CURING 75% OF SPF LUMBER DEGRADE BY INITIAL MC SORTING OF DRY LUMBER

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Introduction

I suspect that many decades before scientists and engineers interested themselves in the subject of lumber drying, conscientious kiln operators made up kiln loads of lumber from logs of common species and provenance to obtain uniform drying characteristics. With small mills fed from relatively small geographic areas this was practical to arrange, and the mill operator would have the direct and immediate feedback from his drying operation to help him learn what worked and did not.

In the Pacific Northwest, as economics and competition led to the present large integrated mills drawing enormous quantities of logs of mixed species from a wide area, the detailed logistics required make such a pragmatic approach impractical. The causes of wide moisture distributions for various species have been studied and are still being investigated to gain a better understanding of the drying arrangements, such as kiln schedules, to reduce the resultant degrade.

This effort falls within the broader theme of what is now called "Six Sigma", the use of statistical tools and scientific methods to manage variation in processes to ensure we cost effectively meet our customers' expectations. The tools are applied to determine the root cause of variation and the most cost effective way to reduce it to acceptable levels. The core issue for the forest products industry is that our primary feed stock, timber, has high natural levels of variability in key parameters affecting its processing, e.g., moisture content.

In the 1970's and 1980's, M. Salamon experimented with sorting green softwood lumber by weight (Western Hemlock and mixed spruce/pine/fir (SPF)) to reduce drying degrade, an early recorded attempt to improve the uniformity of the moisture content of softwood lumber kiln loads. In 1986, the first online moisture content sorting system was successfully demonstrated on the green chain at a softwood dimension mill in Williams Lake, British Columbia. An infrared sensor that detected the temperature rise as the lumber passed under a bar heater was tied into the mill's existing sorting system.

Today, initial moisture content sorting on the green chain before kilning is becoming best practice among manufacturers of dimension lumber and added value products. It has been shown that if the moisture variation in the kiln charge is controlled the economic gain is $10 to $19 per thousand board feet for SPF lumber, due to reduced drying degrade. However, we need more accurate, reliable and cost effective technologies to measure lumber moisture content (M.C.) on line. We cannot yet sort accurately enough to adequately control the drying characteristics of the kiln charge. Alternatives, such as re-drying western red cedar, are not cost effective.

However, with all the different methods and procedures being evaluated, the preferred choice is the simplest and least costly solution to the actual quality problems experienced at the mill. This paper presents an example of one such case, where an expensive sensor had been installed to sort green lumber into several moisture content ranges and it was discovered later that the same benefits could be achieved using a less complex tool.

Investigation of Final Moisture Content Distribution

The mill where this work was performed had monitored the variation in oven dry (OD) M.C. of its green lumber over a period of 3 years as part of an ongoing program to improve drying quality. Because of the wide variation in M.C. that was found, it was decided to install an advanced M.C. sensor and sort the green lumber into several M.C. ranges. This was found to be an effective but relatively expensive strategy, with considerable difficulty in determining the best sorting strategy.

Concerns with the cost and maintenance of the existing M.C. sensor, uncertainty about the effectiveness of the current sorting method and a desire to shorten drying schedules led to a study of the final moisture content distribution after the planer. This information was available from an on-line capacitive M.C. sensor and the mill provided data from four shifts. At the time the green line M.C. sorting system was down for maintenance. The results are summarized below:

Shift Distribution	1st, 1999/ 11/30 Figure 1	2nd, 1999/ 11/30 Figure 2	1st, 1999/ 12/01 Figure 3	2nd, 1999/ 12/01 Figure 4
# boards	19061	30906	27521	32997
Passed (< 20% M.C.)	95%	97%	95%	97%
Over dried (< 11%M.C.)	25%	24%	24%	32%
Average M.C.	13.2%	12.9%	13.3%	12.4%
Standard Deviation	3.7%	3.3%	3.6%	3.5%

Clearly, the dry kiln was providing consistent results during the four shifts sampled, and less than 5% of the production was over the 19% maximum M.C. standard – an acceptable level for the mill. However 24 to 32% of the output was drier than 11%, this over-drying appeared to be a cause of degrade and it represented a significant loss of energy. With a standard deviation about 3.5%, shortening the drying cycle would not help, as the number of "wets" would increase unacceptably. Additional equalizing during drying would increase drying times and costs and reduce mill output.

It was decided to conduct an investigation to try to understand the root causes of the wide range of final moisture content, confirm its impact on degrade, and identify possible corrective actions.

