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Standard Methods for Conducting Machining Tests of Wood and Wood-Base Materials[1]

This standard is issued under the fixed designation D 1666; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

One of the significant characteristics of wood is the facility with which it can be machined and fabricated. Different species, however, vary greatly in their behavior under cutting tools, so that some systematic method is needed for determining their suitability for uses where the character of the machined surface is of prime importance. Such uses include cabinetwork, millwork, and other products where favorable machining properties are essential to good finish. For such products as common boards, on the other hand, good machining properties are secondary, although still an asset.

The machining test procedures presented in these methods cover such common operations as planing, shaping, turning, boring, mortising, and sanding. They are the result of many years of extensive research and development and include practical methods for qualitatively evaluating and interpreting the results. Because of their satisfactory use with a wide range of materials, it is believed that the methods are equally applicable to species, hardwoods and softwoods, and to wood-base materials, such as plywood, particleboard, and hardboard.

1. Scope

1.1 These methods cover procedures for planing, shaping, turning, mortising, boring, and sanding; all of which are common wood-working operations used in the manufacture of wood products. These tests apply, in different degrees, to two general classes of materials:

1.1.1 Wood in the form of lumber, and

1.1.2 Wood-base panel materials.

1.2 Because of the importance of planing, some of the variables that affect the results of this operation are explored with a view to determining optimum conditions. In most of the other tests, however, it is necessary to limit the work to one set of fairly typical commercial conditions in which all the different woods are treated alike.

1.3 Several factors enter into any complete appraisal of the machining properties of a given wood. Quality of finished surface is recommended as the basis for evaluation of machining properties. Rate of dulling of cutting tools and power consumed in cutting are also important considerations but are beyond the scope of these methods.

1.4 Although the methods presented include the results of progressive developments in the evaluation of machining properties, further improvements may be anticipated. For example, by present procedures quality of the finished surface is evaluated by visual inspection, but as new mechanical or physical techniques become available that will afford improved precision of evaluation, they should be employed.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—The values stated in inch-pound units are to be regarded as the standard. The metric equivalents of inch-pound units may be approximate.

2. Definitions and Descriptions of Terms

2.1 A number of special terms relating to wood and to machining are used in describing the procedures for the various machining studies. Definitions and descriptions of a number of the important terms used are presented in Appendix X1.

3. Significance and Use

3.1 Machining tests are made to determine the working qualities and characteristics of different species of wood and of different wood- and wood-base materials under a variety of machine operations such as are encountered in commercial

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manufacturing practice. The tests provide a systematic basis for comparing the behavior of different species with respect to woodworking machine operations and of evaluating their potential suitability for certain uses where these properties are of prime importance.

4. Apparatus

4.1 *Machines*—To yield data that can be duplicated for comparative purposes, all machines used in these tests shall be modern commercial size machines of good make, in good mechanical condition, and operated by fully qualified persons. Numerous machines meet these requirements, and no attempt is made to do more than describe the preferred type of machine for each test in very general terms (Note 2). Complete information on the machine used, the cutting tool, and the operating conditions of each test shall be made part of the record.

NOTE 2—Where machines with all of these qualifications are not available, machines that are inferior in some respects have limited uses, such as for comparing the machining properties of species for local use under local conditions.

4.2 *Sharpness of Knives and Cutters*—Carbide-tipped knives and cutters shall be the preferred type because of the much longer sharpness life of that material. High-speed steel shall be second choice and carbon steel third. The cutting tool material used shall be made part of the record. Every precaution shall be taken to keep the sharpness uniformly good in all tests by resharpening when necessary.

NOTE 3—A practical measure of the deterioration of a machined lumber surface because of dulling of the cutting tool can be had by the use of two check samples. They should come from the same board of some species that machines exceptionally well, such as mahogany. Both should be machined with a freshly sharpened cutting tool at the outset. One will be retained in that condition as a control, and the other, at intervals of 1 h or so as experience dictates, shall be machined with the regular test specimens and compared with the control. When the machined surface deteriorates perceptibly, as indicated by this comparison, the cutting tool should be resharpened.

Similarly with particle board or hardboard, some well-known product that has good machining properties may be used as a control material for comparison.

5. Shipment and Protection of Samples

5.1 All test material shall be properly protected in shipment to ensure its delivery in satisfactory condition for the required tests. On receipt, the material shall be carefully protected to prevent deterioration pending the preparation for the tests.

6. General Requirements of Samples

6.1 The tests shall be made on seasoned material.

6.2 Lumber shall be clear (Note 4), sound, well-manufactured, and accurately identified as to species. It may be either rough or dressed.

NOTE 4—Clear means free from all defects, including knots, stain, incipient decay, surface checks, end splits, compression wood, and tension wood.

6.3 Particleboard and hardboard samples may be typical commercial products or samples of new boards under development as the occasion requires. In either case the kind or kinds of wood, the density, and the amount and kind of binder should be known and made part of the record. Particleboard and hardboard shall be typical of the product under consideration as they are manufactured and marketed. For the planing and sanding tests, the particleboard and hardboard samples should be procured in the unsurfaced condition, whenever possible, so that these evaluations may be made on the same part of the material that will be removed from the board in the normal use conditions where planing and sanding are done.

6.4 Test samples of lumber shall be so selected as to exclude the small amount at each extreme that is not fairly typical of the species under consideration in number of rings per inch (average ring width per millimetre).

NOTE 5—Number of rings per inch is determined by visual count along a line perpendicular to the growth rings. Different samples of a given species often differ widely in this respect, and often the samples at both extremes are not typical in their properties.

7. Dimensions and Weight of Samples

7.1 Lumber samples shall be dried to a uniform moisture content of 6 percent before testing, or to such other moisture content as may be specified.

7.2 Samples must be large enough to yield the minimum acceptable size (0.75 by 5 in. by 4 ft) (19 by 127 mm × 1.2 m) when at the prescribed moisture content and surfaced smoothly on two sides. Where it is desired to make more planer cuts than are specified, lumber thicker than 1 in. (25 mm) may be used.

7.3 Lumber test samples shall be so selected as to exclude the small amount at each extreme of weight that is not typical of the species under consideration.

NOTE 6—Different samples of a species sometimes vary in density by as much as a 2 to 1 ratio. The properties exhibited by samples at either extreme of density are not typical of the species as a whole.

7.4 Particleboard and hardboard test material shall be typical in dimensions and weight of the products under consideration as they are manufactured and marketed.

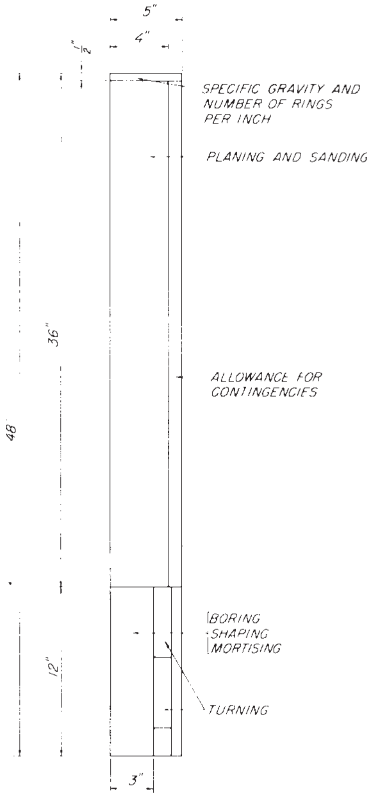
8. Sampling

8.1 A total of 50 test samples of lumber is required for each species tested (Note 7). Except in the few species where the making of some quartered lumber is standard practice, the samples shall be commercial flat grain. The test material shall be selected by one fully qualified to identify the species, to judge if it is fairly representative of the product being shipped and if it meets the specifications. If only exploratory tests are to be made, a smaller number of samples may be selected.

NOTE 7—It is desirable that the samples represent numerous different trees and logs. The material for tests should preferably be obtained in log form and then sawn to the desired size. When this is not possible it will be necessary to select random samples from a lumber pile.

8.2 For each type of particleboard tested, five samples (Note 8) shall be selected, one from each of five different sheets. The size of these samples (Fig. 1) shall be 2 by 4 ft (610 by 1220 mm), and the thickness in different products shall be as manufactured (Note 9).

NOTE 8—Particleboard and hardboard of any one process and mill are much more uniform in their properties than different boards of a given species. For this reason, five samples selected as described in 8.2 are



METRIC EQUIVALENTS

in.	½	3	4	5	12	36	48
cm	1.3	7.6	10.2	12.7	30.5	91	122

FIG. 1 Diagram for Sawing Lumber Samples into Smaller Samples for Individual Tests

considered sufficient to give representative results.

NOTE 9—For sawing tests where power consumption is an important factor, material thicker than 0.75 in. (19 mm) shall be reduced to that thickness before test. For material thinner than 0.75 in., a sufficient number of pieces shall be laminated together to provide the 0.75-in. thickness.

8.3 For each type of hardboard tested, five samples shall be selected, one from each of five different sheets. The size of these samples shall be 2 by 4 ft (610 by 1220 mm), and the thickness shall be that of the hardboard as manufactured.

9. Preparation of Test Specimens from Lumber

9.1 Each different test has its own procedure as described in Sections 11-16. The following steps in preparing the test specimens apply to all tests with lumber:

9.1.1 Mark each board, nominal 1 by 5 in. by 4 ft (as by 127 mm by 1.2 m) to identify adequately the species source and individual sample.

