Understanding Dry Kilns

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WHY DRY LUMBER

- Fresh cut lumber contains a great deal of water. Green wood of some species are almost 50% water by weight.
- Properly dried lumber is more valuable and is much easier to work with than lumber that hasn't been dried.
- When lumber is dried properly, it machines better, glues better, finishes better and takes preservative treatments better.
- Drying improves the strength of lumber, kills infestations, hardens pitch, preserves color, reduces weight and controls shrinkage.
- Lumber that is not dried under controlled conditions is prone to warping, staining, and other degrades.

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HOW MUCH WATER IS IN LUMBER?

- A lot. In fact, some species of wood are more than half water in terms of their weight when they're fresh cut.
- Moisture content in lumber is generally expressed as a percentage of the dry weight.
- For example, if a fresh cut board weighs five pounds per Board Foot(BF), then weighs 3 pounds per BF after drying, that means it had two pounds of water in every board foot.
- Two pounds of water per board foot equates to 67% moisture content

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WHAT IS “FREE WATER” AND “BOUND WATER”?

- When trees are growing there is liquid water moving through the cells of the wood.
- This water is called “free water” because it exists in water form and can be removed relatively easily from the wood.
- Hygroscopic or “Bound water” is moisture contained in, as vapour, or associated with the cell wall structure and is more difficult to remove.
- When wood is dried, the first thing that happens is that the free water evaporates until the lumber drops to “Fiber Saturation”, or when the moisture content reaches around 28%.
- Wood does not shrink until it is below fiber saturation and the bound water begins to be removed from the cells of the wood.

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DIFFERENCES BETWEEN DRYING HARDWOODS AND SOFTWOOD

- The actual species of the wood is really more important than whether it's a hardwood or softwood. The terms hardwood and softwood generally refer to whether the wood comes from a tree with leaves (hardwood) or a tree with needles (softwood).
- Some hardwoods are actually softer than many softwoods.
- Some hardwoods (i.e. oak) have to be dried very slowly or they degrade badly.
- Pines need to be dried at a fast rate or they stain and mould.
- That doesn't mean all hardwoods should be dried slowly, or that all softwoods should be dried as quickly as pine.
- Different species require drying at different temperatures and different speeds to produce the best results.
- There are specific drying schedules for nearly every species of lumber to produce the best results.

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WILL KILN DRIED WOOD REMAIN DRY

- Wood's moisture content is constantly changing to match the air surrounding it, so its moisture content can change after it's been dried.
- In dry air, the wood gives up water to the air until it is dried, as it equalizes with the air. When the air is more humid, wood absorbs water from the air.
- Wood expands when it absorbs water, and shrinks when it gives up water.
- In worst case winter heated conditions, wood indoors may dry to a moisture content (MC) of 6% as it gives up water to the dry air.
- In the humidity of summers, it may pick up moisture to about 15-16% MC.
- If dried lumber is exposed to outdoor conditions long enough, it will eventually reach about 12% MC.

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WHAT IS KILN DRYING

- Kiln drying is where lumber is placed in a chamber (i.e. dry kiln) where airflow, temperature, and humidity are controlled so that the wood can be dried as rapidly as it can tolerate without increasing or causing defects.
- There are several types of kilns, and those different types are defined by the manner in which the temperature and humidity are controlled.
- The most common types of kilns are Conventional, Hardwood, Dehumidification, and Solar.

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WHAT IS A CONVENTIONAL SOFTWOOD KILN

- This type of kiln is common for drying softwoods which are far more tolerant of rapid drying cycles.
- A Softwood kiln uses heat provided by either steam or hot water coils or more commonly, a hot air furnace to heat the kiln chamber.
- Vents remain closed until the temperatures are high enough to draw moisture from the wood.
- Vents then open allowing the water saturated air to escape.
- This heating/venting cycle continues until the wood is brought to the desired moisture content.

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WHAT IS A CONVENTIONAL HARDWOOD KILN

- A Hardwood kiln uses heat from either or both steam injection or hot water coils from a furnace to heat the kiln chamber.
- The airflow in the kiln chamber is very important. The velocity of the air over the wood affects the drying rate and provides even drying. Generally, wetter lumber requires a higher velocity of air through the lumber.
- Baffles are used to direct and control air flow. Improper use of baffles can cause uneven or incomplete drying.
- When the kiln raises the temperature with steam, with vents closed, it keeps the outside of the wood super saturated until the inside wood temperature rises to match the chamber temperatures which contributes to lower wood stresses and lower degrade.
- The water evaporated from the wood, is then exhausted from the kiln via roof vents along with the heated air.
- They can provide a very good quality of dried lumber when proper methods of kiln control are provided, but their energy consumption is much higher.

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SHOULD THE FANS REVERSE?

