Designation: D1666 – 17

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

This standard is issued under the fixed designation D1666; 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 and wood-base panels is the facility with which they can be machined and fabricated. Different species and products, 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 applications 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 test methods cover such common operations as planing, routing/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 panel materials, such as plywood, particleboard, fiberboard, and hardboard.

1. Scope

1.1 These test methods cover procedures for planing, routing/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 such as plywood and wood-base fiber and particle panels.

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 or wood-base panel. 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 test 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 The values stated in inch-pound units are to be regarded as the standard. The metric equivalents of inch-pound units may be approximate.

1.6 *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.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*

[1] These test methods are under the jurisdiction of ASTM Committee D07 on Wood and are the direct responsibility of Subcommittee D07.01 on Fundamental Test Methods and Properties.

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D9 Terminology Relating to Wood and Wood-Based Products
D1038 Terminology Relating to Veneer and Plywood
D1554 Terminology Relating to Wood-Base Fiber and Particle Panel Materials
D4442 Test Methods for Direct Moisture Content Measurement of Wood and Wood-Based Materials
D4933 Guide for Moisture Conditioning of Wood and Wood-Based Materials
D7438 Practice for Field Calibration and Application of Hand-Held Moisture Meters

3. Terminology

3.1 For definitions of terms used in this standard, refer to Terminology D9, D1038, and D1554.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *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.

3.2.2 *planer knife clearance angle*—planer cutterhead knife angle *(c)* depicted for both knife alternatives in Fig. 1.

3.2.3 *planer knife cutting angle*—planer cutterhead knife angle *(a)* depicted for both knife alternatives in Fig. 1.

3.2.4 *planer knife cutting bevel*—planer cutterhead knife bevel angle *(b)* depicted for Knife Alternative 2 in Fig. 1.

3.2.5 *planer knife cutting circle*—the circumference *(d)* defined by the outer limits of the planer knives of a cutterhead and depicted in Fig. 1.

3.2.6 *computer numeric controller (CNC) machine*—a computer automated machine center often used to machine wood and wood-based panel materials that are typically integrated with drafting software and may have the capabilities to perform machining activities that include cutting, routing, drilling, shaping, and turning.

3.2.7 *feed rate*—the resultant rate of movement measured in feet (metres) per minute at which material moves through a machining tool that includes the combination of machining tool and material motion.

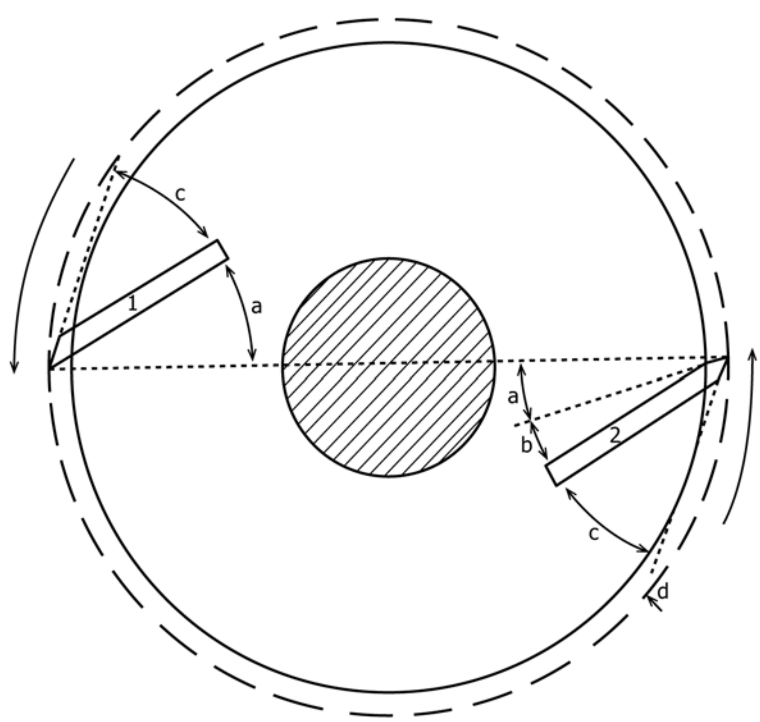
3.2.8 *fuzzy grain*—small particles or groups of fibers that did not sever clearly in machining but stand up above the general level of the surface.

3.2.9 *jointing*—an equalization of the projection of all the knives in the cutterhead performed by bringing a sharpening stone into contact with the knife edges while the cutterhead revolves.

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

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

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



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

FIG. 1 Terms Used in Connection with Planer Knives

4. Significance and Use

4.1 Machining tests are made to determine the working qualities and characteristics of different species of wood and of different wood-based panel materials under a variety of machine operations such as are encountered in commercial manufacturing practice. The tests provide a systematic basis for comparing the behavior of different products with respect to woodworking machine operations and of evaluating their potential suitability for certain uses where these properties are of prime importance.

5. Apparatus

5.1 *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 1). Complete information on the machine used, the cutting tool, and the operating conditions of each test shall be made part of the record.

NOTE 1—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.

5.2 *Feed Rates*—While either automated or manual feed machines may be used, preference shall be given to machines with automated feed systems. To the extent possible, the feed rates used for the tests shall be chosen to correspond with the desired cutting conditions that will be employed for production. The feed rates and cutting conditions shall be kept constant throughout each test type and reported.

5.3 *Knives and Cutters*—Insert tooling or one-piece cutters may be used for testing. 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, manufacturer, and any relevant grade information shall be made part of the record. Every precaution shall be taken to keep the sharpness uniformly good in all tests by resharpening or replacing the knives and cutters when necessary.

NOTE 2—A practical measure of the deterioration of a machined lumber surface because of dulling of the cutting tool can be obtained by the use of two check samples. They should come from the same board of some species that machines exceptionally well, such as maple or any other closed-grain species. 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, should 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 or replaced.

Similarly with wood-base panels, some well-known product that has good machining properties may be used as a control material for comparison.

NOTE 3—Whenever possible, preference should be given to carbide insert tooling (Fig. 2). Carbide insert tools are inexpensive and can be readily replaced in the tool holder. Replacing the tooling in place of resharpening will increase the repeatability of the method. Tooling manufactures have tables of recommended carbide tooling for the various wood-based products. Preference should be given to the grade and type of tooling recommended. Experience has shown that there can be a difference in performance between carbide tools produced by different manufacturers.

