COPING WITH CONFLICTS: WELCOME TO THE REALITY OF THE DRY KILN OPERATOR

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Introduction

Lumber dry kiln operators have a difficult task to perform. They often walk a fine line between creating degrade in quality while attempting to achieve a drying objective. To make matters worse, they frequently operate between the risk of two different types of degrade, while having to avoid both. To further complicate their work, the potential types of degrade change throughout the drying schedule. Their challenge is to minimize this risk as it develops at each stage of the drying operation.

In the course of their daily work, kiln operators deal with conflicting consequences. For example, if they try to use higher temperature to avoid causing stain early in the run; the consequence is increased risk of degrade from surface checks and end splits. At the end of the run, they may extend the drying period in order to bring the moisture content down in the wet boards; the consequence of this may be an increased percentage of boards that over dry and suffer from warp type degrades.

Experienced kiln operators have learned that designing a dry kiln schedule requires knowledge and finesse to carefully work between the opposing trade-offs of degrade. The purpose of this article is to raise awareness of these conditions. For each drying objective presented, corresponding risks of degrade are also presented. Suggestions are then made to minimize the risk of creating degrade and maximize quality.

Kiln drying degrade is generally a function of four independent factors: 1) dry bulb temperature, 2) wet bulb temperature, 3) time of each setting (including total drying time), and 4) air velocity. Of these, the first three are controlled by the kiln operator through design of the drying schedule. Regarding effects on air velocity, the kiln operator has control over use of baffles and kiln loading procedures. To significantly alter the air velocity is generally out of the daily control of the kiln operator since it would require a physical change in the fan designs, air delivery system, sticker thickness, etc. Some of the newer kilns have been installed with variable speed fan motors. This article will concentrate on those situations most easily controlled by the kiln operator.

Kiln operator skill is needed to achieve the desired objective without creating undesirable degrade. This skill requires training and experience. It is not within the scope of this publication to provide all of this training. There are numerous manuals, workshops and short courses available for training. Experience will be gained on the job. Also required are dry kilns that are properly engineered and maintained, with adequate heat source, ability to maintain humidity, venting capacity and adequate air velocity through the sticker openings. A properly calibrated control system is needed to perform the required drying functions. Perhaps most important to kiln operator performance is support and commitment from management.