- Fans usually reverse in larger kilns. This applies to all types of kilns.
- This prevents uneven drying by forcing the air to enter the lumber pile first from one direction and then from the other. It also corrects for dead air spots which may result from the way the lumber is stacked.
- Generally, lumber that is stacked over 12 feet (3.5 meters) deep in the direction of the airflow should have reversing fans. If the lumber stack is less than 12 feet thick, reversing the fans will not make any significant difference in the drying.

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CAN PITCH BE SET IN PINE

- When softwoods are dried, the pitch sets at the final temperature of the drying cycle. For example; if the last step of drying is 120F (approx. 50C), then the lumber has to be get above that temperature again before the pitch starts to run.
- In some instances where accelerated stabilization/fixation is done in kiln like chambers, the temperatures may exceed the pitch fixed temperature as mentioned above.
- If the pitch must be set, it can be done by heating the lumber at the end of the drying cycle to the necessary temperature because during pitch setting you are not removing water from the wood you're just applying heat.

UNDERSTANDING DRY KILNS

HEATING SYSTEMS

Direct Fired dry kilns use hot air furnaces which;

- Blows heat directly to chamber
- Suitable for softwoods/plywood, not for hardwoods
- This system does not use a boiler, but a type of furnace to heat air passing through it.
- By keeping the vents closed at the beginning of the cycle and only venting once temperatures has risen, some humidity control can be achieved.
- As there is no boiler involved, no live steam is available to use.

Steam heated kilns use boilers to generate steam and hot water

- The hot water is passed through the heating coils and then returned to the boiler, for reheating.
- This is suitable for most retail type products
- Maintenance is much higher than a forced air kiln due to the extra care needed in the form of chemical conditioning and monitoring of the water passing through the boiler.
- This type of kiln has better drying control (live steam) and is suitable for a wider range of products

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RECORDER/CONTROL SYSTEMS

- In the past, in older systems, spray valves, vents and heating systems were regulated by air-operated or electric recorder-controllers set to maintain wet and dry bulb temperatures.
- Today kilns mostly use fully automatic or semi-automatic systems.
- Semiautomatic systems record and control on set points that are changed from time to time during the kiln run by an operator.
- Either may be a circular chart style with auto or semi auto controls.
- Making everything fully electronic can be accomplished by using a PLC with touch screen interface.
- In many instances the PLC can be linked to a computer to be used as an interface and for data recording.

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AIR FLOW AND HUMIDITY CONTROL (VENTING)

- Constant circulation of air is necessary in kiln drying to carry heat to the wood being dried and to carry away evaporated moisture.
- Air circulation fan motors are special sealed motors able to withstand high temperatures as they are generally mounted above the ceiling inside the kiln. They are also able to reverse rotation for more even air flow to control heat and humidity.
- The control of humidity is essential to satisfactory kiln drying and so is the release of that humidity from the kiln. Moisture is generated as water is drawn from the wood in the drying process. Vents allow the release of moisture and the intake of fresh air.
- Vents are arranged along the entire length of the kiln and the lids are all joined to a central shaft, allowing uniformly controlled opening and closing.

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Temperature Measurement

- The older style wet-bulb and dry bulb temperature sensing bulbs are still used in some kilns today.
  - Dry Bulb
    - Usually two, one on each end of the airflow, so the temperature can be monitored when the fans reverse. The dry bulb measures the "Hot" side of the air flow before it flows through the wood piles.
  - Wet Bulb
    - The wet-bulb is the same construction as the dry bulb but is covered by a wick, its end submerged in a water filled trough. The wet wick causes the temperature reading to be lower than the dry bulb, and it is the difference, when calculated that determines the relative humidity. Only one wet bulb is needed for the entire kiln.
    - Frequent source of problems, due to water quality and wick issues.
- The newest kilns now often use Electronic Relative Humidity (RH) sensors, which send a direct signal to a PLC (Programmable Logic Controller) or directly to a computer. These sensors carry out the same tasks as the older wet and dry bulbs.

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BASIC KILN CONSIDERATIONS

- Air Circulation is paramount; it is the circulation of the air in the kiln which carries the heat to the wood and carries away the evaporated moisture.
- Heat is essential whether generated through coils, via live steam or simply via hot air furnace. Heat is necessary to evaporate moisture from the wood cells.
- Humidity control determines the speed of drying and also the quality of drying. Some species can withstand very rapid drying while others requires high humidity and longer times to dry to avoid degrade. Hardwoods may need two to three weeks to dry while some softwoods can be dried in less then 24 hours.
- Evaporation, Control of Equilibrium Moisture Content (EMC), is achieved by computer software allowing the operator to control the rate of evaporation and venting.

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EQUILIBRIUM MOISTURE CONTENT (EMC)

"The moisture content at which wood neither gains nor loses moisture when surrounded by air at a given RH (relative humidity) and temperature"

- EMC establishes the rate of drying
- Misinterpreting EMC is a leading cause of drying defects where wood may dry too fast, leading to degrade.
- Understanding EMC and using it properly is a key factor in the prevention of "Case-Hardening"
- High EMC early in cycle, reduces drying stress and degrade.

