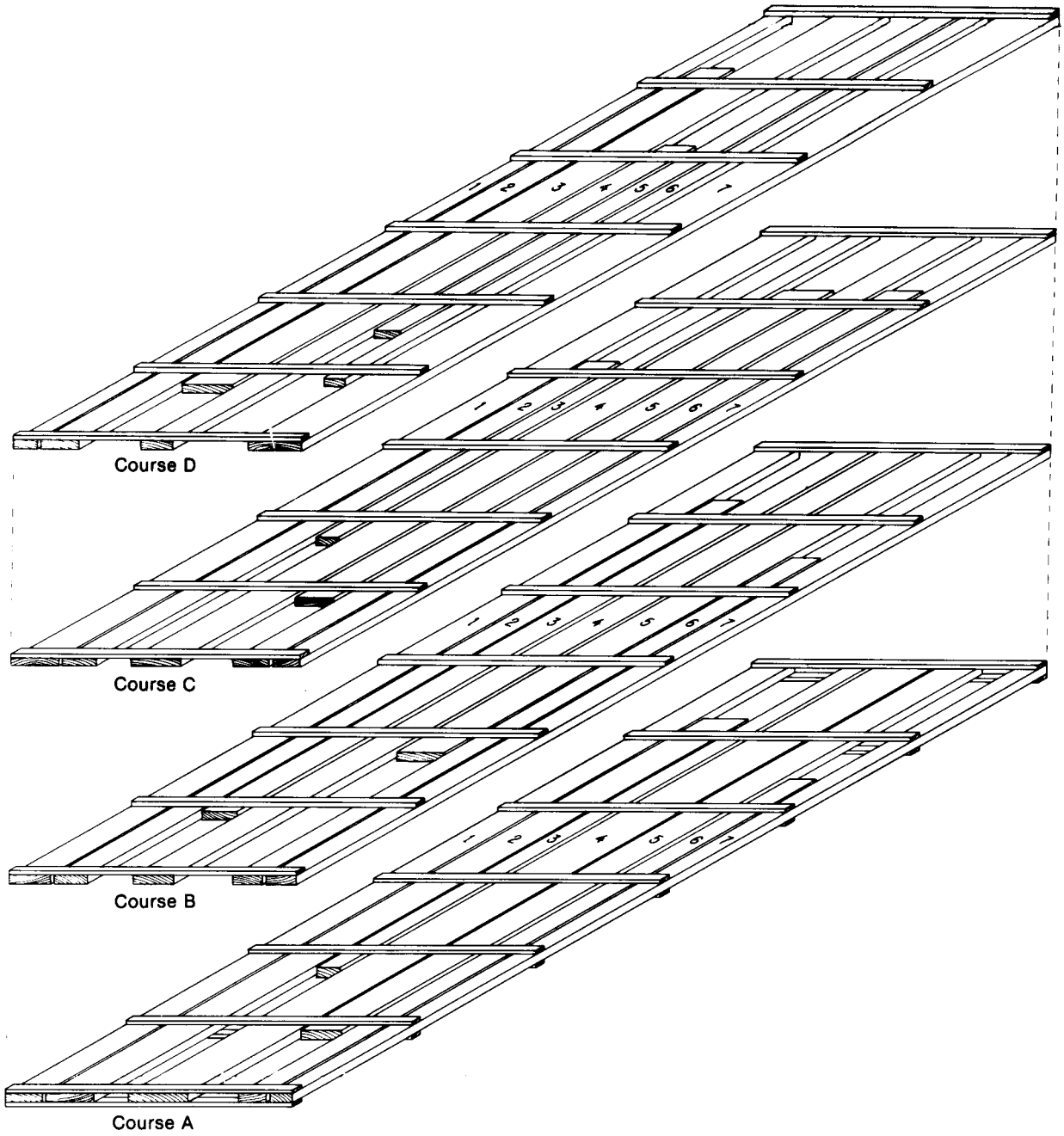


Figure 6. Example of box piling with full-length boards along each outside edge of the course and shorter boards alternate ended inside the "box."

20b. Overlapped boards in package

When building the packages either mechanically or by hand, boards may become overlapped. This overlap blocks airflow through the sticker space, causes the overlapped board to cup or possibly split, and bends or even breaks the stickers over it. The high spot caused by the double board thickness prevents even stacking of the courses above the overlapped boards and makes the entire package unstable. Check at the ends of at least 10 packages.

Rating
4 - No overlapped boards can be seen
3 - Fewer than 3 boards overlap
2 - Fewer than 5 boards overlap
1 - More than 5 boards overlap

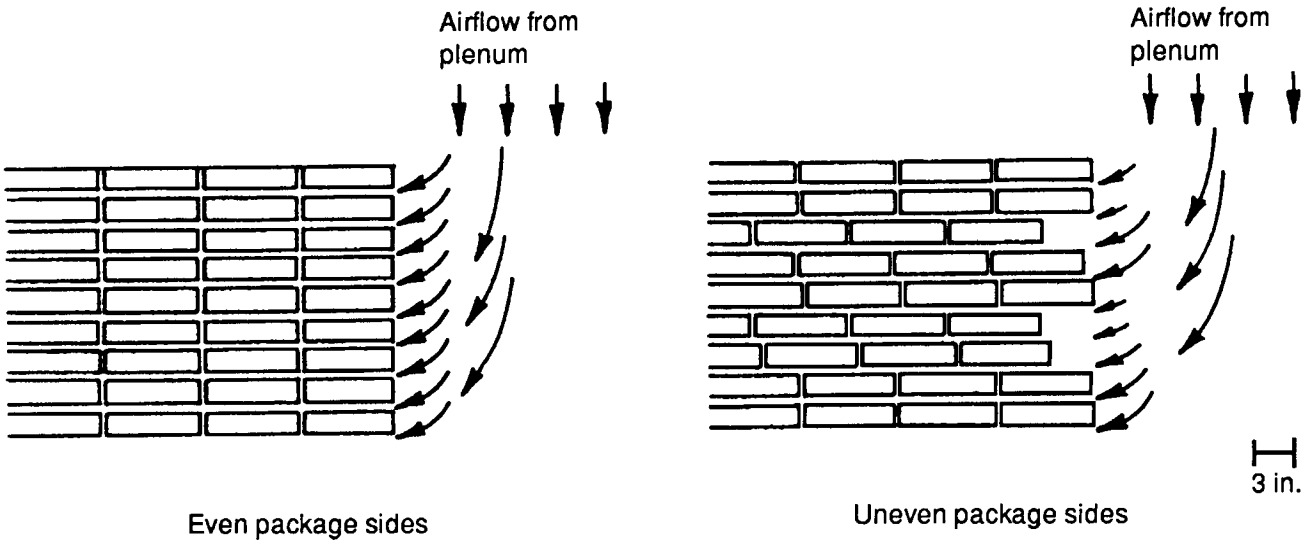


Figure 7. Uneven sides on package result in uneven airflow. The horizontal distance from the narrowest course should be no more than 3 in. Length of arrows is proportional to airflow.

20c. Sides of packages even

Holdback arms on the stacker or manipulation by individuals working on the semiautomatic stacker should ensure that the sides of the packages are even from top to bottom. This gives all sticker slots equal opportunity for airflow. When courses are staggered more than 3 in. within the package, some sticker openings get more airflow than others, as illustrated in Figure 7. Check both sides of at least five packages.

Rating
4 - Sides of all packages are even
3 - No more than 1 course per package is not even
2 - No more than 3 courses per package are not even
1 - More than 3 courses per package are not even

21. Bolster and Package Placement

21a. Bolster (bunk) placement between packages

Bolsters should be placed in vertical alignment with every column of stickers. This assures that the weight is transferred down through the load without causing bow or sticker kink. With 2-ft sticker spacing, bolsters should be under every column of stickers. When stickers are on 1-ft spacing, bolsters maybe placed under every other column of stickers.

Bolsters are out of alignment when the sticker column is not over at least part of the bolster. Figure 8 shows bolsters in alignment and out of alignment. Check the alignment of 15 bolsters. If you can see that a bolster is skewed rather than being placed straight across the package, count it as being out of alignment.