Green vs. Final M.C. Investigation Procedure

Specimens of 2x4 and 16' long 2x6 lumber were selected at random from the green chain, marked for identification and graded.

%MC	Pieces	%PCS	Average-per-Board Histogram
<	62	0.3	
6	227	1.1	
7	557	2.9	
8	1045	5.4	
9	1380	7.2	
10	1569	8.2	
11	1712	8.9	
12	1900	9.9	
13	1847	9.6	
14	1822	9.5	
15	1813	9.5	
16	1537	8.0	
17	1157	6.0	
18	808	4.2	
19	499	2.6	
20	347	1.8	
21	232	1.2	
22	171	0.8	
23	163	0.8	
24	124	0.6	
25	80	0.4	
26	9	0.0	
>	0	0.0	

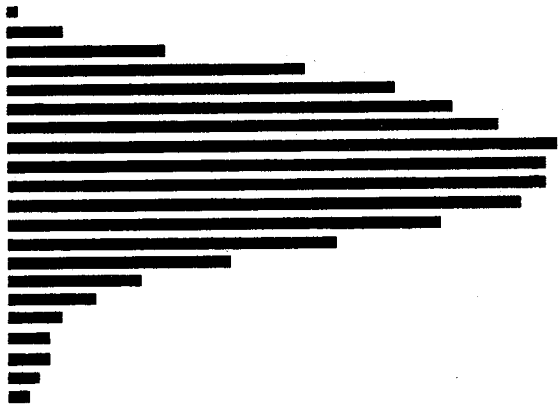

FIGURE 1. Moisture content distribution for 1st shift, 11/30/99.

%MC	Pieces	%PCS	Average-per-Board I Histogram
<	54	0.1	
6	222	0.7	
7	709	2.2	
8	1517	4.9	
9	2362	7.6	
10	2531	8.1	
11	3009	9.7	
12	3435	11.1	
13	4095	13.2	
14	3835	12.4	
15	3149	10.1	
16	2203	7.1	
17	1390	4.4	
18	817	2.6	
19	460	1.4	
21	250	0.8	
22	183	0.5	
23	164	0.5	
24	125	0.4	
25	80	0.2	
26	16	0.0	
>	0	0.0	

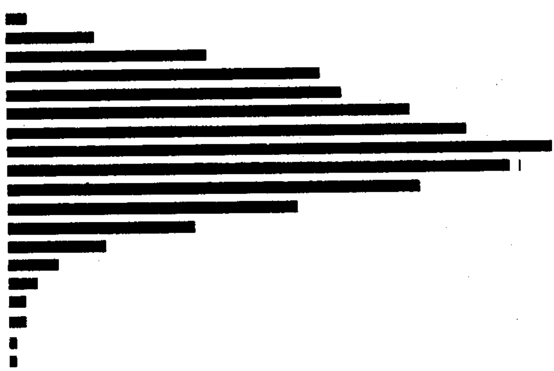

FIGURE 2. Moisture content distribution for 2nd shift, 11/30/99.

%MC	Pieces	%PCS
<	57	0.2
6	382	1.3
7	893	3.2
8	1413	5.1
9	1876	6.8
10	1881	6.8
11	2041	7.4
12	2617	9.5
13	3154	11.4
14	3155	11.4
15	2917	10.5
16	2331	8.4
17	1594	5.7
18	999	3.6
19	680	2.4
20	488	1.7
21	337	1.2
22	276	1.0
23	215	0.7
24	160	0.5
25	55	0.1
26	0	0.0
>	0	0.0

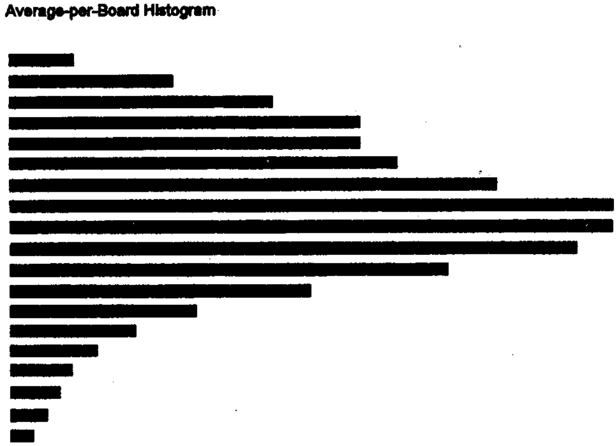

FIGURE 3. Moisture content distribution for 1st shift, 12/01/99.