9.1.2 Cut a 0.5-in. (13-mm) cross section from one end of each nominal 1 by 5 in. by 4 ft board for specific gravity determinations and for counting the number of annual rings per inch (average ring width in millimetres) (Note 5).

9.1.3 Condition the boards to a 6% equilibrium moisture content (EMC), or to such other EMC as may be specified.

NOTE 10—Conditioning chambers are usually necessary for obtaining constant EMC conditions. The local drying practice may be followed, keeping in mind that the data will apply only to these specific conditions. In any event, the material should be conditioned to a uniform moisture content, and the actual moisture content determined and recorded.

9.1.4 Joint one edge and one side of the boards flat and plane the other side to provide a final board thickness of 0.75 in. (19 mm).

9.1.5 Saw the boards into the specified smaller sizes for the different tests as shown in Fig. 1. Each of the test specimens shall bear the same number as the board from which it was cut; take care to place the number where it will not be lost in the machining process.

NOTE 11—The specimen for shaping, boring and mortising (Fig. 1) must be accurately cut to size to ensure proper fit in the test jig. The turning specimens also must be accurate since they have to fit special lathe centers. The size of the planing specimen is less critical and, if necessary, it may be 1 in. (25 mm) or so short of the specified 3 ft (910 mm) without serious objection.

10. Preparation of Specimens from Particleboard and Hardboard

10.1 Each different test has its own procedure as described in Sections 18-23. The following steps in preparing the test specimens apply to all tests with particleboard and hardboard:

10.1.1 Mark each 2 by 4-ft (610 by 1210 mm) board to identify the source and the individual sample.

10.1.2 Condition the boards to the standard 6% EMC (see 9.1.3) or to such other moisture condition as may be specified.

10.1.3 Saw each of the original particleboard, and hardboard samples into smaller sizes for the different tests as shown in Fig. 2.

10.1.4 Each of the test specimens shall bear the same number as the board from which it was cut.

METHODS OF TESTING LUMBER

11. Planing

11.1 A moulder (Fig. 3) is the preferable machine for the planing test because of its relatively wide range of feeds and speeds and because of the ease of changing heads. In the absence of a moulder, a planer or planer-matcher may be used. In any case use only straight knives, and plane only one side of the test specimen at a time.

11.2 Steel knives shall be freshly ground at the outset and jointed to a point where each knife shows a hairline land for the entire length of the blade. When the land or jointed portion of the edge becomes as much as ¹⁄₃₂ in. (0.80 mm) wide, as a result of repeated jointings, the knives shall be reground before continuing with the test.

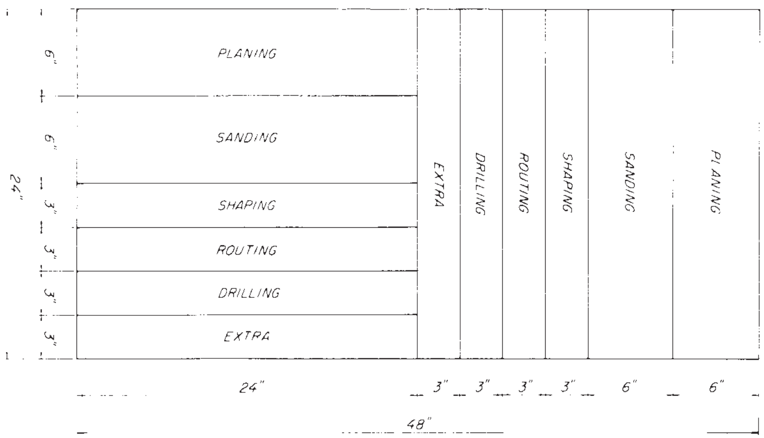
11.3 All specimens used in this test (50 per species) shall be 0.75 by 4 in. by 3 ft (19 by 102 by 910 mm).

11.4 The moisture content shall be 6% or such other value as may be specified.

11.5 All cuts shall be ¹⁄₁₆ in. (1.6 mm) deep. A test specimen 0.75 in. (19 mm) thick will permit making seven cuts before the specimen becomes thin enough to introduce a new variable.

11.6 When several species are being tested, mix them well to equalize the effect of the gradual dulling of the knives.

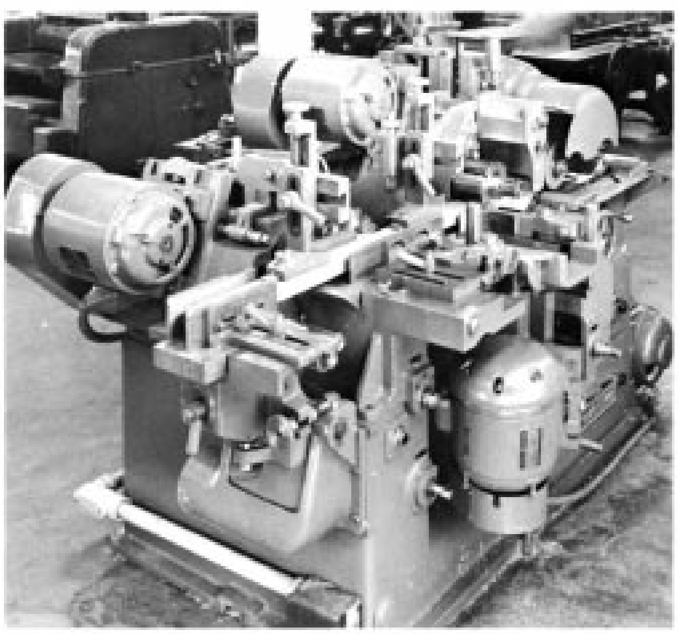
11.7 Feed the specimens into the machine, so that half are machined with the grain and half against the grain.



METRIC EQUIVALENTS

in.	3	6	24	48
cm	7.6	15.2	61	122

FIG. 2 Diagram for Sawing Hardboard and Particleboard Samples into Smaller Samples for Individual Tests



NOTE 1—This moulder offers a much wider range of cutterhead speeds and feed rates than does the typical planer. The slip-on heads are easy to change as desired. Moulders come with four and sometimes five cutterheads to permit machining four sides with one pass. In planing tests, however, only one cutterhead is used, the top head equipped with straight blades, as shown in this figure.

FIG. 3 Desirable Type of Machine for Use in Planing Tests

NOTE 12—It is suggested that alternative cuts be made on opposite faces to avoid cupping from the release of interior stress.

11.8 Mark the end of each specimen as it emerges from the machine to indicate the direction of feed and the side that has just been machined. Feed individual specimens in the same direction at each cut.

11.9 Make four runs with knives at cutting angles (Note 13) of 15, 20, 25, and 30°. Adjust the feed rates and cutterhead speeds to give 20 knife marks in. (0.8/mm).

NOTE 13—Because there are no accepted standards, the terms used in connection with planer knives vary considerably. Fig. 4, which shows the cross section of a cutterhead, illustrates a common usage; the one that is followed in this method. With both knives, angle *a* is the cutting angle and angle *c* the clearance bevel. Knife No. 2 has a cutting bevel or back bevel, *b*, and the cutting circle is *d*.

Cutting angles, which have an important influence on the quality of work in planer-type machines, may be changed in two general ways: (*1*) By changing the angle of the knife slot or slot that holds the knife in the head. This, of course, means a different cutterhead for every different knife angle. Heads with knife slots ground at 20 to 30° are common, but there are definite limits beyond which this method cannot be carried without danger of weakening the cutterhead too much. (*2*) By grinding a "back-bevel" on knives, as shown on knife 2 in. Fig. 4. This means one cutterhead with, say, four sets of knives back-bevelled at four different degrees achieves four different cutting angles.

11.10 Make three runs with a 20° cutting angle, while feed rates and cutterhead speeds are adjusted to give 8, 12, and 16 knife marks/in. (0.3, 0.5, and 0.6/mm).

NOTE 14—Where each knife in the cutterhead is doing its share of the work, the number of knife marks per inch will agree with the following formula:

No. of knife cuts per inch = $(A \times B)/(C \times 12)$

No. of knife cuts per millimitre $(A \times B)/C$

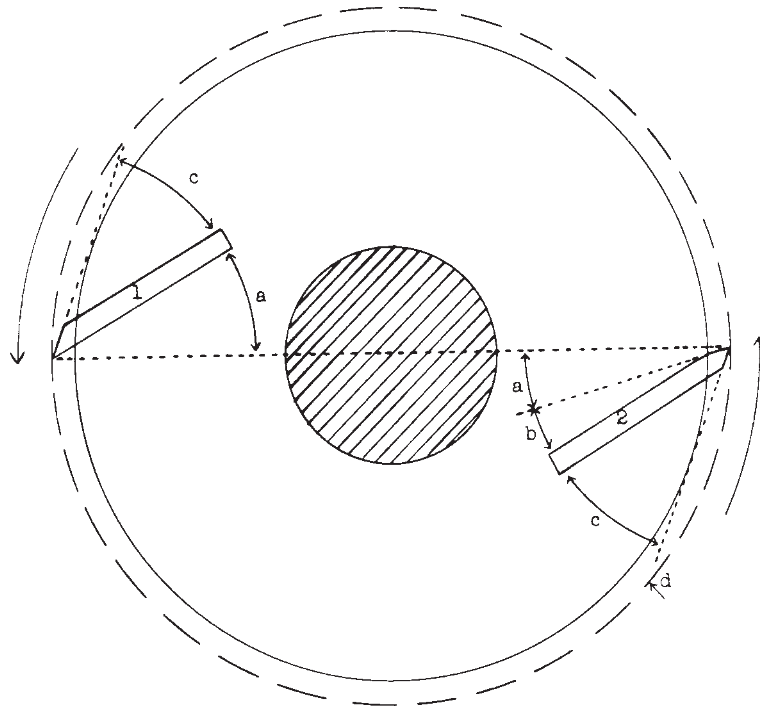
where:

A = revolutions per minute,
B = number of knives in head, and
C = feed rate, ft/min. (mm/min)

If the theoretical number does not agree with the actual number, the jointing is probably inadequate. This should always be checked visually (Fig. 5).

