

EQUALIZING AND CONDITIONING, THE RIGHT MOISTURE CONTENT FOR THE PRODUCTS

Charles J. Kozlik
Kozlik-VanDeventer, Inc.
Portland, OR

The definitions for equalizing and conditioning from the Dry Kiln Operator's Manual (5) are as follows: **Equalization**-bringing the pieces of lumber in a kiln charge to a nearly uniform moisture content. **Conditioning**-a controlled high temperature-high relative humidity condition used in a dry kiln after the final stage of drying to bring about a uniform moisture distribution in the boards and to relieve drying stresses. These terms are used interchangeably throughout the industry but each treatment has a specific effect on the final quality of the lumber.

EQUALIZING

This procedure is to bring the final moisture content (MC) to the desired level among and within the boards in the kiln. The final desired MC varies with the final use of the product. If the lumber is dimension or framing grade, the MC must not exceed 19% and/or 15% depending on which MC the mill is marketing the lumber. Softwood grades of Selects, Finish, Shop and Moulding must be dried so at least 85% of items must not exceed 12% MC and no portion may exceed 15% MC. Hardwood lumber used for moulding, paneling, furniture, flooring or interior finish is dried to an MC not exceeding 8 percent. Specialty stock of softwoods and hardwoods is kiln dried to a MC agreed upon by the manufacturer and purchaser.

The dry bulb temperature (DBT) and wet bulb depression (WBD) in the final step of a kiln schedule is generally 160° to 190°F DBT with a WBD of at least 30°F. which gives a 5.8% and 5.5% EMC, respectively. This condition for EMC is too low for proper equalization of all grades of softwood lumber and a little high for hardwood lumber.

The Dry Kiln Operator's Manual (5) outlines an equalization procedure using kiln sample boards when drying to a final desired average MC of 8 percent. Since kiln samples generally are not used in our western mills, equalization of lumber to a final average MC from 6% to 12% MC follows a different procedure.

A general procedure used in the western mills is to set the EMC at 3 percentage points lower than the final desired MC when the final DBT may be 160° to 190°F. The total time to equalize depends upon species, average MC of lumber prior to equalizing, difference of MC from shell to core, thickness, and the acceptable spread between the high and low final MC's.

We know pine equalizes faster than Douglas-fir, 4/4 equalizes quicker than 8/4, and a larger spread in the final MC requires less time to equalize than a minimum spread.

The average MC before equalizing and the difference of the MC from shell to core has an impact on equalizing. The desired average MC can cause problems. For instance, 12% final MC could have boards ranging from 5% to 19% or an 6% final MC could have boards ranging from 3% to 9% MC creating a longer equalizing time than a narrower Mc spread prior to equalizing. The difference of the MC from shell to core using MC's cited above can compound the problem of time for proper equalization. Any boards at an average of 19% MC to be equalized to a final 12% MC could have a shell MC of 7% and a core MC of 31 percent. A final MC of 6%

with boards having a 9% average MC could have a shell MC of 3% and a core MC of 15 percent. This average MC and MC difference from shell to core is generally caused by using a "hot" kiln schedule (a 45° to 50°F WBD prior to equalization. A "hot" kiln schedule may be used on many species without causing additional degrade. This schedule used to dry hem-fir, sugar pine, cottonwood, oak or any species infected with bacteria will produce a range of MC's, as shown in Figure 1, that could double the equalization time and may still have boards which are not within the acceptable final MC range. Any species containing wood of greater average specific gravity is slower in drying, Figure 2, and will require a longer equalization time.

Since I have outlined some of the items making the equalizing cycle a difficult task, we will return to the procedure of using an EMC of 3 percentage points lower than the final desired MC. We will assume the final DBT is 180°F. and the target MC will be 6% or 12 percent. When drying to a 6% MC, the WBD should be set at 50° to 52°F. A 6% final MC will generally have a WBD at 50°F prior to the equalization, so this setting should be maintained to obtain the final desired average 6% MC. When drying to a 12% MC, the WBD should be set at 15°F or a 9% EMC. The WBD will be greater than the prescribed 15°F prior to equalizing, since the WBD at the end of the drying cycle was 30°F or greater. The 15°F WBD will cause a rise in the DBT with the injection of steam spray. The kiln operator can let this rising DBT prevail and depending on steam pressure of the spray line, tightness of the dry kiln, etc., the kiln settings will be eventually achieved. Preventing a rising DBT can be accomplished by shutting off the heat and spray and opening the doors and vents with the fans on to cool the lumber and kiln. This generally takes about 4 hours and the kiln is restarted and the desired DBT and WBD will be maintained. This situation occurs during conditioning.

