KILN TUNE-UPS TO CORRECT NONUNIFORM KILN-DRYING CONDITIONS

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Improper design and care of lumber dry kilns and their integral parts will invariably result in nonuniform drying conditions. A study of the drying conditions within a kiln, through the use of temperature-measuring devices and instruments for determining air velocities, will assist the operator in determining if drying conditions are uniform and, if not, in locating the cause of the nonuniform drying conditions, whether they be due to improper kiln design or to lack of care. After he locates the source of trouble, it should be corrected as soon as possible.

In some cases the corrective measures are simple and involve but little time or expense. In others considerable time and money may have to be spent.

The purpose of this report is to call the attention of the dry-kiln owners and operators to alterations in the heating, humidifying, venting, and air-circulating systems and in the kiln structure that will assist them to obtain better dry-kiln performance.

It is to be realized, however, that there are many types of lumber dry kilns, and that alterations that result in improved kiln performance in one type may not produce the same result when tried in a kiln of a different type. It is therefore suggested that lumber dry-kiln manufacturers and engineers be consulted for advice before major alterations are attempted.

Heating System

Coils

Coil size.—The more the resistance to steam flow within a coil is reduced, the less will be the tendency for the coil to waterlog and air-bind and the more uniform will be the temperature along its length. Coils should, therefore be kept as short and as small in number of runs as possible. In general, it has been found that return header heating coils more than 50 feet long are likely to produce large variations in temperature along their length. In as far as possible, therefore, all coils should be held within a length of 50 feet.
Short coils.--A short coil, while superior to a long coil in reducing resistance to steam flow, nevertheless presents problems of poor temperature control. A few precautions in design and operation, however, will minimize these.

Short coils should be designed to provide radiation not too much in excess of kiln requirements. Perfect design is difficult to attain because of the many variables that must be considered. Flexible control afforded by several small coils, each of which can be turned on or off by hand-operated valves, will overcome difficulties in design created by one or two larger units. The closer the ideal of constant steam flow can be approached, the smaller will be the temperature-time cycle and the longitudinal temperature range, and the less will be the tendency for the coils to become waterlogged, air-bound, or clogged with dirt.

Long coils.--In long coils, the number of runs, or pipes per header, should be held to the absolute minimum necessary to obtain the desired radiation. The coil should be so designed that short circuits will be prevented. As is the case of short coils, the kiln temperatures will be more uniformly distributed longitudinally when the amount of radiation is so reduced that the control valve must be open most of the time in order to maintain the desired temperature. To take full advantage of this principle, the radiation should be split into a number of small coils. Each of these coils should be supplied with a hand valve on both the supply and the discharge end.

General suggestions applicable to all coils.--Coils of the single-return-bend type will, in general, give more satisfactory results than will straight header coils. The return-bend design will prevent air and water from being drawn into the coils by the water seal formed by condensate that drains to the lower section of the coil in and near the drain header.

Regardless of type or size, all coils must be assembled so that there is a gradual downward pitch toward the drain header of at least 1/8 inch per foot of coil length, and must be supported at intervals of 6 to 8 feet so that the pipes do not sag and form pockets in which condensate can collect. Large coils are very heavy, and their supports must be made of material strong enough to support their weight. The spacing of runs should be uniform and large enough to allow adequate air movement between them. Pipe fittings should be kept to a minimum consistent with good performance. In joining lengths of pipe, the rough inside edges at their ends caused by cutting should be removed, as such obstacles resist steam flow and interfere with the drainage of condensate.

Badly corroded coils develop leaks that seriously affect kiln drying conditions and increase steam costs. All coils should be inspected at frequent intervals, and all leaky coils should be removed and replaced by new pipes of the same diameter. If it be found that the coils are clogged, they should be cleared of the obstructing material. Leaky control or shut-off valves should be immediately repaired or replaced. These can be detected, as a rule, by touching the inactive coils with the hand. If a valve is leaking, the inactive coil will be very warm. Also, a slow steady increase above the desired kiln temperature usually indicates a defective valve in the feed system. It
is a good practice to inspect and clean all coils once a year. Some operators have found that the natural tendency of steam pipes to corrode is resisted by frequently spraying them with a suitable oil or grease.