FIG. 2 Illustration of a Router Head With Insert Tooling

6. Shipment and Protection of Samples

6.1 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.

7. General Requirements of Samples

7.1 The tests shall primarily be made on seasoned material brought to an equilibrium moisture content in a conditioned environment of 68 ± 11°F (20 ± 6°C) and 65 % (±5 %) relative humidity. Methods for determination of completion of conditioning are given in Guide D4933. Alternative conditioning may be specified provided that it is recorded.

7.2 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.

7.3 Wood-base panel 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. Wood-base panels shall be typical of the product under consideration as they are manufactured and marketed. For the sanding tests, the wood-base panel 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 sanding is done.

7.4 Test samples of lumber shall be so selected as to exclude extremely high or low ring counts per inch (average ring width per millimetre) that are not typical of the species under consideration.

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.

8. Dimensions, Weight, and Moisture Content of Samples

8.1 Samples must be large enough to yield the minimum acceptable size (0.75 by 5 in. by 4 ft) (19 by 127 mm by 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.

8.2 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.

8.3 Wood-base panel test material shall be typical in dimensions and weight of the products under consideration as they are manufactured and marketed.

8.4 The moisture content of a representative sampling of test material shall be determined and recorded. The moisture content of sawn lumber materials shall be determined using either the oven dry method of Test Methods D4442 or a hand-held meter in accordance with Practice D7438. If a pin-type hand-held meter is used to determine the moisture content prior to machining, then the moisture content reading shall be taken away from the surface that will be machined. The moisture content of composite materials shall be determined in accordance with Test Methods D4442.

9. Sampling

9.1 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.

9.2 For each type of wood-base panel tested, five samples (Note 8) shall be selected, one from each of five different sheets. The size of these samples (Fig. 3) shall be 2 by 4 ft (0.6 by 1.2 m), and the thickness in different products shall be as manufactured (Note 9).

NOTE 8—Wood-base panels from 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 9.2 are 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. (19 mm), a sufficient number of pieces shall be laminated together to provide the 0.75-in. (19-mm) thickness.

10. Preparation of Test Specimens from Lumber

10.1 Each different test has its own procedure as described in Sections 12 – 17. The following steps in preparing the test specimens apply to all tests with lumber:

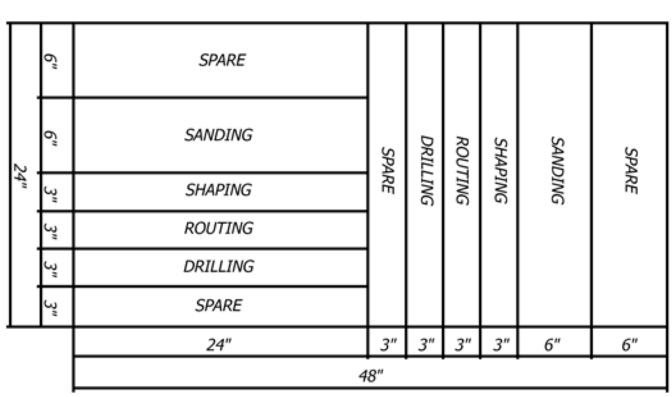
10.1.1 Mark each board, nominal 1 by 5 in. by 4 ft (25 by 127 mm by 1.2 m) to identify adequately the species source and individual sample.

10.1.2 Cut a 0.5-in. (13-mm) cross section from one end of each nominal 1 by 5 in. by 4 ft (25 by 127 mm by 1.2 m) board for specific gravity determinations and for counting the number of annual rings per inch (average ring width in millimetres) (Note 5).

10.1.3 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).

10.1.4 Saw the boards into the specified smaller sizes for the different tests as shown in Fig. 4. 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. The specimen for routing/shaping, boring, and mortising (Fig. 4) shall be accurately cut to size to ensure proper positioning. The turning specimens also shall be accurate since they have to fit special lathe centers.

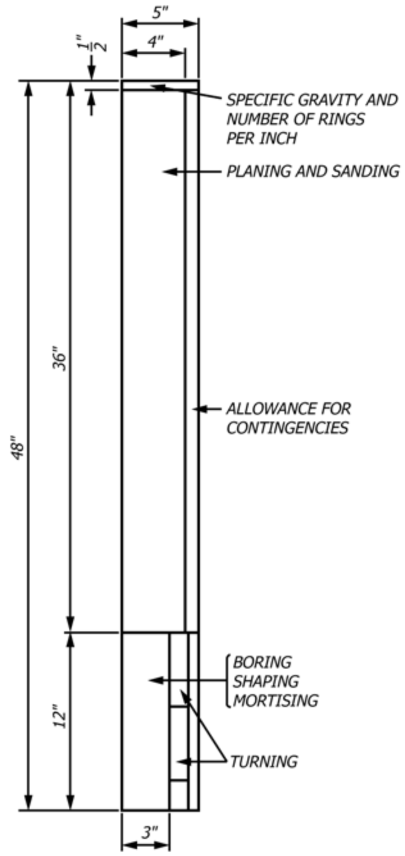
NOTE 10—The size of the planing specimen is not critical and, if necessary, it may be 1 in. (25 mm) or so short of the specified 3 ft (0.9 m) without serious objection.



METRIC EQUIVALENTS

in.	3	6	24	48
mm	76	152	610	1220

FIG. 3 Diagram for Sawing Wood-Base Panel Samples into Smaller Samples for Individual Tests



METRIC EQUIVALENTS

in.	½	3	4	5	12	36	48
mm	13	76	102	127	305	910	1220

FIG. 4 Diagram for Sawing Lumber Samples into Smaller Samples for Individual Tests

11. Preparation of Specimens from Wood-Base Panels

11.1 Each different test has its own procedure as described in Sections 19 – 22. The following steps in preparing the test specimens apply to all tests with wood-base panels:

11.1.1 Mark each 2 by 4-ft (0.6 by 1.2 m) board to identify the source and the individual sample.

11.1.2 Saw each of the original wood-base panel samples into smaller sizes for the different tests as shown in Fig. 3.

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

METHODS OF TESTING LUMBER

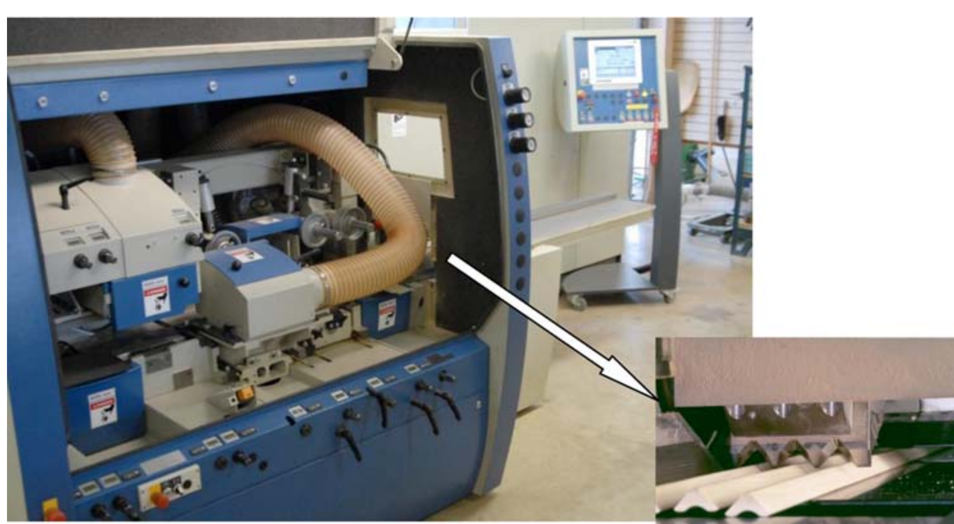
12. Planing

12.1 A moulder (Fig. 5) 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.

12.2 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. (0.79 mm) wide, as a result of repeated jointings, the knives shall be reground before continuing with the test. Provided that the feed rates are adjusted to maintain the required knife marks per inch as outlined in 12.8, it shall also be acceptable to use a single knife finish instead of a jointed knife finish.

12.3 All specimens used in this test (50 per species) shall be 0.75 by 4 in. by 3 ft (19 by 102 mm by 0.9 m).

12.4 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.



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 two or more cutterheads to permit machining up to four sides with one pass. In planing tests, however, only one cutterhead is used, the bottom head equipped with straight blades.

FIG. 5 Desirable Type of Machine for Use in Planing Tests

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

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

NOTE 11—It is suggested that alternative cuts be made on opposite faces to avoid cupping from the release of interior stress.

12.7 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.

12.8 *Cutting Angles and Knife Mark Frequencies*—The cutting angles and knife mark frequencies used for the testing shall be as required to satisfy the test objectives:

12.8.1 *Optimization Testing*—If the goal of the test program is to optimize the cutting angle or knife mark frequency, or both, then make four runs with knives at cutting angles of 15, 20, 25, and 30°. The feed rates and cutterhead speeds for these tests shall be adjusted to give 20 knife marks/in. (0.8/mm). Three additional runs shall then be made with a fixed 20° cutting angle. Feed rates and cutterhead speeds for these additional runs shall be adjusted to give 8, 12, and 16 knife marks/in. (0.3, 0.5, and 0.6 knife marks/mm).

12.8.2 *Representative Testing*—If the cutting angle and knife mark frequency are recommended by the tooling manufacturer or otherwise known, then make four runs using the known conditions. The cutting angle and knife mark frequency used for the test shall be recorded.

NOTE 12—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. 1. This means one cutterhead with, say, four sets of knives back-bevelled at four different degrees achieves four different cutting angles.

NOTE 13—Where each knife in the cutterhead is doing its share of the work, the number of knife marks per inch (millimetre) should agree with the following formula:

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

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

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 using a datasheet as shown in Fig. 6, where the numbers in the column refer to the grade of the specific defect under consideration.

12.9 Visually examine each test specimen carefully for planing defects after each run (Note 14). For each specimen, grade any planing defect that may be present according to degree and record on prepared forms (Note 15). 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
Grade 4, poor
Grade 5, very poor

NOTE 14—The runs described in Section 12 cover the more critical conditions. If additional runs are desired for any reason, additional test material will be needed.

NOTE 15—The characteristic of black walnut with respect to planing qualities is illustrated by Grades Nos. 1 and 5 in Fig. 7. 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 a defect that is 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 (millimetre) 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. 8-11 show the intermediate grades, Nos. 2, 3, and 4, which may be considered as slight, medium, and advanced degrees.

12.10 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 shall be kept in mind: (*1*) Consecutive grades merge gradually without any abrupt change in quality or any sharp dividing line, and (*2*) Any given grade is not completely uniform in quality, but has some range between the best and the poorest examples within the grade.

13. Sanding

13.1 The machine shall preferably be either a two-head, wide-belt sander or a drum sander. If neither of these machines are available, then the machine used shall be reported including the type of roll or drum employed. Conduct the sanding operation using a contact roll or drum. Report the roll or drum hardness in Shore A durometer units. Do not use a stroke sanding machine.

13.2 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.

13.3 Feed rates shall be on the order of 20 ft/min (6100 mm/min) or representative of the proposed production conditions.

13.4 The depth of cut shall be 1⁄16 in. (1.2 mm).

13.5 The test specimens (50 per species) shall be 5⁄16 by 4 in. by 1 ft (8 by 102 mm by 0.3 m) cut from the 5⁄16-in. (8 mm) material left after the planing test.

13.6 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.

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. 6 Sample Data Sheet Used in Planing Test

14. Boring

14.1 The borer shall be a single-spindle electric machine equipped with power feed. The preferred option is to use a drill bit mounted on a computer numeric controlled (CNC) router. If necessary, a manual machine with hand or foot feed may be used.

14.2 The bit shall be a 1-in. (25-mm) size of the single-twist, solid-center, brad-point type (Fig. 12). Sharpen it lightly at intervals of not more than 1 h of work.

