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Kiln Drying of 5/4 Alpine Fir Lumber

by

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Prepared for

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Summary

A study was carried out to evaluate the drying of 5/4 inch (32 mm) alpine fir (*Abies lasiocarpa* (Hook.) Nutt.) lumber. This work was part of a joint Canadian Forest Products Ltd. (Canfor) – Forintek Canada Corp. project sponsored by B.C. Forestry Innovation Investment to investigate opportunities to extract maximum value from the B.C. alpine fir wood resource.

Drying sub-alpine fir freshly green can be quite challenging. On one hand, the wide distribution of the initial moisture content makes it difficult to estimate a significant average value to guide the initial drying conditions. On the other hand, it is necessary to ensure that enough heat reaches the lumber otherwise wet pocket areas will not dry and therefore create quality issues at the end of the drying process or during normal service conditions.

Lumber used for the drying study came from three alpine fir trees, one dominant, one co-dominant and one intermediate, from a Canfor logging site in the Fort St. James, B.C. harvest region. Eight foot long logs from these trees were cut into 5/4 inch lumber on the Forintek Canada Corp. Wood Mizer horizontal band saw and edged into 4, 6 and 8 inch widths at the Canfor pilot plant. The approximately 1000 fbm (2.4 m^3) lumber was dried in a single kiln charge of the Forintek 8-foot kiln using a moderate drying schedule designed to maximize grade recovery.

The alpine fir lumber used for the study had mean green moisture content of 58.5%, with maximum and minimum individual board moisture contents ranging between 130.1% and 38.1%. This wide moisture content distribution is characteristic of alpine fir. All 200 boards were graded before and after drying by the same licensed Canfor grader. Estimated degrade loss due to drying was approximately US$189 per Mfbm. The estimated degrade loss is significantly high. The results obtained in this study should be interpreted as ***preliminary results*** because of the following:

- sample size not large enough to allow definitive conclusions regarding grade recovery,
- insufficient lumber to carry out additional drying runs which should be used to validate and/or refine the proposed drying schedule, and
- appropriateness of grading the lumber before planing since it would be expected that perhaps a significant portion of the observed warp could be removed during this operation, or some uses such as laminating stock could tolerate a degree of warp.

For these reasons the amount and value of lumber degrade observed in this short study may considerably over-estimate the amount and value of degrade that would occur in commercial practice. Additional drying studies involving a larger sample size and an industrial phase to validate the findings obtained during the laboratory study are recommended.

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1 Objective

The objective of the "Kiln Drying" study phase of the project "Extracting Greater Value from the B.C. Alpine Fir Wood Resource" was to kiln dry and estimate drying degrade of 5/4 inch thick rough green lumber from B.C. interior alpine fir.

2 Introduction

Drying sub-alpine fir freshly green can be quite challenging. On one hand, the wide distribution of the initial moisture content makes it difficult to estimate a significant average value to guide the initial drying conditions. On the other hand, it is necessary to ensure that enough heat reaches the lumber otherwise wet pocket areas will not dry and therefore create quality issues at the end of the drying process or during normal service conditions. Previous Forintek and Canfor drying studies of alpine fir have concentrated on nominal 2 inch thick dimension lumber [1-3]. Nevertheless, the basic challenges of drying alpine fir in the thinner 5/4 inch thickness would be expected to be much the same.

3 Materials and Methods

3.1 Materials

Lumber used for the drying study came from three alpine fir (*Abies lasiocarpa*, (Hook.) Nutt.) trees, one dominant, one co-dominant and one intermediate, from a Canfor logging site in the Fort St. James, B.C. harvest region. Canfor foresters assigned these growth classifications based on the trees' growth positions in the forest canopy. Eight foot long logs from these trees were cut into 5/4 inch (32 mm) lumber on the Forintek Canada Corp. Wood Mizer horizontal band saw and edged into 4, 6 and 8 inch widths at the Canfor pilot plant.