Balanced Radiation

In a kiln equipped with double-end control — that is, with coils at either end that are operated independently of each other — the radiation should be balanced. If a coil composed of a comparatively large number of pipes is used at one end and one composed of a smaller number of pipes at the other end of the kiln, the temperature differential between the coils will at some time during the drying operation be large and result in nonuniform drying and possibly in severe drying defects. Coils of the same size, when supplied by steam under the same pressure, will produce much the same temperatures if they are performing efficiently. Under certain circumstances, it may be well to trap the coils separately at each end of the kiln.

Steam Pressure

Good design and construction of heating coils are of little avail in maintaining uniform kiln temperatures if steam pressures are not kept constant. The greater the steam pressure, the higher is the temperature of the steam. A coil that is supplying the correct amount of radiation at a steam pressure of 25 pounds per square inch will produce excessive radiation at any pressure above 25 pounds and not enough radiation at any pressure below 25 pounds. A fluctuation in pressure above or below that for which the amount of radiation is adjusted will have a detrimental effect on temperature control.

The use of a good reducing valve in the feed line from the boiler, preferably near the control valves, will assist in maintaining uniform pressures. In order to make sure that the proper pressures are being obtained, however, an accurate pressure gage should be installed between the reducing and control valves. Pressures should be frequently checked, and if variations occur, the reducing valve should be adjusted to the desired pressure. It frequently happens that steam flows such a long distance in large supply lines before it reaches the kiln that its pressure is reduced on the way. With fluctuating steam supply and unusual demands for steam at the kilns, often the available steam does not satisfy requirements. To meet this situation, a 2- or 3-inch high-pressure line can be run to the kilns and the steam from this line discharged into the large low-pressure line when its pressure drops below a desired value.

Traps

Kiln manufacturers and engineers and steam-trap manufacturers should be consulted on trap installations so as to minimize failures in the trapping system.
The following summary of trap troubles will assist the kiln operator in locating and correcting such troubles.

**Trap fails to discharge.**—When a steam trap fails to discharge, the failure may be due to (1) excessive operating pressures, (2) no water coming to trap; (3) plugged bucket vent, (4) trap filled with dirt, (5) worn or defective parts, or (6) excessive back pressures in the return line.

Excessive operating pressures may be caused by the failure of the reducing valve, by the pressure gage reading being too low, by back pressures in the return line from the trap to the boiler caused by too small a discharge line or a plugged discharge line, or by the raising of operating pressures without changing the valve orifice in the trap.

When the condensate fails to reach the trap, the failure may be due to a plugged line to the trap, to a closed valve in the line between the coils and the trap, or to a leaking bypass valve that allows the condensate to bypass the trap.

Dirt in the condensate may plug the bucket vent. This can be prevented by installing a strainer ahead of the trap and cleaning the strainer at frequent intervals. This strainer will also prevent the trap body from being filled with dirt.

Worn or defective parts may cause complete trap failure. Their frequent inspection and proper maintenance will minimize failures and insure better operation.

**Constant water flow from trap.**—Continuous discharge of water from the trap may be due to an excessive flow of water into the trap or to too small a trap. A high-pressure orifice, if used on a low-pressure set-up, will also cause constant water flow. These difficulties can be prevented by installing a trap of the proper size.

**Trap blows live steam.**—When the trap blows live steam, its valve may not be seating or the trap may have lost its prime. Pieces of dirt lodged between the valve and valve seat or a badly worn valve seat will cause improper seating of the discharge valve. When the trap loses its prime, it is usually due to sudden or frequent drops in steam pressure. If this occurs frequently, a good check valve should be installed ahead of the trap and, also, the trap should be located well below the unit being drained.

