

Section IV:

Lumber: Receiving, Drying and Storage

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Process Overview

The drying process removes water from lumber, keeping it up to manufacturing quality specifications. The typical functions of lumber receiving, drying and storage include:

- ! unloading
- ! grading
- ! stacking
- ! air drying/shed drying/predrying
- ! kiln drying
- ! dry shed storage
- ! maintaining inventory records
- !

Potential Wastes: Solid and Hazardous

- ! wood
- ! energy
- ! air emissions from boilers

Waste Reduction Options/Case Studies/Checklists

Inspection and Sorting Lumber

Modern manufacturing concepts recommend a close partnership with suppliers which encourages more shared responsibility and trust. This partnership can eliminate costly, non-value-added steps such as inspection and reshuffling materials. Quality programs which document out-of-spec materials will give both the supplier and the customer the facts to measure and improve performance. Train suppliers as you would your own inspectors so that they know and meet your needs. Consider pre-shipment inspections and "custom" shipments that are one length, one grade, etc. so that these costly additional steps afterwards are avoided.

Many times lumber is shipped in packages with a random mixture of lengths from 6 to 16 feet in one foot increments. Sorting and inspection can be done at this time to meet desired lumber lengths, thicknesses, and quality to reduce wood waste.

Take the time to weigh out the feasibility of this measure in terms of overall cost savings. Compare the cost of sorting and inspection to yard space and drying space through this elimination of large voids in the packages resulting from mixed board lengths. Mixed lengths will cause improperly supported stacks and associated defects, and potentially damaged lumber caused by the movement of lumber packages with protruding boards.

Sorting results in savings by increasing space utilization, improving the quality of lumber and generating less

Sorting can be done by hand or by mechanical sorters. The investment in mechanical sorters can be significant. Hand sorting is less capital intensive.

Benefits

- ! conserve raw material
- ! less lumber damage and waste

- ! lumber meets quality expectations
- ! efficient space utilization
- ! improve productivity

Properly Align Kiln Sticks

While unpackaging incoming lumber, it is important to consider how the boards will be restacked to optimize drying and reduce warping and bowing. As lumber is stacked, considerable weight is put on the bottom lumber; therefore, it is crucial for the kiln sticks to be perfectly vertically aligned.

Failure to properly align the kiln sticks can result in bowed, warped and wavy wood as the wood dries completely.

The recommended spacing is 24 inches in all cases; use closer spacing if lumber is extremely valuable.

Benefits

- ! conservation of raw material
- ! less lumber damage and waste
- ! improved drying

Kiln Dry Lumber to Correct Moisture Content Level

An important first step is to check for moisture coming from the kilns, including both the average moisture content (MC) and the spread of MC. Many companies today are specifying an average MC of 6.25 to 7.25 percent MC with a spread (measured as a standard deviation) of 0.6 percent. In order to determine the average and spread accurately requires taking no fewer than 20 samples. But, remember that most kiln operators use only 8 or 10 samples and these samples are located on the edge of the pile. It is not a lie to say that often the kiln operator really doesn't know the true MC of the load of lumber--over-drying is common and under-drying is also not unheard of. Of course, the kiln operator gets his instructions from the boss, so it is up to the boss to specify the correct average MC and the desired spread and how it will be measured in the kiln operation. (Or perhaps the customer insists that the boss do this.) If the MC is wrong, it costs the furniture plant many thousands of dollars each year, especially in the winter when the lumber is often too wet.

Once the lumber has been dried correctly and stresses relieved properly, store the lumber under controlled conditions--that is, controlled relative humidity (RH) as mentioned below. RH in a shed or storage building can be done by installing expensive humidification and dehumidification equipment. Or, it can be done quite inexpensively by controlling the heat to the storage building.