%MC	Pieces	%PCS
<	34	0.1
6	331	1.0
7	1126	3.4
8	2348	7.1
9	3325	10.0
10	3444	10.4
11	3584	10.8
12	3798	11.5
13	3510	10.6
14	3051	9.2
15	2462	7.4
16	1876	5.6
17	1366	4.1
18	858	2.6
19	567	1.7
20	385	1.1
21	233	0.7
22	245	0.7
23	181	0.5
24	141	0.4
25	116	0.3
26	13	0.0
>	3	0.0

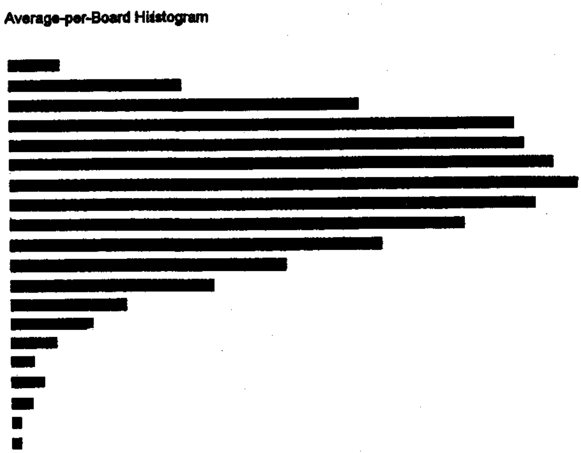

FIGURE 4. Moisture content distribution for 2nd shift, 12/01/99.

Samples were cut from each specimen for OD M.C. measurements

The specimens were placed in the kiln charge and dried.

The specimens were retrieved and graded after drying.

Additional OD M.C. samples were taken from each specimen.

Green vs. Final M.C. Findings

The measurements of lumber grade before and after drying are shown in Figures 5 [2x6], and 6 [2x4]. Moderate but significant degrade due to drying is evident, and it was confirmed that the degraded pieces were from the dry tail of the distribution.

The OD M.C. distributions before and after drying are shown in Figures 7 [2x6] and 8 [2x4]. The final M.C. distributions show much less over drying. For these samples, the final M.C. distributions were wetter and broader than we had found in the earlier planer (final) capacitive M.C. sensor readings. The average M.C. of both the 2x6 and 2x4 specimens are beyond the 20% limit, the standard deviations are 10% and 6% respectively. More than half of the "dry" lumber is above 20% M.C.!

I speculate that this difference between the capacitive and oven dry distributions may be the result of bias in the capacitive M.C. sensor readings due to residual M.C. gradients in the dry lumber. On the other hand, these relatively small samples taken at a different time may have come from a significantly different timber population than the earlier samples. Unfortunately, the available time and resources did not permit an investigation of this discrepancy.

In any case, the green lumber M.C. distributions showed why the final M.C. results are poor. Although the average green M.C. is only 44%, the standard deviations are 18% & 27% for the 2x6 and 2x4 specimens respectively. Notably, a significant proportion of the green lumber is dry enough, or near to it, to ship without further drying.

Both distributions are bimodal, that is, there are two peaks to the M.C. distribution, indicating that we might be dealing with two populations with different drying characteristics. (This can also be detected in the dry M.C. distributions.)

Species M.C. Dependence

We decided to investigate whether this M.C. distribution related to the species of the lumber. Samples were taken from randomly selected green lumber and oven dried after the species was determined by microscopic examination.

Figures 9 and 10 show the green lumber M.C. distributions for the SPF species (White Spruce, Lodgepole Pine and Alpine Fir) for samples collected in the winter and summer respectively. These confirm that the wide bimodal distribution is due to the Alpine Fir being significantly wetter than the other two species.

Figure 9 shows the distributions for all three species, showing that the spruce and pine do have very similar M.C. distributions skewed to the dry end with a peak around 40% M.C.. The fir is wetter with a symmetrical distribution about a mean/mode around 65% M.C..