Rating
4 - All bolsters vertically aligned with every column of stickers
3 - Not more than 2 bolsters out of alignment or missing in a charge
2 - No more than 4 bolsters out of alignment or missing in a charge
1 - More than 4 bolsters out of alignment or missing in a charge

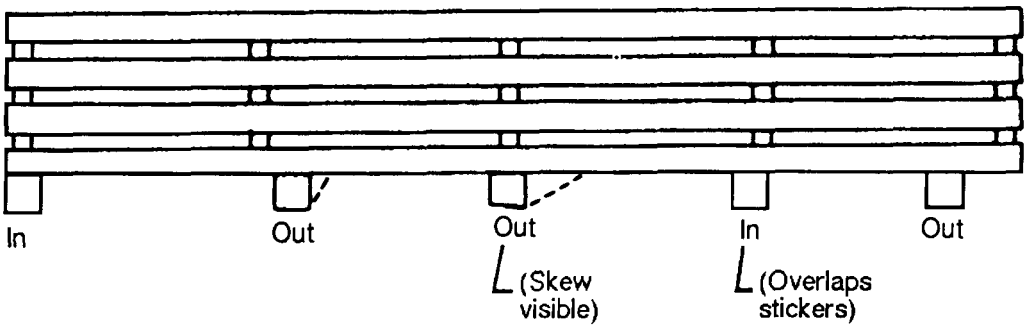


Figure 8. Bolster placement.

21 b. Bolster (bunk) placement on floor

As mentioned previously, the main objective in stacking is to distribute the weight of the lumber through good vertical alignment of stickers and bolsters, including the bolsters between floor and packages. Careful, exact placement of bolsters under every tier of stickers is strongly encouraged. Lack of attention to this detail will likely cause losses in the lower courses of lumber as a result of kink or warp. Check the alignment of 15 bolsters and count the number out of alignment.

Rating
4 - All floor bunks are vertically aligned under stickers
3 - No more than two floor bunks not in vertical alignment under stickers or missing
2 - No more than four floor bunks not in alignment or missing
1 - More than four floor bunks not in alignment or missing

21 c. Chimney allowance (track-loaded kilns)

Careful side-by-side placement of lumber packages on the kiln truck is important to make sure that the air can readily move from one package to its adjacent neighbor. The fork lift operator should leave a 2- to 3-in. space to act as a manifold or chimney between the two packages. The air can then pass through one package of lumber and have a small “plenum” to provide uniform airflow through the second package. The chimney should be closed at the top by pushing on the top two or three courses with the tines of the forklift. Otherwise, the airflow can pass out the top of the chimney and partially bypass the second package. Chimney placement is shown in Figure 9.

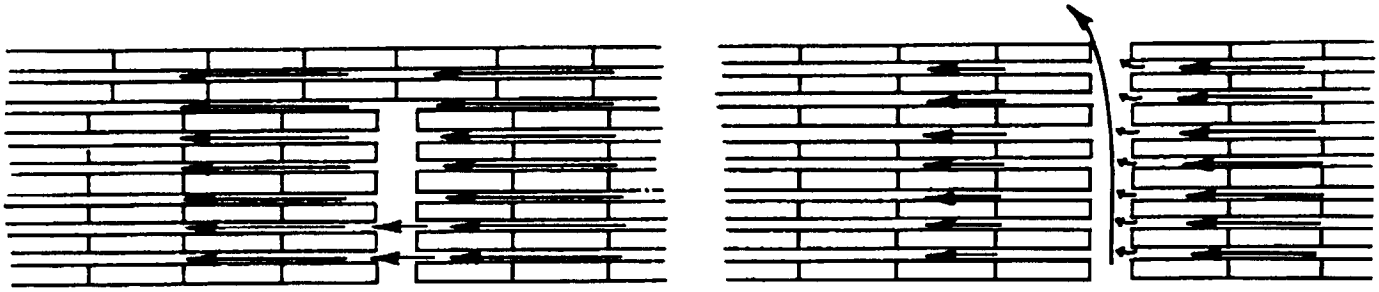
The lack of a proper chimney between adjacent packages on a truck will cause wet packages to occur in what often appears to be a random pattern. It may also be responsible for the wood temperature not getting high enough to set pitch and/or kill insects.

Rating
4 - Chimney between adjacent packages is 2 to 3 in. wide and restricted at the top
3 - Chimney is 2 to 3 in. wide but is not restricted at the top
2 - Chimney is 3 to 6 in. wide but is not restricted at the top
1 - Chimney is larger than 6 in.

21 d. Packages placed at edge of kiln trucks

Each package should be placed on the kiln truck so that the side of the package is vertically in line with the supports on the kiln truck. If the package is placed in from the end of the supports, there will be a space between the bottom baffle and the edge of the lumber where air can bypass. It can also interfere with the chimney between lumber packages. Packages that overhang the truck supports decrease the plenum width and may be more prone to tipping. Check all packages in a kiln charge.

Rating
4 - All packages are placed within 1 in. of the edge of the kiln truck supports
3 - One package is not even with edge of kiln truck supports
2 - Two packages are not even with the edge of the kiln truck supports
1 - More than two packages are not even with the edge of the kiln truck supports



Narrow chimney restricted at top; rating 4

Unrestricted chimney; rating 3 to 1 based on chimney width

Figure 9. Chimney allowance for airflow through the pile. Arrow length is proportional to airflow.

Drying Degrade

Because of the products for which it is commonly used, e.g., furniture, cabinets, flooring, the tolerance of drying defects, including variations in MC, is very exacting when drying hardwood lumber. Softwoods dried for furniture, mouldings, and other trim closely approach the standards required for hardwoods. In drying hardwoods, quality is extremely important, and in making decisions, the first question should always be how will this affect drying quality. After this question is answered, then questions of how much time or energy can be saved should be asked.

Drying defects such as surface and end checks, internal checking, end splits, and stain are considered more important than warp when drying hardwoods. This is partly because warp is not considered a major defect according to National Hardwood Lumber Association (NHIA) grading rules. Hardwood lumber grades are largely based on size and amount of clear face cuttings that can be obtained from a given board. Any adverse effect of warp is related to the size of cuttings required.

Variation in final MC of lumber is of considerable concern; usually no more than 2% to 3% is generally acceptable. Hardwood grades do not imply any specified MC. Final MCs and tolerances must be specified by buyer or negotiated between buyer and seller.

In the hardwood drying checklist, most of the emphasis is on drying defects that can be seen while the dry rough lumber is still stacked. A smaller part requires observations at the planer or in the rough mill to judge drying defects on surfaced and/or cut up lumber.

22. Drying Degrade Seen In Rough Dry Lumber

22a. End checking and/or end splits visible in stickered lumber

End checking and end splits can start in log ends or as soon as freshly exposed ends are generated during the manufacture of lumber. End checking and end splitting caused by drying (some end splits can be caused by growth stresses) can be minimized by applying end coating to log ends but is more commonly done after stacking the green lumber. For maximum effectiveness, end coating should be applied as soon as possible after fresh ends are generated during manufacture. Historically, only lumber 6/4 or thicker has typically been end coated, with 4/4 and 5/4 lumber end coated in some higher value species such as walnut and in some higher value imported species. Recently, there has been increased interest in end coating 4/4 and 5/4 lumber of the more refractory species such as oak and beech. Check the ends of 10 packages, count and record the number of end checks and splits deeper than 2 in.

Rating

4 - No end checks or end splits are visible
3 - End checks or end splits are deeper than 2 in. in no more than 10 boards per package
2 - End checks or end splits are deeper than 2 in. in no more than 20 boards per package
1 - End checks or end splits are deeper than 2 in. in more than 20 boards per package

22b. Surface checking visible in stickered lumber

Surface checking can be a very serious problem in furniture and cabinet lumber. Some have suggested it is the number one drying defect for dense woods such as oak and beech. Generally, if even modest surface checking can be seen in the stickered rough lumber, then losses in the rough mill will be substantial. Because it is difficult to see surface checks in stickered lumber packages, try to observe for checks as the packages are being broken down. Also, observe sample boards for surface checking. A later section explains evaluation of surface checking after the lumber is planed.