11.11 Visually examine each test specimen (Note 14) carefully for planing defects after each run. For each specimen, grade any planing defect that may be present according to degree and record on prepared forms. Classify the planing characteristics of each specimen by visual examination on the basis of five grades or groups as follows:

Grade 1, excellent
Grade 2, good
Grade 3, fair



(*a*) Cutting angle.
(*b*) Cutting bevel.
(*c*) Clearance bevel.
(*d*) Cutting Circle.

FIG. 4 Terms Used in Connection with Planer Knives

Grade 4, poor
Grade 5, very poor

NOTE 15—The runs described in Section 11 cover the more critical conditions. If additional runs are desired for any reason, additional test material will be needed.

NOTE 16—The characteristic of black walnut with respect to planing qualities is illustrated by Grades Nos. 1 and 5 in Fig. 6. The top sample, Grade No. 1, is easy to classify because it is practically free from any and all machining defects. Traces of chipped grain can be seen around the small burls in this specimen. They would not be visible, except in oblique light, and represent about as large defects as are admissible in this grade. Knife marks, which are quite plainly visible in this specimen, are not considered a machining defect, because they are largely unavoidable in planing. They vary in visibility according to the number per inch and, to some extent, with the species. For exacting uses, they are customarily removed by sanding as would be the traces of chipped grain. The second specimen, also black walnut, shows torn grain too extreme to be allowed in any grade above No. 5. In this instance, the degrade was no doubt due to a dip in the grain. The third sample, which illustrates an extreme degree of fuzzing in quartered mahogany, probably due to abnormal fibers, is also a Grade No. 5.

While the extreme conditions seen in the two lower specimens may occur in any species, they are usually lacking or negligible in most species, except when planing under very unfavorable conditions. Figs. 7-10 show the intermediate grades, Nos. 2, 3, and 4, which may be considered as slight, medium, and advanced degrees.

11.12 Base comparisons of planing properties of different species on percentages of defect-free pieces. Most of the planing specimens were either defect-free or only slightly defective. Although Grade Nos. 3, 4, and 5 were of relatively infrequent occurrence, they served to give a more complete picture of the degree of any defects that were present. Two things should be kept in mind: (*1*) Consecutive grades merge gradually without any abrupt change in quality or any sharp dividing line. (*2*) Any given grade is not completely uniform in quality, but has some range between the best and the poorest examples within the grade.

12. Sanding

12.1 The machine shall preferably be a two-head, wide-belt sander. If such a machine is not available then the machine shall be fully described. Conduct the sanding operation using a contact roll or drum. Do not use a stroke sanding machine.

12.2 The first head shall carry an 80-grit, aluminum-oxide, cloth or paper-back belt. The second head shall carry a 120-grit, aluminum-oxide cloth or paper-back belt.

12.3 Feed rates shall be on the order of 20 ft/min (6.1 m/min).

12.4 The test specimens (50 per species) shall be 5⁄16 by 4 in. by 1 ft cut from the 5⁄16-in. material left after the planing test, and shall be conditioned to 6 % EMC, or to such other moisture content as may be specified.

12.5 Examine the specimens and grade them for scratching and fuzzing, and the basis of comparison shall be the percentage of specimens that are free from these defects.

NOTE 17—The remaining 2 ft (610 mm) of the 5⁄16-in. (1-cm) material left from the planing test may, if desired, be used in testing the splitting tendencies of different woods with nails and screws.

13. Boring

13.1 The borer shall preferably be a single-spindle electric machine equipped with power feed. (If necessary, a smaller machine with hand or foot feed may be used.)

FOREST PRODUCTS LABORATORY, MADISON, WISCONSIN

Kind of test Planing Date

Species Red oak Moisture content 6 % Feed rate f.p.m. 100

Speed r.p.m. 3600 Knives H.S. Steel Cutting angle 20°

Sample Number	Defect-free	Raised grain	Fuzzy grain	Torn grain	Chip marks				
1		4	4	3	4				
2		4	4	3	4				
3	✓								
4	✓								
5	✓								
6	✓								
7	✓								
8	✓								
9	✓								
10		4	4	3	4				
11		4	4	3	4				
12	✓								
13	✓								
14	✓								
15	✓								
16	✓								
17	✓								
18	✓								
19	✓								
20		4	4	3	4				
21	✓								
22		4	4	3	4				
23	✓								
24	✓								
25	✓								
26	✓								
27	✓								
28	✓								
29	✓								
30		4	4	3	4				
31	✓								
32	✓								
33	✓								
34		4	4	3	4				
35	✓								
36	✓								
37	✓								
38	✓								
39		4	4	2	4				
40	✓								
41	✓								
42	✓								
43	✓								
44	✓								
45		4	4	3	4				
46		4	4	3	4				
47	✓								
48	✓								
49		4	4	3	4				
50	✓								
TOTAL	38	3							
AV.	76%								

NOTE 1—This form may be modified for use in other tests. The numbers in the column refer to the grade of the specific defect under consideration.

FIG. 5 Sample Data Sheet Used in Planing Test

13.2 The bit shall be a 1-in. (25 mm) size of the single-twist, solid-center brad-point type (Fig. 9). Sharpen it lightly at intervals of not more than 1 h of work.

13.3 The test specimens shall measure ¾ by 3 by 12 in. (19 by 76 by 305 mm), and shall be conditioned to 6% EMC, or such other moisture content as may be specified.

13.4 The borer shall be run at a spindle speed of 3600 r/min.

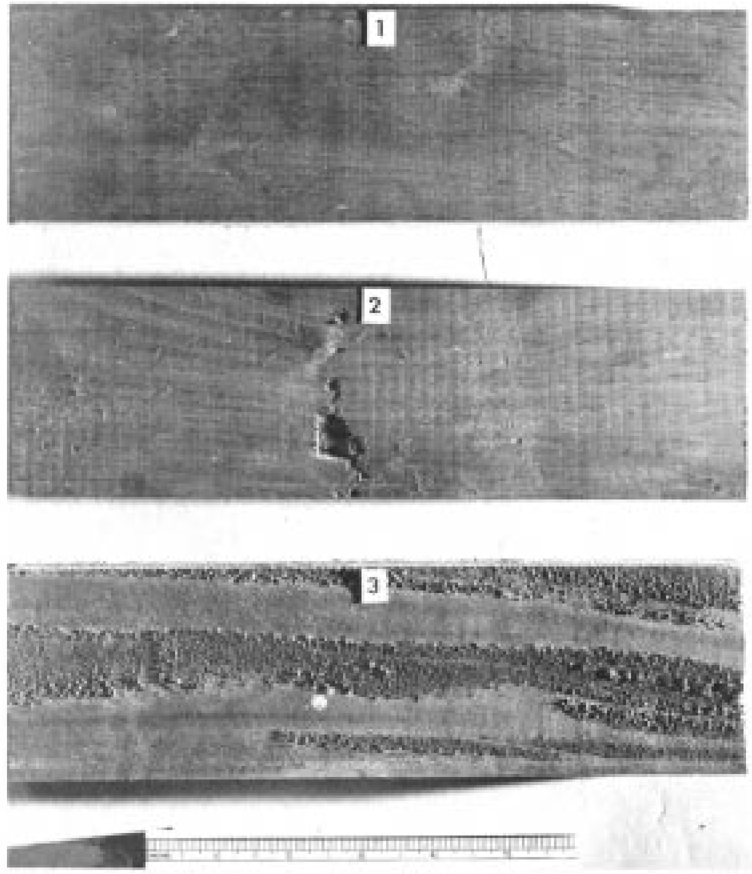
13.5 The rate of boring shall be low enough to enable the drill to cut rather than tear through the specimen.

13.6 Bore two holes through each specimen.

NOTE 18—The same specimens are used for three different tests, first for boring, then for shaping, and finally for mortising. Where the specimens are to be bolted on a shaping jig for a later test, as in this case, the holes must be accurately and uniformly placed. Although the identical procedure and spacing described here need not necessarily be followed elsewhere, the details are presented as descriptive of a satisfactory method.

In order to locate the holes accurately and uniformly, the boring jig shown on the top in Fig. 11 is used. The jig is positioned on the table of the borer with the point of the bit 1 in. (25 mm) from one edge of the recess, 8½ in. (216 mm) from one end, and 10⅜ in. (216 mm) from the other. The jig is then fastened in that position with C clamps and remains stationary.