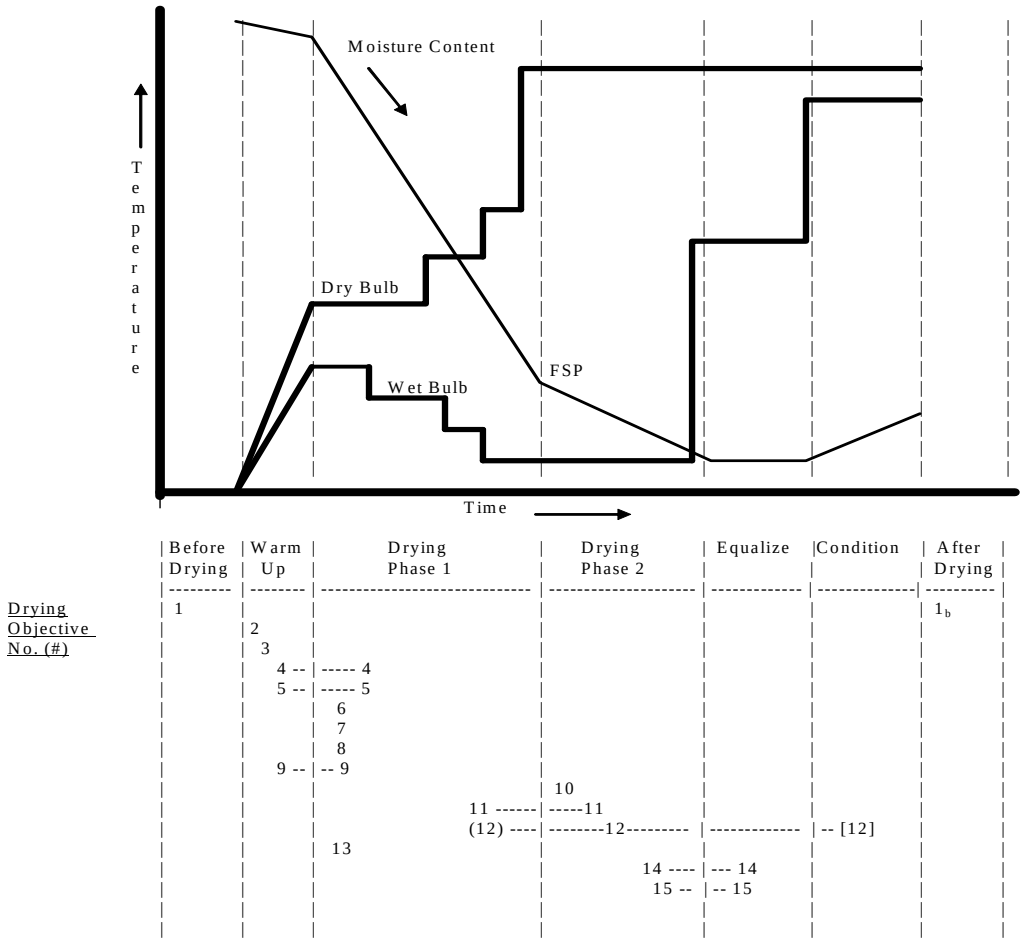

FIGURE 1. Steps of drying process.

Figure 1 shows the drying steps of an "idealized" softwood-drying schedule along with the related drying objectives. In the schedule, Drying Phase 1 has milder drying conditions and ends when the average moisture content reaches fiber saturation point (30%). Drying Phase 2 has more aggressive drying conditions to accelerate the drying rate. The lower half of Figure 1 shows when the drying objectives typically occur during the schedule. The corresponding number used in the text of this paper indicates this occurrence in the schedule. Its number depicts the relative timing of each objective while a horizontal line between numbers indicates the relative length of each occurrence. We should, however, note that this is not an all-inclusive list of drying objectives.

DRYING OBJECTIVE	RISK	SUGGESTION
#1) The sawing pattern used to convert logs into lumber will effect the quality of lumber drying. For example, wide width lumber sawn from small diameter logs.	#1a) Risk is to develop cup in the lumber during drying with subsequent roller split when surfaced. This is most critical when the wide boards are sawn across or near the center of the log. In small logs, this is the only place to get wide boards.	#1b) Since the sawing patterns effect drying quality, the first option is to change the pattern to saw narrower boards. If wide boards are to be sawn, several processing practices must be followed. The sawn lumber must be of uniform thickness. Use ample stickers (on 18 or 24 inch spacing) in an attempt to hold the lumber flat. Stickers must of uniform thickness and placed in vertical alignment. To help reduce roller split, change the surfacing machine from one with straight knifes and a hold down bar to a spiral head or abrasive planer.
#2) Use of a thawing schedule for frozen lumber To thaw frozen lumber in preparation for drying, a low dry bulb temperature (100-110°F) along with a high wet bulb setting with the steam spray off may be considered. This will keep the vents closed to retain heat while preventing steam spray from entering the kiln and freezing on the lumber.	#2a) Risk of developing surface checks, as well as blue and brown stains Since the steam spray is turned off, surface checks may develop due to the lack of humidity in the kiln. Since the vents are closed, the subsequent high humidity may result in blue stain and the onset of brown stain if the dry bulb temperature is above 120°F.	#2b) In order to attain the initial wet bulb setting, leave the vents closed and the steam spray turned off. This may require having a shut-off hand valve on the airline to the vent (if air operated), or an electrical over-ride switch (if electrically operated).

DRYING OBJECTIVE	RISK	SUGGESTION
#3) Cold weather start up with use of steam sprays To achieve the initial dry bulb temperature setting during a cold weather start up, heat as well as steam spray may be used.	#3a) Risk of developing surface checks, as well as blue and brown stains If the lumber has been partially air dried such that surface checks have started, then the use of steam sprays may cause these checks to close due to condensation of the steam on the surface of the lumber. This will cause deeper surface checks to develop. In addition, blue stain may develop from the use of high humidity.	#3b) In order to attain the initial wet bulb setting, leave the vents closed (to retain humidity) but also turn off the steam sprays (to avoid introducing moisture). This may require having a shut-off hand valve on the airline to the vent (if air operated), or an electrical over-ride switch (if electrically operated).
#4) Reduce surface checking and end splitting (No.1) To reduce surface checking of lumber, use a high relative humidity (above 87 %) and slower air velocity (less than 350 fpm) for woods whose drying rate is less than 4% per day. This includes species such as the oaks, cherry, and walnut. To reduce end splitting of boards, protect them with end coating.	#4a) Risk of developing blue stain, brown stain, sticker stain, mold Use of high relative humidity (above 87%) and low air velocity (below 350 fpm) may result in blue stain, brown stain, gray stain, sticker stain, and mold. [See # 2,3,6,7,10,13]	#4b) This condition is often a 'dance with the devil.' Uniform air velocities are essential. Below the fiber saturation point, air velocities above 350 fpm can be used. For some species, such as maple, 500 fpm is better. And for most pines, 750 fpm or above is better (see #5) To achieve uniform air velocities, ensure that the baffles are properly positioned, all fans are properly positioned in their shrouds and that fans are rotating in their proper direction.

