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Time-Based Kiln Drying Schedule for Sugar Maple for Structural Uses

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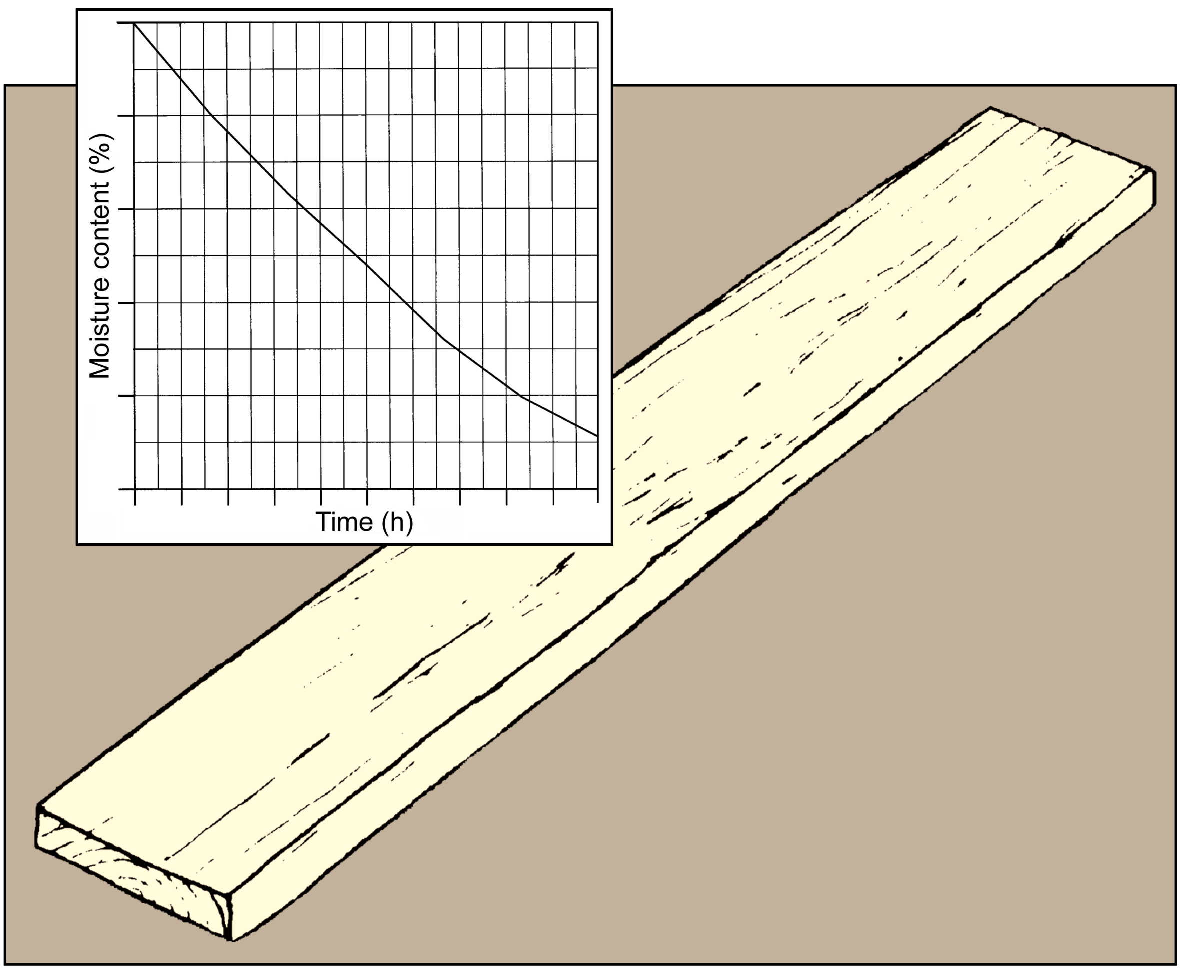

Abstract

This report describes the conversion of a moisture-content-based kiln schedule to a time-based schedule for drying nominal 2- by 6-in. (standard 38- by 140-mm) sugar maple lumber for structural use. The recommended schedule requires 115 h of drying time followed by a 15-h equalizing period.