14.3 The test specimens shall measure 0.75 by 3 by 12 in. (19 by 76 by 305 mm).

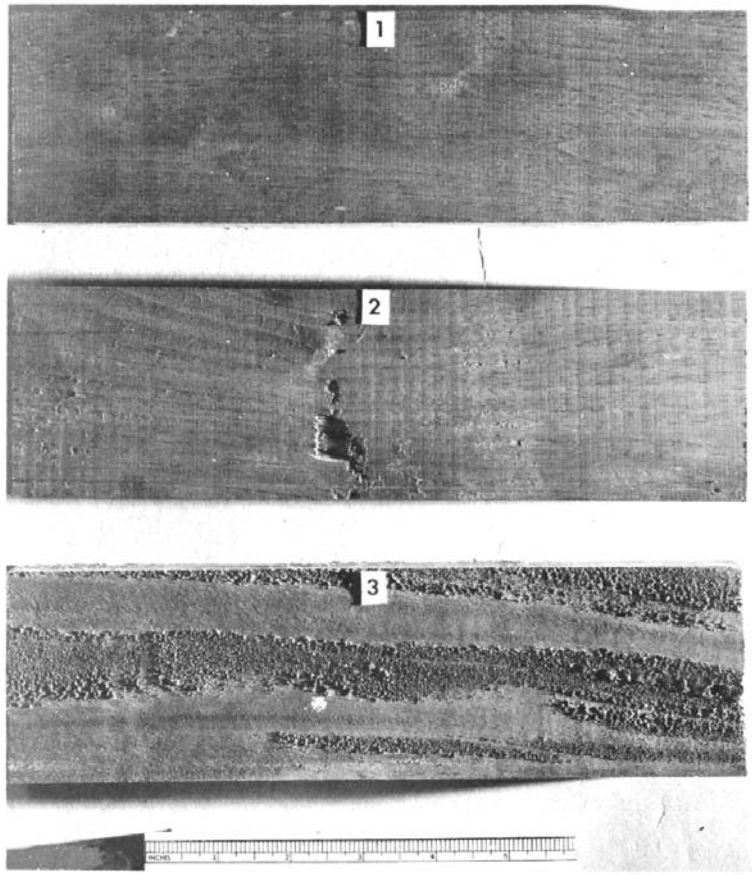
14.4 The borer shall be run at a spindle speed of 3600 r/min.

14.5 The rate of boring shall be consistent between specimens and low enough to enable the drill to cut rather than tear through the specimen.

14.6 Bore two holes through each specimen.

NOTE 16—The same specimens are used for three different tests, first for boring, then for router/shaping, and finally for mortising. If a CNC router is used for these tests, then they can be done sequentially while the specimen is mounted on a router table.

14.7 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 17) on



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

FIG. 7 Planing Grades Nos. 1 and 5

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 17—In tests with 23 North American 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.

15. Routing/Shaping

15.1 The machine shall be a commercial size computer numeric controlled (CNC) router with a feed system capable of at least 20.8 ft/min (6350 mm/min) and a spindle speed of at least 15 000 revolutions per minute.

NOTE 18—While shapers are designed primarily to cut patterns on curved surfaces, such as a quarter-round pattern on the edge of a round table top, routers are capable of cutting the same patterns on straight or curved surfaces. Routers are also capable of doing it automatically with a machine controlled feed speed and movement pattern. For these reasons, the standard was updated to use a router as the recommended machine for this testing. The results are judged applicable to shapers operated with similar feed and spindle speeds.

15.2 The knives shall be ground as shown in No. 1, Fig. 13, and maintained in good cutting condition.

15.3 The test specimens (50 for each species) shall be 0.75 by 3 by 12 in. (19 by 76 by 305 mm) in size.

15.4 Make a preliminary roughing cut with the router to approximate the shape shown in Fig. 12. The edge of the blanks are parallel for half of their length, while the remainder of the length is a parabola. Take care to cut with the grain as far as possible. Make a second clean up cut with the router prior to making the edge pattern as this will ensure that any damage to the edge due to the rough cut is removed (Note 19).

NOTE 19—The blank for this test can be fastened onto the router table in any number of ways depending upon the capability of the router. It can be held through a vacuum, vacuum pods, gaskets, or screwed to the spoil board. If screws are used, then they should be carefully placed to avoid interfering with the other tests that use the same specimen.

15.5 Make a finishing cut 1⁄16 in. (1.6 mm) deep using a spindle speed of not less than 15 000 revolutions per minute and a feed speed of not less than 20.8 ft/min (6350 mm/min).

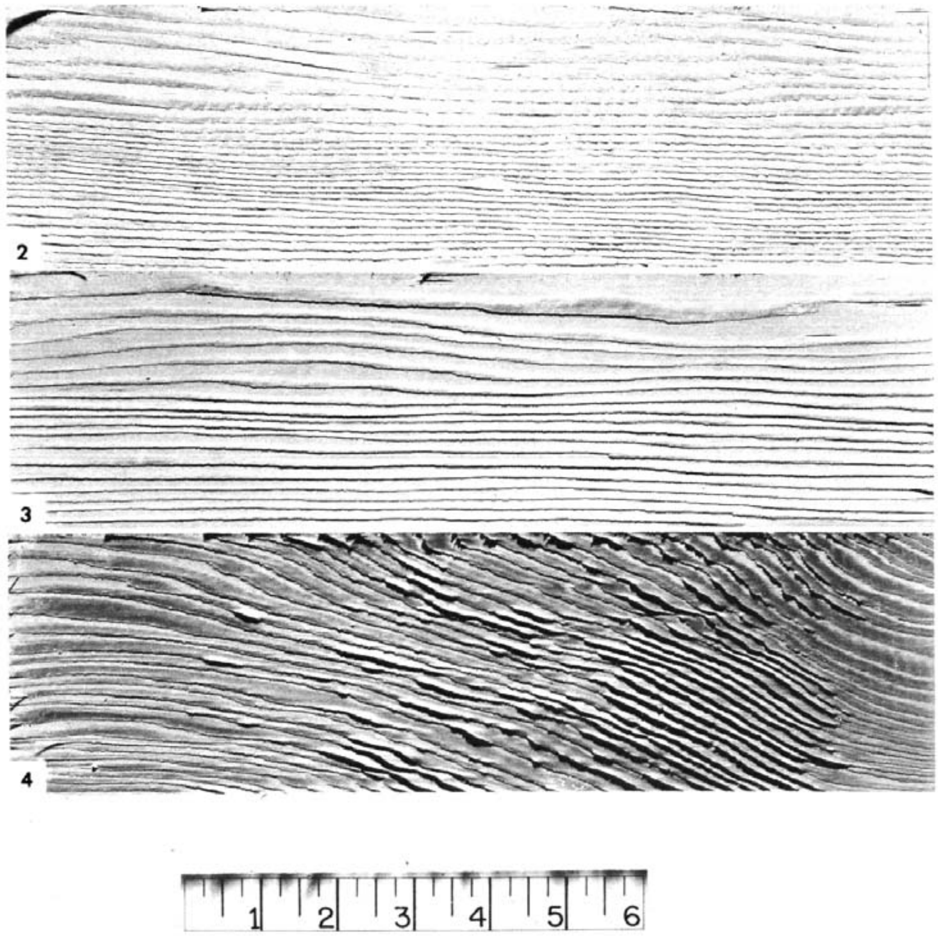


FIG. 8 Raised Grain in Douglas-Fir, Grades Nos. 2, 3, and 4

15.6 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.