The blank is placed in the recess on the top of the jig, slid to the extreme left, and hole No. 1 is bored. The blank is then slid to the extreme right, and hole No. 2 is bored. In order to prevent splintering out at the bottom, all holes are bored completely through the blank and about 1⁄16 in. (1.6 mm) into a hardboard backing. (This backing can be removed and



(*1*) Black Walnut Grade No. 1.
(*2*) Black Walnut Grade No. 5.
(*3*) Mahogany Grade No. 5.

FIG. 6 Planing Grades Nos. 1 and 5

replaced when desirable.) The openings through the bottom of the jig, one at each end, permit the shavings to fall through as the blanks are slid back and forth.

13.7 The boring properties of different woods shall be based on examination of the holes for crushing, tearouts, fuzziness, and general smoothness of cut. Grade each hole (Note 19) on a scale of five as in preceding tests, and base the comparison of different species on the percentage of Grades No. 1 and No. 2 holes present.

NOTE 19—In tests with 23 native hardwoods it has been found that, although the size of the holes in different species varies, in different degrees, from the size of the bit, the amount of the variation is not enough to affect the strength of dowelled joints significantly. For this reason, measuring the size of the holes with a plug gage, as was done in early tests, appears to be unnecessary.

14. Shaping

14.1 The machine shall be a commercial size, hand feed spindle shaper with either one or two spindles.

NOTE 20—Shapers are designed primarily to cut patterns on curved surfaces, such as a quarter-round pattern on the edge of a round table top. By far the commonest type of shaper is the spindle shaper, that carries one or two vertical spindles on which knives or cutters are mounted. When there are two spindles, these revolve in opposite directions, so that the cut can always be made with the grain. Single-spindle machines typically run at higher speeds that are relied on to make a satisfactory cut either with or against the grain. It is recommended that only a single spindle be used to make the cuts for these tests.

14.2 The knives shall be ground as shown in No. 1, Fig. 12, and maintained in good cutting condition.

14.3 The test specimens (50 for each species) shall be 0.75 by 3 by 12 in. (19 by 76 by 305 mm) in size and conditioned to 6 % EMC, or to such other moisture condition as may be specified.

14.4 The specimens shall be bandsawn to pattern as shown in Fig. 13.

14.5 Make a preliminary roughing cut with the shaper making use of the jig (Note 21) shown in Fig. 13 and Fig. 14 and taking care to cut with the grain as far as possible.

NOTE 21—Fig. 13 shows a jig (disassembled) that has been found satisfactory in the shaping test. It should be made from a hard, fine-textured wood such as birch or hard maple. The base of this jig (No. 3) is of a 2-in. (50 mm) material, and the other two pieces (Nos. 1 and 2) are 1 in. (25 mm). Flathead wood screws are used to fasten the parts together. Test specimen No. 4 has merely been bandsawn from the rectangular blank; No. 5 has been both bandsawn and shaped. The edges of the blanks are parallel for half of their length, while the remainder of the length is a parabola. The bolts, which pass through the holes in the test specimens,

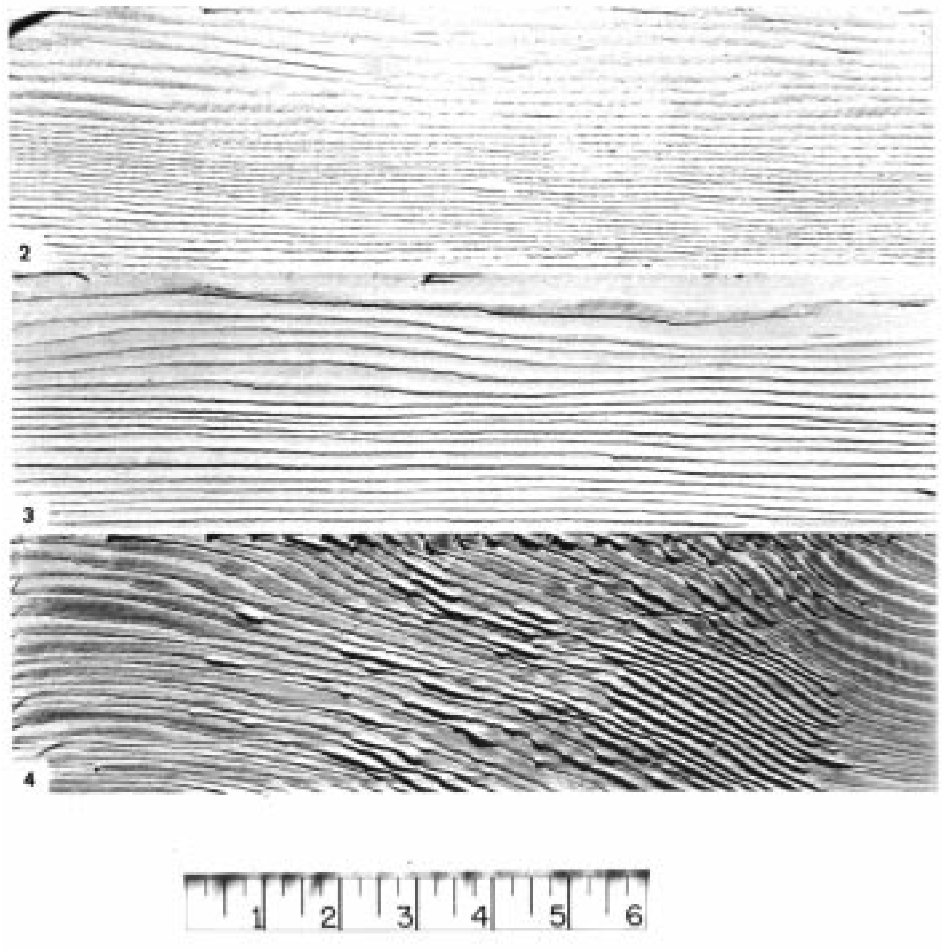


FIG. 7 Raised Grain in Douglas-Fir, Grades Nos. 2, 3, and 4

are ¾ in. (19 mm) in diameter, whereas the holes are 1 in. (25 mm). The knurled nuts that hold the specimens in place are tapered at the base to exert a centering effect when tightened on the test specimens. Fig. 14 shows this same jig assembled.

14.6 Make a finishing cut 1⁄16 in. (1.6 mm) deep.

14.7 The speed shall not be less than 7200.

14.8 Grade the test material piece by piece for raised, fuzzy, and chipped grain and rough-end grain and record the results on prepared forms. Keep a separate record for side-grain and end-grain cuts.

14.9 Base the comparisons of shaping properties on percentage of Grades Nos. 1 and 2 specimens present.

15. Mortising

15.1 The mortising machine shall be of the hollow chisel type equipped with power feed and spindle speed of 3600 r/min. As a second choice, hand or foot feed may be used.

15.2 The chisel shall be the ½-in. (13 mm) size.

15.3 Resharpen both the bit and the chisel at intervals of not more than 1 h of work.

15.4 Use the same specimens used for the shaping and boring tests also for mortising (see Fig. 15).

15.5 Operate the machine at a spingle speed of 3600 r/min.

15.6 Make two mortises in each specimen extending through into a hardwood backing.

15.7 Cut the mortises with two sides parallel to the grain and two sides perpendicular to it. They need not be placed in any specific part of the specimen.

15.8 Grade all mortises (Note 22) on a scale of five, as in previous tests, and base the comparison of species on the percentage of No. 3 and better mortises. The defects to be considered in grading the mortises are crushing, tearing, and general smoothness of cut.

NOTE 22—In tests with 23 native hardwoods, there showed a measurable variation between species in the difference between the size of the hollow chisel and the size of the mortise made by it. For the customary uses, this difference in size was too small to be significant. For any applications where unusually close tolerances are required, however, it is quite practical to measure small openings with a tapered plug gage.

16. Turning

16.1 The lathe shall be a well-made machine of the hand lathe type with a swing over the bed of not less than 12 in. (305 mm) and with several speeds the maximum being not less than 3200 r/min.

16.2 It shall be equipped with a compound rest, such as is used in metal turning.

16.3 A one-piece, milled-to-pattern knife, as shown in Figs. 16 and 17, shall be made, together with a suitable tool holder,