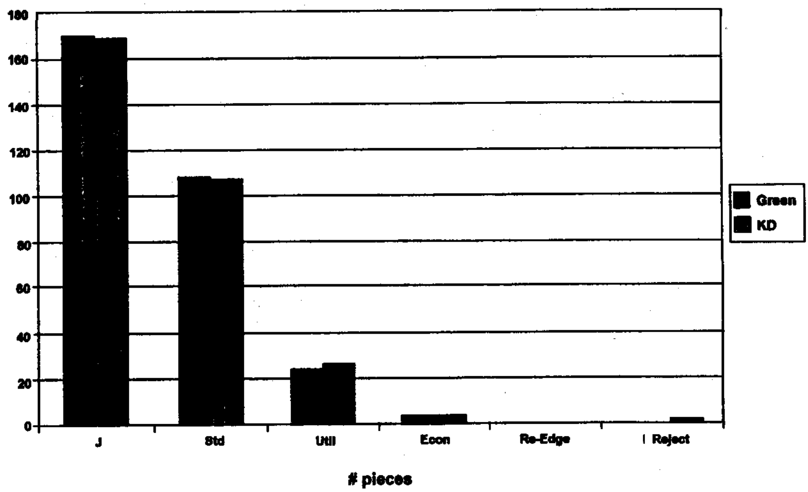

FIGURE 5. Grade of SPF 2 x 6 - 16' before and after drying.

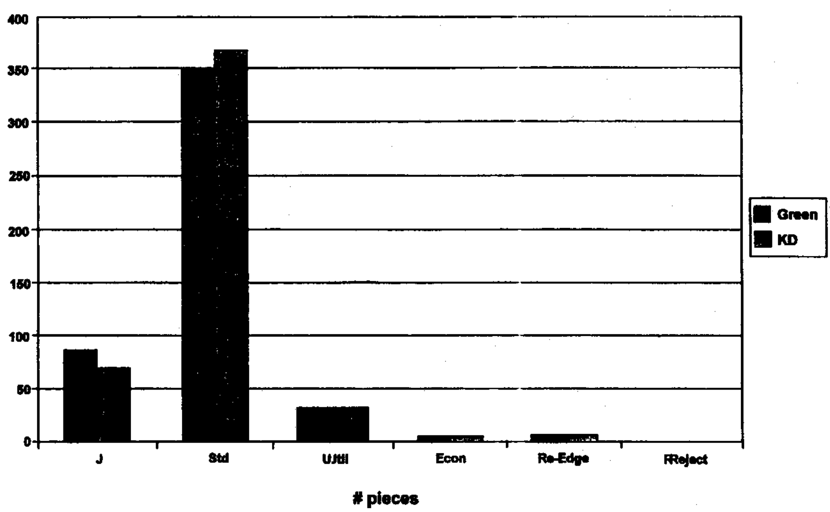

FIGURE 6. Grade of SPF 2 x 4, 16' before and after drying.

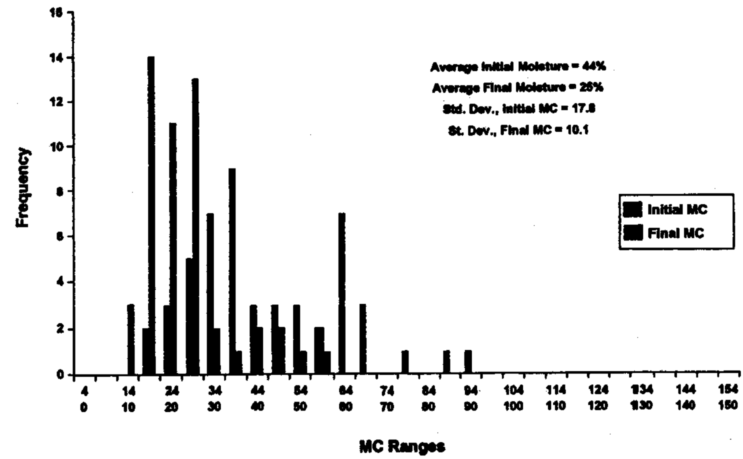

FIGURE 7. Initial and final moisture content distributions for 2 x 6.

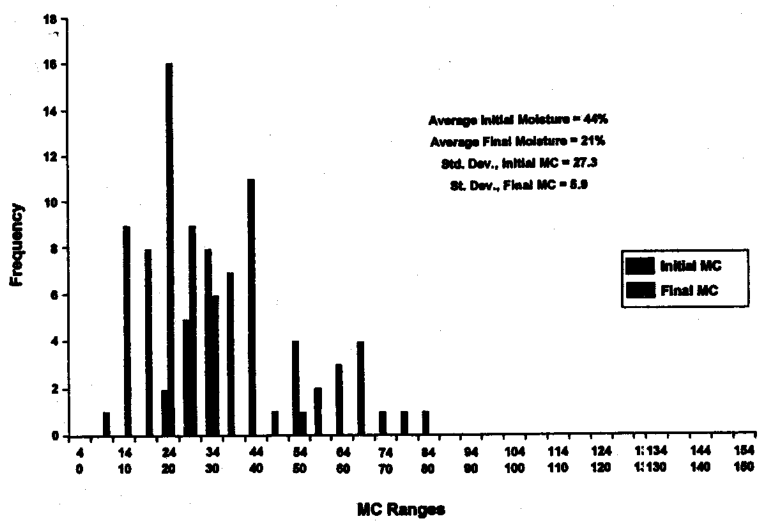

FIGURE 8. Initial and final moisture content distributions for 2 x 4.

