The Use of Elevated Temperatures for Seasoning Western Softwoods.

Most lumbermen strive to get the best possible seasoning production consistant with good seasoning quality. This has always been the goal, in early days as well as in present day air and kiln drying. However, efforts to speed up the drying of lumber have been so limited in nature that progress along this line has been slow.

One early break in seasoning rate was seen in the application of high temperatures in an atmosphere of superheated steam with no air present. This method was difficult to control within the capacities of lumber to dry with good quality. It was not until more recent applications of high temperatures improved the control of the relative humidity within the chamber by limiting wet bulb temperatures below 212 degrees that a practical application appeared to be in sight.* This more recent research in the field of high temperature drying appears to have such good possibilities that the Western Pine Lab has been studying this application on some of the woods of the Western Pine Region. However, since special equipment is required for this method to be used successfully, temperatures close to the limit of conventional kiln equipment were also tested for comparison. Our interest was to determine how above average temperatures affect the drying of these species as to drying time, moisture content pattern and drying quality. In so far as practical, matched samples were tested for three major drying conditions:

1. conventional schedules (the control)
2. elevated temperatures (limit of conventional kilns)
3. high temperatures (temperatures above boiling point in air vapor mixtures)

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* Report to 8th Annual Western Dry Kiln Clubs Berkeley, California, May 1956 by F. W. Guernsey, Canadian Forest Products Laboratory, Vancouver B. C.

Equipment

A special laboratory kiln designed for high temperature drying was constructed at the Western Pine Laboratory. It is metal lined, has adequate heat and humidity capacity as well as ample air circulation. The kiln holds up to 120 board feet of lumber. The drying charge rests upon a scales built into the kiln so that the weight can be checked at any time in order to follow the drying progress. A remote reading moisture meter is installed as a cross check of the moisture content by weight method.

Test Procedure

Matched boards were cross cut into three pieces from 16 foot lumber in order to make close comparisons of the different conditions applied. Each piece was cut on the inside freshly cut end for green oven moisture samples. From these sample data the oven dry weight of the charge was calculated. Thus, at any time the current moisture content of the charge was known as based upon the current weight of the charge. ~~Although the ends of the boards were not sealed no significant end check was observed in any of the drying tests.~~

The boards were again cut back for moisture content oven samples at the end of the drying period. Observations of drying quality included season checking, knot quality, moisture content (average, range and gradient) color and warp. The aim in test procedure was to change one factor only from test to test--mainly the factor of temperature level. The levels of Equilibrium Moisture Content were kept as nearly alike as practical from run to run in each series. But since no method of determining the exact moisture content is infalliable the levels of final moisture content average were approximate. The species tested were Douglas Fir, Larch, White Fir and Engelmann Spruce

Results

Douglas Fir and Larch are species that tolerate high temperatures very well for the most part. This was found to be especially true of the Dimension grades and the Selects. The black knots in the Common grades gave us some trouble as to looseness with high temperatures but it is very possible that a closer control of final moisture content may have given us more positive evidence of that factor. No increase in season checking was noted at equal E.M.C. conditions. Although moisture content gradients increase in relation to drying rate they can be reduced by conditioning at the end of the drying period if need be. Of course, the extra time required to do this reduces the savings in drying time achieved by the use of higher temperatures ~~and~~ if a shorter drying time is a main ~~objection~~ objective of the process.

The tests on Douglas Fir and Larch were aimed primarily at the Larch because it has so slow a transfusion rate that it lags far behind the Douglas Fir when dried as a mixture of the two species--a common practice. It was found possible to even up the final moisture content between individual pieces of these two species with the use of a generous conditioning treatment. This was applied at near saturation in order to prevent the Fir dried with the Larch from becoming too dry. This was found to be the only way that sinker type boards included in the charge could be brought down reasonably near the moisture content of other Larch pieces. A better practice would be to sort the sinker separately where end use moisture content ~~are~~ is critical.

The gain in drying time by the use of higher temperatures is considerable. Although a low temperature control was not used in this first series we know that the drying times of the Larch dried at 210 degrees are only about 60% the time of conventional schedules. High temperature of 230 degrees required about 40%. The only difference in quality that was noticable was an increased darkening of the wood as temperatures rise.