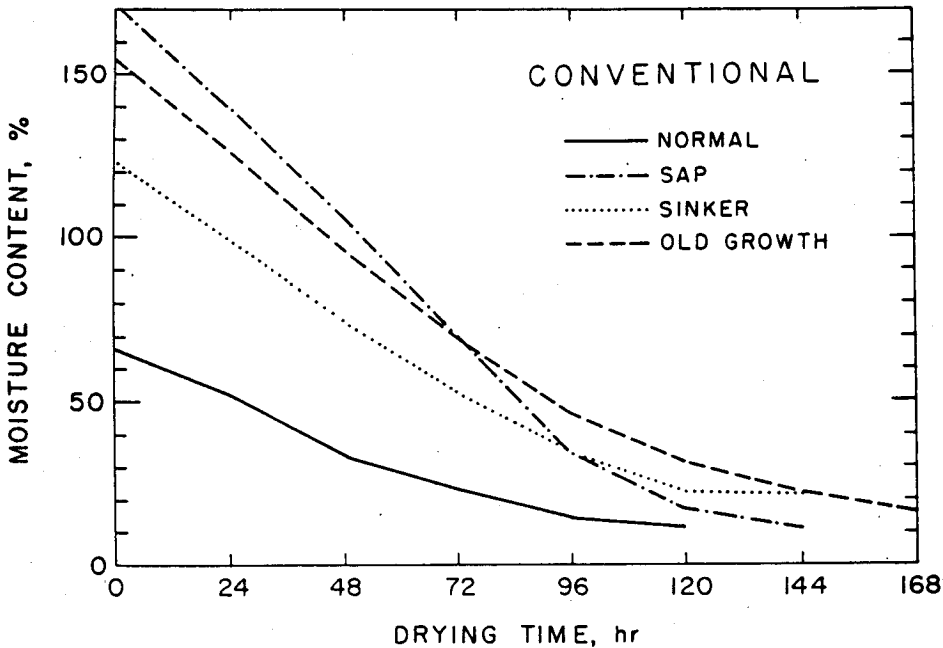


Figure 1. Change of moisture content for four board types of 2 by 6-inch western hemlock lumber kiln dried with conventional temperature schedule.

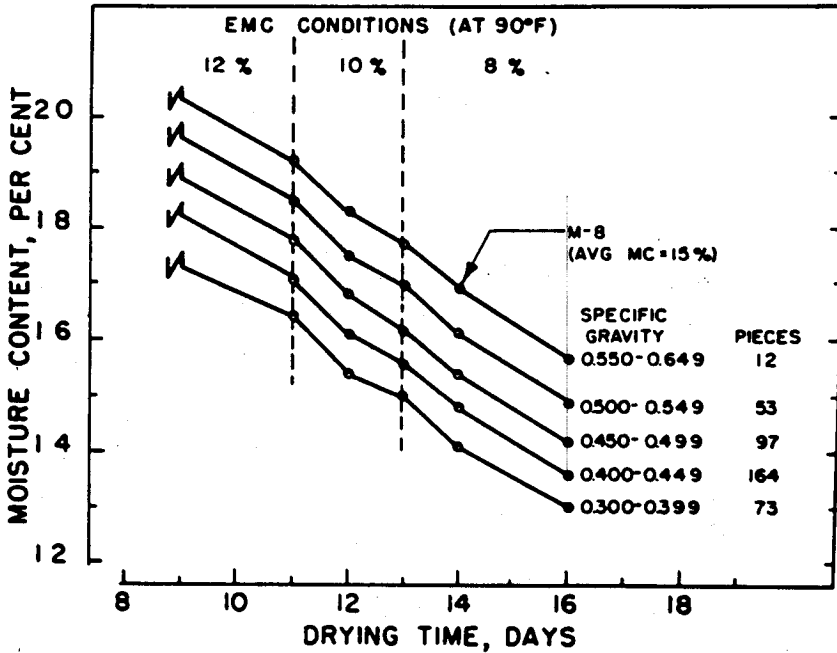


Figure 2. Drying rate of 2 by 8-inch Douglas-fir of different specific gravity ranges.

The equalization cycle should be held until the desired average final MC and acceptable range of low and high MC's is achieved, Figure 3.

The flatter or lesser moisture gradient from shell to core reduces the time for conditioning and is more effective for stress relief. A good target for the moisture gradient from shell to core is 5 or less percentage points.

CONDITIONING

Conditioning of lumber is not required by the grading rules but must be utilized for any stock going for remanufacturing. If complete stress relief is not achieved, the lumber being remanufactured will crook during ripping and cup during resawing.