3.2 Drying Schedule

The approximately 1000 fbm (2.4 m^3) of 5/4 inch lumber manufactured from the three alpine fir trees was dried in a single kiln charge using the Forintek 8-foot kiln. The schedule illustrated in Figure 1 was designed to allow the lumber to heat slowly and at high relative humidity to prevent rapid surface moisture evaporation during the early stages of the drying process. After the heat up period, the kiln temperature is increased over the course of 40 hours to a maximum value of 180 ºF. The lowest equilibrium moisture content that the lumber is exposed to at the end of the drying schedule is about 8.1%. Under the conditions illustrated in Figure 1, the drying schedule used in the study can be considered moderate, that is, it was designed to attempt to maximize grade recovery.

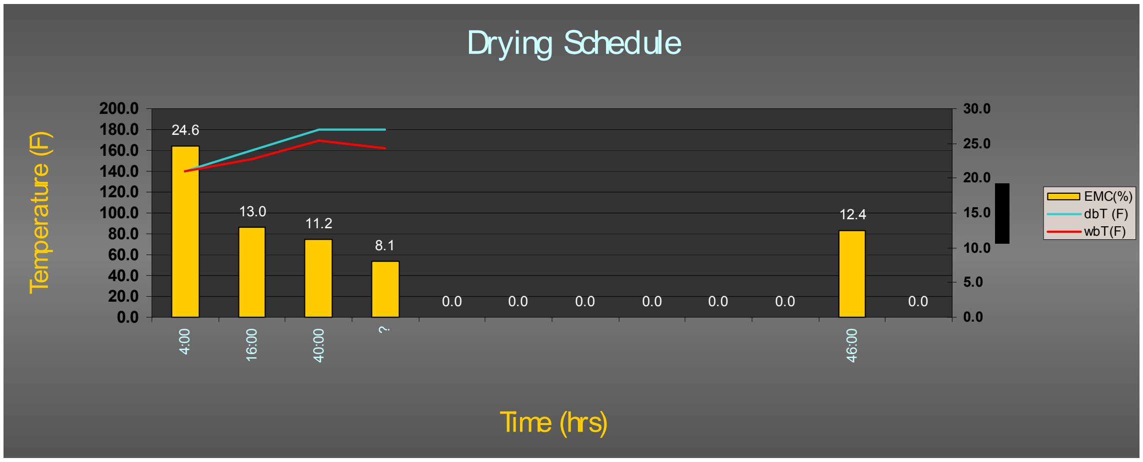

Figure 1: Drying schedule used (sub-alpine fir 8 ft long and 1.25" thick by random width)

4 Results

4.1 Initial Moisture Content Distribution

Sub-alpine fir is particularly known throughout the industry in British Columbia for its wide moisture content distribution. In fact, the large variation of initial moisture content is normally associated with over and under-drying observed in most industrial situations. In some cases, to alleviate the problem caused by the wide distribution of moisture content, some companies carry out one to two months of air-drying in order to reduce the initial moisture content before kiln drying. Figure 2 illustrates the initial moisture content distribution for the lumber used in the study.

