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CONTROL OF REDDISH-BROWN COLORATION IN DRYING MAPLE SAPWOOD

ABSTRACT

Producers of hard maple lumber have difficulty in consistently kiln-drying it to the normal light orange-yellow color or the very whitest color specified for some products. For the white color, they believe winter-cut, air-dried material is required.

Research has shown that normal, white, or discolored lumber can be produced from air-dried or green 4/4 or 5/4 hard maple by changing kiln conditions. A low-temperature, low relative humidity kiln schedule produced white stock. A moderate-temperature, moderate-humidity schedule produced the normal-colored maple. Operational malfunctions that cause unwanted high-humidity conditions that produce reddish-browned stock are discussed, and precautions in using the low-temperature schedule are included.

CONTROL OF REDDISH-BROWN COLORATION IN DRYING MAPLE SAPWOOD

By
JOHN M. McMILLEN, Forest Products Technologist
Forest Products Laboratory,[1] Forest Service
U.S. Department of Agriculture

INTRODUCTION

Light orange-yellow, or normal-colored, maple, a standard product of the hardwood industry of North America, is in wide demand for a variety of products. The kiln schedule, T8-C3, recommended in the Dry Kiln Operator's Manual (*7*, p. 122)[2] for dryirig 4/4, 5/4, and 6/4 maple, produces the normal-colored wood. With certain finishing systems, very attractive, bright, natural-finish maple can be produced.

White maple also is a standard product of the hardwood industry. It is in demand for special items such as bowling alley bedstock and juvenile furniture. It is desirable for special lines of furniture, cabinets, and decorative as well as utilitarian housewares. It might be in greater demand if the maple producers could consistently supply the white maple when specified.

The producers of both of these maple color types are sometimes confounded by encountering dried maple in various shades of pink to reddish-brown unsuitabde for their intended purposes. In addition, firms that produce items such as molding, which must be consistently color matched, have problems in getting exact matches even in lightly colored normal stock. Yet there is no general understanding in the industry of the particular seasoning conditions that produce undesirable colors or what is needed to consistently produce the desired colors.

In dark reddish-brown samples submitted to the Laboratory by industry, microscopic examination of the wood disclosed that the color was associated with a large amount of dark brown material in the wood rays. Slightly grayed white maple, as well as gray-brown, sticker-marked areas of otherwise normal maple, revealed a small amount of brownish matter in the wood rays. The physical characteristics of interior graying, sticker staining, and reddish-brown discoloration of maple are described and illustrated in a Forest Service research paper (*5*).

The discoloration problem probably is not related to maple from any particular area or source. The Laboratory has received samples of discolored maple from sources throughout the whole hard maple area. Some samples have been light pinkish-brown; most, moderately pink or brown; and a few, even dark cherry-red. However, lumber or products that are very white and bright are also available from widely distributed sources.

Brown is not one of the spectral colors; it results from the graying of yellow to red. To the eye, however, highly discolored maple appears redder if it is darkened. Thus, "reddish browning" seems more appropriate than "browning"or "pinking" as a generic term.

The research results in this Note are based on two studies. The first study was small-scale to deliberately produce both reddish-brown and white material from the same green or partly air-dried stock (*4*). The second was more comprehensive, and covered reddish browning, interior graying, and sticker staining (*5*). In the portion of the second study on reddish browning, kiln runs were made with the schedule for white maple and with the schedule T8-C3 normally recommended for 4/4 to 6/4 maple. The color of the specimens from these runs, as well as that of specimens received from industry, was evaluated quantitatively.

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[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2] Italicized numbers in parentheses refer to Literature Cited at the end of this report.

This Note is a résumé of the air- and kiln-drying conditions that produced the white, the normal (light orange-yellow), and the reddish-brown sugar maple (Acer saccharum Marsh.), and includes recommendations for controlling these conditions to obtain the degree of coloration desired. A more complete description of conditions that influence reddish-brown coloration is given in a USDA Forest Service Research Paper in preparation.