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

16. Mortising

16.1 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.

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

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

16.4 Use the same specimens used for the routing/shaping and boring tests also for mortising (see Fig. 12).

16.5 Operate the machine at a spindle speed of 3600 r/min.

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

16.7 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.

16.8 Grade all mortises (Note 20) 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 20—In tests with 23 North American hardwoods, a measurable variation between species was found for differences between the size of the hollow chisel used and the size of the mortise formed. 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.

17. Turning

17.1 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.

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

17.3 The testing may be completed using either the custom one-piece knife of 17.3.1 or a series of knives as indicated in 17.3.2.

17.3.1 A one-piece, milled-to-pattern knife, as shown in Figs. 14 and 15, shall be made, together with a suitable tool

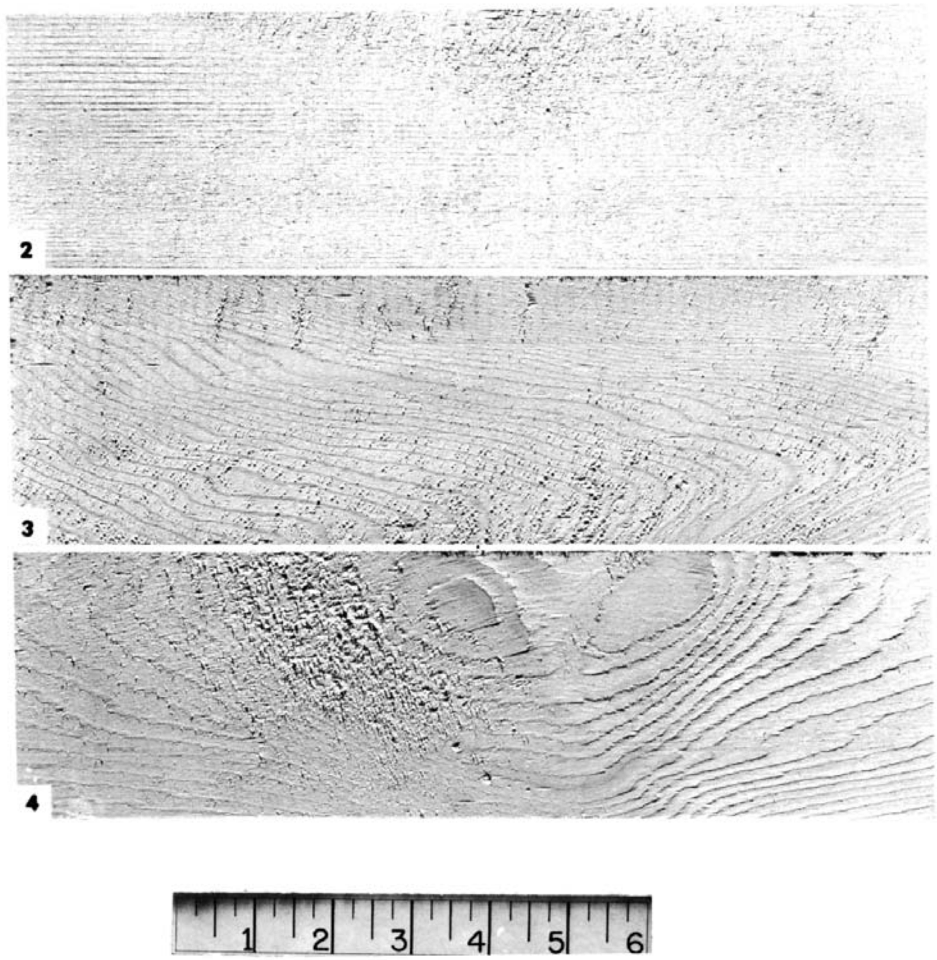


FIG. 9 Fuzzy Grain in Engelmann Spruce, Grades Nos. 2, 3, and 4

holder, to hold this knife in place on the compound rest (Note 21). The knife may be hardened to reduce the amount of sharpening that will be necessary.

NOTE 21—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. 16 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.

17.3.2 A series of lathe tools may be used to create a cove, bead, straight cut (90°), and an angle cut (45°). The tools selected shall result in a profile similar to that depicted in Fig. 14 and Fig. 15. The tools will be placed in a compound holder one at a time to create the respective geometry.

17.4 Lathe centers, like those shown in Fig. 16, are desirable if a large number of turnings are to be made. They are made with square recesses ⅜ in. (9.5 mm) deep which taper from 13⁄16 in. (21 mm) on the entrance end to ⅝ 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.

17.5 Number each 0.75 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.

17.6 Adjust the position of the knife to make turnings ⅜ in. (9.5 mm) thick at the thinnest point, using trial pieces to ensure correct size.

17.6.1 Test at 3200 r/min or as near thereto as possible.

17.7 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 and make comparisons based on the percentage of the two best grades. The common defects of turning are fuzzy grain, roughness, and torn grain.

17.8 Base the comparisons of turning properties on the proportion of Grades Nos. 1, 2, and 3 pieces present. Fig. 17 illustrates typical turning grades from the best to the poorest. In