Rating
4 - No surface checking visible
3 - Surface checking visible in fewer than 4 boards per package
2 - Surface checking visible in 4 to 8 boards per package
1 - Surface checking visible in more than 8 boards per package

22c. Warp (including kinks) related to snickering and stacking

Warp in lumber is any deviation of the face or edge of a board from flatness or any edge that is not at right angles to the adjacent face or edge. In the checklist, we are interested in looking for the five types of warp shown in Figure 10: crook, bow, twist, kink, and cup. Crook is defined as a distortion of a board in which the edges deviate from a straight line from end to end of the board. Bow is defined as a distortion in a board that deviates from flatness lengthwise but not across its faces. Twist is a form of warp caused by the turning of the edges of a board so that the four corners or any face are no longer in the same plane. Kink is a form of warp in which there are sharp deviations from flatness such as when the piece is sharply bent by misplaced stickers, bolsters or warp around a knot. Cup is a distortion of a board in which there is a deviation flatwise from a straight line across the width of a board.

Warp will occur in some boards regardless of how they are dried. The warp that is of most concern in evaluating the quality of drying is that which could have been prevented by good drying practices. This means, for example, that bow caused by lack of restraint (top loading) or the occurrence of tension wood in boards near the top of the pile is of less concern than bow caused by poor sticker placement.

The warp assessment is best done as the dry lumber packages are taken out of the package kiln or removed from the kiln cars. Watch for more warp occurring in one section of the kiln than in others. Look at how warp is related to snickering and stacking. You can frequently see where boards are kinked due to misplaced or missing stickers. If bolsters or floor supports are not in line with the sticker columns, the bottom courses may sag or kink. Too wide a sticker spacing can result in sag in all boards. At the ends of the packages, you can see where thin boards cupped or twisted because they were not supported by the stickers. These observations will help explain the need for accurate stacking.

Count and record the total number of warped boards, including all five forms of warp, in the charge of lumber that can be related to sticker or bolster misplacement or package placement. Be sure to look at each bolster or kiln truck support, at places where the stickers are missing, misplaced, or on edge, and at boards that overhang the stickers. Remember that one poorly placed bolster or sticker may affect all the boards across the pile.

Rating
4 - No warp or kinks observed
3 - Warp or kinks in no more than 10 boards per package
2 - Warp or kinks in no more than 20 boards per package
1 - Warp or kinks in more than 20 boards per package

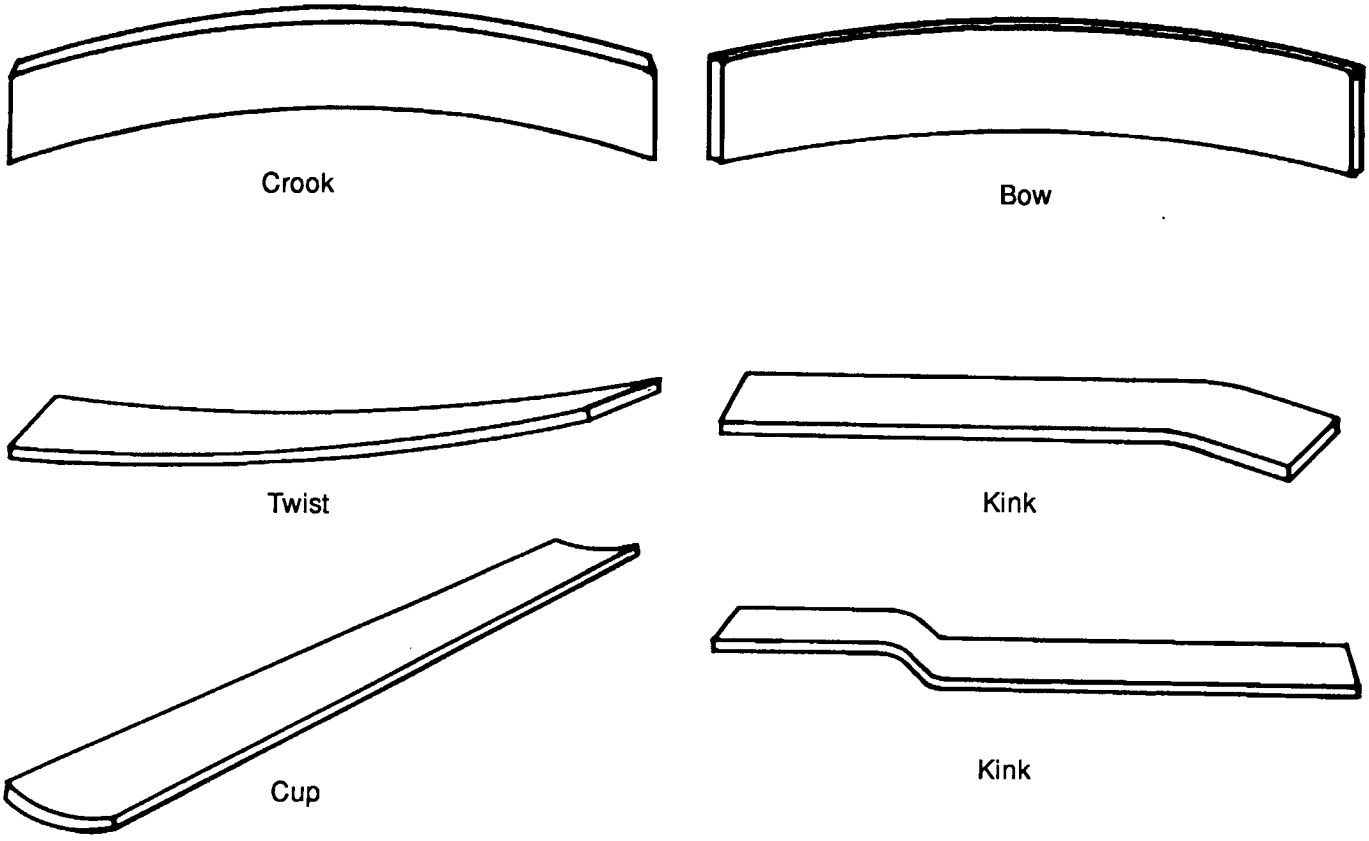


Figure 10. Types of warp.

23. Drying degrade problems reported that are not readily seen in rough dry lumber

23a. Rough mill and/or glue room complaints

Lumber may make it all the way to the rough mill, planer mill, or maybe even the glue room before drying problems like surface checks, honeycomb, end checks, stain, variations in MC are apparent.

Evaluation of the following types of drying defects should be made in the rough mill, planer mill, or by communicating with personnel or supervisors in those operations: surface checking, internal checking, end checks/end splits, and stain. Scoring on the checklist should be self explanatory.

Rating
4 - Seldom receive complaints
3 - Complaints of MC-related (too wet-too dry) problems affecting less than 5% of production
2 - Complaints of MC-related problems affecting less than 10% of production
1 - Complaints of MC-related problems affecting more than 10% of production

23b. Surface checking seen on surfaced lumber or cuttings

In many cases, surface checking cannot be seen on hardwood lumber until it has been surfaced. This is usually because surface checks that formed in the early stages of drying have closed, or partially closed, in the later stages of drying and cannot be seen in the rough dry lumber. Removing the rough surface then exposes the open check. In some instances, very small surface checks that are tightly closed are not seen until the piece gets all the way to the finishing room and stain or finish is applied.

Rating
4 - Surface checking seldom reported as a problem
3 - Surface checking reported for an occasional kiln charge
1 - Surface checking frequently reported as a problem

23c. Internal checking or honeycomb seen on ends or surfaces

In many cases, internal checking, also called honeycomb, cannot be seen in rough, dry lumber. It may not be noticed until it reaches the rough mill and is being ripped or cross cut into furniture or cabinet parts, or perhaps even later when it is being assembled to fabricate glued-up panels. If it occurs in very many boards, the kiln operator or kiln supervisor usually is notified.

Rating
4 - Internal checking seldom reported as a problem
3 - Internal checking reported for an occasional kiln charge
1 - Internal checking frequently reported as a problem

23d. End checks and/or end splits seen on surfaced lumber or cuttings

End checks or splits seen on surfaced pieces or furniture parts are the result of the end checks that started in the log or freshly sawn lumber. They also can be generated when fresh ends that are produced from cross cutting are exposed to air with an EMC lower than the lumber. This is a fairly common problem in nonhumidified plants during the cold months of the year. This may be traced to problems during drying or to improper storage between drying and manufacture.