Two facts help us understand why heating works. First, when air is heated, its RH drops, and when it is cooled, the RH rises. Second, the RH outside in almost the entire U.S. and Canada will be at or close to 100 percent RH in the early morning hours just before sunrise. So, to control our storage shed, all we need do is keep the shed a few degrees warmer than the outside temperature. The control temperature in the shed can be set every day or two, based on the weather reports, or the heat can be tied into a humidistat, where high RH indications turn on the heat. Specific heating values are:

Desired Equilibrium Moisture Condition (percent)	Heat Above The Low Temperature (degree F)
6	27
7	22
8	18
9	15

This amount of heat can be obtained in a closed shed by painting the roof and walls a dark color on the outside, thereby absorbing solar heat. (Perhaps there is even a tax credit for solar heating). All that is required is a small fan to stir the air in the building to avoid trapping all the hot air near the ceiling.

Checking Moisture Content

There are two basic approaches--first is to sample the MC of the incoming lumber and eliminate those pieces that are too dry and too wet. A sample of 30 pieces per load will give a precise estimate of the MC of the entire load, both spread and average MC. The second approach is to measure every piece of lumber with an in-line MC meter (usually located in front or behind the rough planer).

Example: Assume the average was measured to be 7.08 percent MC. With a standard deviation of 0.4 percent, then 98 percent of the pieces are between 6.28 percent and 7.88

There are also two choices on moisture meters--the pin-type meter that measures electrical resistance and relates the resistance to MC, and the dielectric meter that measures a dielectric coefficient and then relates the value to MC. Both meters have certain advantages and disadvantages and are listed below. In short, both work well. A comparison of these meters on over 250 pieces of kiln dried lumber did not show a clear preference for one or the other. A plant concerned about MC should have both types.

Resistance Meter	Dielectric Meter
Not highly sensitive to species	Highly sensitive to species variations
Not highly sensitive to density	Highly sensitive to density variations
Sensitive to temperature	Not highly sensitive to temperature
Measures at a very small spot	Measures over a small area
Measures at a given depth	Measures an average over 3/4-inch depth or so
Best between 7 percent to 25 percent MC	Best from 4-1/2 percent to 25 percent MC
In-line is difficult	In-line is easy, measuring lengthwise or cross-wise in 2 or 3 locations

Improve Dry Kiln Boiler Efficiency

Drying kilns often use wood fire boilers to generate the necessary heat to dry the wood. Check the boiler for potential leaks and other avenues that may result in loss of energy efficiency. If your plant has more than enough wood waste to supply the boiler, thus alleviating the obvious need for efficiency (other fuel or electricity wasted), it is still a good idea to use this checklist as a way to avoid additional reportable BTU's to the regulating agencies.

Also keep aware that the wood ash residue from the boilers must comply with state and federal regulations. In Wisconsin, the ash must be tested or determined for being hazardous or not before being disposed of.

Check your boiler for these potential efficiency and emission losses:

- ! pipes, valve and trap leaks,
- ! inadequate insulation on boiler and pipe surfaces,
- ! inefficient fuel burning,
- ! dirty heat transfer surfaces,
- ! inadequate condensate return to boiler,
- ! poor boiler water treatment,
- ! poor steam pressure,
- ! pressure reduction valves,
- ! high moisture content in the wood waste fuel,
- ! poor fire and combustion air, and
- ! inadequate maintenance.

Many states and local power companies offer programs to help conserve energy through energy efficiency programs. Let them check your boilers as part of an energy conservation assessment. Most of these programs are provided at no cost and can improve the energy efficiency of your boiler and overall operations resulting in considerable cost savings and pollution prevention. In Wisconsin energy audits are usually provided by electric and gas utilities, or by the Energy Analysis & Diagnostic Center at UW-Milwaukee.

Benefits

- ! energy conservation
- ! reduced energy costs
- ! reduced air emissions

Improve Drying Kiln Efficiency

Operate drying kilns at capacities that result in the best efficiency and lumber quality. Filling a kiln too full of lumber may prevent adequate air movement leading to increased drying times. This results in wasted energy, increased non-combusted materials in the air and higher costs. Utilizing the kiln at low capacities may provide for adequate air movement and fast drying times, however it will also result in higher costs, as the kiln operation may not be optimal. Monitor drying times, lumber capacity, and kiln temperature to allow for optimum efficiency of this process. See Section X on fuel burning.