DRYING OBJECTIVE	RISK	SUGGESTION
#5) Avoid surface checking and end splitting (No.2) The causes of surface checking and end splitting are related to the rate of drying of those areas of the lumber. The rate of drying is affected by the temperature and relative humidity (see #4). Since the temperature and relative humidity are affected by the rate at which air moves over the surface of the lumber, then air velocity and volume are important to reducing surface checking and end splitting.	#5a) Risk of wrong air velocity causing surface checking and end splitting Different species of wood dry and shrink at different rates. Thus slow drying woods may suffer from surface checking and end splitting if the air velocity is too high for their tolerance. This has become a critical issue as modern kilns are built with capacity for high air velocities. If these same kilns may be used to dry several different species of wood, the air velocity needs to be adjusted accordingly.	#5b) Some general guidelines are offered here, but training, review of the literature and experience will refine information. For species that are prone to surface check, such as the oaks, use air velocities of 350 feet per minute (fpm). For species that dry quickly and are less prone to surface check, like maple, use air velocities of 500 fpm. And for most of the softwoods, the pines, hemlocks, and white firs, use air velocities of 750 fpm. Note: use 350 fpm when drying softwood species that are prone to collapse, such as redwood, spruce, and some of the cedars. End splitting can be effectively reduced with proper use of end coatings, proper stacking, and use of end baffles.
#6) Avoid brown stain from enzymatic oxidation (No.1) To avoid chemical stains (enzymatic oxidation) such as brown stain, pinking, and interior graying, rapid drying is generally recommended. This may require a fairly large wet bulb depression (10-degree) during the early portion of the run.	#6a) Risk of developing surface checks, end splits, collapse, etc Use of fairly large wet bulb depression (10-degree) early in the run may result in surface checks, end split, collapse, and/or honeycomb.	#6b) Drying of freshly harvested logs and sawn lumber is one of the best ways to reduce the risk of developing brown stain. In addition, use of uniform air velocities as high as possible (above 350 fpm), will help. Initial dry bulb temperatures above 105°F will also help. Dry as rapidly as possible with out causing checks and splits.

DRYING OBJECTIVE	RISK	SUGGESTION
#7) Avoid brown stain from enzymatic oxidation (No.2) Brown stain typically occurs in lumber from old logs. Even though the lumber looks 'bright' when sawn, it may stain in the kiln during drying. This problem can be reduced by using dry bulb temperatures below 130°F, perhaps even as low as 120°F throughout the run. A wet bulb depression greater than 10 degrees may also help reduce stain.	#7a) Risk that pitch will not be set, nor will lumber be sterilized Use of dry bulb temperatures this low will not set the pitch in pines and other resinous species. Likewise, low temperatures will not sterilize wood that is infected with insects (often common in old logs).	#7b) Sometimes there is no answer or tradeoff in the operating conditions. If brown stain is to be avoided, it may be necessary to find a sales market that does not need the pitch to be set.
#8) Avoid blue stain and mold To avoid blue stain and mold use rapid drying of freshly sawn lumber during the early portion of the run.	#8a) Risk of developing surface checks, end splits, collapse, etc Use of fairly large wet bulb depression (10-degree) early in the run may result in surface checks, end split, collapse, and/or honeycomb.	#8b) Use of air velocities as high as possible (above 350 fpm), and as uniform as possible will help reduce the risk of blue stain and mould. See #5 for more comments on air velocity related to lumber species. In addition, initial dry bulb temperatures above 105°F will also help. Dry as rapidly as possible with out causing checks and splits.