Rating
4 - End checks/splits seldom reported as extending more than 3 in. into piece
3 - End checks/splits extending more than 3 in. reported for an occasional kiln run
2 - End checks/splits extending more than 5 in. reported with some frequency
1 - End checks/splits extending more than 5 in. area constant problem

23e. Stain, including sticker stain, related to drying in species and grades in which it, is a degrading condition.

Discolorations or stains in hardwood lumber can lower its value and limit its uses, particularly when the end use requires a clear, natural finish. Unwanted discolorations can develop in the tree, during storage of logs and green lumber, or during drying. Discolorations may also develop when light, water, or chemicals react with exposed surfaces of dried wood. Drying discolorations have been traditionally classified as being associated with fungal attack or with chemicals in the wood. Sticker stains or sticker marks, both considered a form of chemical stain, are probably the most common type of drying related stain in hardwoods. A detailed discussion of discolorations and stains is given in Chapter 8 of the DKOM. In many cases, stains and discolorations are not seen until the lumber is surfaced.

Rating
4 - Staining problems are rarely reported
3 - Stain affects less than 5% of production
2 - Stain affects less than 10% of production
1 - Stain affects more than 10% of production

Checklist for Quality Drying of Hardwood Lumber

Standard Operating Practices

1. Maintenance and Inspection

Low High

1a. Equipment above fan floor inspected regularly. 1 2 3 4

Rating
- 4 - Fans, motors, bearings, shafts, and other equipment inspected monthly
- 3 - Inspected quarterly
- 2 - Inspected annually
- 1 - Inspections are not made regularly

1b. Air velocity checks made regularly. 1 2 3 4

Rating
- 4 - Checked at least semiannually and when unusual lumber load configuration or package arrangement exists
- 3 - Air velocity is checked when there is a problem
- 2 - Air velocity was checked when the kiln was new or rebuilt
- 1 - Air velocity has never been checked

1c. Traps checked for proper operation and plumbed for checking. 1 2 3 4

Rating
- 4 - Traps are checked for condensate backup and passing steam weekly; traps are properly sized for the load
- 3 - Traps checked at least every 30 days, or traps are not quite large enough to handle condensate during startup
- 2 - Traps are checked at least every 6 months, or traps are very undersized
- 1 - Traps are rarely checked, inaccessible, not plumbed for regular checks

1d. Air supply to control instruments and operating valves checked at regular intervals. 1 2 4

Rating
- 4 - Air filters and compressors are checked and drained daily
- 3 - Inspected on some other schedule but at least monthly
- 2 - Inspected only when a problem is suspected
- 1 - Inspected only when the controller or air supply does not work

1e. Regular maintenance program for steam valves. 1 3 4

Rating
- 4 - Valves are inspected at least every 90 days
- 3 - Inspected at least annually
- 1 - Inspected only when a problem is suspected

1f. Regular calibration of temperature sensing devices and indicators. 1 2 3 4

Rating
- 4 - Calibration checks sensors are made at least every 6 months; results are recorded and filed
- 3 - Calibration checks are made more than 6 months apart but at least every 2 years
- 2 - Calibration is checked when a problem is suspected
- 1 - Not calibrated since installation

1g. Wet-bulb wicks changed on a regular schedule. 1 2 3 4

Rating
- 4 - New wick(s) used every charge
- 3 - Wick(s) changed on some other regular schedule
- 2 - Wick(s) changed when they are dirty, feel crusty, or falling apart
- 1 - Wick(s) changed rarely

Low High

1h. EMC wafers changed on a regular schedule 1 3 4

Rating
- 4 - Equipment manufacturer's replacement schedule followed exactly
- 3 - Equipment manufacturer's replacement schedule usually followed
- 1 - Wafers changed only when EMC readings are obviously in error

1i. Regular maintenance program for dehumidification kilns 1 3 4

Rating
- 4 - Equipment manufacturer's maintenance checklist followed exactly
- 3 - Equipment manufacturer's maintenance checklist usually followed
- 1 - Little attention paid to equipment manufacturer's checklist

2. Moisture Content Monitoring and Recordkeeping

2a. Knowledge of histoty of lumber before going into kiln 1 2 3 4

Rating
- 4 - The history of the lumber going into the kiln is known
- 3 - You can reconstruct the history by asking a few questions or making a phone call or two
- 2 - You do not know the history
- 1 - No effort was made or did not know the history

2b. Use of sample boards (kiln samples) to monitor moisture content 1 2 3 4

Rating
- 4 - Sample boards are always selected, prepared, placed, and used as recommended in Chapter 6 of the DKOM
- 3 - Sample boards are usually used, with minimal attention to selection and usually only two or three boards used
- 2 - Sample boards are used only when drying an unfamiliar species or a thickness not commonly dried
- 1 - Sample boards never used

2c. In-kiln moisture content monitoring equipment is used when available 1 2 4

Rating
- 4 - In-kiln sensors are used according to the manufacturer's instructions
- 2 - In-kiln sensors are used but some of the operators do not pay attention to them or not all sensor locations are operating
- 1 - In-kiln sensors are available but not used

2d. Moisture content control practices for each charge 1 2 3 4

Rating
- 4 - Sample boards always used, every charge spot checked with moisture meter, and all records kept with the kiln charts
- 3 - Sample boards usually used, meter spot checks are infrequent, but records are kept with kiln charts
- 2 - Sample boards seldom used, no meter spot checks, no moisture records kept
- 1 - Sample boards not used, no meter spot checks, no records kept

2e. Dry storage of lumber 1 2 3 4

Rating
- 4 - Dry lumber is always moved to and stored in closed shed
- 3 - Dry lumber is always moved to and stored in covered shed
- 2 - Dry lumber maybe left out in weather for several days
- 1 - No protection from weather for lumber after removal from kiln

2f. Control charts labeled and filed for reference 1 2 3 4

Rating
- 4 - Complete set of records is kept and retrieval is easy
- 3 - Available information is kept for a while in a manner that allows retrieval
- 2 - Charts are kept but finding records for a charge of lumber dried 6 months ago is difficult
- 1 - No information is kept

Low High

2g. Records of moisture content checks are kept with control charts 1 3 4
Rating
4 - Complete records are filed together for easy retrieval
3 - Records of MC checks are kept but not filed with control charts
1 - Records are not kept

3. Discussion and Feedback from Rough Mill or Glue Room Supervisors

3a. Communications with rough mill or glue room supervisor 1 2 3 4
Rating
4 - Communicate regularly, at least weekly
3 - Communicate only at scheduled production meetings
2 - Communicate only when there are problems
1 - Communicate rarely

4. Learning Opportunities

4a. Opportunities to visit other sites and meet other operators 1 2 3 4
Rating
4 - Visit other kiln drying sites three or more times per year
3 - Visit other kiln drying sites twice a year
2 - Visit other kiln drying sites once a year
1 - Never visit other kiln drying sites

4b. Attend Dry Kiln Association meetings and drying workshops. 1 2 3 4
Rating
4 - Attend Dry Kiln Association meetings yearly and have attended at least one workshop
3 - Regularly attend meetings but have never been to a workshop
2 - Attend meeting every 2 or 3 years
1 - Never attend meetings or workshops

Control Room

5. Valves Operate Properly

5a. Steam heat valves operate properly. 1 2 4
Rating
4 - No steam passes when valves close, valves open fully during full-steam demand
2 - With valve closed, passed steam is barely detectable by sound; valves open more than 90% during full-steam demand
1 - Bypassing steam is easily detected when valves are closed or valves open less than 90% during full-steam demand

5b. Steam spray valve fully opens and closes 1 4
Rating
4 - No steam passes when valve closes, valve opens fully
1 - Steam enters spray line when valve is closed or valve opens less than 90% when steam spray demand is high

5c. Gauges are working and readable. 1 4
Rating
4 - All gauges are working and easily readable
1 - Any gauge nonfunctioning or unreadable

6. Controls Operate Properly

Low High

6a. Vents and spray are not on together. 1 2 3 4

Rating
- 4 - Steam spray and vent opening never alternate off and on during any part of the drying schedule
- 3 - Steam spray and vent opening occasionally alternate during some part of the schedule
- 2 - Steam spray and vent opening alternate rapidly during some part of the schedule
- 1 - Steam spray is on and vents are open simultaneously