Benefits

- ! energy conservation
- ! reduced air emissions
- ! reduced costs
- ! improved yield

Improve Kiln Drying Efficiency with Variable Speed Fans

A technique that maximizes energy efficiency is enabling the fan speed to be adjusted for the need. During the initial phase of drying when moisture is readily available, the fans are run at normal speeds. Later, when water diffuses from the wood more slowly, the fan speed is reduced without reducing the drying rate.

Benefit

! electrical energy savings

Dehumidification Drying

Where steam is unavailable, dehumidification can be economical. Lumber to be dried is placed in a drying building or kiln. Some of the kiln air is then circulated via ducts to heat pumps that condense moisture (water disposal must be addressed here) and remove it from the air. The air is re-heated and passed back over the lumber to evaporate more water.

Benefit

! no boiler required for drying

Caution

! this process can lead to increased electrical costs

Maintain Adequate Relative Humidity Levels

Wood is a hygroscopic material, meaning that it is continually trying to achieve an equilibrium moisture condition (EMC) with its environment. As the relative humidity (RH) changes, so does the moisture content (MC) of the wood. The following tabulation expresses the relationship between MC and RH.

%MC	%RH	%EMC
5	19 - 25	5
6	25-32	6
7	32-39	7
8	39-46	8
9	46-52	9
10	52-58	10
11	58-64	11

Note that temperature is not an important factor; it is just the RH. Also, these numbers hold true for all North American species of wood.

The properties of wood change with changes in MC--most noteworthy is that wood shrinks and swells substantially with MC changes. With the property changes come changes in processing--gluing, machining, fastening, and finishing.

The most troublesome change has to be shrinkage and swelling--wood shrinks when the MC decreases and swells when the MC increases. To complicate matters, wood shrinks differently in the three directions:

! lengthwise shrinkage is usually quite close to zero;

Wood Products Value-Added Manufacturing and Finishing Manual

- ! across the grain, parallel to the rings (width of a flatsawn piece) wood shrinks up to 1 percent for a 3 percent to 4 percent MC change; and
- ! across the grain, perpendicular to the rings (thickness of a flatsawn piece) wood shrinks about 1 percent for a 7 percent MC change.

There is variation from piece to piece of the same species, as well as variation from species to species. The following tabulation gives the average change in size for a 3 inch wide, flatsawn piece of lumber for a 2 percent MC change for several important species. Shrinkage is essentially a linear function of MC, so double the values for a 4 percent MC change, triple them for 6 percent MC change, and so on. (Note: Often 0.006 inches size variation is large enough to result in gluing problems.)

Species	Size Change (in.)	Species	Size Change (in.)
Aptiong	0.031	Mahogany	0.014
Ash, white	0.016	Maple, hard	0.021
Basswood	0.020	Maple, soft	0.015
Banak	0.019	Oak, red	0.022
Birch, yellow	0.020	Oak, white	0.020
Cherry	0.015	Pine, Southern	0.016
Hackberry	0.019	Pine, white	0.012
Hemlock, Eastern	0.014	Teak	0.011
Hickory	0.019	Yellow poplar	0.017

Provide Adequate Dry Shed Capacity and Environment

Significant cost and effort have gone into adequately drying the lumber produced by the drying kiln; therefore it is important to protect it by storing it in a dry location. Store kiln-dried lumber in an enclosed shed where it is protected from the weather. If the lumber is stored long-term (over four weeks), controlled humidity (e.g. 36 percent relative humidity provides a 7 percent moisture content) is required to prevent undesired moisture changes.

