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An investigation by O. W. TORGESON, associate engineer of the Forest Products Laboratory, determines the

Proper Sawing Allowances for Warp in Maple and Birch Dimension

DEFINITE figures on the proper sawing allowances for taking care of warp in mixed-grade Maple and Birch dimension stock have been determined by 0. W. Torgeson, associate engineer of the Forest Products Laboratory, of Madison, Wisconsin.

The information covers stock of various widths and thicknesses in lengths of 18, 24, 30, 36 and 48". Two cars of sugar Maple and yellow Birch, shipped from Northern Wisconsin as low-grade logs and sawed up at the laboratory, supplied the material for the tests. The logs were woods waste averaging 7½ to 8" in diameter. These were plain sawed and, of the approximately 9,000 pieces of dimension stock sawed, dried and measured, it is estimated that 66 per cent were entirely clear. The remaining 34 per cent contained knots not more than 1/2" in diameter on one or both faces. One of the main purposes of the investigation, according to Mr. Torgeson, was to obtain some idea of the warping tendencies of woods waste when utilized as dimension stock; hence some material necessarily was included that would not meet the specifications for a clear grade.

IN all lengths of both Maple and Birch, 1 by 1" pieces were most numerous, making about 44 per cent of the total; in Maple, 1½ by 1½" pieces stood next in number (about 12 per cent), and 2 by 2's third (9 per cent). In yellow Birch, however, 2 by 2's outnumbered 1½ by 1½'s three times over. Other sizes were 1 by 2, 1 by 3, 1 by 4, 1 by 6, 1½ by 3, and 1½ by 4. Nearly one-third of all the pieces were in the 18" length class.

The Maple stock was divided into three equal groups. Each group was dried in a different manner to a moisture content of 20 per cent; the first group by means of air seasoning, the second by kiln drying under a mild schedule, and the third, after end coating, by kiln drying under a rather severe humidity schedule. The following table shows what is meant by the *mild* and *severe* humidity schedules used :

	MILD		SEVERE	
	Temperature F.	Relative Humidity Per Cent	Temperature	Relative Humidity Per Cent
Initial conditions..	130	85	120	50
Final at 20 per cent moisture content.	145	70	120	50

All three groups were then kiln dried under an identical schedule (160° F. temperature and 25 per cent relative humidity) from 20 to 7 per cent moisture content, at which stage the material fairly represented a good standard of commercial drying. All the Birch was dried under the same conditions as the third group of Maple stock. Checking was prac-

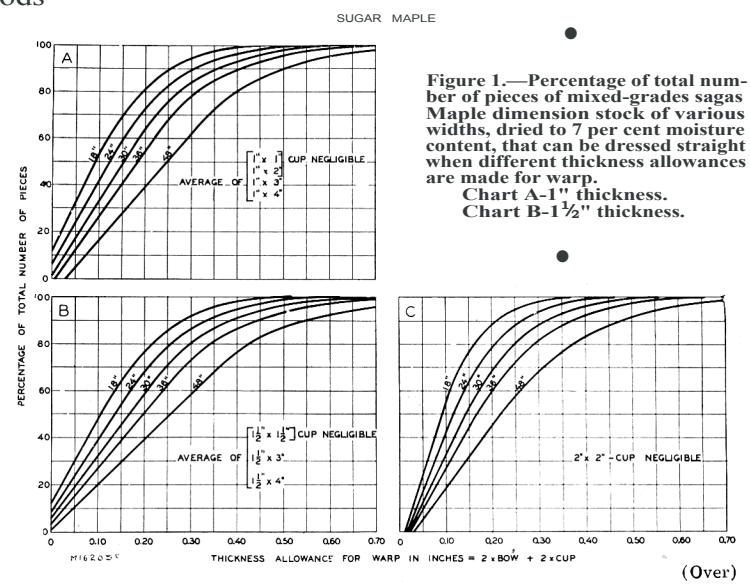

Figure 1.—Percentage of total number of pieces of mixed-grades sagas Maple dimension stock of various widths, dried to 7 per cent moisture content, that can be dressed straight when different thickness allowances are made for warp.
Chart A-1" thickness.
Chart B-1½" thickness.

(Over)

tically absent, the main defect being confined to warp. The average warp of Maple varied only slightly from group to group, indicating that dimension stock need suffer no special damage from rather severe drying, so far as relative humidity is concerned, provided end coatings are used to prevent checking.

THE warp resulting from drying, classified as bow, crook, cup and twist, was measured by the maximum deflections in each piece. From the measurements it was possible to figure averages for each type of distortion in each size and length of material. In general, Birch and Maple were found about equally subject to bowing, the largest figure being 1/5" average bow for 1 by 1" Maple 48" long, the lea st 1/75" bow for 1 by 6" Maple 18" long.

It can be taken as a rule that the longest material h a s the greatest total bow, but at the same time the longer the piece *the less the bow per foot;* hence in drying any given width of dimension stock it is recommended that the stock be dried in multiples of its final length, if possible, and crosscut afterward. The force of this suggestion is well brought out by the drying behavior of 1 by 1" Maple. If dried as a 48" length, it will have only 1/80" bow per foot, whereas if cut into four 12" pieces and dried, each piece will bow to the extent of about 1/15" per foot. (Bow per foot is obtained by dividing the deflection at center by the square of the length of the piece in feet, a mathematical rule applying almost exactly to this type of curvature.)

The measurements showed no appreciable cupping of either Birch or Maple up to a width of 2". Beyond that width cupping increased much more rapidly in Maple than in Birch. Average figures for Maple 1" thick were : 3 inches wide, 0.011" cup; 4 inches wide, 0.029"; 6 inches, 0.079". For 1" Birch the figures were : 4 inches wide, 0.006" cup; 6 inches, 0.029". As a rule the wider the piece the greater is the amount of cup per inch; hence there is less of this distortion in pieces ripped before drying than in the same pieces ripped after drying, unless cupping in the latter is concentrated along one narrow zone.