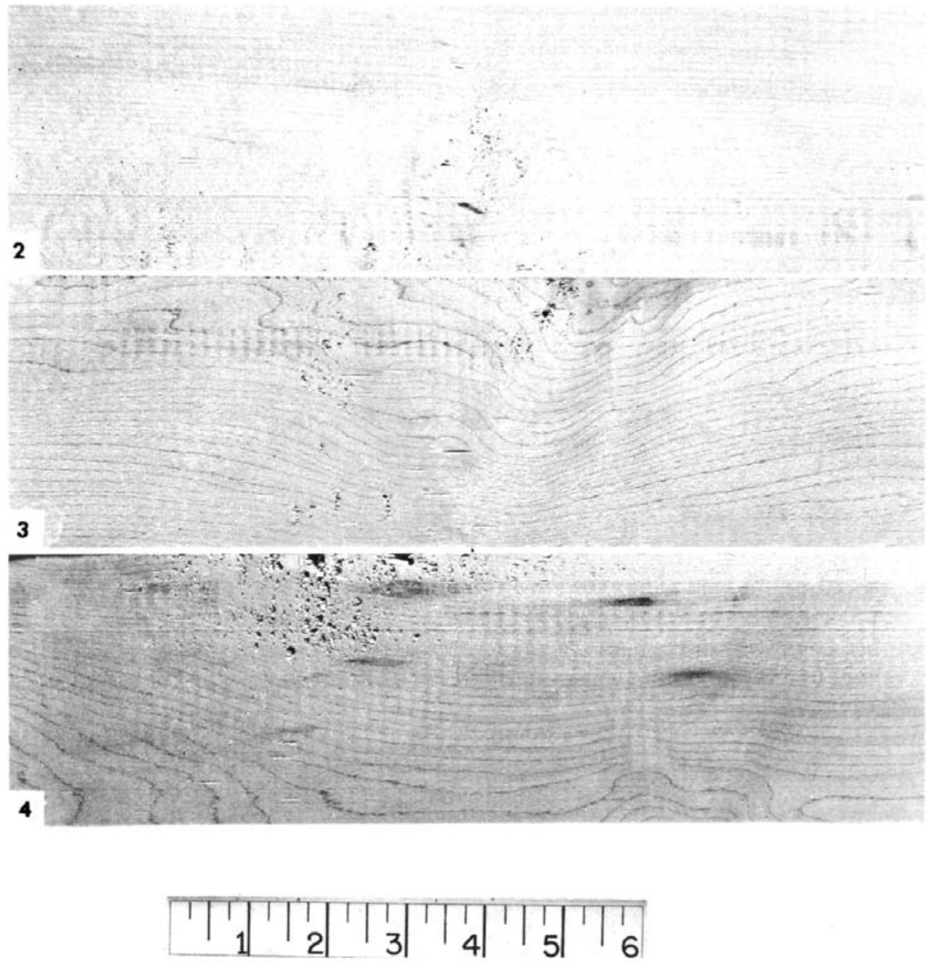


FIG. 10 Torn Grain in Hard Maple, Grades Nos. 2, 3, and 4

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 22—An apparent inconsistency results from basing the planing quality on percentage of defect-free specimens, while router/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 the best and the poorest of some 20 North American hardwood species.

METHODS OF TESTING WOOD-BASE PANELS

18. General Considerations

18.1 Although wood-base panels can be machined with the same equipment used for machining lumber, the following differences should be kept in mind:

18.1.1 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.

18.1.2 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.

19. Sawing

19.1 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 in. (305-mm) and 14-in. (356-mm) diameter saws.

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

19.3 Adjust the saw to project approximately ¼ in. (6.4 mm) through the test material.

19.4 Use the saw cuts made in cutting the 2 by 4-ft (0.6 by 1.2-m) boards into smaller test specimens, as shown in Fig. 3, in the grading. Grade the wood-base panel for sharp edges,

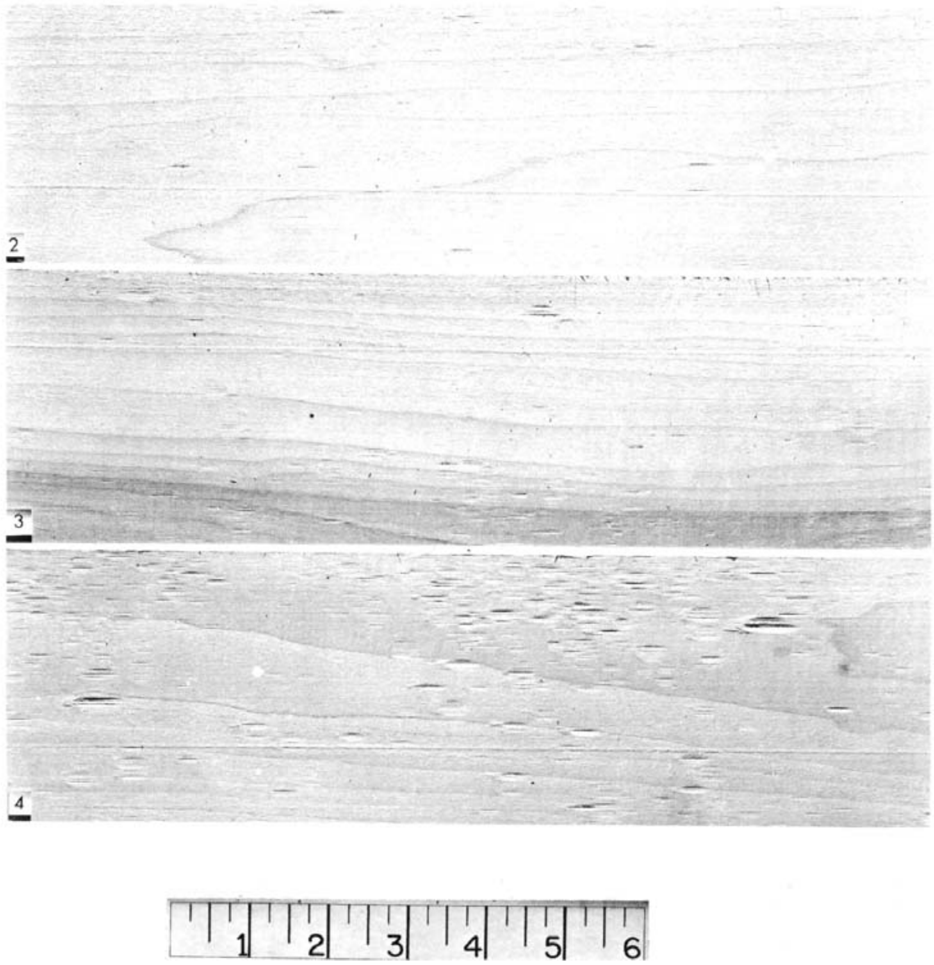
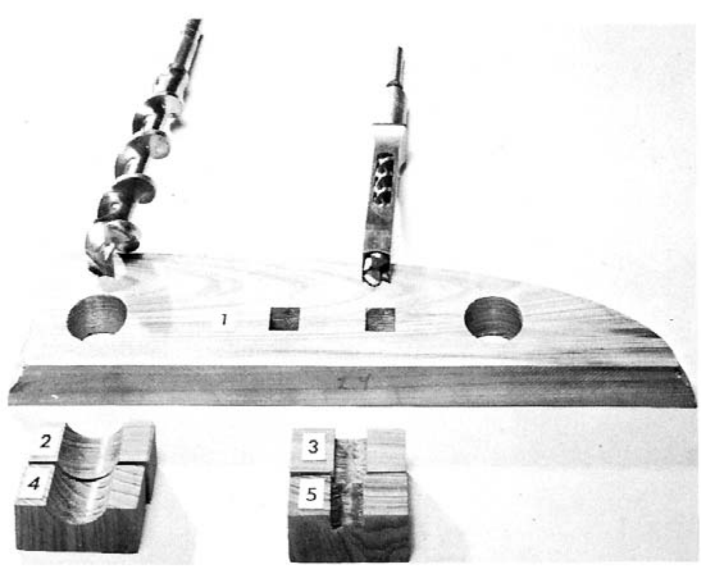
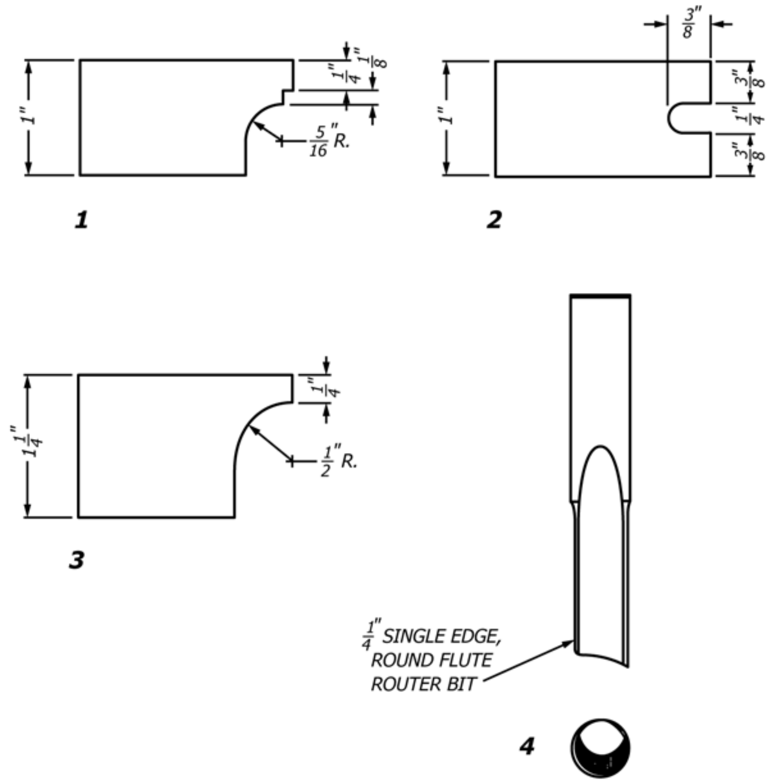