Summary Checklist for Quality Drying of Softwood Lumber

Rate on a scale of 1-4 where 1 is low and 4 is high

Kiln _____

Date _____

Standard Operating Practices

- | | |
|---|-----------------|
| 1. Maintenance and Inspection | Low High |
| 1.a. Equipment above fan deck inspected regularly | 1 2 3 4 |
| 1.b. Air velocity checks made regularly | 1 2 3 4 |
| 1.c. Traps checked for proper operation and plumbed for ease of checking | 1 2 3 4 |
| 1.d. Air supply to kiln controllers checked at regular intervals | 1 2 3 4 |
| 1.e. Regular maintenance program for steam valves | 1 2 3 4 |
| 1.f. Regular calibration of each temperature sensing device and indicator | 1 2 3 4 |
| 1.g. Wet-bulb wicks changed on a regular schedule | 1 2 3 4 |
|
 | |
| 2. Moisture Content Monitoring and Recordkeeping | Low High |
| 2.a. Moisture checks on each charge made as standard practice | 1 2 3 4 |
| 2.b. In-kiln MC monitoring equipment is used when available | 1 2 3 4 |
| 2.c. Control charts are saved and filed for reference | 1 2 3 4 |
| 2.d. Records of MC checks are kept with control charts | 1 2 3 4 |
|
 | |
| 3. Discussion and Feedback from Planer Operators and Graders | Low High |
| 3.a. Regular communication with planer operators and graders | 1 2 3 4 |
|
 | |
| 4. Learning Opportunities | Low High |
| 4.a. Opportunities to visit other sites and meet other operators | 1 2 3 4 |
| 4.b. Attend Dry Kiln Association meetings and drying workshops | 1 2 3 4 |

Control Room

- | | |
|--|-----------------|
| 5. Valves Operate Properly | Low High |
| 5.a. Steam heat valves fully open and close | 1 2 3 4 |
| 5.b. Steam spray valve fully opens and closes | 1 2 3 4 |
| 5.c. Manual vents are used appropriately | 1 2 3 4 |
|
 | |
| 6. Controls Operate Properly | Low High |
| 6.a. Vents and spray are not on at the same time | 1 2 3 4 |
| 6.b. Control charts show fan reversals occur | 1 2 3 4 |
| 6.c. Setpoint changes are made according to the schedule | 1 2 3 4 |
| 6.d. Correct control charts are used | 1 2 3 4 |

Fan Deck and Kiln Roof

- | | |
|---|-----------------|
| 7. Fans | Low High |
| 7.a. Fans and shrouds are well maintained | 1 2 3 4 |
| 7.b. Fans turning for proper airflow | 1 2 3 4 |
|
 | |
| 8. Heat Distribution Systems | Low High |
| 8.a. Steam heating coils clean and free of debris | 1 2 3 4 |
| 8.b. Steam heating coil baffles present | 1 2 3 4 |

8.c. Direct-fired, heat distribution system structurally sound and clean 1 2 3 4

9. Vents **Low High**

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

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

Yard Area

10. Sticker and Bolster Thickness **Low High**

10.a. Sticker thickness uniformity 1 2 3 4

10.b. Bolster thickness uniformity 1 2 3 4

10.c. Green lumber inventory control 1 2 3 4

Inside an Empty Kiln

11. Inside a Cold Kiln **Low High**

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

11.b. Reheat (center) coils clean and free of debris 1 2 3 4

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

11.d. Adequate water flowing to wet-bulb 1 2 3 4

12. Kiln Operational Checks **Low High**

12.a. Heating coils and steam pipe free of steam or water leaks 1 2 3 4

12.b. Steam spray free of liquid water 1 2 3 4

12.c. Steam spray uniformly distributed 1 2 3 4

While Preparing Charges and Loading the Kiln

13. Lumber Quality and Package Loading **Low High**

13.a. Lumber thickness variation 1 2 3 4

13.b. Package arrangement to accommodate short packages 1 2 3 4

14. Package Support **Low High**

14.a. Bottom load support uniformity 1 2 3 4

14.b. Rails (track-loaded kilns) 1 2 3 4

During Kiln Startup and Operation

15. During Kiln Startup **Low High**

15.a. Adequate airflow across wet-bulb 1 2 3 4

15.b. Confirm that traps are functioning 1 2 3 4

16. While Kiln Is Operating **Low High**

16.a. Doors, walls, and roof free of leaks 1 2 3 4

16.b. Confirm fan reversal by feeling airflow direction 1 2 3 4

After Drying Is Completed

- | | |
|---|-----------------|
| 17. Before Unloading Kiln | Low High |
| 17.a. Pile height uniform | 1 2 3 4 |
| 17.b. Baffles used properly | 1 2 3 4 |
| 17.c. Adequate plenum width | 1 2 3 4 |
|
 | |
| 18. Before Plies Are Broken Down | Low High |
| 18.a. Spot check MC with a moisture meter | 1 2 3 4 |
| 18.b. Dry end covered | 1 2 3 4 |