FROM what has been said, it might be supposed that the ideal form of dimension stock for drying would be some type of long, narrow slats—length to keep down bowing, narrowness to prevent cupping. This might be true if it were not that width of stock further reduces bow. Sawing allowance to take out all distortion (except crook) is twice the bow plus twice the cup; therefore up to a certain point wide stock may hold down the total sawing allowance.

Laboratory tests indicate that the critical width will vary with the kind of wood, and perhaps with the size of log. In 4/4 Maple from the small logs used, the necessary allowance was at a minimum for stock 21/2" wide; above that width the increase in cup more than made up for the reduction in bow. In Birch, having considerably less cupping tendency, the width for minimum allowance was 4½".

In dressing out the twist, only half the total twist need be taken from each side, and, since this amount was found usually to be much less than twice the bow plus twice the cup, it was not considered in estimating the proper thickness allowance for warp. Crook affects only the width, and hence can also be neglected as far as thickness allowance is concerned. In square material, all lengthwise curving was recorded as bow, not crook. In the material 2" and wider, crook figured out a very small amount, from 0.006" per foot for 48" lengths, up to about 0.011" per foot for some 18" stock.

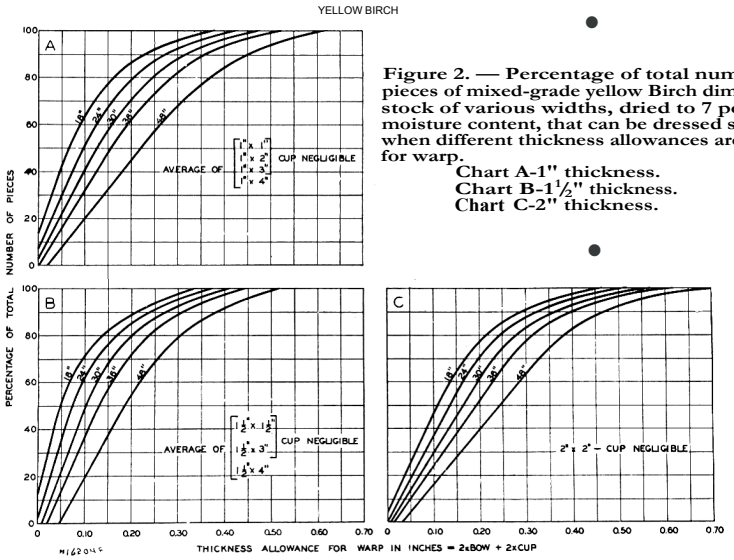

Figure 2. — Percentage of total number of pieces of mixed-grade yellow Birch dimension stock of various widths, dried to 7 per cent moisture content, that can be dressed straight when different thickness allowances are made for warp.
Chart A-1" thickness.
Chart B-1½" thickness.
Chart C-2" thickness.

Assuming that perfectly straight dry stock 18 to 48" long and dressed to a thickness of 13/16" is desired, the laboratory tests reveal interesting findings on the question of the proper thickness of the green rough material. Assuming also that the thickness allowance for warp is to take care of 75 per cent of the pieces, then the measurements for Maple nominally 1" thick and 48" long, of all widths, show that the allowance should be 0.37 (or % inch); it is better economy, according to the tests, to reject a few wild lengths than to saw all pieces with the allowance necessary for the wild ones. Since this allowance takes care only of warp, however, additional allowance for shrinkage is called for. One-sixteenth of an inch is regarded as satisfactory for this purpose. No allowance is made for dressing, because the piece will be dressed as the warp is taken out. Irregularities caused by sawing are also disregarded for purposes of the report. Adding the %" for warp to the 1/16" for shrinkage makes a total allowance of 7/16". This, plus the 13/16" finished thickness, conies to PA" as the necessary green rough thickness of the mixed-grade stock examined. This thickness would take care of not only 75 per cent of the 48" stock, but also 86 per cent of the 36", 91 per cent of the 30", 95 per cent of the 24", and 98 per cent of the 18" stock.

Similarly, in the case of Birch, 75 per cent of mixed-grade stock 48" long and nominally 1" thick, and higher percentages of shorter stock, would dress straight to 13/16" with a green rough size of 1 3/16". These figures and those that follow can *be* derived by the use of the accompanying charts (Figures 1 and 2), which afford a practical summary of the findings.

IF the green rough size of 4/4 flat Maple stock is PA", as is quite common in practice, then the thickness allowance would be 1¹A" minus 13/16" for dressed size and minus 1/16" for shrinkage, or 1/4" in all. This allowance would take care of 50 per cent of the 48" material, 68 per cent of the 36", 75 per cent of the 30", 83 per cent of the 24", and 90 per cent of the 18" material. The report points out that if the 18 and 24" lengths had been dried respectively as 36 and 48" pieces and then cut to length, these percentages would have been even higher, which means that the manufacturer could then profitably decrease the thickness allowance for warp. Moreover, if a certain amount of bow or cup is permissible, then the thickness allowance for warp can be reduced by twice the permissible amount.

For material nominally 11/2" thick and dressed to 1 5/16", the green rough size may be figured as 1 13/16" for Maple and 1W' for Birch. For 2" squares to be dressed to 1%" a satisfactory allowance would be 2 3/16" for both Maple and Birch. One-sixteenth inch shrinkage per inch of thickness can be taken as an approximate amount for the shrinkage of both Maple and Birch when dried from a green condition to 7 per cent moisture content.

In conclusion, it should be specifically understood that the figures reported apply in detail to the particular type and grade of material examined, while allowances for other types and species remain to be determined in further studies.