Keywords: kiln schedule, sugar maple

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Time-Based Schedule for Kiln Drying Sugar Maple for Structural Uses

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Introduction

A previous study (Simpson and others 1998) showed that maple could be kiln dried successfully for structural uses by a schedule that was accelerated in comparison with the traditional maple schedule intended for products where appearance is important, such as furniture. In addition to being unnecessarily conservative and slow for lumber intended for structural uses, the traditional maple schedule is controlled on the basis of moisture content. Changes in kiln conditions are made when the lumber reaches certain levels of moisture content; this requires some method of estimating moisture content during the kiln run. Because of the less exacting quality requirements of structural lumber compared to appearance-grade lumber, traditional kiln schedules for softwood structural lumber are usually based on time; that is, changes in kiln conditions are made at predetermined time intervals rather than at predetermined moisture content levels. Thus, periodic estimates of moisture content during the kiln run are not necessary, and time-based schedules are therefore more efficient than are schedules based on moisture content.

The primary objective of the study reported here was to convert the moisture-content-based kiln schedule developed in the previous study (Simpson and others 1998) to a schedule based on time. A secondary objective was to examine the effectiveness of several equalizing periods on moisture content variability.

Material and Methods

Nominal 2- by 6-in. (standard 38- by 140-mm), 8-ft- (2.4-m-) long sugar maple lumber was obtained from the Upper Peninsula of Michigan. Enough boards were obtained for three kiln runs of 84 boards each. The moisture-content-based kiln schedule developed in the previous study (Simpson and others 1998) and the time-based schedule used in the study reported here are shown in Table 1. The time-based schedule was developed from the relationship between moisture content and time found in the previous study; this relationship is shown in Figure 1, along with notations for the time-based schedule. Air velocity ranged from 500 to 600 ft/min (2.54 to 3.03 m/s), with fan reversal every 6 h.

The kiln schedule was followed by three different equalizing periods (12, 24, and 48 h) at 180°F (82°C) dry-bulb and 170°F (77°C) wet-bulb temperatures. Moisture content variability was determined gravimetrically. Each board was weighed three times: in the green condition, after drying, and after oven drying at 220°F (104°C) for long enough to reach a constant weight.

Results

Lumber green moisture content levels and their frequency distributions for the three kiln runs are shown in Figure 2. Moisture content after drying is summarized in Figure 3, histograms of final moisture content distributions for the three kiln runs, which had different equalizing periods. Runs 1 and 2 each had one outlying data point; that is, a final moisture content value that was very different from other values. These outliers (2% and 41% moisture content) were eliminated from the analysis.

Table 1—Moisture-content- and time-based kiln schedules for nominal 2- by 6-in. (standard 38- by 140-mm) sugar maple lumber intended for structural use

Moisture content (%)	Time (h)	Dry-bulb temperature (°F)	Dry-bulb temperature (°C)	Wet-bulb temperature (°F)	Wet-bulb temperature (°C)
50+	0–24	160	71	153	67
50–40	24–48	160	71	150	66
40–35	48–60	160	71	145	63
35–30	60–72	160	71	135	57
30–25	72–84	170	77	130	54
25–Final	84–120[a]	180	82	130	54
Equalizing	—	180	82	170	77

[a]In the recommended time-based schedule developed in the study reported here, final drying time is shortened to 115 h and followed by 15 h of equalizing.