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KILN MATH

Air Circulation, Heat, Humidity

- Increase any one or more of the above;
  - Increase Evaporation
  - Decrease Time
- Decrease any one or more of the above
  - Decrease Evaporation
  - Increase Time

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PRIMARY CAUSES OF DRYING DEFECTS

- Drying Stresses;
  - Differential shrinkage between wood in the shell and wood in the core regions of the lumber resulting in internal stress. If not relieved via conditioning, stresses cause distortion of the wood leading to warping, twisting, or casehardening.
- Surface Checking;
  - Checks result from excessive drying stress when the tensile strength of the wood is exceeded. Usually occurs early in the process when temperature and EMC are too aggressive.
- End Checking;
  - End checking occurs when boards are allowed to dry at the end, faster than in the middle. Placement of stickers directly on the end of the boards help slow the drying rate and reduce splits. Baffling also redirects air toward the center of packs and away from the ends.

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PRIMARY CAUSES OF DRYING DEFECTS (cont)

- Raised Grain;
  - Usually results when lumber is not sufficiently dried at time of machining. Knives force the denser latewood into the softer earlywood bands and damage or break the bond between the two. Subsequently the compressed wood recovers leaving a “raised” grain.
- Colour;
  - Exposure to elevated temperatures and humidity result in darker wood. Also, cycles which lead to heavy initial expansion of treating solutions and subsequent bleeding, surface wicking, and surface evaporation can cause further discoloration from residue

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Final Moisture Content Check

- Resistance meters most common; pin type
- For accurate readings correction factors must be applied for the following;
  - Temperature – very difficult to determine wood temperature with specialized equipment
  - Species; the species must be entered before readings are taken as different species have different electrical conductivity and will result in different values.
- Calibrate before every use by taking a reading and then oven drying the sample to compare results.

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TUNING UP THE PROCESS – TROUBLESHOOTING

10 everyday things that make your kiln inefficient.

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TUNING UP THE PROCESS – TROUBLESHOOTING

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Plan your charges, to maximize kiln space usage.

- Consider overtime costs vs. energy costs
- Nominate a dedicated employee who will learn and control all aspects of the kiln operation.

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TUNING UP THE PROCESS – TROUBLESHOOTING

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Keep the vents closed so the kiln can double as a shrimp steamer

- Proper initial heat up needed
- You don’t want to “stew” and drip
- 80 mbf @ 15 pcf = 6785 imp-gal

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TUNING UP THE PROCESS – TROUBLESHOOTING

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- Kiln efficiency requires records and what the records tell you.
- Use properly calibrated charts for the application.
- learn to “diagnose” what your data is telling you.

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TUNING UP THE PROCESS – TROUBLESHOOTING

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Proper bulbs

- Wet bulb control is the most overlooked area of kiln
- Clean wet bulb wicks are critical to accurate readings, inaccurate readings may cause damage to the wood.
- Inspect the wet bulb wick every charge and change if needed.
- Make sure the water supply to the wet bulb is clean and working, if the wick dries out, you have one more dry bulb and loss of control.

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TUNING UP THE PROCESS – TROUBLESHOOTING

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If your recorder charts bounce all over the place

- diagnose and respond accordingly
- your kiln could be out of control
  - Check the wet bulb wicks
  - Check for sticking vents and fan control
- be sure pen colors are distinctly different to be able to find problems easier.
- Calibrate all control devices annually

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The water supply to the wet bulb is caked in deposits

- water should not impinge on the probe
- It must be a clean and controlled supply
- drain outside so as not to overflow your sump.

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Your shift operator shuts off the steam traps because they're noisy

- never by-pass traps, it is a crucial safety issue
- Periodically inspect steam traps to be sure the traps fire and are not full of water
- Set up routine inspections and service as part of the maintenance program
- Have steam traps sized by a professional to ensure they are sized properly

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TUNING UP THE PROCESS – TROUBLESHOOTING

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Baffles are extremely important

- Learn how to load the kiln correctly, the benefits are huge
- top, side, and bottom baffles are needed
- Air moves to where there is the least resistance, so if a baffle is not in place, the air will not go where it should.
- Regularly check belts, shafts, motors and blades to be sure all are in good working order
- Make monthly kiln equipment inspections an integral part of your maintenance program

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TUNING UP THE PROCESS – TROUBLESHOOTING

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You try to squeeze too much material into the kiln

- proper loading is crucial to air flow
- don’t mix sizes, make sure your stacking does not impede air flow
- use 3/4” stickers for Lumber & Plywood
- use at least 3-4x4’s for round stock
- baffle top, ends, and bottom

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TUNING UP THE PROCESS – TROUBLESHOOTING

And #1

It pays to educate your people. Hire qualified technicians.

- Create a kiln position of responsibility to
  - schedule
  - load
  - operate
  - maintain