Evaluate Stacking and Its Effect on Drying Quality

- | | |
|---|-----------------|
| 19. Sticker Placement | Low High |
| 19.a. Sticker alignment | 1 2 3 4 |
| 19.b. Stickers missing | 1 2 3 4 |
| 19.c. Stickers on edge | 1 2 3 4 |
| 19.d. Double stickers (one on top of the other) | 1 2 3 4 |
| 19.e. Sticker placement at ends of packages | 1 2 3 4 |
|
 | |
| 20. Board Placement In Packages | Low High |
| 20.a. Packages are square at both ends | 1 2 3 4 |
| 20.b. Sides of package even | 1 2 3 4 |
| 20.c. Overlapped boards in package | 1 2 3 4 |
|
 | |
| 21. Package and Bolster Placement | Low High |
| 21.a. Bolster (bunk) placement | 1 2 3 4 |
| 21.b. Package (crib) placement on supports | 1 2 3 4 |
| 21.c. Chimney allowance between packages when loading kiln trucks | 1 2 3 4 |
| 21.d. Packages placed at edge of kiln trucks | 1 2 3 4 |

Drying Defects and Drying Problems Reported

- | | |
|--|-----------------|
| 22. Drying Defects | Low High |
| 22.a. Drying defects related to stickering and stacking | 1 2 3 4 |
| 22.b. Drying defects related to overdrying .. | 1 2 3 4 |
| 22.c. End checking or end splits visible in stickered lumber | 1 2 3 4 |
| 22.d. Stain related to drying conditions | 1 2 3 4 |
|
 | |
| 23. Lumber Moisture Content and Degrade Problems Reported | Low High |
| 23.a. Planer operators and graders report of problems | 1 2 3 4 |
| 23.b. Moisture content reports from planer | 1 2 3 4 |

"Quality Drying of Softwood Lumber Guidebook/Checklist;" USDA Forest Service; Forest Products Laboratory; FPL-IMP-GTR-1 1991

Summary Checklist for Drying Quality Hardwood Lumber

Rate on a scale of 1-4 where 1 is low and 4 is high

Kiln _____

Date _____

Standard Operating Practices

1. Maintenance and Inspection **Low High**

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

2. Moisture Content Monitoring and Recordkeeping **Low High**

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

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

- 3.a. Regular communication with rough mill or glue room supervisor 1 2 3 4

4. Learning Opportunities **Low High**

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

Control Room

5. Valves Operate Properly **Low High**

- 5.a. Steam heat valves operate properly 1 2 3 4
- 5.b. Steam spray valve fully opens and closes 1 2 3 4
- 5.c. Gauges are working and readable 1 2 3 4

6. Controls Operate Properly **Low High**

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

Fan Deck and Kiln Roof

- 7. Fans** **Low High**
- 7.a. Fans and shrouds are well maintained 1 2 3 4
 - 7.b. Fans turning for proper airflow 1 2 3 4
 - 7.c. Fan deck (fan floor) in good repair 1 2 3 4
 - 7.d. Easy access to fan deck and roof vents 1 2 3 4
- 8. Heat Distribution Systems** **Low High**
- 8.a. Heating coils clean and free of debris 1 2 3 4
- 9. Vents** **Low High**
- 9.a. Vent lids open and close fully 1 2 3 4
 - 9.b. Vent actuators and linkages operate properly 1 2 3 4