**Coils fail to heat properly.**—When one trap serves two or more coils, the condensate may short-circuit the trap and flow into the other coil or coils. This condition will cause waterlogging and air-binding and loss in coil efficiency. Furthermore, the trap may lack adequate air-handling capacity for more than one coil, which will also result in loss of coil efficiency. To prevent these faults, all coils should be individually trapped.
Control Instruments

Calibration.—All precision instruments get out of adjustment during normal use, and recording-controlling instruments are no exception. Controlling instruments must be properly calibrated in order to obtain and maintain the desired kiln temperatures. It is recommended that all recording-controlling instruments be calibrated at frequent intervals, at least once a month and preferably once every two weeks.

Double-end control.—Many kilns have coils at each end that each extend half the length of the kiln. These coils are usually operated independently of each other, that is, two controlling dry bulbs are used, one to control the temperature in one half of the kiln length and the other to control it in the other half. This is known as double-end control. If these two dry bulbs are not calibrated to obtain and maintain identical temperatures, longitudinal temperature variations will occur and drying conditions will not be uniform throughout the kiln.

Sensitivity and loose linkage.—Over a period of years, dirt gathers on the movable parts of controlling instruments and causes excessive wear and friction. Eventually, the linkage becomes so badly worn or fouled by dirt that improper control of drying conditions results. This fault can be minimized by frequent inspection of the instruments, and by cleaning or replacing the movable parts as needed. It is recommended, however, that in as far as possible this work be done by the instrument manufacturers.

Humidifying System

Steam Spray

If injected too rapidly or in too large amounts, steam spray will increase beyond the requirements the relative humidity, temperature, ventilation, and heat consumption of a dry kiln. For this reason, steam spray should be fed into the kiln slowly, and the amount be held to the minimum consistent with relative-humidity requirements. In the early stages of drying, especially of green stock, relative-humidity conditions can usually be controlled by venting alone, as the large amount of moisture evaporated from the lumber supplies sufficient vapor to the air.

Wet-bulb Operation

To obtain proper control of relative humidity, the wick covering the wet bulb must be kept saturated at all times. The best way to insure constant saturation is to keep the water level in the wet-bulb water pan constant by means of a float valve or constant water feed. Excess water can be drained from the water pan by an overflow line.

The wick should be kept clean. The impurities contained in the water and the kiln air form a thick deposit on the wick in a short time. The deposit will
affect the rate at which the water evaporates from the wick and result in erroneously high wet-bulb readings. It is recommended that the wet-bulb wick be replaced approximately every 7 days.

The wick should also be kept smooth; rough edges should not extend beyond the bulb. This will prevent localized drying of the wick and will insure better wet-bulb control.

It is extremely important that the wet bulb be located well within the current of circulating air. If the bulb is baffled in any manner or so located that it is not exposed to the air currents, the rate at which the water evaporates from the wick will be decreased with the result that the wet-bulb reading will be too high. The bulb should also be located so that it will not be affected by direct radiation from the heating coils, steam spray lines, or adjacent kiln walls.

When a porous sleeve is used to cover the wet bulb, a film of water must cover the entire bulb at all times. The sleeve must also be kept clean. The wet-bulb pen readings of the recording-controlling instrument should be checked frequently by other acceptable means, such as thermometers, thermocouples and the like, so that errors in wet-bulb control can be eliminated. If the instrument is unreliable, it should be repaired or replaced.

 Venting System

 Vent Size and Location

The ventilators in a dry kiln should be large enough to expel the water evaporated from the lumber to the outside atmosphere as rapidly as necessary to maintain the desired relative-humidity conditions. If this is not done, the relative-humidity conditions may be higher than required and the drying time will be prolonged. Furthermore, the vents should be uniformly distributed along the length of the kiln so as to reduce excessive heat demands in any one zone.

 Vent Operation

Ventilators can be manually or automatically controlled. When manual control is employed, kiln conditions must be checked at frequent intervals and the vents opened or closed whenever necessary in order to maintain the desired relative-humidity conditions. Sometimes it is possible to get good control of these conditions during certain periods of drying by adjusting the vent openings so as to attain the proper amount of venting at all times.