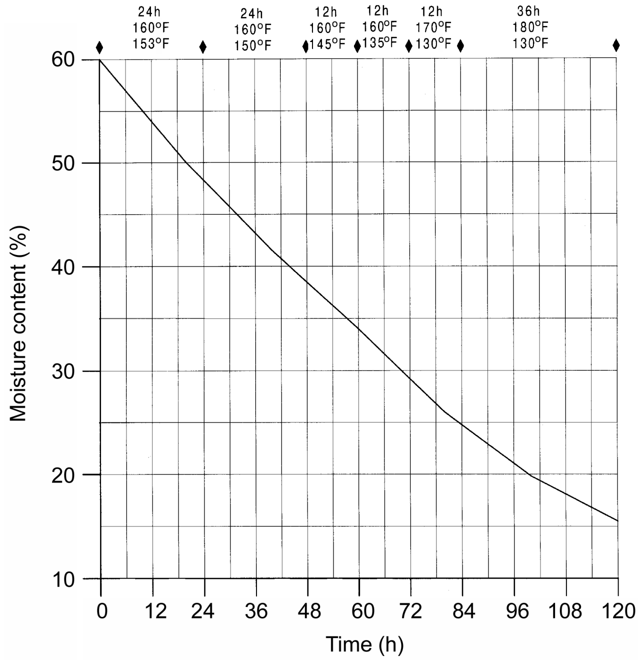

Figure 1—Drying curve for nominal 2- by 6-in. (standard 38- by 140-mm) sugar maple lumber derived from a kiln schedule based on moisture content (Simpson and others 1998) and converted to a schedule based on time.

One way to analyze the influence of equalizing time on final moisture content is to compare standard deviation values. If longer equalizing time reduces the standard deviation in final moisture content, then a longer equalizing time can be judged effective in reducing the variation in final moisture content. If standard deviation does not decrease as equalizing time is increased, then there is no justification for prolonging equalizing time. If the outliers had been included in the analysis, they would have had such a great effect on the standard deviations that the remaining results would have been distorted and would likely have led to false conclusions.

Average final moisture content values for the three kiln runs, in order of progressively increasing equalizing time, were 13.4%, 14.1%, and 13.2%, with corresponding standard deviations of 1.91%, 2.75%, and 1.64%. Because there was no progressive decrease in standard deviation with increasing equalizing time, we cannot conclude that longer equalizing time is necessary to reduce variation in final moisture content.

The final moisture content values observed may be a little lower than would be necessary for structural lumber. Structural lumber is commonly kiln dried to a target moisture content of 15%. The data for this study were only for the final moisture content at the end of drying plus equalizing