DRYING OBJECTIVE	RISK	SUGGESTION
#9) Avoid sticker stain To avoid sticker stain on freshly sawn lumber, rapid drying of the surface moisture is generally recommended. This may require a fairly large wet bulb depression (10-degrees) during the first six hours of drying.	#9a) Risk of developing surface checks, end splits, collapse, etc Use of a fairly large wet bulb depression (10-degree) early in the run may result in surface checks, end split, collapse, and/or honeycomb.	#9b) Use of air velocities as high as possible (above 350 fpm), and as uniform as possible will help reduce the risk of sticker stain. Stickers should be dry and clean. Fluted type stickers will help reduce sticker stain. In addition, initial dry bulb temperatures above 105°F will also help. Dry as rapidly as possible with out causing checks and splits
#10) Achieve Sterilization To achieve sterilization of the lumber (i.e. to kill blue stain, mold, mildew and insect infestation), use a dry bulb temperature of 150°F or higher until the center of the board reaches that temperature for at least 4 hours	#10a) Risk of developing sticker stain Dry bulb temperatures in this range may cause sticker stain and brown stain. Note: Some drying systems may not have the heat capacity to reach 150°F in order to sterilize the lumber.	#10b) Use of dry stickers will help reduce the risk of sticker stain. This means stickers made from dry lumber, sterilized lumber; and, stickers that have been kept out of the rain and snow.
#11) Achieve rapid drying during middle portion of run Rapid drying during the middle and latter portions of the run may result in uneven drying.		#11b) Strive for uniform drying by having uniform conditions in the kiln: uniform lumber thickness, uniform sticker thickness, uniform air velocity, uniform heating, uniform humidity, etc.

DRYING OBJECTIVE	RISK	SUGGESTION
#12) Relieve casehardening of the wood Casehardening occurs naturally as wood dries below the fiber saturation point. The degree of casehardening will vary with the drying rate. The importance will vary with end use and grade.	#12a) Risk of casehardening is unavoidable. The degree of degrade caused by this condition is dependent upon its end use. Casehardening is less problematic in structural lumber because there is limited remanufacturing of the boards. However, if the lumber is remanufactured into molding, millwork or other finished products, casehardening can cause serious degrade.	#12b) To reduce degrade resulting from casehardening, a number of options can be considered. Reduce the rate at which the lumber is dried and passes through the fiber saturation point (30% MC). Or, introduce an effective conditioning cycle into the kiln schedule to relieve the casehardening.
#13) Prevent knot split and lose knots. To prevent knot split and lose knots, use mild schedules with low dry bulb temperatures and high wet bulb temperatures (i.e. high EMC).	#13a) Risk that blue stain may develop High EMC conditions increase the risk of causing blue stain and reduce the drying rate.	#13b) Keep dry bulb temperature below 130 °F with an EMC of about 12 % until the fiber saturation point (30 % MC) is reached. Then drying conditions can become more rigorous. Use of higher air velocities will also help reduce risk of stain.
#14) Achieve rapid drying to final moisture content Rapid drying late in the run is often achieved by using a high dry bulb temperature with a large wet bulb depression.	#14a) Risk of developing degrade as a result of shrinkage (bow, crook, twist) Rapid drying at low moisture contents often results in shrinkage related degrade from warp (bow, crook, twist).	#14b) Be careful not to over dry the lumber to moisture contents lower than needed. Uniform thickness of lumber will help reduce the warp type degrades. Uniform drying throughout the kiln will help reduce uneven drying and thus shrinkage related degrade in the drier pieces.

DRYING OBJECTIVE	RISK	SUGGESTION
#15) Achieve low final moisture content Shrinkage continues as long as moisture is being removed from the wood.	#15a) Risk of developing degrade as a result of shrinkage (bow, crook, twist) Continued shrinkage to low moisture contents increases the risk of warp type of degrades due to bow, crook and/or twist.	#15b) Be careful not to over dry the lumber to moisture contents lower than needed. Uniform thickness of lumber will help reduce the warp type degrades. Uniform drying throughout the kiln will help reduce uneven drying and thus shrinkage related degrade in the drier pieces.

Summary of Drying Objectives

- The sawing pattern used to convert logs into lumber will affect the quality of lumber drying.
- Use of a thawing schedule for frozen lumber.
- Cold weather start up with use of steam sprays.
- Reduce surface checking and end splitting (No. 1).
- Avoid surface checking and end splitting (No. 2).
- Avoid brown stain from enzymatic oxidation (No. 1).
- Avoid brown stain from enzymatic oxidation (No. 2).
- Avoid blue stain and mold.
- Avoid sticker stain.
- Achieve sterilization.
- Achieve rapid drying during middle portion of run.
- Relieve casehardening of the wood.
- Reduce knot split and loose knots.
- Achieve rapid drying to final moisture content.
- Achieve low final moisture content.