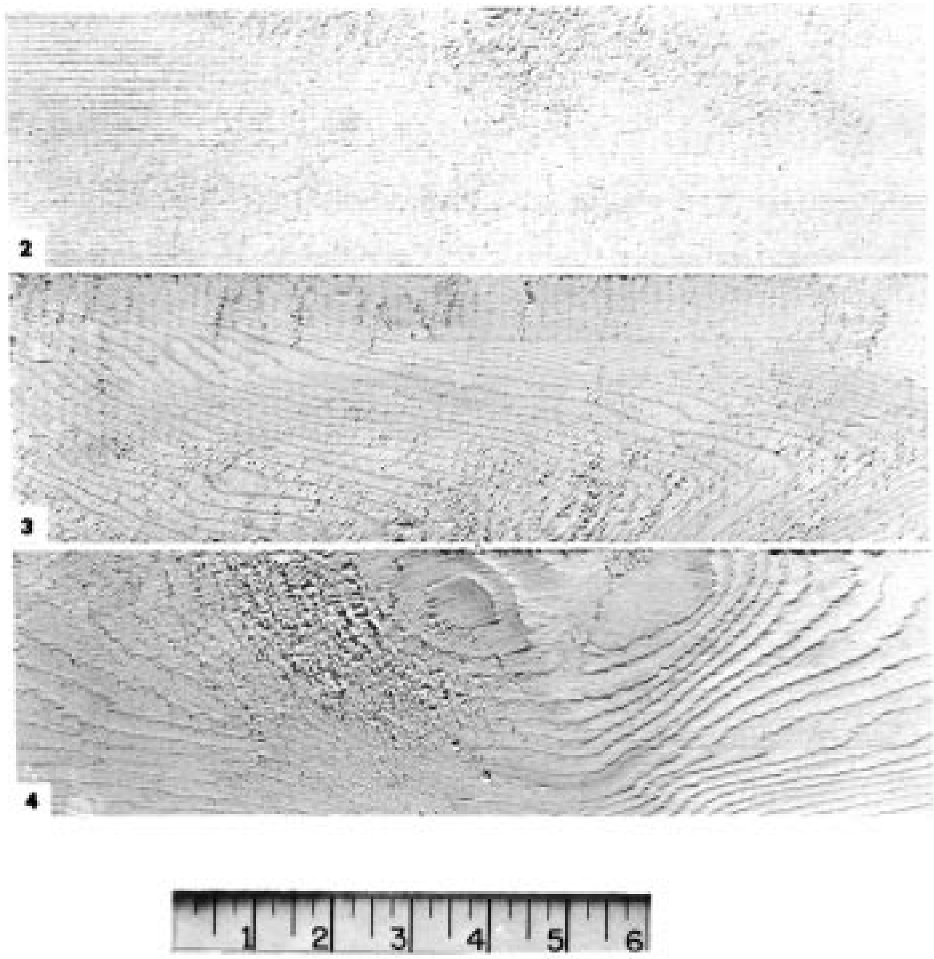


FIG. 8 Fuzzy Grain in Engelmann Spruce, Grades Nos. 2, 3, and 4

to hold this knife in place on the compound rest (Note 23). The knife may be hardened to reduce the amount of sharpening that will be necessary.

NOTE 23—The design of this knife embodies such turning features as the bead and the cove, as well as the ability to cut at different angles to the grain of the turning. The advantage is that it enables the operator to make several hundred rather complicated but uniform turnings in the course of a day's work. Fig. 18 shows the knife in operation with a half-completed turning. In this method, the cut is made on the lower side of the test specimen instead of at or slightly above the center line, as is customary in hand turning. This necessitates reversing the usual direction of rotation of the test specimen. In some belt-driven lathes this can be accomplished by twisting the belt. With some types of motor it can be accomplished by changing the wiring.

16.4 Lathe centers, like those shown in Fig. 18, are desirable if a large number of turnings are to be made. They are made with square recesses 3⁄8 in. (9.5 mm) deep which taper from 13⁄16 in. (21 mm) on the entrance end to 5⁄8 in. (16 mm) at the bottom. These automatically center the squares and hold them firmly against the thrust of the knife. The tail center at the right is ball bearing.

16.5 Number each by 0.75 by 5 in.-turning specimen (19 by 19 by 127 mm) near one end, where the mark will not be machined off.

16.6 Adjust the position of the knife to make turnings 3⁄8 in. (9.5 mm) thick at the thinnest point, using trial pieces to ensure correct size.

Test at 3200 r/min or as near thereto as possible. One of the two turning specimens from each board shall be at 6 % EMC and the other at 12 % EMC.

16.7 Grade the test specimen piece by piece making a record of all defects found on a scale of five, as in the previous machining operations. Average the results for both moisture contents and make comparisons based on the percentage of the two best grades. The common defects of turning are fuzzy grain, roughness, and torn grain.

16.8 Base the comparisons of turning properties on the proportion of Grades Nos. 1, 2, and 3 pieces present. Fig. 19 illustrates typical turning grades from the best to the poorest. In this instance, Grades Nos. 2, 3, and 4 are determined by different degrees of fuzzy grain and Grade No. 5 by tearouts and a broken corner.

NOTE 24—An apparent inconsistency results from basing planing quality on percentage of defect-free specimens, while shaping quality is based on percentage of Nos. 1, 2, and 3 specimens, and turning quality is based on percentage of Nos. 1, 2, and 3 specimens. This was done because those grades or combination of grades best reflected the spread between

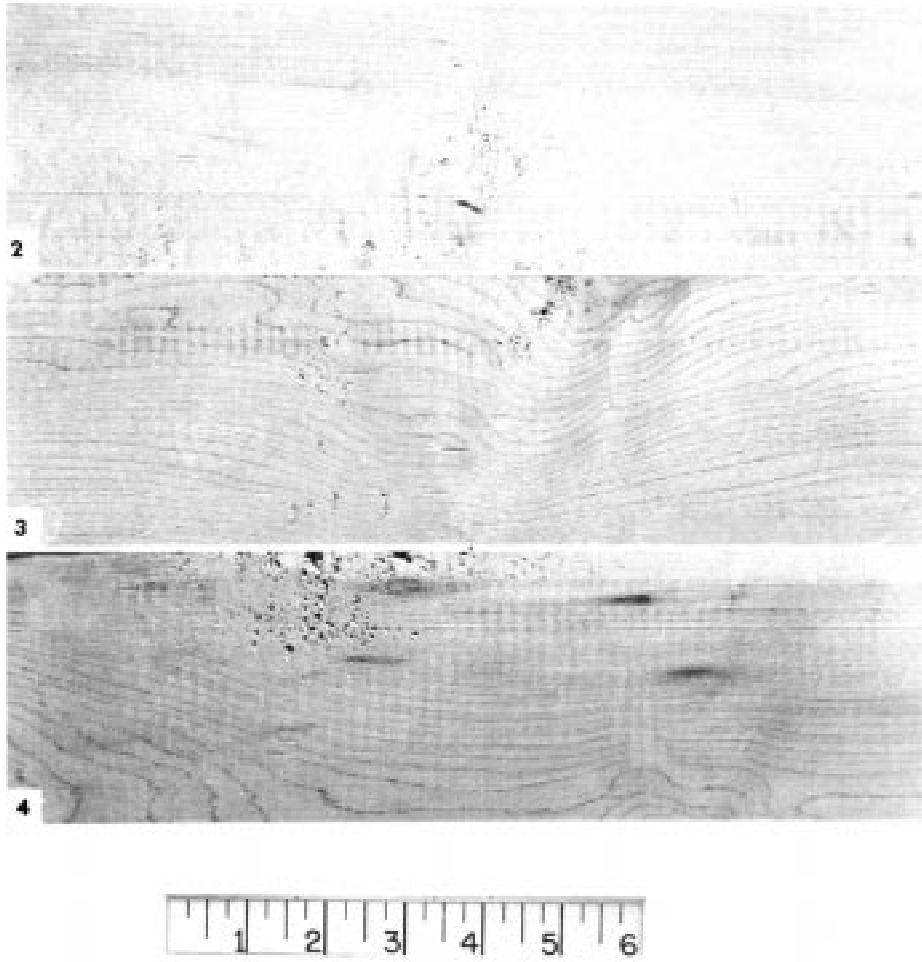


FIG. 9 Torn Grain in Hard Maple, Grades Nos. 2, 3, and 4

the best and the poorest of some 20 native hardwood species.

METHODS OF TESTING PARTICLEBOARD AND HARDBOARD

17. General Considerations

17.1 Although particleboard and hardboard can be machined with the same equipment used for machining lumber, the following differences should be kept in mind:

17.1.1 Since these panel materials, unlike lumber, are fabricated, their properties can be controlled to a considerable degree by controlling such factors as size and shape of the component particles and fibers, the degree of compression, and the amount of binder. In practice, this means that they are so engineered as to be suitable for the prospective use.

17.1.2 They are often concealed in use. Particleboard, for instance, is often used as core stock and faced with veneer, while hardboard is often faced with some plastic overlay. Edges may be covered with metal molding or with solid wood "banding." In such cases, smoothness of finish in the boards is less important than with finish lumber, and a lower quality of surface smoothness is generally adequate.

17.1.3 Particleboard and hardboard differ from lumber in their structure. Particleboard, as the name suggests, is made of small chips or particles, which often have fairly conspicuous voids between them. It may or may not have a definite "grain" direction depending on the manufacturing process that was used. Hardboard is made of wholewood fibers and fiber bundles produced by the same processes as mechanical pulps. It is without definite fiber orientation.

18. Sawing

18.1 Use a power-feed table saw equipped with a carbide-tipped saw blade with triple chip teeth followed by a raker. There should be 60 teeth for 10-in. (250-mm) diameter saws and 72 teeth for 12 and 14-in. diameter saws.

18.2 The speed shall be 3600 r/min, and the feed rate 40 to 50 ft (12 to 15 m)/min.

18.3 Adjust the saw to project approximately ¼ in. (6 mm) through the test material.

18.4 Use the saw cuts made in cutting the 2- by 4-ft boards (610 by 1220-mm) into smaller test specimens, as shown in Fig. 1, in the grading. Grade the particleboard for sharp edges and corners free from chipping. Grade the hardboard for chipping and fuzzing at the edges and for any tendency to spark during sawing.