6b. Recent control charts show fan reversals occur 1 2 3 4

Rating
- 4 - Fan reversals all occurred on schedule according to recent charts
- 3 - At least 9 out of 10 fan reversals occurred on schedule
- 2 - At least 7 out of 10 fan reversals occurred on schedule
- 1 - Less than 7 out of 10 scheduled fan reversals were actually made

6c. Recent charts show set point changes are made according to the schedule 1 3 4

Rating
- 4 - Set point changes are made within 2 hours of reaching the appropriate MC indicating a change is needed, according to recent charts and records
- 3 - Set point changes are made within 5 hours of reaching the appropriate MC indicating a change is needed, according to recent charts and records
- 1 - Changes in set point are only loosely associated with MC of lumber at time of change

6d. Correct instrument charts are used. 1 4

Rating
- 4 - Chart paper matches recording instrument
- 1 - Wrong paper is used

Fan Deck and Kiln Roof

7. Fans

7a. Fans and shrouds are well maintained 1 2 4

Rating
- 4 - All fans are tight on the shaft, centered in shrouds both radially and axially, and no blade damage
- 2 - One of the above is not correct
- 1 - More than one problem is found

7b. Fans turning for proper airflow 1 3 4

Line-shaft kilns

Rating
- 4 - All fans proper “handedness” and pitch set correctly
- 3 - All fans proper “handedness” but pitch not set correctly
- 1 - One or more fans wrong “handedness” or not turning

Cross-shaft kilns

Rating
- 4 - All fan motors turn the same direction and pitch set correct
- 3 - All fan motors turn the same direction but pitch not set correctly
- 1 - One or more fan motors turning the wrong direction or fan not turning

Low High

7c. Fan deck (fan floor) in good repair. 1 3 4

Rating

4 - Fan floor extends to the edge of the lumber piles and can support personnel during maintenance

3 - Fan floor extends to the edge of the lumber piles but minor corrosion, rust, or small holes are visible

1 - Fan floor does not extend to the edge of the lumber pile and/or rust and holes in the floor make it unsafe for walking

7d. Easy access to fan deck and roof vents. 1 2 4

Rating

4 - Stairway or permanent ladder to roof and easy access to fan deck are available

2 - Ladders are available for reaching roof and fan floor

1 - Only access to roof and fan floor is by being lifted by fork lift and climbing through the vents to the roof

8. Heat Distribution System

8a. Heating coils clean and free of debris 1 2 3 4

Kilns with fin pipe

Rating

4 - Can see space between fins; Coils look clean

3 - Some dirt, rust, or coating on coils or between fins

2 - Moderate dirt, rust, or coating; difficult to see pipe

1 - Cannot see pipe in places or foreign material on coils

Kilns with plain (nonfinned) pipe

Rating

4 - Coils are clean

3 - Small amounts of dirt, rust, or coating on coils

2 - Moderate dirt, rust, or coating on coils

1 - Heavy dirt, rust, coating, or foreign material on coils

9. Vents

9a. Vent lids open and close fully. 1 2 3 4

Rating

4 - All vents open to the same height: no vent leakage can be seen or felt with vents closed

3 - Slight leakage of vent lids: a little vapor can be seen from outside but light cannot be seen around vents from inside the kiln

2 - Major leakage of vent lids or light can be easily seen around vents when they are closed

1 - Vent lids do not close and leak significantly; one or more vent lids bent or broken

9b. Vent actuators and linkages operate properly 1 2 3 4

Rating

4 - Vent actuators and mechanical linkages open vent lids to proper height and close vent lids completely

3 - Mechanical linkage is worn so vents only partially open or desired vent opening height cannot be achieved for other reasons

2 - One or more vent lids disconnected from connecting linkage

1 - Vents inoperative, vent activators not functioning, or linkages disconnected

Yard and Stacker Area

10. Sticker and Bolster Thickness

Low High

10a. Sticker thickness uniformity 1 2 3 4

Rating
- 4 - Range of sticker thickness is 1/32 in. (0.031 in.) or less
- 3 - Range of sticker thickness is 1/16 in. (0.063 in.) or less
- 2 - Range of sticker thickness is 1/8 in. (0.125 in.) or less
- 1- Range of sticker thickness is greater than1/8 in. (0.125 in.)

10b. Bolster thickness uniformity 1 2 3 4

Rating
- 4 - Range of bolster thickness is 1/8 in. (0.125 in.) or less
- 3 - Range of bolster thickness is 1/4 in. (0.250 in.) or less
- 2 - Range of bolster thickness is 3/8 in. (0.375 in.) or less
- 1 - Range of bolster thickness is greater than 3/8 in. (0.375 in.)

10c. Uniformity of sticker straightness. 1 2 3 4

Rating
- 4 - All stickers have less than 2 in. of crook or kink
- 3 - No more than 3 stickers have 2 in. or more crook or kink
- 2 - No more than 5 stickers have 2 in. or more crook or kink
- 1 - More than 5 stickers have 2 in. or more crook or kink

Inside an Empty Kiln

11. Inside a Cold Kiln

11a. Condensation or other water inside of kiln. 1 2 3 4

Rating
- 4 - No evidence of condensation or water in kiln
- 3 - Some evidence of condensation near walls, at the base of structural members, or under vents, or small water leaks
- 2 - Much evidence of condensation, corrosion problems, or water leaks
- 1 - Kiln damage as a result of condensation or large amounts of water entering kiln

11b. Drainage from kiln floor 1 2 3 4

Rating
- 4 - No water standing on kiln floor
- 3 - Small amounts of water present
- 2 - Small puddles covering less than one-fourth of floor
- 1 - Drains are plugged; water standing in kiln

11c. Proper wet-bulb wick isused 1 2 3 4

Rating
- 4 - Wick is thick, 100% cotton, and feels very wet to the touch
- 3 - Wick feels soft but is only damp, not wet
- 2 - Wick feels crusted on top and only damp, not wet
- 1 - Wick is crusted and dry

11d. Adequate water flowing towet-bulb. 1 2 4

Rating
- 4 - Water runs out of wet-bulb pan at a rate between 1/8 and 1/2 cup in 3 minutes
- 2 - Wick is wet but there is less than 1/8 cup of water or more than 1/2 cup overflowing the pan in 3 minutes
- 1 - Wick is barely damp or dry or pan is empty

12. Kiln Operational Checks

Low High

12a. Heating coils and steam pipe free of steam or water leaks 1 2 3 4
(See section 12a in the Guidebook for definitions of leaks)
Rating
4 - No leaks present
3 - Small leaks around fittings, in coils, or in steam pipes
2 - Several small leaks or one medium leak
1 - Several medium or large leaks

12b. Steam spray free of liquid water 1 2 4
Rating
4 - No liquid water comes out when steam spray comes on, drain line is open, no water spots on lumber
2 - Improper slope on line or drainage point is blocked
1 - Water spots on lumber that can be traced to the steam spray line or spray line not draining to outside of kiln

12c Steam spray uniformly distributed. 1 2 4
Rating
4 - All nozzles appear to produce equal steam spray
2 - Steam spray appears not uniform or one nozzle plugged
1 - More than one nozzle plugged

While Preparing Charges and Loading the Kiln

13. Lumber Quality and Package Loading

13a. Lumber thickness variation 1 2 3 4
Rating
4 - All boards are of uniform thickness and touching stickers; stickers are not bent
3 - Fewer than 10 boards per package do not touch stickers or stickers bend slightly over thick or thin lumber
2 - Thickness variation is sufficient to bend stickers or show gaps more than 1/8 in. wide above boards
1 - Thickness variation is great enough to make stacking visibly irregular

13b. Plenum width adequate. 1 2 3 4
Rating
4 - Plenum width equals the sum of the sticker and bolster openings
3 - Plenum width is between 3/4 and 1-1/4 times the sum of the sticker and bolster openings
2 - Plenum width is between 1/2 and 1-1/2 times the sum of the sticker and bolster openings
1 - Plenum width is less than 1/2 or more than 1-1/2 times the sum of the sticker and bolster openings

13c. Package arrangement to accommodate short packages. 1 2 4
(See Fig. 2 in section 13 of the Guidebook for examples)
Rating
4 - Shorter length packages are always on the top and away from the top and end baffles so there are no voids
2 - Voids are next to the top or end baffles but these do not go through the load
1 - Openings go through the load