METHODS OF STUDIES

In the first study on which this work is based, five boards each of green and of well air-dried 5/4 sugar maple sapwood were used. Each board was divided into two end-matched specimens. One specimen was dried by a low-temperature, nonpinking schedule similar to one used successfully on hickory; the other, by a schedule designed to produce considerable reddish browning. The schedule for reddish browning employed the same dry-bulb temperatures as the T8 schedule (7). The relative humidity purposely was maintained very high during the first half of the drying. The low-,temperature schedule used to produce the white stock is given in table 1, A. The air-dried material was placed in the kilns with the green material when the green material was estimated to be at or just below

Table 1. —Kiln schedule to produce whitest 4/4 and 5/4 sugar maple

Moisture content at start of step	Dry-bulb temperature[1]	Wet-bulb depression[2]	Wet-bulb temperature
Pct	°F	°F	°F
A—FORINITIAL MOISTURE CONTENT 50 PERCENT OR LOWER			
Above 28	105	10	95
28	108	13	95
24	108	18	90
20	108	23	85
16	115	35	80
13	125	45	80
10	160	55	105
Conditioning[3] ±12 hrs.	170	16	154
B—FORINITIAL MOISTURE CONTENT 51 PERCENT OR HIGHER			
Above 40	105	10	95
40	108	13	95
35	108	18	90
30	108	23	85
26	108	28	80
20	115	35	80
16	125	45	80
12	160	55	105
Conditioning[3] ±12 hrs.	170	16	154

[1] If wet-bulb depressions stated cannot be obtained at these temperatures, raise the dry-bulb temperatures just enough to obtain the depressions.

[2] Air-dried stock below 24 pct moisture content that has undergone surface moisture regain by rain or prolonged high humidity should be run 12 to 16 hours on a 10° to 13°F wet-bulb depression, then shifted to the depression corresponding to the moisture content.

[3] These conditions are for a final moisture content of 5 pct. If a different final moisture content value is desired, the kiln operator should adjust wet-bulb depressions. A 7 pct moisture content was attained with 4/4 stock by 4 hours at 165°F, 15°F wet-bulb depression, followed by 6 hours at 170°F, 7½° wet-bulb depression.

30 percent moisture content. Other details of this experiment have been described (*4*). Because of the limited number of specimens, color was not measured.

In the second study (*5*), several kiln runs were made on green lumber: one using a modification of the low-temperature schedule mentioned (table 1, B); the others, the usually recommended schedule T8-C3 (*7*) or very slight modifications. Each of these runs consisted of 1,000 board feet of rough 4/4 sugar maple sapwood. Air velocity through the loads was about 300 feet per minute. In addition to these kiln runs, a number of specimens from industry were examined and tested for color. The most pertinent details of the seasoning of these specimens are given with the specimen descriptions in "Results."

In the second study (*5*), color was measured with a Beckman spectrophotometer. The specimens were illuminated by standard light source A. In addition to obtaining diffuse reflectance curves for typical specimens, a computer program, developed by Nelson and included in work by Nelson, Maeglin, and Wahlgren (*6*), was used to compute dominant wavelength (hue), luminance, and excitation purity (saturation) for these specimens.

RESULTS

In the first study, the specimens dried by the low-temperature schedule were white, whereas those dried by the normal temperature, high-humidity schedule were considerably discolored. Most of the specimens dried from the green condition by the high-humidity schedule were about as dark a reddish-brown as the darkest samples the Laboratory received from industry. The two wettest air-dried specimens had a light grayish-brown color rather than the reddish-brown typical of green material dried by this schedule. The three driest air-dried pieces were bright. With the low-temperature schedule (table 1, A), the results were entirely satisfactory. Both the green and the air-dried specimens kiln-dried bright and fully white. There actually was no consistent difference between the color of the air-dried and the green groups dried by this schedule.

In the second study, one kiln charge dried by the nonpinking schedule (table 1, B), was as white as the white specimens in the first study. A matched charge dried by the recommended schedule T8-C3 (*7*) was a light orange-yellow. This color is considered normal, for it has been obtained frequently in demonstrations at the Laboratory using schedule T8-C3 and commonly in commercially dried maple. Figure 1 shows representative boards from each charge; they were planed, but not finished. A third charge dried by schedule T8-C3 also had the normal light orange-yellow color. A fourth charge, matched to the third, was stored in the kiln for a few days with the doors closed before kiln drying. The temperature was above 70°F. The kiln then was started and run 2 days at 130°F with relative humidity above 80 percent, in accordance with schedule T8-C3. Other steps of the schedule, with relative humidities below 80 percent, were followed thereafter. The color of the dried lumber was somewhat darker than normal; it has been designated "close to normal."

Among the specimens submitted by industry was a cutting board, the entire middle portion of each strip or segment appeared dark in contrast to the white margins along the gluelines. Color-test specimens taken from the dark portion, however, showed the color was essentially normal. The white margins came from surface zones that remained white because of outdoor air drying before kiln drying. Another specimen was slightly yellowed; supposedly it had been dried as white maple for billiard cues. The kiln operator had partially air-dried the squares, then used one of various kiln schedules starting with 120° or 130°F and a 7°F wet-bulb depression (about 80 pct relative humidity). A third industrially dried specimen was reddish browned by a kiln run in which the operator thought he was avoiding degrade by using an ultramild (high relative humidity) schedule. In this run, all of the lumber became dark reddish-brown. Another dark reddish-brown specimen was from lumber sawed from logs that had been left in the woods 6 months. This lumber was dark before kiln-drying with kiln schedule T8-C3.

