RECOGNIZING THE FOUR STAGES OF DRYING IN THICK OAK

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Problems in drying refractory woods such as oak have been increasing. Oak continues to be in high demand for furniture, trim, and moulding, and lumber production from this species continues at a level of about 3.5 billion board feet per year. Oak leads all other hardwood species in volume use.

The use of oak for furniture and trim requires an attractive defect-free appearance and quality drying is important if drying defects such as checks, splits, honeycomb, and collapse are to be avoided.

Contributing to the problems of drying is that species of lowland and southern oak are being utilized in increasing amounts. These oaks tend to be faster growing and produce denser wood which is harder to dry and machine. Northern and Appalachian lowland and southern oak are being utilized and produce denser wood which is harder to dry and machine. Northern and Appalachian sites generally produces wood of slower growth and lower density (upland oaks) which are easier to dry and machine. One other problem plaguing the drying of refractory woods such as oak is the presence of bacteria-infected wood. The heartwood of living trees can become infected with bacteria which produce enzymes capable of weakening wood. This commonly results in ring shake in the tree, and when cut, the wood emits a rancid odor. During drying under regular mild kiln-drying schedules, this bacteria-weakened wood will degrade and cause honeycomb and ring failure.

Research is underway at the Forest Products Laboratory in Madison to find methods of drying infected wood and identifying and isolating bacterially infected material. Thus, infected logs or lumber could be handled separately to minimize drying degrade.

The usual method of handling and drying thick refractory woods like oak is to air dry first, removing most of the free water, then kiln drying to a specified final moisture content. Quite often heavy degrade develops in thick oak while on the air drying yard because of severe exposure conditions. Degrade accrued during air drying is often severe enough to cause permanent damage which subsequent kiln drying cannot correct.

Before thick oak is handled it should be end coated to prevent end checking losses which can easily exceed 5 percent of the board volume.

With the exception of specified time periods, the stages of drying discussed in this report apply in general to thick oak (6/4 and thicker). Specific time periods refer to 8/4 oak.

Throughout the handling and drying of thick refractory woods such as oak, four basic drying stages can be identified. Each stage has an effect on the lumber and is controlled by regulating the temperature, relative humidity, and to a certain extent air velocity.

It is well known that dry, cool wood is stronger than wet, warm wood, therefore when drying begins with a refractory wood such as oak, low dry bulb conditions are necessary to prevent degrade (Stage I). During this same stage, high relative humidities control surface checking.

During Stage II temperatures must remain in low but relative humidities may be lowered slowly as tension in shell begins to diminish.

Stage III is characterized by stress reversal and moisture contents dropping below the fiber saturation point. Temperatures can be raised and humidity lowered.

After Stage III has been completed, the stock requires an equalizing and conditioning treatment as described in Stage IV. An analysis of stress relief effectiveness (conditioning) is determined by cutting stress sections.

Figure 1 is a detailed breakdown of the drying stages in heavy oak. The requirements of each stage dictate the necessary drying conditions. The graphs are based on actual stress and moisture content values in drying 8/4 oak from basic work by J.M. McMillen of the Forest Products Laboratory.
Stage I

From green to about 50% MC

1. Low temperature to maintain wood strength so as to prevent collapse or subsequent honeycomb.
2. High relative humidity to prevent surface checking.

Period required to tension-set the shell: about 20 days in dry kiln or 30-60 days if on yard. May be even longer if in a tight shed. (Usually after 1/3 green moisture evaporated).

- A. Dry kiln
- B. Tight shed
- C. Forced-air dryer with relative humidity control and restricted air velocity
- C. Center of yard with roof covers

During this period, tension in shell rapidly builds to a maximum due to shrinkage. Greatest danger of surface checking is present. Compression in core builds with possible weakening of cells unless temperature kept low (5 days). Deep surface checks can occur, particularly in open yard. Maximum temperatures of 110°F with 4° depression recommended; therefore dry kiln best for this stage. In summertime it may not be possible to hold these conditions on yard or in kiln, therefore wintertime sawing and drying may be necessary.

Stage II

From 50% to 30% MC

1. Maintain low temperature.
2. Slowly lower relative humidity as tension in shell subsides.

13-30 days if started in kiln.
60-120 days if on yard.

- A. Return to yard with roof covers
- A. Open shed
- A. Dry kiln
- A. Forced air dryer, good air velocity

Maximum tension in shell is falling off, therefore if little or no checking has occurred, safe to slowly lower relative humidity. Because compression on core is at maximum during this period, keep temperature low to maintain wood strength. Slight temperature increase permitted as core compression forces diminish (28 days in kiln and average moisture content below 10 percent). Yard conditions with brisk wind and lower relative humidities are now safe. Tight shed with restricted air flow should be opened up. Stress reversal occurs late in this stage tightly closing any existing normal checks. Deeper checks caused in Stage I due to alternate wetting and drying of lumber may not close.

**Figure 1:** Four Stages of Drying Thick Oak

- Maximum tension in shell
- Period required to tension-set the shell
- Preferred drying conditions
- Comments
- Graphs
NO STRESS
THICKNESS

S-tag, I'll raise temperature to final gradually as last of MC free water evaporates. Final temperature depends on final use of product.

2. Low relative humidity 30-50 days if started A. Dry kiln If on yard, move into dry kiln Maximum tension building in core. If deep checking occurred in Stage I, it may develop into honeycomb (bottle-neck checks). Stock must be moved into dry kiln to achieve low final moisture content. At end of this stage, shell is "set" in tension, core has some compression set. Stock is said to be "case hardened" (50 days).

An equilibrium moisture content (EMC) will approach or equal outside equilibrium moisture content (EMC) of material in kiln, if air is of same relative humidity as drying condition. This is followed by a high relative humidity period which relieves the drying stresses (conditioning). Bars represent stress which develop through cross sections of their hard and soft bars and change volume during drying (case hardening). Stock would be "cage hardened" (30 days).