Low High

13d. Package placement in package kilns. 1 2 3 4
(See Fig. 3 in section 13 of the Guidebook)
Rating
4 - Initial or back row tight against one wall; next row side shifted tight against opposite wall
3 - Rows staggered, but package ends more than 2 ft from walls
2 - No effort made in positioning packages to avoid short circuiting of air
1 - Extra or additional row of packages placed in plenum space next to loading door

13e. Package placement on kiln trucks in track kilns 1 2 3 4
(See Fig. 4 in section 13 of the Guidebook)
Rating
4 - All truck load supports are vertically aligned under stickers
3 - No more than one truck is not in vertical alignment
2 - No more than two trucks are not in vertical alignment
1 - More than two trucks are not in alignment

13f. Rails in track kilns. 1 2 3 4
Rating
4 - All rails level and well supported with no sign of deflection
3 - Rails settle or move slightly in one or two places
2 - Dips in rails or more than 1/2 in. of deflection when loaded
1 - Rails visibly out of level or have a large amount of deflection

During Kiln Startup and Operation

14. During Kiln Startup

14a. Adequate airflow across wet bulb. 1 2 3 4
Rating
When airflow is measured at the wet-bulb sensor
4 - Measured airflow 300 ft/min or greater
3 - Measured airflow 150 to 300 ft/min
2 - Measured airflow is less than 150 ft/min
1 - Wet bulb is blocked from airflow

When airflow is estimated at the wet-bulb sensor
4 - Can easily feel air moving across wick
3 - Airflow is not easy to feel, but a handkerchief can be blown by the air
2 - Cannot feel air movement or see handkerchief move
1 - Wet bulb is blocked from airflow

14b. Confirm that traps are functioning 1 2 3 4
Rating
4 - All traps are working
3 - Traps don't quite handle condensate during startup
2 - Traps are very undersized for startup and hold back a large amount of condensate
1 - One or more traps are not working

15. While Kiln Is Operating

15a. Doors, walls, and roof are free of leaks. 1 2 3 4
(See section 15a. in the Guidebook for definition of leaks)
Rating
4 - No leaks are visible or only slight leaks around rails
3 - Slight leaks around doors or other small leaks
2 - Large leaks
1 - Holes visible in the kiln structure

Low High

15b. Confirm fan reversal by feeling airflow direction 1 4

Rating

4 - Airflow actually reverses

1 - Airflow does not actually reverse when timer or control chart indicates it should

Moisture Content Control and Equalizing and Conditioning Treatments

16. Control of Moisture Content

16a. Proper selection and use of kiln sample boards 1 2 3 4

Rating

4 - Sample boards always selected, prepared, placed, and used as recommended in the DKOM, with at least six samples per charge

3 - Sample boards are usually sampled and prepared well with at least six samples per charge

2 - Sample board selection is poor, samples placed in bolster spaces without proper baffling, or fewer than six samples per charge

1 - No real thought given to sample selection, samples poorly placed in the kiln or only one to three sample boards per charge

16b. Moisture content variation using kiln sample boards 1 2 3 4

Rating

4 - All sample boards are within 1% MC of target when kiln run is completed

3 - No sample board more than 2% MC off target

2 - No sample board more than 3% MC off target

1 - Sample boards not used

16c. Moisture content variation measured by in-kiln monitors. 1 2 3 4

Rating

4 - All readings of sensors in monitored boards are within 1% MC of target when kiln run is completed

3 - No reading is more than 2% MC off target

2 - No reading is more than 3% MC off target

1 - Readings of monitored boards off target by 4% or more

16d. Moisture content variation measured by electric moisture meter 1 2 3 4

Rating

4 - All values are within 2% MC of target

3 - All values are within 3% MC of target

2 - All values are within 4% MC of target

1 - Some values are greater than 4% MC off target

17. Equalizing and Conditioning Treatments

17a. Equalizing and conditioning treatments used correctly and used when needed 1 2 3 4

Rating

4 - Equalizing treatment used when MC spread is 2% or greater, conditioning used when stress relief is required, with close attention paid to achieving correct wet-bulb depressions

3 - Equalizing treatment used when MC spread is 5% or greater, conditioning used when stress relief is required, correct wet-bulb depressions usually achieved in a few hours

2 - Equalizing treatment seldom used, conditioning done if required, correct wet-bulb depressions not usually achieved until near the end

1 - Equalizing treatment not used and conditioning consists of steaming for a few hours, with no control of wet-bulb depression

Low High

17b. Check for drying stresses using prong test 1 2 3 4

Rating

4 - Several boards, wide, narrow, and average width, are checked from each kiln charge and show no stress

3 - Only one or two boards checked from each kiln charge or several boards show slight stress

2 - Drying stresses are checked only when trouble is reported or regularly show severe drying stress

1 - Drying stresses are never checked

After Drying Is Completed

18. Before Unloading Kiln

18a. Baffles used properly 1 2 3 4

Rating

4 - Baffles are placed flush against the top, bottom, and ends of the load and were held securely during drying

3 - No spaces greater than 6 in. between baffles and the load, and baffles were held securely

2 - No spaces greater than 12 in. between baffles and the load, and baffles were held securely

1 - Baffles are missing, bent, or openings are greater than 12 in. between baffles and the load; any baffles were unsecured

18b. Package height uniform for good top baffle contact 1 2 3 4

Rating

4 - All pile heights are the same

3 - Pile heights vary but are uniform under baffle

2 - Pile heights vary by 1 ft, and one pile does not reach baffle

1 - Pile heights vary by more than 1 ft, and several packages do not reach baffles

Evaluate Stacking and Its Effect on Drying Quality

19. Sticker Placement

19a. Sticker alignment 1 2 3 4

(See Figure 5 in Guidebook for illustration of procedure)

Rating

4 - All stickers vertically aligned or less than 2 stickers out of alignment

3 - No more than 5 stickers out of alignment

2 - No more than 10 stickers out of alignment

1 - More than 10 stickers out of alignment

19b. Stickers missing 1 2 3 4

Rating

4 - All stickers present or no more than 2 stickers missing

3 - No more than 5 stickers missing

2 - No more than 10 stickers missing

1 - More than 10 stickers missing

Low High

19c. Stickers on edge 1 2 3 4

Rating
4 - No more than 2 stickers on edge
3 - No more then 5 stickers on edge
2 - No more than 10 stickers on edge
1- More than 10 stickers on edge

19d. Sticker placement at ends of packages 1 2 3 4

Rating
4 - All stickers are within1 sticker width of package ends
3 - No more than 3 stickers are more than 2 sticker widths in from the end
2 - No more than 5 stickers are more than 2 sticker widths in from the end
1 - More than 5 stickers are more than 2 sticker widths in from the end

20. Board Placement in Packages

20a. Packages are square at both ends 1 2 3 4

(See Fig. 6 in section 20a. of the Guidebook)
Rating
4 - All boards in all packages reach and are supported by the end sticker; ends of the package are vertical
3 - Not more than 5 boards per package either do not reach the end sticker or extend beyond it by more than 3 in.
2 - Not more than 10 boards per package do not reach the end sticker or extend beyond it by more than 6 in.
1 - More than 10 boards per package do not reach the end sticker or extend beyond it by more than 6 in.

20b. Overlapped boards in package.. . . . . 1 2 3 4

Rating
4 - No overlapped boards can be seen
3 - Fewer than 3 boards overlap
2 - Fewer than 5 boards overlap
1 - More than 5 boards overlap

20c. Sides of package even 1 2 3 4

(See Fig. 7 in section 18c. of the Guidebook)
Rating
4 - Sides of all packages are even
3 - No more than 1 course per package is not even
2 - No more than 3 courses per package are not even
1 - More than 3 courses per package are not even

21. Bolster and Package Placement

21a. Bolster (bunk) placement between packages 1 2 3 4

(See Fig. 8 in section 21a. of the Guidebook)
Rating
4 - All bolsters vertically aligned with every column of stickers
3 - No more than 2 bolsters out of alignment or missing in a charge
2 - No more than 4 bolsters out of alignment or missing in a charge
1 - More than 4 of bolsters out of alignment or missing in a charge

Low High

21 b. Bolster (bunk) placement on floor 1 2 3 4
(See Fig. 8 in section 21a. of the Guidebook)
Rating
4 - All floor bunks are vertically aligned under stickers
3 - No more than two floor bunks not in vertical alignment under stickers or missing
2 - No more than four floor bunks not in alignment or missing
1 - More than four floor bunks not in alignment or missing

21c. Chimney allowance (track-loaded kilns) 1 2 3 4
(See Fig. 9 in section 21c. of the Guidebook)
Rating
4 - Chimney between adjacent packages is 2 to 3 in. wide and restricted at the top
3 - Chimney is 2 to 3 in. wide but is not restricted at the top
2 - Chimney is 3 to 6 in. wide but is not restricted at the top
1 - Chimney is larger than 6 in.