The reflectance curves and complete data on color characteristics in the second study are given in a research paper (*5*). There was no basic difference in hue among all of the colors observed; all had dominant wave-

lengths of 590.0 ± 0.016 nanometers. There were, however, large differences in luminance and some differences in purity (table 2). The general comments about color in the previous specimen descriptions are based largely on the luminance values. Neither the color characteristic data nor chromaticity coefficients derived from them are adequate to explain small color differences in maple within one of the three general color classes (white, normal, reddish-brown). But by using relative reflectances (comparing the other reflectance curves with that of white maple) large differences were found in the blue-to-yellow region of the spectrum (fig. 2).

A relatively simple spectrophotometric device using light in the blue-green part of the spectrum could be set up to precisely monitor color of maple produced for specific purposes, whether the desired color was white, normal, or somewhat darker than normal.

Table 2-Color characteristics of white, normal (light orange-yellow), and discolored sugar maple sapwood

Color type	Luminance	Purity
	Pct	Pct
White	69.1	28
Yellowed	62.4	33
Normal	59.5	32
Close to normal	54.3	36
Redd ish browned	49.1	40

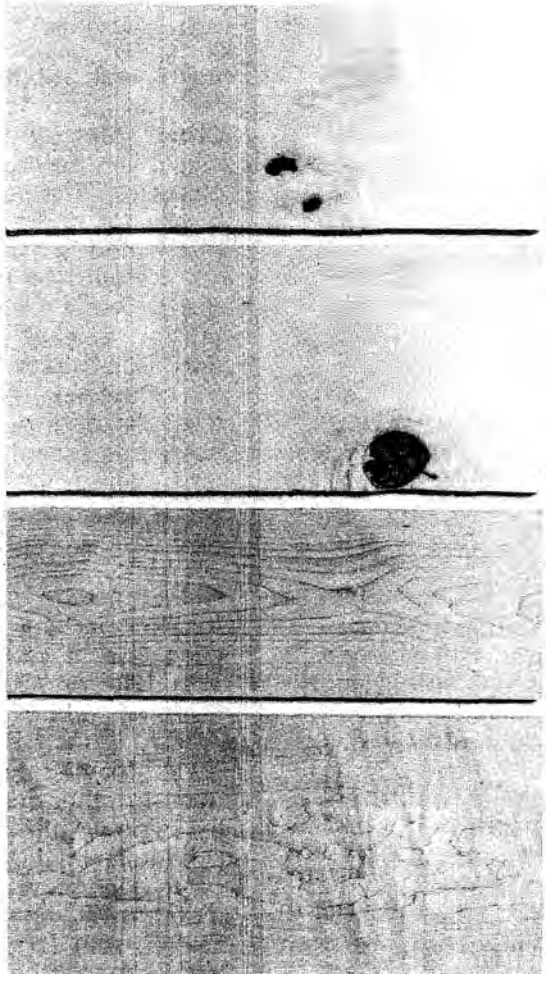

Figure 1.-White and normal (light orange-yellow) color sugar maple sapwood boards kiln-dried from green condition by the low-temperature schedule (top) and by the recommended schedule T8-C3 (bottom).