Yard and Stacker Area

- 10. Sticker and Bolster Thickness** **Low High**
- 10.a. Sticker thickness uniformity 1 2 3 4
 - 10.b. Bolster thickness uniformity 1 2 3 4
 - 10.c. Uniformity of sticker straightness 1 2 3 4

Inside an Empty Kiln

- 11. Inside a Cold Kiln** **Low High**
- 11.a. Condensation or other water inside kiln 1 2 3 4
 - 11.b. Drainage from kiln floor 1 2 3 4
 - 11.c. Proper wet-bulb wick is used 1 2 3 4
 - 11.d. Adequate water flowing to wet-bulb 1 2 3 4
- 12. Kiln Operational Checks** **Low High**
- 12.a. Heating coils and steam pipe free of steam or water leaks 1 2 3 4
 - 12.b. Steam spray free of liquid water 1 2 3 4
 - 12.c. Steam spray uniformly distributed 1 2 3 4

While Preparing Charges and Loading the Kiln

- 13. Lumber Quality and Package Loading** **Low High**
- 13.a. Lumber thickness variation 1 2 3 4
 - 13.b. Plenum width adequate 1 2 3 4
 - 13.c. Package arrangement to accommodate short packages 1 2 3 4
 - 13.d. Package placement in package kilns 1 2 3 4
 - 13.e. Package placement on kiln trucks in track kilns 1 2 3 4
 - 13.f. Rails in track kilns 1 2 3 4

During Kiln Startup and Operation

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

- 15. While Kiln Is Operating** **Low High**
- 15.a. Doors, walls, and roof free of leaks 1 2 3 4
 - 15.b. Confirm fan reversal by feeling airflow direction 1 2 3 4

Moisture Content Control and Equalizing and Conditioning Treatments

- 15. Control of Moisture Content** **Low High**
- 15.a. Proper selection and use of kiln sample boards 1 2 3 4
 - 15.b. Moisture content variation using kiln sample boards 1 2 3 4
 - 15.a. Moisture content variation measured by in-kiln monitors 1 2 3 4
 - 15.b. Moisture content variation measured by electric moisture meter 1 2 3 4

- 16. Equalizing and Conditioning Treatments** **Low High**
- 16.a. Equalizing and conditioning treatments used correctly and used when needed 1 2 3 4
 - 16.b. Check for drying stresses using prong test 1 2 3 4

After Drying Is Completed

- 18. Before Unloading Kiln** **Low High**
- 18.a. Baffles used properly 1 2 3 4
 - 18.b. Package height uniform for good top baffle contact 1 2 3 4

Evaluate Stacking and Its Effect on Drying Quality

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

- 20. Board Placement In Packages** **Low High**
- 20.a. Packages are square at both ends 1 2 3 4
 - 20.b. Overlapped boards in package 1 2 3 4
 - 20.c. Sides of package even 1 2 3 4

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

Drying Defects and Drying Problems Reported

- 22. Drying Degrade Seen in Rough Dry Lumber** **Low High**
- 22.a. End checking or end splits visible in stickered lumber 1 2 3 4
 - 22.b. Surface checking visible in stickered lumber 1 2 3 4
 - 22.c. Warp (including kinks) related to stickering and stacking 1 2 3 4

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

"Quality Drying of Softwood Lumber Guidebook/Checklist;" USDA Forest Service; Forest Products Laboratory; FPL-IMP-GTR-21 1992