21d. Packages placed at edge of kiln trucks 1 2 3 4
Rating
4 - All packages are placed within 1 in. of the edge of the kiln truck
3 - One package is not even with the edge of the kiln truck
2 - Two packages are not even with the edge of the kiln truck
1 - More than two packages are not even with the edge of the kiln truck

Drying Degrade

22. Drying Degrade Seen in Rough Dry Lumber

22a. End checking or end splits visible in stickered lumber 1 2 3 4
(Exclude ring failure, ring and wind shake)
Rating
4 - No end checks or end splits are visible
3 - End checks or end splits deeper than 2 in. in no more than 10 boards per package
2 - End checks or end splits deeper than 2 in. in no more than 20 boards per package
1 - End checks or end splits deeper than 2 in. in more than 20 boards per package

22b. Surface checking visible in snickered lumber 1 2 3 4
Rating
4 - No surface checking visible
3 - Surface checking visible in fewer than 4 boards per package
2 - Surface checking visible in 4 to 8 boards per package
1 - Surface checking visible in more than 8 boards per package

22c. Warp (including kinks) related to stickering and stacking 1 2 3 4
(This includes all distortions that can be related to sticker and bolster misplacement in any form. Bow, crook, twist, kink, and sag occurring because boards are not properly supported are included.)
Rating
4 - No warp or kinks observed
3 - Warp or kinks in no more than 10 boards per package
2 - Warp or kinks in no more than 20 boards per package
1 - Warp or kinks in more than 20 boards per package

23. Drying Degrade Problems Reported

Low High

23a.Rough mill and/or glue room complaints 1 2 3 4

Rating
- 4 - Seldom receive complaints
- 3 - Complaints of MC-related (too wet-too dry) problems affecting less than 5% of production
- 2 - Complaints of MC-related problems affecting less than 10% of production
- 1 - Complaints of MC-related problems affecting more than 10% of production

23b. Surface checking seen unsurfaced lumber or cuttings 1 3 4
(exclude those around knots)

Rating
- 4 - Surface checking seldom reported as problem
- 3 - Surface checking reported for an occasional kiln charge
- 1 - Surface checking frequently reported as problem

23c. Internal checking or honeycomb seen on ends or surfaces. 1 3 4

Rating
- 4 - Internal checking seldom reported as problem
- 3 - Internal checking reported for an occasional kiln charge
- 1 - Internal checking frequently reported as a problem

23d. End checks and/or end splits seen on surfaced lumber or cuttings 1 2 3 4
(exclude those associated with ring separation, shake or bucking/felling shatter)

Rating
- 4 - End checks/splits seldom reported as extending more than 3 inches into piece
- 3 - End checks/splits extending more than 3 inches reported for an occasional kiln run
- 2 - End checks/splits extending more than 5 inches reported with some frequency
- 1 - End checks/splits extending more than 5 inches are a constant problem

23e. Stain, including sticker stain, related to drying in species and grades
in which it is a degrading condition 1 2 3 4

Rating
- 4 - Staining problems are rarely reported
- 3 - Stain affects less than 5% of production
- 2 - Stain affects less than 10% of production
- 1 - Stain affects more than 10% of production

Appendix 1
Summary Checklist for
Quality Drying of Hardwood Lumber

Appendix 1 contains all the items from the checklist and in the same order; only the rating system has been omitted. This will shorten the number of checklist pages, and filing the checklist with the kiln records will require less space.

Kiln _____

Date _____

Summary **Checklist for Drying Quality Hardwood Lumber**

Standard Operating Practices

1. Maintenance and Inspection

		Low			High
1a.	Equipment above fan floor inspected regularly	1	2	3	4
1b.	Air velocity checks made regularly.	1	2	3	4
1c.	Traps checked for proper operation and plumbed for checking	1	2	3	4
1d.	Air supply to control instruments and operating valves checked at regular intervals	1	2	3	4
1e.	Regular maintenance program for steam valves	1		3	4
1f.	Regular calibration of temperature sensing devices and indicators	1	2	3	4
1g.	Wet-bulb wicks changed on a regular schedule	1	2	3	4
1h.	EMC wafers changed on a regular schedule	1		3	4
1i.	Regular maintenance program for dehumidification kilns	1		3	4

2. Moisture Content Monitoring and Recordkeeping

2a.	Knowledge of history of lumber before going into kiln	1	2	3	4
2b.	Use of sample boards (kiln samples) to monitor moisture content	1	2	3	4
2c.	In-kiln moisture content monitoring equipment is used	1	2		4
2d.	Moisture content control practices for each charge	1	2	3	4
2e.	Dry storage of lumber	1	2	3	4
2f.	Control charts labeled and filed for reference	1	2	3	4
2g.	Records of moisture content checks are kept with control charts	1		3	4

3. Discussion and Feedback from Rough Mill or Glue Room Supervisors

3a.	Communications with rough mill or glue room supervisor	1	2	3	4

4. Learning Opportunities

4a.	Opportunities to visit other sites and meet other operators	1	2	3	4
4b.	Attend Dry Kiln Aassociation meetings and drying wookshops	1	2	3	4

Control Room

5. Valves Operate Properly

5a.	Steam heat valves operate properly	1	2	4
5b.	Steam spray valve fully opens and-closes.	1		4
5c.	Gauges are working and readable	1		4

6. Controls Operate Properly

6a.	Vents and spray are not on together.	1	2	3	4
6b	Recent control charts show fan reversals occur	1	2	3	4
6c.	Recent charts show setpoint changes are made according to the schedule	1		3	4
6d.	Correct instrument charts aroused	1			4

Fan Deck and Kiln Roof

7. *Fans*

	Low			High
7a. Fans and shrouds are well maintained	1	2		4
7b. Fans turning for proper airflow	1		3	4
7c. Fan deck (fan floor) in good repair	1		3	4
7d. Easy access to fan deck and roof vents	1	2		4

8. Heat Distribution System

8a. Heating coils clean and free of debris	1	2	3	4

9. Vents

9a. Vent lids open and close fully.	1	2	3	4
9b. Vent actuators and linkages operate properly	1	2	3	4

Yard and Stacker Area

10. Sticker and Boister Thickness

10a. Sticker thickness uniformity..	1	2	3	4
10b. Bolster thickness uniformity.	1	2	3	4
10c. Uniformity of sticker straightness.	1	2	3	4

Inside an Empty Kiln

11. Inside a Cold Kiln

11a. Condensation or other water inside of kiln	1	2	3	4
11b. Drainage from kiln floor	1	2	3	4
11c. Proper wet-bulb wick is used.	1	2	3	4
11d. Adequate water flowing to wet bulb	1	2		4

12. Kiln Operational Checks

12a. Heating coils and steam pipe free of steam or water leaks	1	2	3	4
12b. Steam spray free of liquid water	1	2		4
12c. Steam spray uniformly distributed.	1	2		4

While Preparing Charges and Loading the Kiln

13. Lumber Quaiity and Package Loading

13a. Lumber thickness variation	1	2	3	4
13b. Plenum width adequate	1	2	3	4
13c. Package arrangement to accommodate short packages	1	2		4
13d. Package placement in package kilns	1	2	3	4
13e. Package placement on kilntrucks in track kilns	1	2	3	4
13f. Rails in track kilns	1	2	3	4

During Kiln Startup and Operation

14. During Kiln Startup

	Low			High
14a. Adequate airflow across wet bulb.	1	2	3	4
14b. Confirm that traps are functioning	1	2	3	4