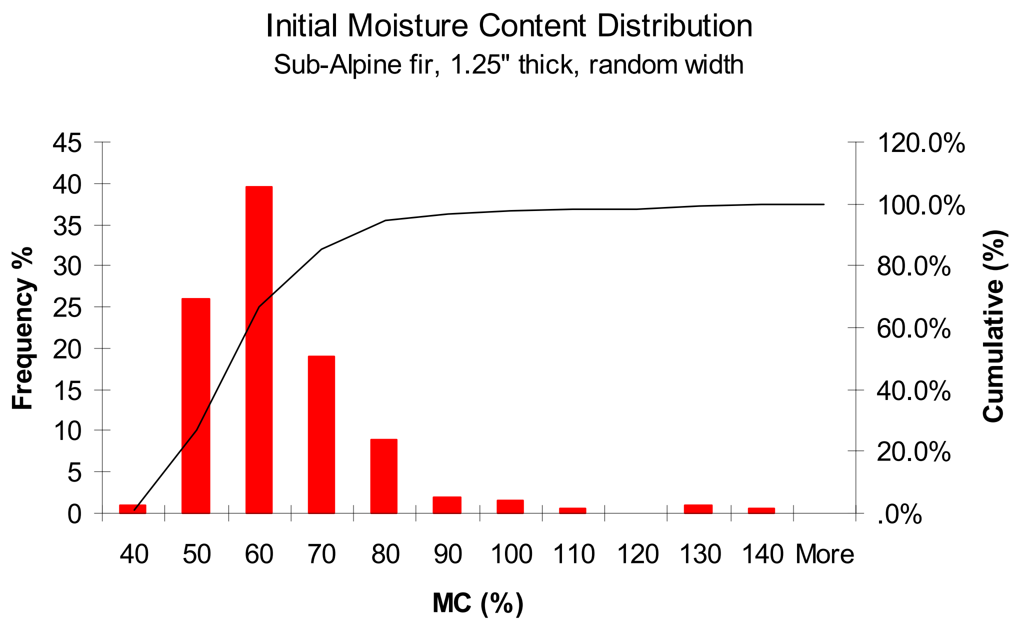

Figure 2: Initial moisture content distribution (206 specimens)

The table below illustrates the main parameters for the distribution:

Parameter	%
Average MC	58.5
Standard deviation	14.0
Minimum MC	38.1
Maximum MC	130.1
Median MC	55.6

MC = moisture content.

4.2 Initial Lumber Grade Distribution

All 200 specimens were graded before and after drying by same grader (Canfor designated licensed grader). The initial distribution of grades was as follows:

Grade	# of specimens	Percentage	Value US $
# 1	105	52.5	419.00
# 2	47	23.5	98.12
# 3	10	5.0	15.38
# 4	38	19.0	37.77
		Total	**570.27**

4.3 Final Moisture Content Distribution

At the end of the drying period, the following results were obtained:

Parameter	%
Average MC	10.7
Standard deviation	1.8
Minimum MC	8.2
Maximum MC	26.2
Median MC	10.4

The distribution of final moisture content is shown in Figure 3.

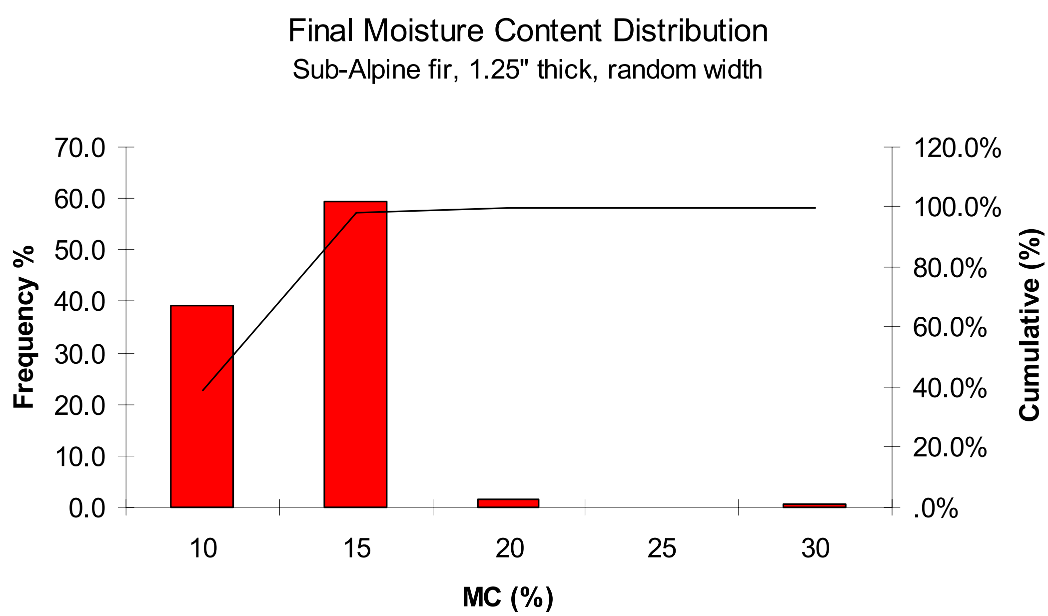

Figure 3: Final moisture content distribution

4.4 Drying Curve

Figure 4 illustrates the average drying curve for the load (all 206 specimens).