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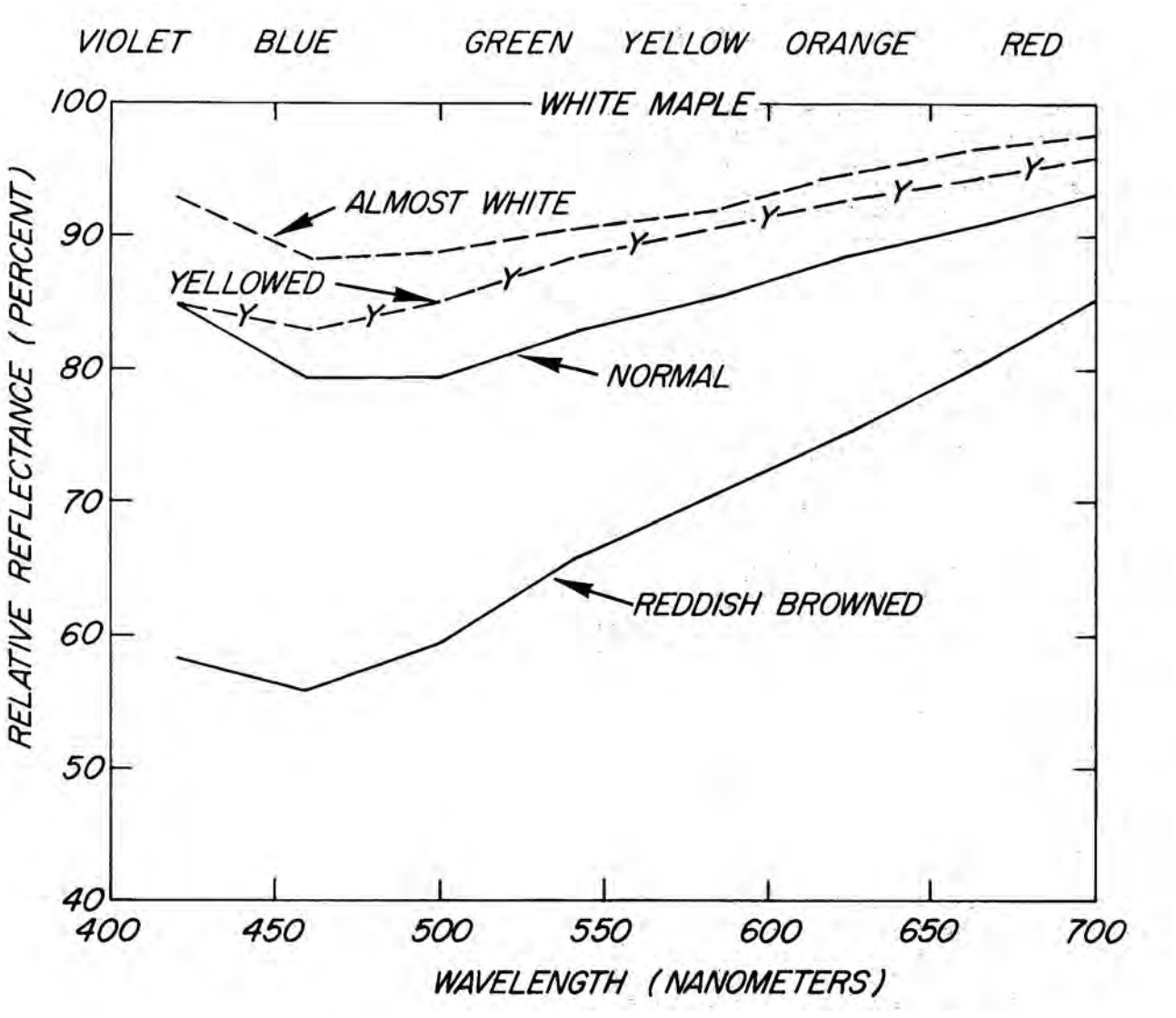

Figure 2. - Relative spectral reflectance of colored sugar maple sapwood. (Maple dried by a nonpinking schedule equals 100.)

(M 143 738)

EXPERIENCE OF INDUSTRY

The kiln schedule shown in table 1 has consistently produced white maple for a Wisconsin firm that kiln dries more than 350,000 board feet annually. Other firms have used slightly higher temperature schedules satisfactorily for 5/4 maple for bowling alley bedstock. A firm in New York has used a starting temperature of 110°F and final temperature of 165°F. Conditioning at 165°F with a 5°F wet-bulb depression is carried out for 4 to 8 hours. Another Wisconsin firm has used an initial temperature of 120°F and a final temperature of 160° to 170°F. Although these schedules probably produce very light-colored stock, it is not known that they produce the whitest stock possible.

Large quantities of hard maple are being dried commercially by the T8-C3 schedule or modifications of it with the resultant light orange-yellow or normal color totally satisfactory for most uses.

Occasional experience by industry has shown that the wrong kiln conditions for color control can occur if maple is dried with some other species, such as oak or beech, that requires a higher relative humidity schedule to avoid checking. Other situations leading to excessive humidity and coloration include the following: Having the kiln slightly out of control with too small an initial wet-bulb depression; using steam spray during kiln warmup; and using a kiln in which the venting is not adequate to attain the prescribed wet-bulb depression.

CONCLUSIONS

Dark discoloration of green 4/4 and 5/4 hard maple sapwood can occur at commonly used kiln temperatures if the humidity is higher than that prescribed by the T8-C3 schedule. Using a schedule with dry-bulb temperatures around 100° to 110°F and with wet-bulb depressions starting at about 10°F and increasing them relatively soon will produce very white stock from green or air-dried material. Pieces with more than 20 percent moisture content in reasonably well air-dried stock are subject to some interior darkening if a kiln temperature of 130°F or higher is used in conjunction with a high relative humidity to start drying.