FIG. 11 Chip Marks in Yellow-Polar, Grades Nos. 2, 3, and 4



NOTE 1—Test specimen No. 1 has been shaped, bored, and mortised. The 1-in. (25 mm) bit and the ½-in. (13 mm) 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. 12 Machined Test Specimens



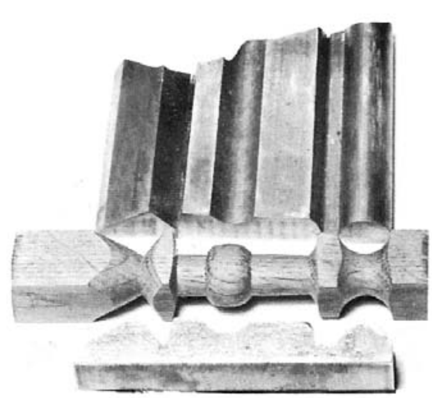
1. Router bit used in cutting a pattern on the edge of lumber test specimens.
2. Router bit used in cutting a tongue (for banding) on the edge of wood-base panel test specimens.
3. Router bit used in cutting quarter-round pattern on the edge of wood-base panel test specimens
4. Type of bit used in routing tests with wood-base panel.

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	0.500	1.00	1.25
mm	3.2	6.4	7.9	9.5	13	25	32