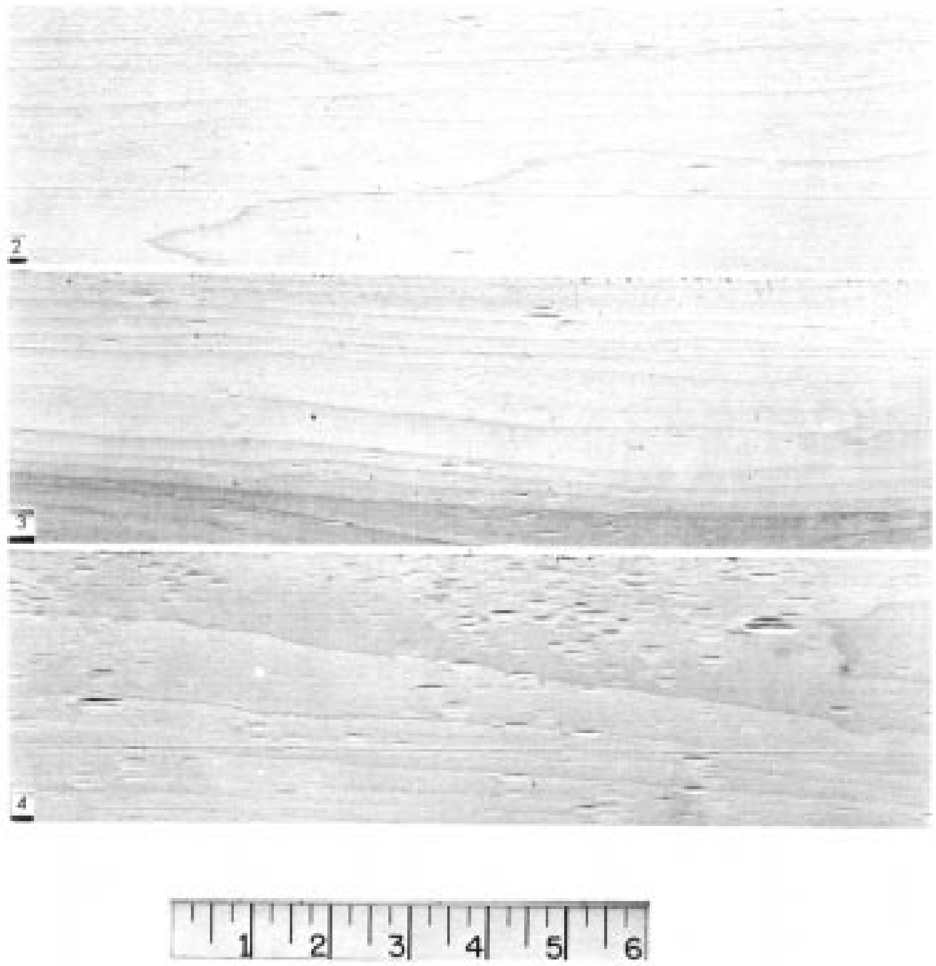


FIG. 10 Chip Marks in Yellow-Polar, Grades Nos. 2, 3, and 4

18.5 For particleboards made by the extrusion process, keep separate records for saw cuts parallel to the extruded direction and for saw cuts perpendicular to it.

NOTE 25—Particleboards of the extruded type possess a definite orientation of particles and must be machined in two directions, parallel to the extruded direction and perpendicular to it. Dividing the original 2 by 4-ft board (610 by 1220-m) in the middle and then sawing each half, as shown in Fig. 1, provides duplicate sets of specimens, one set for each direction.

On the other hand, boards of the conventional flat-press type now on the market with random orientation of particles have no such orientation in the plane of the board, and therefore adjacent edges machine alike. This is also true of hardboard. For this reason, half of a flat-press board or of a hardboard cut, as in Fig. 1, will suffice for the test described in this paragraph.

19. Planing

19.1 Use a cabinet planer or moulder with carbide-tipped knives at a 30-deg cutting angle.

NOTE 26—Much particle board is used for cores in furniture, cabinets, and similar applications in which a smaller thickness tolerance is required than is obtained in particleboard as it comes from the press. The object of planing is to provide a more uniform thickness and a surface that will glue readily. For use in cores, the smoothness of the planed surface may be of less importance than for exposed surfaces.

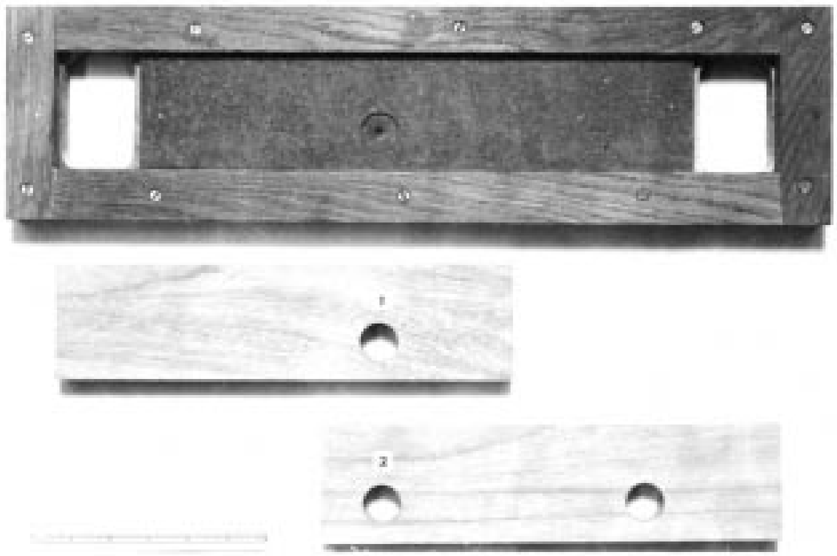
Hardboard is often faced on one side with a plastic laminate for counter tops or imprinted with a wood grain pattern for such uses as television cabinets. For such uses, uniformity of thickness is critical, and hardboard is often planed to obtain the required close tolerance. In most types of hardboard, a wire mesh pattern shows on one side and the planing is done on that side.

19.2 The test specimens shall be 6 in. by 2 ft (152 by 610 mm) cut as shown in Fig. 1.

19.3 Adjust the feed rate and cutterhead speed to give 20 knife cuts per inch (0.8 cuts per millimetre).

19.4 A depth of cut of 1⁄16 in. (1.6 mm) is recommended for general evaluation of homogeneous boards. For nonhomogeneous boards (boards with special faces or screen backs) or for special studies, a smaller depth of cut may be employed when and as needed to simulate requirements of specific applications. In all instances report the depth of cut used.

19.5 Examine the planed surface and grade for smoothness of cut and record the results.



NOTE 1—A type of boring jig to ensure that holes in all samples are spaced accurately and uniformly. The jig remains stationary. Hole No. 1 was bored with the sample at the extreme left end of the recess in the top of the jig. Hole 2 was bored after sliding the sample to the extreme right end of the jig.

FIG. 11 Boring Jig

19.6 For particleboards made by an extrusion process, keep separate records for cuts parallel to the extruded direction and for cuts perpendicular to it.

20. Sanding

20.1 See 12.1.

20.2 See 12.2.

20.3 The test specimens shall be 6 in. by 2 ft (152 by 610 mm), cut as shown in Fig. 1.

20.4 A depth of cut of 1⁄16 in. (2 mm) is recommended for general evaluation of homogeneous boards. For nonhomogeneous boards (boards with special faces or screen backs) or for special studies, a smaller depth of cut may be employed when and as needed to simulate requirements of specific applications. In all instances report the depth of cut used.

20.5 The feed rate shall be 12 to 24 ft (4 to 7 m)/min.

20.6 Examine the sanded surface, grade for smoothness of surface, and record the results.

NOTE 27—Sanding is another method frequently used to bring particleboard and hardboard to close thickness tolerance. Many types of particleboard are presanded at the origin before shipment. Sanding produces a smoother surface than planing because it avoids the tearouts often found in planed surfaces, particularly when planing across the grain. Neither planing nor sanding removes the voids that occur throughout the thickness of many particleboards. The sanding of hardboard is typically done on the mesh side and produces a smoother surface than planing, because it avoids knife marks.

20.7 For boards made by an extrusion process, keep separate records for cuts parallel to the extruded direction and for cuts perpendicular to it.

21. Shaping

21.1 The machine shall be a spindle shaper with carbide-tipped cutters operated at not less than 7200 r/min.

21.2 The knife pattern may be either in quarter round or, in the case of particleboard, a standard flooring tongue as desired, see Nos. 2 and 3 in Fig. 12.

21.3 The test specimen shall be 3-in. by 2-ft strips (76 by 610 mm), cut as shown in Fig. 1.

21.4 Make a preliminary roughing cut with particleboard to remove most of the excess material where the cut is deepest.

21.5 The final cut shall be 1⁄16 in. (1.6 mm) deep.

21.6 The cut shall be a straight line cut for the full length of the test specimen. Use a guide or fence of the conventional type when cutting.

21.7 Examine the shaped surface, grade for smoothness of cut, chipping, and fuzzing, and record the results.

NOTE 28—Although corners and edges of particleboard are not customarily exposed in use, they are sometimes shaped to receive metal fittings or for other reasons. When hardboard edges are exposed in use, they are often shaped with a quarter-round or half-round pattern.

21.8 For boards made by an extrusion process, keep separate records for cuts parallel to the extruded direction and for cuts perpendicular to it.