15. While Kiln Is Operating

15a. Doors, walls, and roof are free of leaks	1	2	3	4
15b. Confirm fan reversal by feeling airflow direction	1	2	3	4

Moisture Content Control and Equalizing and Conditioning Treatments

16.Control of Mofsture Content

16a. Proper selection and use of kiln sample boards	1	2	3	4
16b. Moisture content variation using kiln sample boards	1	2	3	4
16c. Moisture content variation measured by in-kiln monitors	1	2	3	4
16d. Moisture content variation measured by electric moisture meter	1	2	3	4

17. Equalizing and Conditioning Treatments

17a. Equalizing and conditioning treatments used correctly and used when needed.	1	2	3	4
17b. Check for drying stresses using prong test	1	2	3	4

After Drying Is Completed

18. Before Unloading Kiln

18a. Baffles used properly	1	2	3	4
18b. Package height uniform for good top baffle contact	1	2	3	4

Evaluate Stacking and Its Effect on Drying Quality

19. Sticker Placement

19a. Sticker alignment	1	2	3	4
19b. Stickers missing	1	2	3	4
19c. Stickers on edge	1	2	3	4
19d. Sticker placement at ends of packages	1	2	3	4

20. Board Placement in Packages

20a. Packages are square at both ends	1	2	3	4
20b. Overlapped boards in package	1	2	3	4
20c. Sides of package even	1	2	3	4

21. Bolster and Package Placement

21a. Bolster (bunk) placement between packages	1	2	3	4
21b. Bolster (bunk) placement on floor	1	2	3	4
21c. Chimney allowance (track-loaded kilns)	1	2	3	4
21d. Packages placed at edge of kiln trucks	1	2	3	4

Drying Degrade

22. Drying Degrade Seen in Rough Dry Lumber

	Low			High
22a. End checking or end splits visible in stickered lumber	1	2	3	4
22b. Surface checking visible in snickered lumber	1	2	3	4
22c. Warp (including kinks) related to snickering and stacking	1	2	3	4

23. Drying Degrade Problems Reported

23a. Rough mill and/or glue room complaints	1	2	3	4
23b. Surface checking seen unsurfaced lumber or cuttings	1	2	3	4
23c. Internal checking or honeycomb seen on ends or surfaces	1		3	4
23d. End checks and/or end splits seen on surfaced lumber or cuttings	1	2	3	4
23e. Stain, including sticker stain, related to drying in species and grades in which it is a degrading condition	1	2	3	4

Appendix 2
Checklist Arranged by
Drying System Components

Appendix 2 contains the same items as the checklist, but it is arranged so that all the components related to one system are together. For example, all items related to fans are grouped together. The item number is the same as in the guidebook section. If you have a question about a particular item, refer to the guidebook by its item number (for example, 7b.)

Kiln _____

Date _____

Checklist Arranged by Drying System Components

Kiln Structure

	Low			High
7c. Fan deck (fan floor) in good repair.	1		3	4
7d. Easy access to fan deck and roof vents	1	2		4
11a. Condensation or other water inside of kiln	1	2	3	4
11b. Drainage from kiln floor	1	2	3	4
13f. Rails in track kilns	1	2	3	4
15a. Doors, walls, and roof are free of leaks	1	2	3	4

Air Circulation System

Fans and Motors

1a. Equipment above fan floor inspected regularly	1	2	3	4
1b. Air velocitychecks made regularly.	1	2	3	4
6b. Recent control charts show fan reversals occur	1	2	3	4
7a. Fans and shrouds are well maintained	1	2	3	4
7b. Fans turning for proper airflow.	1			4
15b. Confirm fan reversal by feeling airflow direction	1	2	3	4

Baffle sand Plenum

13b. Plenum width adequate	1	2	3	4
18a. Baffles used properly	1	2	3	4

Heating System

1c. Traps checked for proper operation and plumbed for checking	1	2	3	4
1e. Regular maintenance program for steam valves	1		3	4
1i. Regular maintenance program for dehumidification kilns	1		3	4
8a. Heating coils clean and free of debris.	1	2	3	4
12a. Heating coils and steam pipe free of steam or water leaks	1	2	3	4
14b. Confirm that traps are functioning.	1	2	3	4

Venting-Humidification System

9a. Vent lids open and close fully.	1	2	3	4
9b. Vent actuators and linkages operate properly	1	2	3	4
12b. Steam spray free of liquid water	1	2		4
12c. Steam spray uniformly distributed	1	2		4

Control System

	Low High
1d. Air supply to control instruments and operating valves checked at regular intervals	1 2 3 4
1f. Regular calibration of temperature sensing devices and indicators	1 2 3 4
1g. Wet-bulb wicks changed on a regular schedule	1 2 3 4
1h. EMC wafers changed on a regular schedule	1 3 4
2b. Use of sample boards (kiln samples) to monitor moisture content.	1 2 3 4
2c. ln-kiln moisture content monitoring equipment is used	1 2 4
2d. Control charts labeled and filed for reference	1 2 34
5a. Steam heat valves operate properly	1 2 4
5b. Steam spray valve fully opens and closes	1 4
5c. Gauges are working and readable	1 4
6a. Vents and spray are not on together.	1 2 3 4
6c. Recent charts show setpoint changes are made according to the schedule	1 3 4
6d. Correct instrument charts are used.	1 4
11c. Proper wet-bulb wick is used...	1 2 34
11d. Adequate water flowing to wet bulb	1 2 4
14a. Adequate airflow across wet bulb	1 2 3 4
17a. Equalizing and conditioning treatments used correctly and used when needed.	1 2 3 4

Stacking

Sticker Placement

19a. Sticker alignment	1 2 3 4
19b. Stickers missing	1 2 3 4
19c. Stickers on edge	1 2 3 4
19d. Sticker placement at ends of packages	1 2 3 4

Sticker and Bolster Thickness

10a. Sticker thickness uniformity	1 2 3 4
10b. Bolster thickness uniformity.	1 2 3 4
10c. Uniformity of sticker straightness	1 2 3 4

Board Placement in Packages

13a. Lumber thickness variation.	1 2 3 4
20a. Packages are square at both ends	1 2 3 4
20b. Overlapped boards in package	1 2 3 4
20c. Sides of package even...	1 2 3 4

Package Placement

13c. Package arrangement to accommodate short packages..	1 2 4
13d. Package placement in package kilns	1 2 3 4
13e. Package placement on kiln trucks in track kilns	1 2 3 4
18b. Package height uniform for good top baffle contact	1 2 3 4
21a. Bolster (bunk) placement between packages	1 2 3 4
21b. Bolster (bunk) placement on floor	1 2 3 4
21c. Chimney allowance (track-loaded kilns)	1 2 3 4
21d. Packages placed at edge of kiln trucks	1 2 3 4

Moisture Checks and Drying Defects

Moisture Content Checks

	Low High
2a. Knowledge of history of lumber before going into kiln	1 2 3 4
2d. Moisture content control practices for each charge	1 2 3 4
2e. Dry storage of lumber	1 2 3 4
2g. Records of moisture content checks are kept with control chart	1 3 4
16a. Proper selection and use of kiln sample boards	1 2 3 4
16b. Moisture content variation using kiln sample boards	1 2 3 4
16c. Moisture content variation measured by in-kiln monitors	1 2 3 4
16d. Moisture content variation measured by electric moisture meter	1 2 3 4
17b. Check for drying stresses using prong test	1 2 3 4

Drying Degrade

22a. End checking or end splits visible in stickered lumber	1 2 3 4
22b. Surface checking visible in snickered lumber	1 2 3 4
22c. Warp (including kinks) related to snickering and stacking	1 2 3 4
23a. Rough mill and/or glue room complaints	1 2 3 4
23b. Surface checking seen unsurfaced lumber or cuttings	1 2 3 4
23c. internal checking or honeycomb seen on ends or surfaces	1 3 4
23d. End checks and/or end splits seen on surfaced lumber or cuttings.	1 2 3 4
23e. Stain, including sticker stain, related to drying in species and grades in which it is a degrading condition.	1 2 3 4

Communications and Learning Opportunities

3a. Communications with rough mill or glue room supervisor	1 2 3 4
4a. Opportunities to visit other sites and meet other operators	1 2 3 4
4b. Attend Dry Kiln Association meetings and drying workshops.	1 2 3 4