Summary Checklist for Quality Drying in a Hardwood Lumber Predryer

Rate on a scale of 1-4 where 1 is low and 4 is high

Predryer _____

Date _____

Standard Operating Practices

1. Maintenance and Inspection **Low High**

- 1.a. Proper location of dry-bulb sensors 1 2 3 4
- 1.b. Influence of side vents of recorded dry-bulb temperatures 1 2 3 4
- 1.c. Proper location of the relative humidity (RH) sensor 1 2 3 4
- 1.d. Influence of side vents on recorded RH values 1 2 3 4
- 1.e. Use of wet-bulbs to determine RH values 1 2 3 4
- 1.f. Use of EMC sensor to determine humidity in predryer 1 2 3 4
- 1.h. Drip pans positioned below roof vents 1 2 3 4
- 1.i. Condensation of water on predryer floor 1 2 3 4
- 1.j. Removal of dirt and debris from predryer floor 1 2 3 4
- 1.k. Roof is free of leaks 1 2 3 4
- 1.l. Traps checked for proper operation and plumbed for ease of checking 1 2 3 4
- 1.m. Circulating fans turning in proper direction and lubricated properly 1 2 3 4
- 1.n. Exhaust fans turning for proper airflow and lids closing properly 1 2 3 4
- 1.o. Proper functioning of side vents 1 2 3 4
- 1.p. General building inspection 1 2 3 4
- 1.q. Heating coils clean and free of debris 1 2 3 4

2. Moisture Content Monitoring and Recordkeeping **Low High**

- 2.a. Knowledge of history of lumber before going into predryer 1 2 3 4
- 2.b. Use of sample boards (kiln samples) to monitor moisture content 1 2 3 4
- 2.c. Disposition of lumber after removal from predryer 1 2 3 4
- 2.d. Identification of packages of lumber in predryer 1 2 3 4

3. Learning Opportunities **Low High**

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

Control Room

4. Environmental Conditions in Control Room Appropriate **Low High**

- 4.a. Temperature and relative humidity controlled for good working conditions of personnel and control instrumentation 1 2 3 4

5. Instrument Charts **Low High**

- 5.a. Correct instrument charts are used 1 2 3 4
- 5.b. Chart record is clear and legible 1 2 3 4

Lumber Stacking and Loading of Predryer

6. Sticker and Bolster Thickness **Low High**

- 6.a. Sticker thickness uniformity 1 2 3 4
- 6.b. Bolster thickness uniformity 1 2 3 4

6.c. Uniformity of sticker straightness	1 2 3 4
6.d. Lumber thickness variation	1 2 3 4
6.e. Painted lines on floor help proper positioning of stacks	1 2 3 4
6.f. Plenum width adequate	1 2 3 4
6.g. Spacing between lumber piles	1 2 3 4

Operational Checks

7. Dry-Bulb Temperature **Low High**

7.a. Appropriate range of operating temperatures	1 2 3 4
7.b. Accuracy of dry-bulb sensors	1 2 3 4
7.c. Daily variation of dry-bulb temperature	1 2 3 4
7.d. Dry-bulb temperature variation within control zone	1 2 3 4
7.e. Selecting "controlling zone" dry-bulb temperature	1 2 3 4
7.f. Possible shut-down of predryer when main door is open	1 2 3 4

8. Wet-Bulb Temperatures, RH, or EMC **Low High**

8.a. Accuracy of wet-bulb sensor	1 2 3 4
8.b. Accuracy of relative humidity sensor(s)	1 2 3 4
8.c. Daily variation of wet-bulb temperature	1 2 3 4
8.d. Possible shut-down when the main door is open	1 2 3 4
8.e. RH limits in predryer when loading wet lumber	1 2 3 4

9. Fan Operation and Air Velocity **Low High**

9.a. Fans turning for proper airflow	1 2 3 4
9.b. Average air velocity through the load	1 2 3 4
9.c. Air velocity uniformity/variation	1 2 3 4
9.d. Use of baffles in plenum space	1 2 3 4
9.e. Use of end baffles	1 2 3 4
9.f. Use of tapered floor bolsters	1 2 3 4
9.g. Burlap wrap for thick lumber.	1 2 3 4
9.h. Fan control within a control zone	1 2 3 4

10. Monitoring Drying Rate and Degrade Formation **Low High**

10.a. Use of sample boards to monitor drying rate	1 2 3 4
10.b. Monitoring for presence of surface checking on incoming lumber	1 2 3 4
10.c. Recording of final moisture content	1 2 3 4
10.d. Initial set point conditions of dry kiln for lumber from predryer	1 2 3 4

"Quality Drying of Softwood Lumber Guidebook/Checklist;" USDA Forest Service; Forest Products Laboratory; FPL-IMP-GTR-3 1993