Two items should be cited before explaining the method of conditioning. First, if the steam pressure to the dry kiln exceeds 15 psi, the steam spray system should be fitted with a desuper-heater. High pressure steam, especially 30 psi or greater, will cause the DBT to rise by 5°F or more and remain near this level throughout the conditioning cycle. This does not allow the kiln to be controlled as desired. The installation of a pressure reducing valve on the steam spray line will not resolve the problem. Secondly, lumber can not be conditioned when the final average MC is greater than 12 percent. Some kilns which are poorly maintained can not condition lumber even at a final MC of 9 percent. Nearly all dry kilns, new or well maintained, can not hold an EMC of 15% or higher, at the end of the drying cycle.

This final stage of the kiln schedule requires raising the WBD at least 3 percentage points higher than your final desired final average MC. Using the same example in the equalizing cycle, we assume the DBT is 180°F and the final average Mc's are 6% or 12 percent. Conditioning to a final average MC of 6% would have

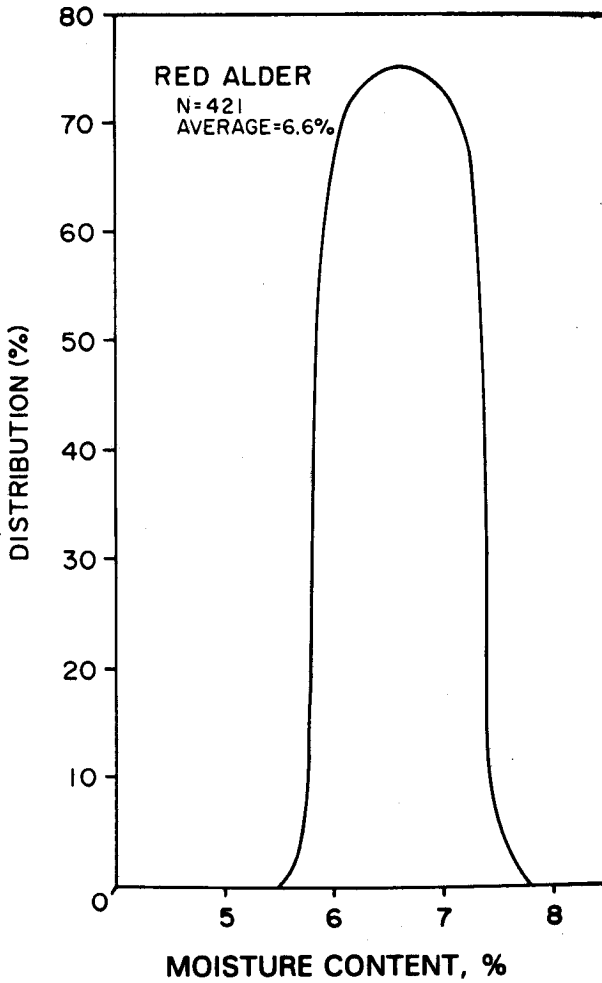


Figure 3. Equalizing 4/4 red alder lumber to a final average moisture content of percent, ± 1 percent.

a WBD of 15°F and at a final average of 12% MC, the WBD would be set 5°F. WBD for conditioning). Factors affecting conditioning are species, thickness, difference of MC from shell to core or a flat moisture gradient, and ability of the dry kiln to maintain the prescribed DBT and WBD.

Pine lumber will condition faster than oak or Douglas-fir and 4/4 lumber can be conditioned faster than 6/4 lumber. A flat moisture gradient from shell to core to less than 5 percentage points of MC will condition faster than lumber having shell to core MC difference of 7 or more percentage points. This moisture gradient influence on conditioning was studied by Espenas and Kozlik (2). A "rule of thumb" for time to condition is 6 hours for each 1/2-inch of thickness, but this is affected by species, moisture gradient and ability of the kiln to control prescribed DBT and WBD. Conditioning time can be drastically reduced by using the highest DBT or 212°F and highest relative humidity or 100 percent, Table 1. This has been known for many years since the installation of high temperature kilns and research by Harry Tiemann and others during the era of World War I. Recent research by Haslett and Simpson (3) showed conditioning at 212°F DBT at or near saturation will relieve casehardening in 25 mm or about one inch thick Pinus radiata in one hour depending on final MC and cooling time prior to conditioning.

Table 1. Effect of time, dry bulb temperature, and EMC for complete stress relief (conditioning) for 4/4 vertical grain western hemlock when dried to a final average moisture content of 8 percent.