22. Routing

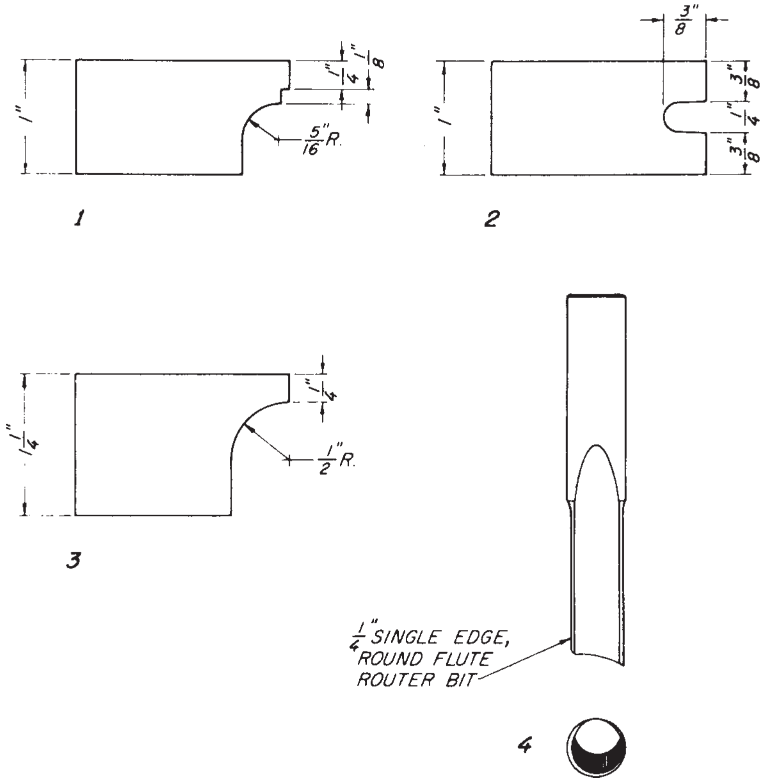
22.1 Use a high-speed router, preferably of the stationary type.

22.2 The carbide bit shall be the standard 1⁄4-in. (6 mm) single-fluted type without spiral as No. 4 in Fig. 11.

22.3 The test specimen shall be 3-in. by 2-ft strips (76 by 610 mm), cut as shown in Fig. 1.

22.4 The speed shall be 15 000 to 20 000 rpm.

22.5 Cut a groove 1⁄4 in. wide by 3⁄8 in. deep (6 by 10 mm) for particleboard and 1⁄8 in. (3 mm) deep for hardboard at 1⁄4 in. (6 mm) from the edge of the strips.



(*1*) Shaper knife used in cutting a pattern on the edge of lumber test specimens.
(*2*) Shaper knife used in cutting a tongue (for banding) on the edge of particleboard test specimens.
(*3*) Shaper knife used in cutting quarter-round pattern on the edge of particleboard test specimens.
(*4*) Type of bit used in routing tests with hardboard and particleboard.

NOTE 1—Change fractions to decimals.

METRIC EQUIVALENTS

in.	⅛	¼	3⁄16	⅜	½	1	1¼
decimal	0.125	0.250	0.312	0.375	.0500	1.00	1.25
cm	0.32	0.63	0.79	0.95	1.27	2.5	3.2

FIG. 12 Cutting Tools Used in Certain Machining Tests

22.6 The groove shall be a straight line cut for the full length of the test specimen. Use a guide or fence of the conventional type when cutting.

22.7 Examine the groove, and grade it for breakouts, sharp corners, chipping, fuzzy edges, and general smoothness of cut.

22.8 For particleboards made by the extrusion process, keep separate records for cuts parallel to the extruded direction and cuts perpendicular to it.

23. Drilling

23.1 Preferably, test with a single-spindle electric machine equipped with power feed.

23.2 Use a ⅛-in. (9.5-mm) twist drill with a 120° point.

23.3 The test specimen shall consist of five 3 in. by 2-ft strips (76 by 610 mm), cut as shown in Fig. 1.

23.4 In particleboard, drill a series of five holes 1 in. (25 mm) deep in the center of the edge of each specimen.

23.5 In hardboard, drill the holes through each specimen at ¼ in. (6 mm) from the edge into a hardwood backing.

23.6 The spindle speed shall be 3500 r/min.

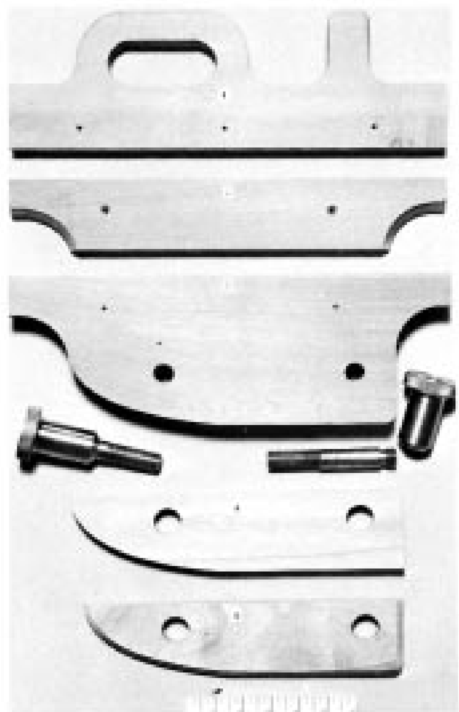
23.7 Examine the holes and grade them for chipping, fuzzing, thickening of the edges, and general smoothness of cut.

23.8 For particleboard made by the extrusion process, keep separate records for holes bored parallel to the grain and for holes bored perpendicular to it.

24. Evaluation of Machining Defects

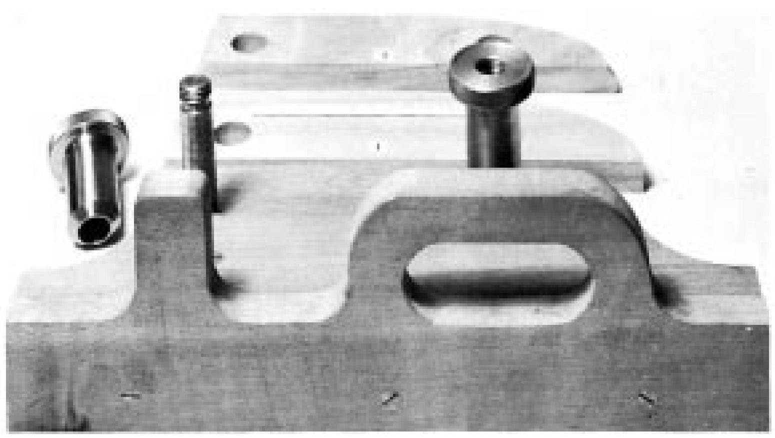
24.1 Promptly upon the completion of a test, visually examine each test specimen carefully for raised, torn, or fuzzy grain, or any other machining defect. When a specimen is defect-free, it shall be so recorded. To give a quantitative measure, give a numerical grade to each defect found to indicate whether it is present in a slight, medium, or advanced degree. The technique is fully described in Sections 11-23 (Note 29). Record all results on prepared forms (see sample form in Fig. 5).

NOTE 29—The quality of a machined surface depends not only upon the frequency of occurrence of machining defects but also upon the severity of any defects that may be present. From the finishing standpoint, the area



NOTE 1—Board No. 1 serves as a handle for guiding the jig past the cutterhead; No. 2 provides a backing during the cutting operation; No. 3 serves as the base; No. 4 is a test specimen that has been band sawed; and No. 5 is a test specimen that has been both band sawed and shaped.

FIG. 13 Type of Jig (Disassembled) Used in Shaping Test



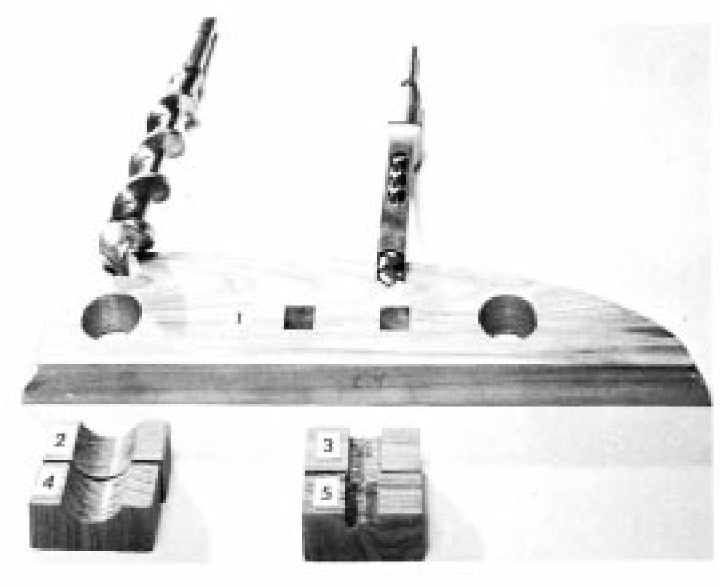
NOTE 1—Test specimen No. 1 has been band sawed, and specimen No. 2 has been both band sawed and shaped.

FIG. 14 Type of Jig (Assembled) Used in Shaping Test

covered by a given defect is usually less important than its depth. The worst point in a defective sample determines its quality, because it determines the amount of additional finishing work that must be done to make it commercially acceptable.