Automatic air-operated ventilators are being increasingly used for the control of relative-humidity conditions within a kiln. Briefly, such a ventilator consists of a linkage system that is connected to the ventilator covers and to an air-operated control valve. The air supply to this valve is controlled by the wet bulb. Whenever the humidity conditions become too high, the vents open, and when the humidity reaches the condition desired, they close.
relative humidity within the kiln can be controlled by operation of the vents only. The ventilator control should be designed for a slight time lag, so that the vents open shortly after the steam-spray valve closes, and close shortly before the steam-spray valve opens. The linkage system is adjustable, so that the amount of vent opening can be increased or decreased as necessary. The operation of an automatic ventilator system should be checked at frequent intervals to make sure that the linkage is not binding nor the air-supply line leaking. If these conditions occur, vent operation is affected and the desired relative-humidity conditions will not be obtained.

Air-Circulation System

Uniform air circulation must be assured to obtain uniform drying. Furthermore, maximum utilization of the circulating air will decrease the drying time. All baffles should, therefore, be properly located and maintained, and the lumber should be properly piled to minimize short-circuiting of the air flow.

Void Space in the Kiln

To obtain uniform air movement, three-fourths of the total cross section of the kiln above the rail should be free of lumber. This void space, of course, includes the sticker openings between the courses of lumber. If the void space is too small, air movement will be impeded, with consequent loss of drying time.

Space Between Kiln Walls and Loads

In a natural-circulation kiln, the difference in weight between the air at the top and that at the bottom of the kiln is not great enough to generate ample air movement unless the openings provided for the air movement are relatively large.

Kilns of the natural-circulation or internal-fan type should have an open space of 24 to 30 inches between the walls and the loads. A narrow opening, especially with a large air delivery, will develop an unequal flow of air across the lumber piles, and stock of varying moisture content will be produced under such conditions. All air passages must be kept clear of obstructions.

Air Scoops, Portholes, and Dampers

In kilns of the blower type, air delivery throughout the length of the kiln should be as uniform as possible. Therefore, air scoops should be properly adjusted, and air portholes properly located to insure uniform delivery. Dampers must also be regulated in all air ducts so as to obtain uniform air flow in all parts of the kiln.
Piling Practices

In as far as possible, large voids between the loads in an end-piled kiln should be avoided, as the circulating air will short-circuit through these voids, thereby prolonging the drying time. The sides of all loads of lumber should be straight, without ragged edges, so as to minimize the deflection of the circulating air as it travels up or down the side of the load.

To facilitate air circulation in a natural-circulation kiln, vertical flues at least 3 to 4 inches wide for every 12 to 14 inches of board width, must be provided. These flues must not have ragged edges and must be kept in vertical alinement in order not to deflect the falling air and thereby contribute to uneven drying of the charge.

Fans

Damaged fans will materially effect drying conditions and drying time. Fans can be easily damaged by falling lumber. They also corrode rapidly. All fans should be inspected at frequent intervals and be kept painted to retard corrosion; and their bearings should be oiled when required to lower repair costs. Any badly damaged fan should be repaired or replaced promptly.

Other Factors

Cracks in Kiln Walls and Ceilings, and Leaky Doors

Cracks in the kiln walls and ceilings and leaky doors will allow the escape of hot air from and the infiltration of cold air into the kiln. This exchange of air may result in the serious disruption of drying conditions, thereby prolonging the drying time and resulting in nonuniform moisture content of the lumber. Furthermore, heat consumption will be increased. The kiln walls, ceiling, and doors should be inspected frequently. Any cracks found should be sealed, and badly fitting or damaged doors be repaired or replaced as soon as possible.

Water Seepage

Water seeping into the kiln will result in high relative humidity conditions and prolongation of the drying time. The seepage of water into a kiln, therefore, should not be permitted. A sump pump will prevent this seepage into kilns, and it should be used whenever this trouble is present.