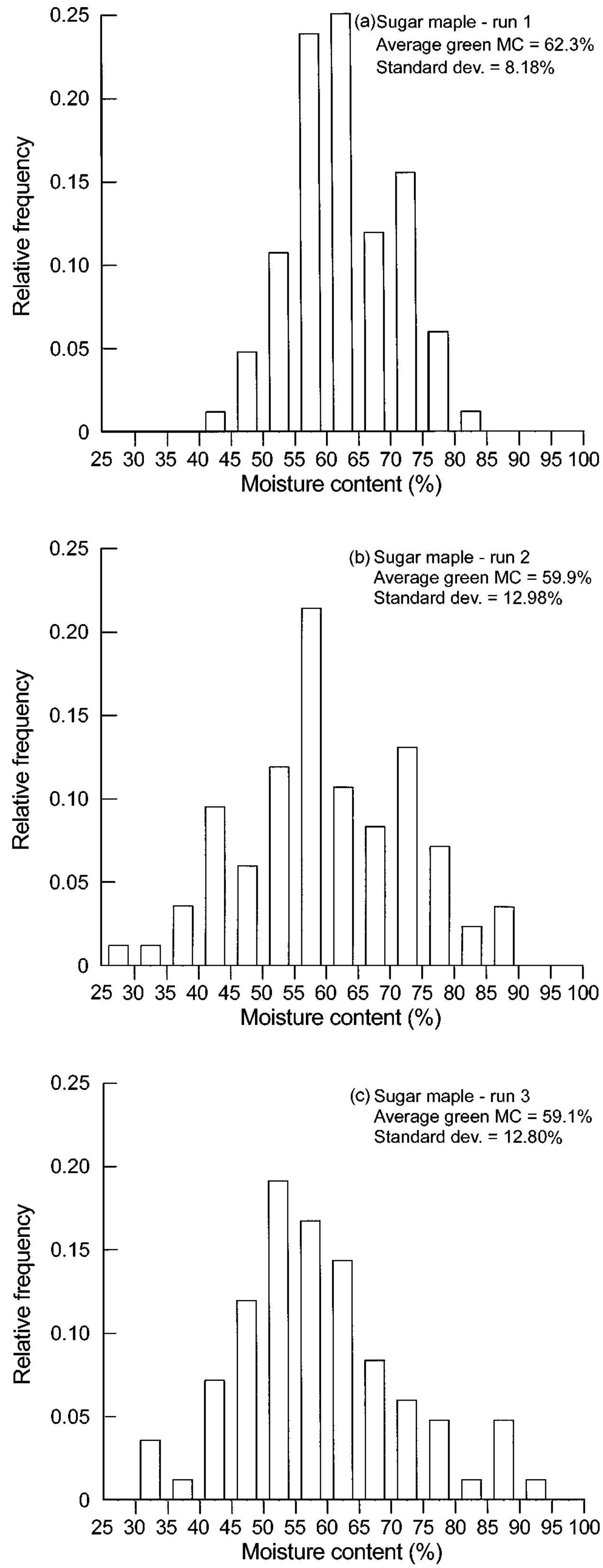

Figure 2—Distribution of green moisture content of lumber for three experimental kiln runs.

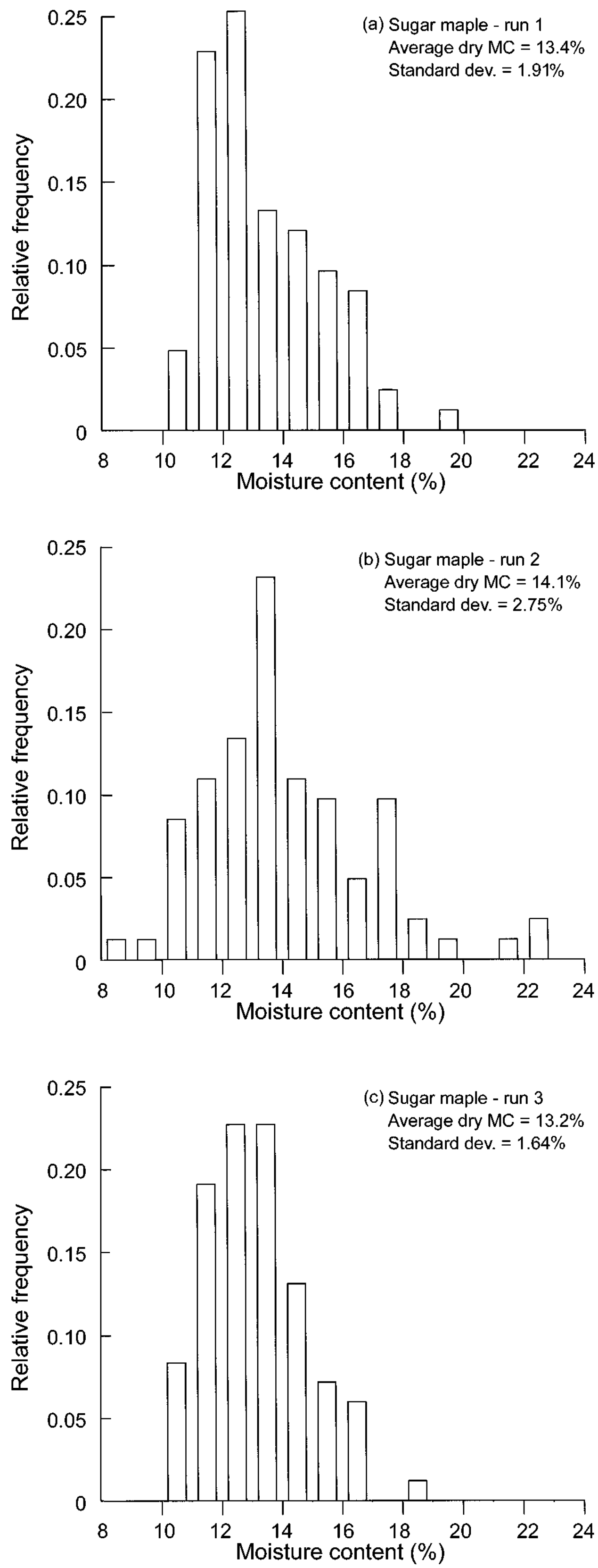

Figure 3—Distribution of final moisture content of lumber for three kiln runs.