Figure 10 emphasizes this finding, lumping the spruce & pine together. The two distinct populations the mill is processing are clear, and it is not surprising that it is difficult to dry them together, even with sorting into tighter M.C. classes.

Conclusions and Recommendations

Drying degrade at this mill is primarily due to over drying of White Spruce and Lodgepole Pine lumber that is already dry or close to it when it goes into the kiln. A low cost capacitive M.C. sensor, the same as the mill used at the planer, could readily sort out this dry lumber and prevent 75% of the drying degrade. The mill has followed this recommendation with the expected improvements, at significantly lower acquisition and maintenance cost than the previous green lumber M.C. sorting system.

Keeping already dry "green" lumber out of the kiln will not allow faster drying times, the present drying schedule is not giving a tight enough final OD M.C. distribution to meet market demand for improved quality. It is recommended that the mill segregate its fir lumber from the spruce and pine when drying, and develop appropriate schedules for each population. This species sort is expected to be more effective than sorting by green M.C., other than extracting the "drys" as recommended above, and should allow shorter drying times for the pine and spruce kiln charges.

The mill is considering its options. No technique is available to sort out the Alpine Fir on the green chain. Segregating logs by species and then sawing the Alpine Fir separately will complicate mill operations and increase manufacturing costs.

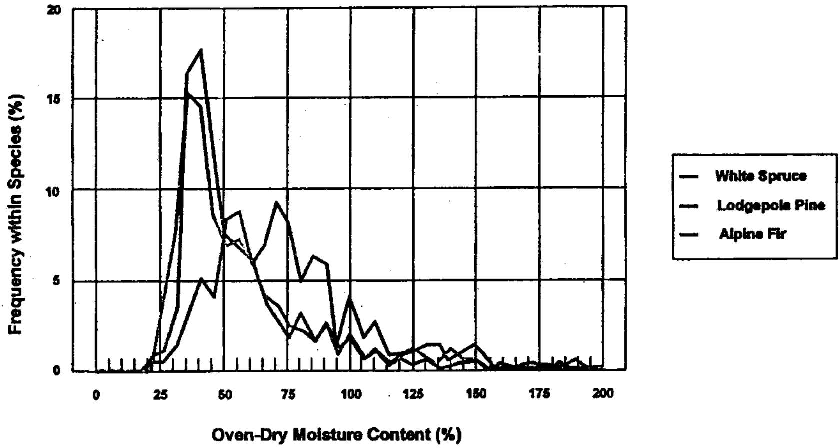

FIGURE 9. Green lumber moisture content distributions for lumber sampled in winter.

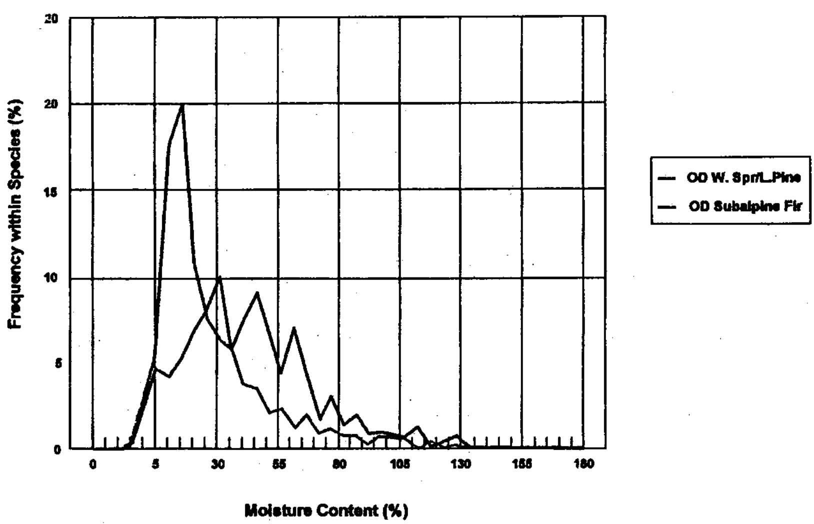

FIGURE 10. Green lumber moisture content distributions for lumber sampled in summer.