White Fir drying tests were made on 4 x 6 and 3 x 6 Unit Decking sizes with the purpose of determining how these thicker items would respond to the application of high temperatures. The results in this item were almost a parallel to the Douglas Fir and Larch. The difference in knot damage due to the three levels of drying were not significant. Warp appeared to also be independent of temperature. The problem of warp in both the Fir and Larch and the White Fir appeared to be related to final moisture content and grain structure within each piece rather than temperature. The same was true of season checking because close examination of the matched samples of each run showed that certain types of dense textured pieces were prone to season checking under all conditions. Actual loss due to checking was minor because this type of grade allows considerable check on the back of the piece. The check allowable did not cause degrade in the pieces dried in the tests. In all cases there was considerable moisture content variation between pieces and between the shell and core moisture contents of each piece.

From a practical standpoint fast drying of Unit Decking has an advantage not first apparent. The deep zone of tension set on the outside of these thick pieces creates a condition where the strength of this dry zone is high. Subsequent drying does not change the dimension of these pieces much, either in the dry kiln later during the run or later on outside of the kiln in storage. There was a tendency toward slight collapse. This happened in the dry kiln at high temperature levels but also was observed at conventionally dried temperatues starting at low levels and working up to intermediate ones. This latter condition was observed to develop in storage where moisture gradients were excessively high It did no harm to the grade of the pieces . Shrinkage across a 6 inch face of a 4 x 6 was not over 1/32 inch after several months storage even with those pecies which had centers above the fiber saturation point at the start of the storage period. Color was deeper as temperatures were raised.

Drying time dropped from 240 hours to a 12% final moisture content level at conventional temperatures to 204 hours at constant 200 degrees to a low of 117 hours at a schedule starting at 220 degrees and rising to a final of 235 degrees.

Engelmann Spruce in 4/4 common and select grades were also studied at three temperature levels. It is normal practice among kiln operators to use low temperatures for this species for drying the 4/4 commons in order to "hold the knots". A top temperature of 140 degrees was used in the low zone. The intermediate temperature was 190 degrees and the high temperature was 230 degrees. The same type of savings in time was to be seen in applying high temperatures to this species as in the preceding ones. The half and half 4/4 common grade took 47 hours to dry starting with an initial moisture content of 120 ~~hours~~ per cent down to 13 per cent. Only 30 hours were required at a constant 190 degrees while 26 hours were required when temperatures up to 235 degrees were applied. No season checking was noted at ~~any~~ any level but color was darker as temperatures rose. Warp was also more severe at high temperatures.

Although knot damage was high at all levels of temperature range it appeared to be highest at the top levels. This trend would seem to ~~be in line with~~ indicate that there may be some basis for the reluctance of most kiln operators to use any but the lower temperature ranges for Engelmann Spruce common grades. Further testing is indicated to get more positive data on this particular factor.

Conclusions

The temperature level studies made by the Western Pine Laboratory so far, point out the definite value of above normal temperatures to many non-staining species of our region. Drying time is enough faster than conventional schedules to make their application well worth considering. It is not necessary to use temperatures above the boiling point of water to benefit by this method. Woods of naturally slow transfusion rates can be dried faster by simply utilizing the higher temperature levels possible in most conventional dry kilns. When safe E.M.C's are applied the drying quality has been shown to be good.

The need for good sorting was shown to be important to the success of all three temperature levels studied. Without it, ~~the~~ safe drying still ~~lags to~~ depends upon the speed of the slowest item. True sinker type pieces still dried much more slowly than the balance of the charge regardless of temperature. However, a generous conditioning period was very beneficial in evening up the moisture content of those boards.

It would be desirable to study further the effect of high temperatures on Engelmann Spruce. Certainly there was no question of the increase in drying rate as temperatures rise. There appeared to be no problem of season check with this species. Color deepened as higher temperatures were used and some increase in warping seemed to accompany high temperatures. The major problem with the common grades of this species was the loosening of encased black knots and checking of the intergrown knots at all temperature levels. Although knot damage increased at higher temperature levels with both classes of knots the final moisture content level of this item is so critical that further testing would be needed to give positive proof of the damaging factor .

The main purpose of the drying studies was achieved. Above average temperatures do safely speed up the kiln drying rate of most of the non-staining species. Their use is a logical way to induce a more rapid transfusion rate in these hard to dry types.

No study of the economics of high temperatures was made. This is difficult to do with the size of load and drying chamber used in the tests.

A trial of this elevated temperature is warranted at plants which have kilns that will withstand their use.