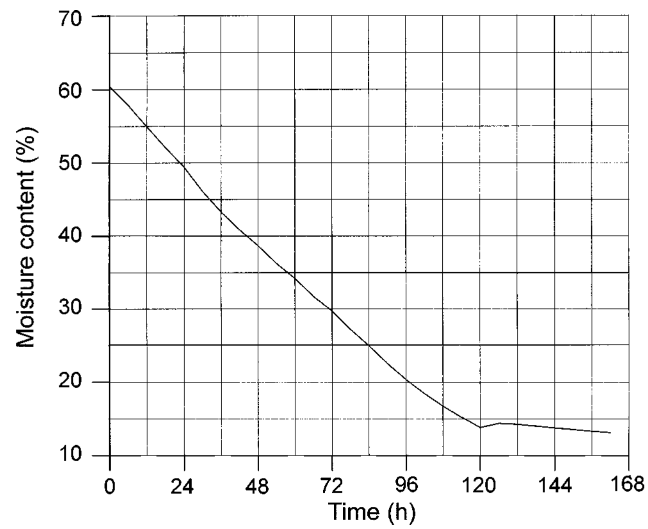

Figure 4—Composite drying time curve representing three kiln runs, with drying time to actual moisture content below 15%.

time. To estimate the time required for the lumber to reach 15% moisture content instead of the actual lower final moisture content of 13.4%, 14.1%, and 13.2% for the three kiln runs, we pooled the initial and final moisture content data of the runs. We then used a computer drying simulation (Hart 1982, Simpson and others 1998) to generate a drying curve that is a composite of the three experimental kiln runs (Fig. 4). As Figure 4 indicates, the drying time to 15% moisture content was about 115 h instead of the 120 h estimated in the schedule (Table 1, Fig. 1).

The drying curve shown in Figure 5 was obtained by shortening the last step of the schedule from 36 to 31 h, so that lumber moisture content reached 15% in a total drying time of 115 h. Figure 5 also shows that an equalizing time of about 15 h (bringing total drying plus equalizing time to about 130 h) will decrease average final moisture content to 15% after the moisture content is increased by adding moisture to the overdried boards and then decreased as the underdried boards continue drying and the overdried boards no longer gain moisture.

Recommendations

The time-based kiln schedule developed in this study, in which the final step is shortened from 36 to 31 h and is followed by a 15-h equalizing period, will result in a final moisture content of about 15%. This schedule is recommended as a starting point for individual kiln operators, with adjustments to be made according to observations over a number of production kiln runs.

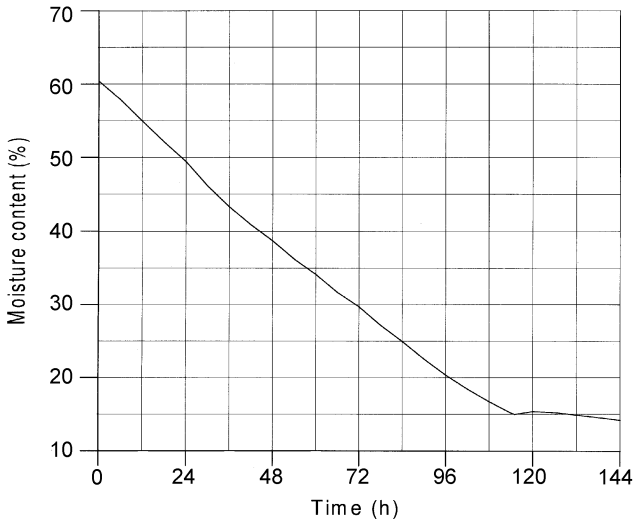

Figure 5—Drying curve representing three kiln runs adjusted to 15% final moisture content.

Acknowledgments

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