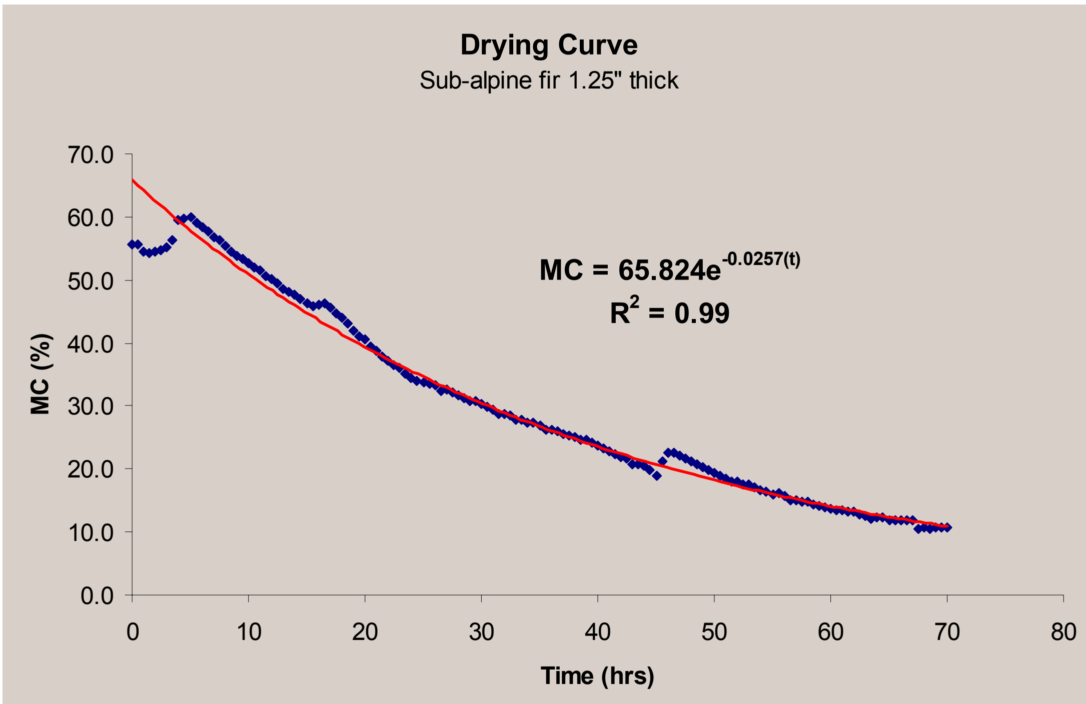

Figure 4: Drying curve

The average drying rate (dr) for the curve above can be given by:

dr = -0.0257 (MC)

where:

dr = drying rate in % of moisture removed per hour
MC = moisture content in %

The graph for the drying rates throughout the drying process is illustrated in Figure 5.