Charge Number	Conditioning Time (hrs)	Dry Bulb Temp. (°F)	EMC (%)	Stress Relief
2	13	165	11	Excellent
4	10	190	13	Excellent
5	4	190	18	Excellent
6	4	190	13	Fair
9	5	200	13	Fair
10	7	200	13	Good
11	4	200	17	Excellent
13	2	210	14	Good
15	2	210	18	Excellent

A steaming chamber erected in the mid 1960's at the old Brooks-Scanlon mill in Bend, OR could thoroughly condition 4/4 pine in 3 to 4 hours depending on cooling time and average moisture content. The chamber had several steam spray lines on each side and no fans.

Many kiln operations strive for a quick conditioning cycle by using the highest DBT and minimum WBD, so time varies for each kiln charge. The use of the aforementioned situation or use of prescribed DBT and WBD for conditioning will cause the DBT to rise above the desired setting. Several methods to correct an override of the DBT are given below (assuming the steam supply to the kilns is 15 psi or a desuperheater is installed):

1. The DBT and WBD are set for the desired EMC and the kiln continues to operate, including the time of a higher undesirable DBT, for a given number of hours to complete the conditioning cycle. This method requires the most kiln residence time.
2. The heating coils and steam spray are shut off, the vents and doors are opened and the fans are turned on. This cooling period varies at different operations from 2 to 8 hours and dependent on temperature of outside air, tightness of the kiln, and a well maintained kiln. Some operations remove the lumber from the kiln and cool for one to 4 hours before recharging the kiln. NOTE: Lumber at temperatures of 140°F and higher can be damaged by discharging the lumber into the outside air which is 40°F or less. The damage in form of surface and/or internal checks is caused by thermal contraction.
3. The lumber is left in the kiln with the heat, spray, and fans turned off and doors and vents closed for 8 to 12 hours. The steam spray and fans are turned on for 2 to 8 hours for 4/4 to 6/4 thicknesses.

The only method to determine if total stress relief is achieved is cutting samples for the prong test which is detailed in the Dry Kiln Operator's Manual (5) and other manuals on kiln operation.

The wide spread in final average MC of dimension lumber, Figures 4 and 5, can be reduced by setting a 8.5% to 10% EMC condition in the kiln for at least 12 hours prior to discharging the kiln. As cited above, the DBT will increase and preventive measures, such as cooling the lumber, low pressure steam supply to the spray line, etc., will decrease the time to obtain the desired spread in the final average MC. Many mills simply shut off the heat and steam spray and leave the doors and vents closed with the fans off for 12 or more hours. Also, this final treatment reduces the moisture gradient from shell to core and adds moisture to the other shell for better machining.

THE FINAL MC TO FIT IN-SERVICE CONDITIONS FOR WOOD

Some examples are given to illustrate whether the final average MC meets in-service conditions. This has an effect on the customer satisfaction of the wood product that has been purchased.

A study by Hopkins (4) showed the range of average MC's for rafters, studs, and bottom plates on a concrete slab floor in Baton Rouge, LA over a 26 month period. The rafters ranged from 8% to 12% MC, studs from 8% to 10% MC, and the bottom plates from 9% to 13% MC. Other reports on measuring of MC showed house siding in the Southwest to the Great Basin will dry 4% to 6%, especially during the summer months. Studs in the Willamette Valley will range from about 14% (near bottom plate) to 6% (near top plate) during a year's cycle.

Burrill Lumber Company in White City, OR has been marketing studs for over 35 years. Mr. Mike Burrill, President, (1) stated the maximum final MC is 10% to 12% for the studs. This MC is on target for in-service conditions, as stated in the previous paragraph.

The sounding boards for pianos delivered in the Phoenix and Tucson, AZ area developed splits and checking within 6 months of delivery. The measured MC averaged less than 3% and the sounding boards at time of shipment were guaranteed to be 6% MC.