Engelmann Spruce Kiln Drying Tests

	Drying Time - Hours (10 – 70): schedule (°F) / E.M.C.	Total Time	Final M.C.	Drying Quality: Season check	Warp	Color	Knots: black	Knots: red	General
Low Temp 1x8 Half & Half Commons	125/110 E.M.C. 9.1%; 130/115 9.7; 140/115 6.9	47 hours	to 13%	Slight	Slight	Bright	Mod. loose Mod. holes	Mod. check	Good
Elevated Below 212° Commons	190/175 8.9; 190/165 6.4	30 hours	to 13%	Slight	Slight	Bright	Many loose Many holes	Mod.	Good
High Above 212° Commons	220/205 8.3; 225/205 6.6	26 hours	to 13%	None	Severe	Darker	Most loose Most holes	Severe	Fair
Normal Temperature Selects	145/130 9.5; 150/130 8.0; 155/130 6.9; 165/130 5.0	73 hours	to 9%	None	Mod	Bright	Least damage	Mod.	Good
Elevated Temperature Selects	190/177 9.6; 190/172 7.9; 190/167 6.8; 190/160 5.5	45 hours	to 9%	Slight	Mod	Bright	Mod. damage	Mod	Good
High Temperature Selects	220/208 9.5; 225/210 [illegible]; 230/205 5.5	41 hours	to 9%	Slight collapse Slight check	Severe	Darker	Most damage	Severe	Fair

Douglas Fir & Larch Drying Tests

Test Conditions	20 40 60 80 100 120 140	Total time	Final M.C.	Drying Quality: Season Check	Warp	Color	Knots: black	Knots: red	Gen.
Elev. Temp. Hi-Med. E.M.C. 4/4 Com. Fir & Larch	Constant 210° 10.0% 7.1%	72 hours	Ave 9.1% Range 6.4–19.1 Ave Fir – 6.8 Larch – 9.1	Very Slight	Mod.	Slightly Darker	Many Loose	No Degrade	Poor Too Dry
Elevated Hi-Low EMC 4/4 Com. Fir & Larch	Constant 210° 10% 4.2	53 hours	Ave 11.5 Range 8–20 Fir – 8 Larch – 13	Mod. to Severe	Mod.	"	Mostly Loose	"	Fair Too Dry
Elevated Hi-E.M.C. Fir & Larch Dim	Constant 210° - - - - - → 200° EMC 10.0% 8.7 10.0 17.7 (12 hrs)	139 hours	Ave 16.3 Range 12–24 Fir – 13 Larch – 19	Very Slight	Severe	"	No Degrade	"	Good
Elevated Hi-E.M.C. Larch Dim	Constant 210° 8.7 17.7 12 hrs	115 hours	Ave 18.0 Range 12–24 1 sinker 32%	Slight	Slight	Darker	"	"	Good
Elevated Dropping EMC Fir & Larch Dim.	Constant 210° 10.0 8.7 17.7% EMC (3 hrs)	76 hours	Ave 16.7 Range 7–16 1 sinker 36%	Mod.	Mod.	Bright	"	"	Fair
High Temp. High E.M.C. Larch Dim.	Constant 230 210/208 6.3 17.7% EMC (1 hr)	53 hours	Ave 16.8 Range 12–19 1 sinker 39	Very Slight	Very Slight	Darkest	"	"	Very Good

White Fir Unit Decking Kiln Tests

	Drying Time–Hours (24, 48, 72, 96, 120, 144, 168, 192, 216)	Total time	Final M.C.	Drying Quality: Season check	Warp	Color	Knots: black	Knots: red	General
4X6 Rising Temp. Lowering E.M.C.	150° in steps to Final of 190° EMC 11.8% to 4.4%	240 hours	AVE 12 Range 7-16 Shell 6-9 Core 7-24	Slight	Slight	Bright	No Degrade	No Degrade	
Elevated T. Lowering E.M.C.	200° Constant 10.8 to 5.4%	223 hours	AVE 12 Range 9-22 Shell 6-12 Core 11-34	Mod	Slight	Darker	No	No	
High Temp Lowering E.M.C.	220 225 235 8.3 to 4.3	117 hours	AVE 12 Range 8-21 Shell 6-11 Core 8-40	Mod.	Slight	Much Darker	No	No	
3X6 Rising Temp. Lowering E.M.C.	150° in steps to 200° 11.8 to 4.3	168 hours	AVE 14 Range 8-19 Shell 8-18 Core 10-28	Mod.	Mod.	Bright	No	No	
Elevated T. High to Med. E.M.C.	200° Constant 11.8 to 7.2	196 hours	AVE 10 Range 9-12 Shell 7-10 Core 9-15	Mod	Mod	Darker	No	No	
Medium Temp High to Med E.M.C.	170° Constant 11.8 to 7.2	199 hours	AVE 15 Range 11-23 Shell 10-19 Core 13-34	Mod.	Mod	Much Darker	No	No	