25. Precision and Bias

25.1 No statement is made about either precision or bias of the test results since they represent subjective and comparative classification characteristics based on visual examination.

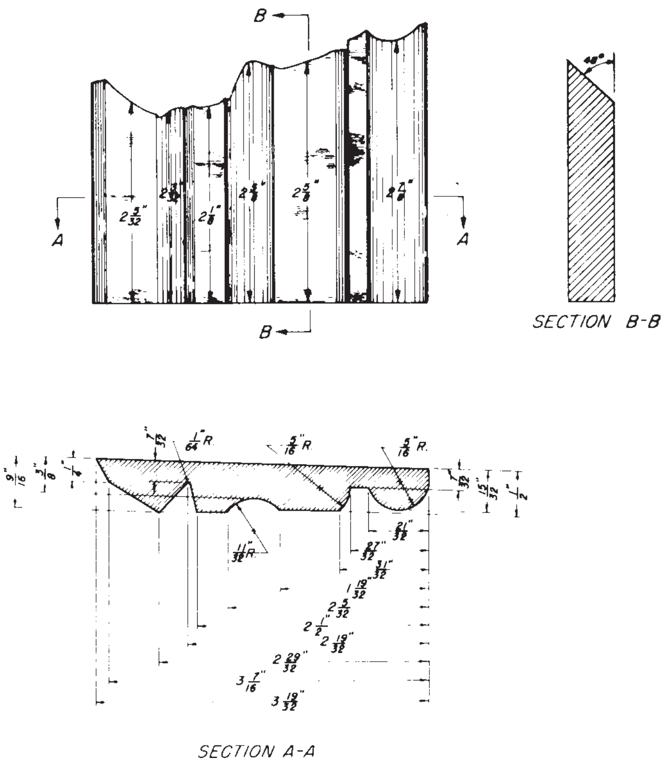


NOTE 1—Test specimen No. 1 has been shaped, bored, and mortised. The 1-in. bit and the ½-in. hollow chisel used in the boring and mortising tests are shown, together with views of the inside of the cuts made by these tools. Test specimen Nos. 2 and 3 have side-grain cuts, while Nos. 4 and 5 have end-grain cuts.

FIG. 15 Machined Test Specimens

NOTE 1—The top view shows a type of one-piece knife used in the turning test; the bottom, a cross section of a knife; and the center, a finished turning in oak.

FIG. 16 Knife Used in the Turning Test



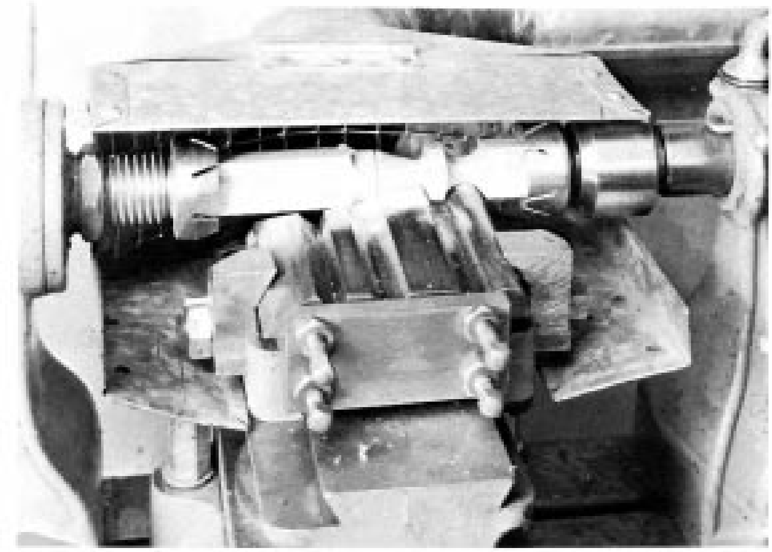
NOTE 1—Top left, general view of knife. Section A-A, cross section of the knife showing radii and angles. Section B-B, cross section showing cutting bevel. It is very important to note that Section B-B cannot possibly describe the sharpening angle for the entire cutting contour as shown in Section A-A. The clearance angle for the entire cutting contour is so complicated as to be impractical to describe in a drawing of this type. A cast epoxy model of this knife will be furnished to any interested party. Address request to U.S. Forest Products Laboratory. P.O. Box 5130, Madison, WI 53705.

NOTE 2—Change all fractions to decimals.

METRIC EQUIVALENTS

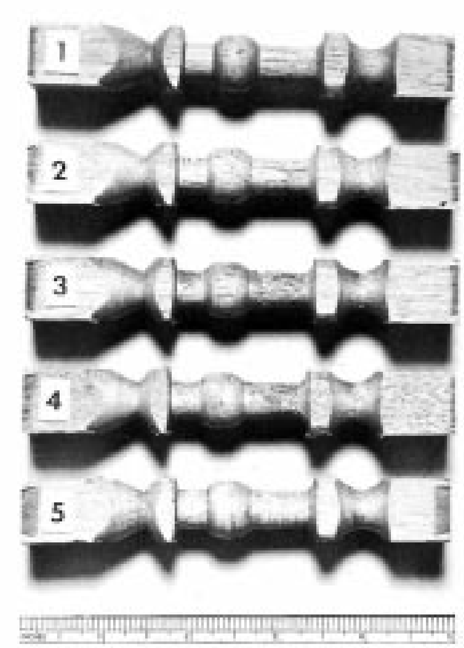
in.	decimal	cm	in.	decimal	cm
1/64	0.156	0.04	27/32	0.844	2.14
7/32	0.219	0.56	31/32	0.969	2.46
1/4	0.250	0.63	1 19/32	1.594	4.05
5/16	0.312	0.79	2 3/32	2.094	5.32
11/32	0.344	0.87	2 1/8	2.125	5.40
3/8	0.375	0.95	2 5/32	2.156	5.48
15/32	0.469	1.19	2 1/2	2.500	6.35
1/2	0.500	1.27	2 19/32	2.594	6.59
9/16	0.562	1.43	2 5/8	2.625	6.67
21/32	0.656	1.67	2 7/8	2.875	7.30
			2 29/32	2.906	7.38
			3 7/16	3.437	8.73
			3 19/32	3.594	9.13

FIG. 17 Diagram of One-Piece Turning Knife



NOTE 1—The special lathe centers are shown, together with an optional exhaust system for carrying away the chips.

FIG. 18 One-Piece Knife Mounted in the Compound Rest With a Partly Completed Turning



NOTE 1—Each number shows the grade of the turning under consideration.

FIG. 19 Grades of Turnings

APPENDIX

X1. DEFINITIONS AND DESCRIPTIONS OF TERMS

chip marks—shallow dents in the surface caused by shavings that have clung to the knives instead of passing off in the exhaust as intended.

clearance angle—See Fig. 4 and explanation in text.

cutting angle—See Fig. 4 and explanation in text.

cutting level—See Fig. 4 and explanation in text.

cutting circle—See Fig. 4 and explanation in text.

feed rate—the rate measured in feet (metres) per minute at which material is passing through a machine.

fuzzy grain—small particles or groups of fibers that did not sever clearly in machining but stand up above the general level of the surface.

hardboard—a fibrous-felted homogeneous or laminated panel having a density range of approximately 31 to 81 lb/ft^3 (500 to 1300 kg/m^3), manufactured under carefully controlled optimum combinations of consolidating pressure, heat, and moisture so that a softening of lignin occurs, and the board produced has a characteristic natural ligneous bond to which other materials may have been added during manufacture to improve certain properties.

hardwoods—generally one of the botanical groups of trees that have broad leaves in contrast to the conifers. The term has no reference to the actual hardness of the wood.

jointing—equalizing the projection of all the knives in the cutterhead. It is performed by bringing a sharpening stone into contact with the knife edges while the cutterhead revolves.

land (*or heel*)—the part of the cutting edges of the knives that comes into contact with the sharpening stone in the jointing operation. The land conforms to the cutting circle and has no clearance.

lumber—the product of the saw and planing mill not further manufactured than by sawing, resawing, passing lengthwise through a standard planing machine, crosscutting to length, and matching.

lumber, edge-grained—lumber so sawed that the annual rings form an angle of 45 to 90° with the surface of the piece.

lumber, flat-grained—lumber so sawed that the annual rings form an angle of less than 45° with the surface of the piece.

particleboard—a panel material composed of small discrete pieces of wood or other ligno-cellulosic materials that are bonded together in the presence of heat and pressure by a synthetic resin adhesive. Particleboards are further defined by the method of pressing. When the pressure is applied in the direction perpendicular to the faces, as in a conventional multi-platen hot press, they are defined as flat-platen pressed, and when the applied pressure is parallel to the faces, they are defined as extruded.

raised grain—a roughened condition of the surface of lumber in which the hard summerwood is raised above the soft springwood but not torn loose from it.

rings, annual—the annual growth layer as viewed on a cross-section of a stem, root, or branch.

softwoods—generally one of the botanical groups of trees that, in most cases, have needle or scale-like leaves; the conifers; also the wood produced by such trees. The term has no reference to the actual hardness of the wood.

speed, cutterhead—the rate measured in revolutions per minute at which a cutterhead is turning.

speed, rim—the rate measured in feet (metres) per minute at which the periphery of a cutting tool (usually a saw) is turning.

torn grain—that part of the wood torn out in dressing.

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