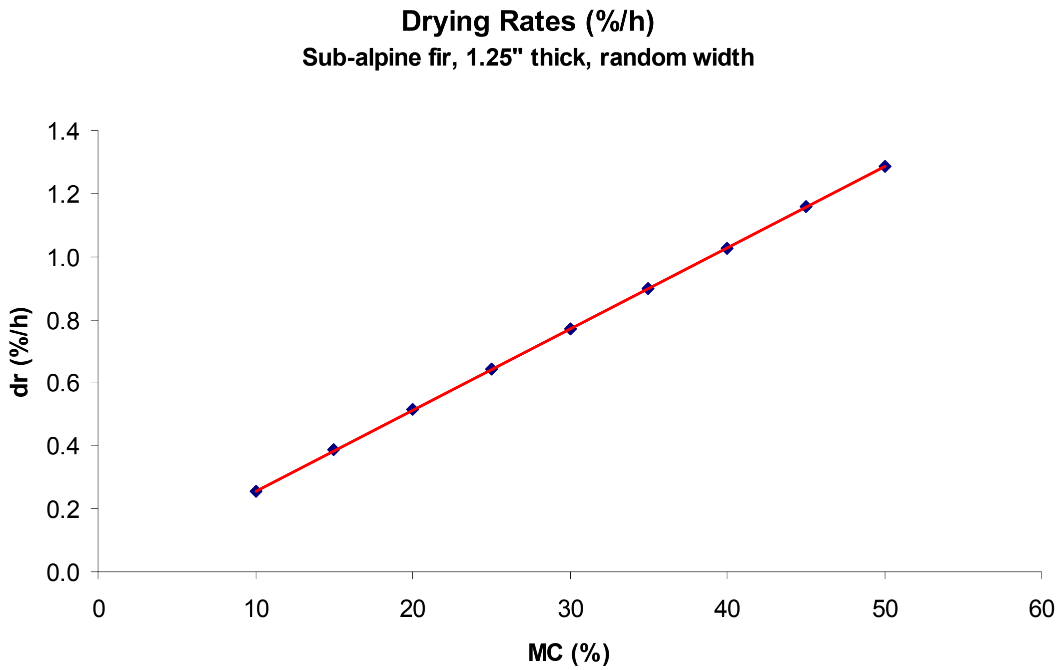

Figure 5: Drying Rates

As shown in Figure 5, the maximum drying rate was about 1.3%/h in the early stages of the process. The drying rate decreased linearly (approximation) with moisture content. The drying rates illustrated above are in general lower than the drying rates usually obtained for 2" thick sub-alpine fir dimension lumber and therefore indicate the relative moderate characteristic of the drying schedule that was used in the experiment. Assuming an average of about 0.77%/h, it is estimated that it would take about 46 hours to dry from an initial moisture content of 50% to final value of 15% (using the drying schedule illustrated in Figure 1).

4.5 Degrade Loss

The grade distribution after drying was as follows:

Grade	# of specimens	Percentage	Value US $
# 1	35	17.5	126.33
# 2	39	19.5	77.67
# 3	62	31.0	103.18
# 4	64	32.0	68.68
		Total	**375.86**

The total degrade loss due to drying was:

Total package value before drying (US $)	Total package value after drying (US $)	Difference (loss) US $
570. 27	375.86	194.40

Considering the nominal volume of lumber (1.028 Mfbm) used in the study, the degrade loss due to drying is approximately 194.40/1.028 ~ 189 US $/Mfbm.

The estimated degrade loss is significantly high and illustrates the problems associated with the production of high value products from the resource utilized in the study. It should be pointed out that:

1) The lumber was graded in the "rough" form. It is believed that warp can be significantly reduced after planing and therefore the loss due to drying degrade can be substantially reduced.

2) The final average moisture content (10.7%) was lower than the target value of 12% and therefore the lumber was over-dried which in turn contributes for the development of warp. However, it must be emphasized that it is too difficult to dry unsorted sub-alpine fir and reach the target moisture content within a reasonable drying time without either over-drying or under-drying. Thus, it is highly recommended, especially for the type of product used in this study, to carry out some green sorting prior to drying. In order to achieve the target moisture content of 12%, it may be necessary to dry at lower temperatures and for longer drying periods.

3) No weight restraint was used during the experiments. It is believed that to achieve higher grade recovery, that is, to reduce degrade due to drying substantially, weight restraint will need to be used throughout the drying runs and possibly during the cooling down period after drying. Industry experience has shown that top or weight restraints of about 60 lb/ft^2 can be quite effective for warp reduction.

5 Discussion

The results obtained in this study should be interpreted as ***preliminary results*** because of the following:

a) sample size not large enough to allow definitive conclusions regarding grade recovery,
b) insufficient lumber to carry out additional drying runs which should be used to validate and/or refine the proposed drying schedule, and
c) appropriateness of grading the lumber before planing since it would be expected that perhaps a significant portion of the observed warp could be removed during this operation.

One proposed use for the 5/4 inch alpine fir lumber is laminating stock for value-added lumber products. Small amounts of warp would be tolerated and removed by the laminating process. For the reasons discussed here, the amount and value of lumber degrade observed in this short study may considerably over-estimate the amount and value of degrade encountered in commercial practice.

6 Recommendations

It is recommended to carry out additional work involving larger sample size and include an industrial phase to validate the findings obtained during the laboratory study.

7 References

1. Casilla, R.C. 1997. Drying strategy for alpine fir lumber (*Abies lasiocarpa)*. Canadian Forest Products Ltd., Research and Development Centre, Vancouver, B.C.

2. Oliveira, L.C. 1995. Drying rates of SPF lumber. Forintek Canada Corp. Project 1212K039 Report.

3. Oliveira, L.C. 1996. Comparing drying rates of SPF lumber. Forintek Canada Corp. Project 1212K039 Report.