On the basis of results of various drying times in the two studies described here, it is judged that commercial drying by the low-temperature white maple schedule would require about 35 percent more time than would drying by the recommended T8-C3 schedule.

A number of unknowns in the normal and the abnormal color changes of maple remain. The question, whether a temperature as low as 105°F is needed to produce maple of maximum whiteness, is still not definitely answered. It is apparent, however, that temperature and humidity control are needed at all times of the year to prevent excessive coloration.

RECOMMENDATIONS FOR COMMERCIAL PRACTICE

The recommendations that follow are based on observations of current commercial practice as well as research results. They cover handling of maple logs and green lumber to avoid blue stain, interior graying, and sticker staining as well as reddish browning, also the control of reddish-brown coloration itself during drying.

Handling Maple Logs and Green Lumber

Logs that will be stored more than 1 month between April 1 and November 1 should be protected against these discolorations, preferably by sprinkling (*3*). However, sprinkling is effective only if all the logs are kept wet continuously.

When kiln drying cannot be started within 5 days after sawing, serious consideration should be given to dipping the freshly sawed lumber in a fungicide (*9*). Ordinarily, dipping should start May 1 and continue until October 1, but it may be desirable to start earlier or continue later if the weather is expected to be warm in April or October. Thirty-day weather outlook maps by the National Weather Service make it possible for a kiln operator or a manager of a drying yard to know when a period of "warmer than normal" weather is due. These maps are often printed in newspapers or periodicals, and are regularly available by mail from the Service.

Dipped or nondipped green maple lumber should not be held in a solid pile, inclusive of truck or rail shipment, for more than 30 days except when average temperatures are below 45°F. In warm humid weather, the holding period should not exceed 15 days. If the lumber has been solid piled longer than these two periods or if there has been a 4-day or longer period of rain and extremely high relative humidity during or soon after stickering, danger of interior graying is high. The lumber should be exposed to 3 days of very rapid air drying (line-type yard, single line) or 1 day at a 10° F wet-bulb depression in a kiln or forced-air dryer before starting ordinary kiln drying or air drying.

If possible, weather-protective sheds should be used for dipping and green lumber storage.

Controlling Reddish-brown Coloration During Drying

To produce normal, light orange-yellow stock, use the recommended kiln schedule T8-C3. Proceed through the first two steps of the T8-C3 schedule as rapidly as the kiln samples will allow. Use rapid air circulation. Extra venting may be necessary at the start to avoid wet-bulb depressions less than 5°F. If the material is to be held on kiln trucks or in an air-drying yard for a week or two before kiln-drying, care should be taken to avoid excessive exposure to rapid air-drying conditions, otherwise the surface zone may dry so fast that it remains white.

To produce very white maple, use one of the following three procedures:

1. Air-dry the stock in piles built with narrow dry stickers in a shed or under an overhanging pile roof until the stock is down to 20 percent moisture content, then kiln-dry by the schedule in table 1, A starting at the 20 percent moisture content level.
2. Dry to 20 percent moisture content in a predryer, then kiln-dry as suggested in the first procedure. In a high-air-velocity predryer (*2*), an initial wet-bulb depression of 8° F (about 12 pct EMC) with temperatures in the 70° to 85°F range should be satisfactory. In a controlled air-drying system (*1*) relative humidity would be set at 60 percent. If only maple sapwood were being dried, perhaps relative humidity could be set lower than 60 percent.
3. Kiln dry from the green condition with the low-temperature schedule in table 1, B.

To produce maple with a darker than normal color, use the same dry-bulb temperatures as the T8-C3 schedule, but decrease the initial wet-bulb depression to less than 5°F. Maintain the depression in the 3° to 7°F range during the first one-third of the total drying time.

For general information on air-drying practices and kiln schedules, consult references 7 and 8.

Caution should be exercised in using an initial wet-bulb depression as high as 10°F on green stock. Hard maple sapwood of 4/4 and 5/4 thickness with no heartwood should withstand this depression at 105° F or lower. Commercial sapwood with considerable heartwood on the poorest face, 6/4 sapwood, and random mixtures of sapwood and heartwood probably will require a smaller depression, perhaps 7° or 8°F, at the low dry-bulb temperatures mentioned.

To consistently produce either normal-colored or white maple, the kilns should be well designed. The kiln operator should follow a regular procedure for inspection and maintenance, as outlined in Chapter 4 of the Dry Kiln Operator's Manual (*7*). Perhaps many cases of discoloration result from some abnormal condition that brings about relative humidities higher than in either the recommended schedule for normal-colored stock or the low-temperature schedule outlined.

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