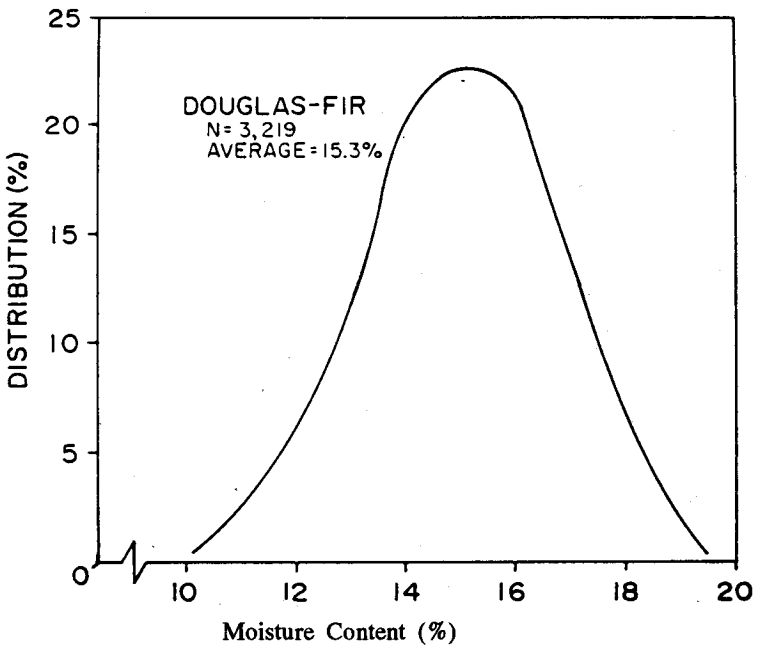


Figure 4. Final moisture content distribution for 2 by 6-inch Douglas-fir dimension lumber kiln-dried to a maximum 19% moisture content. Moisture content measurement taken with a resistance moisture meter with one inch long electrodes.

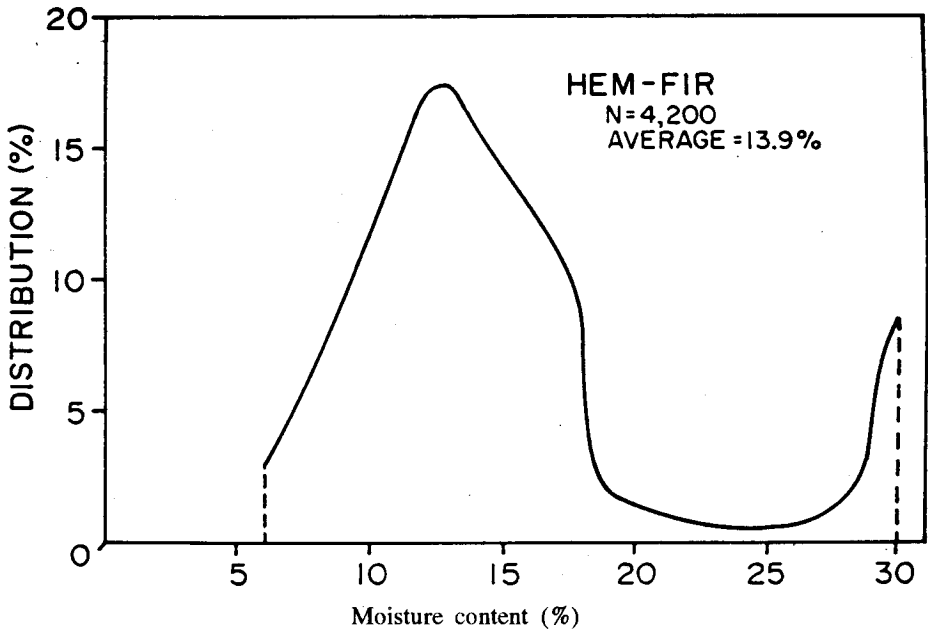


Figure 5. Final moisture content distribution for 2 by 6-inch western hemlock dimension lumber kiln dried to a maximum 19% moisture content. Moisture content measurement taken with a resistance moisture meter with one inch long electrodes.

Many of the carvings or novelties from the tropic zone are free of checking prior to purchase or shipment. After arrival in the U.S., the carvings will begin to check. The EMC in the tropic zone will range from 15% to 19% EMC. The EMC in most homes in the U.S. is 10% or lower.

An average MC specification of 3.5-inch clear Douglas-fir squares shipped to Holland, Belgium and Germany was not to exceed 16 percent. A minimum dimension or size was specified. The stock was containerized for shipment but after arrival in Europe, the stock was removed from the container and shipped to moulding plants in the 3 countries and stored in a heated area for about 6 months prior to remanufacturing. A claim was filed that the stack was undersized and below the specified 16% MC. The stock averaged about 11% MC. This situation occurred with about 4 shipments containing 20,000 BFM until the U.S. producers kiln dried the stock to a maximum of 12% MC; no more claims were filed.

In conclusion, wood in lumber form is highly desired and is becoming a high cost commodity. The highest quality in the lumber product, dimension to clear, must be maintained during processing. This requires modern and well maintained equipment and most importantly, persons who are dedicated to the quality of the final product. The kiln operator must have good knowledge of how wood dries with minimum degrade, and operation and maintenance of kiln equipment. His responsibility in making decisions regarding the conditioning lumber for cut stock to prevent crook and cup in remanufacturing is just one example of adding quality to the product.

REFERENCES

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