FIG. 13 Cutting Tools Used in Certain Machining Tests

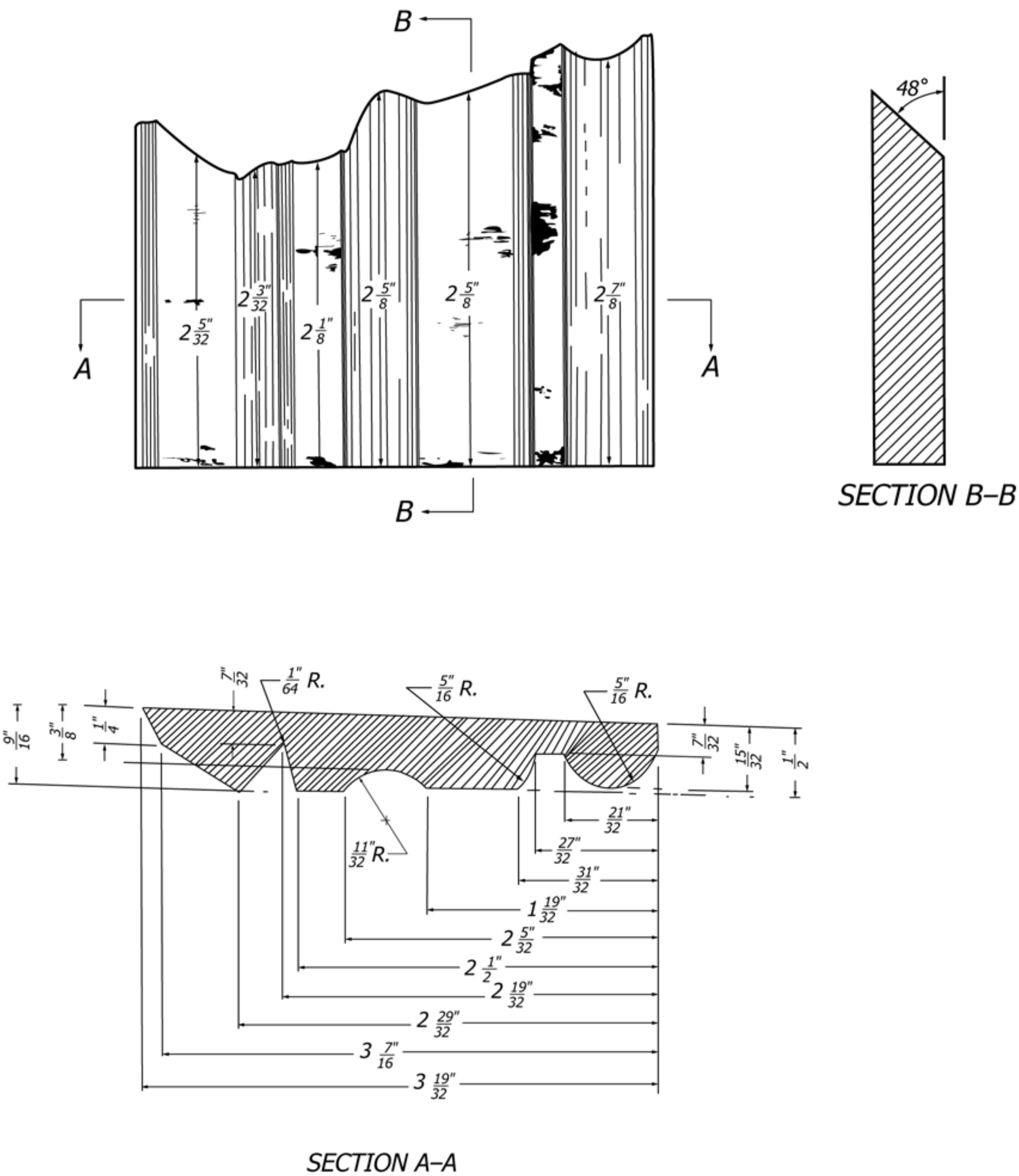


NOTE 1—The top view shows a type of one-piece knife used in the turning test; the bottom, a cross section of a knife; and the center, a finished turning in oak.

FIG. 14 Knife Used in the Turning Test

corners free from chipping, chipping and fuzzing at the edges, and for any tendency to spark during sawing.

19.5 For wood-base panels made with an orientation, keep separate records for saw cuts in each direction (Note 23).



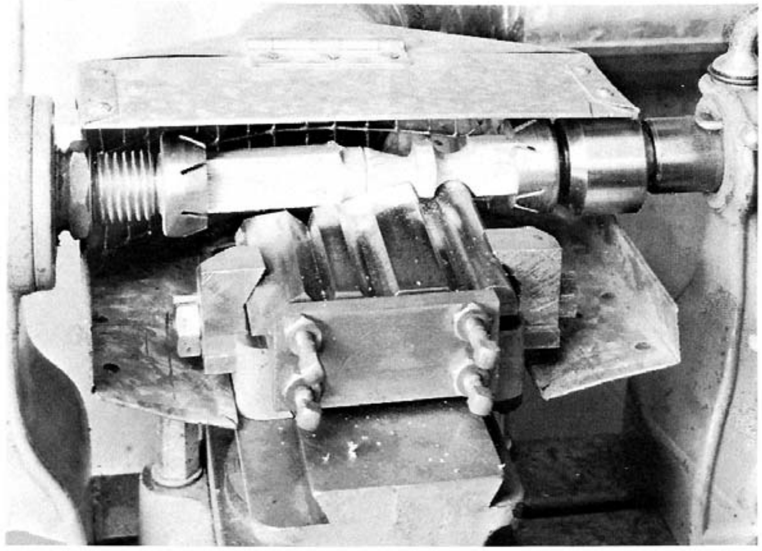
NOTE 1—Top left, general view of knife. Section A-A, cross section of the knife showing radii and angles. Section B-B, cross section showing cutting bevel. It is very important to note that Section B-B cannot possibly describe the sharpening angle for the entire cutting contour as shown in Section A-A. The clearance angle for the entire cutting contour is so complicated as to be impractical to describe in a drawing of this type.

NOTE 2—Change all fractions to decimals.

METRIC EQUIVALENTS

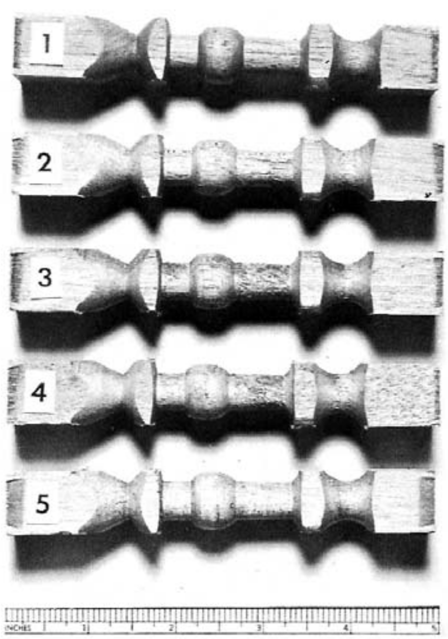
in.	decimal	mm	in.	decimal	mm
1/64	0.156	0.40	27/32	0.844	21.4
7/32	0.219	5.6	31/32	0.969	24.6
1/4	0.250	6.4	1 19/32	1.594	40.5
5/16	0.312	7.9	2 3/32	2.094	53.2
11/32	0.344	8.7	2 1/8	2.125	54.0
3/8	0.375	9.5	2 5/32	2.156	54.8
15/32	0.469	11.9	2 1/2	2.500	63.5
1/2	0.500	12.7	2 19/32	2.594	65.9
9/16	0.562	14.3	2 5/8	2.625	66.7
21/32	0.656	16.7	2 7/8	2.875	73.0
			2 29/32	2.906	73.8
			3 7/16	3.437	87.3
			3 19/32	3.594	91.3

FIG. 15 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. 16 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. 17 Grades of Turnings

NOTE 23—Some wood-base panels like plywood and particleboards of the extruded type possess a definite orientation of the constituent materials and are machined in two directions to understand the machining performance. Dividing the original 2 by 4-ft (0.6 by 1.2 m) board in the middle and then sawing each half, as shown in Fig. 3, provides duplicate sets of specimens, one set for each direction.

On the other hand, some wood-base panels are produced with random orientation of the constituent materials and therefore adjacent edges machine alike. For these materials, half of a panel, as in Fig. 3, will suffice for the test described in this paragraph.

20. Sanding

20.1 See 13.1.

20.2 See 13.2.

20.3 The test specimens shall be 6 in. by 2 ft (152 by 0.6 m), cut as shown in Fig. 3.

20.4 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.

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 24—Sanding is a method frequently used to bring wood-base panels to close thickness tolerance. Many types are pre-sanded 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. 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 wood-base panels made with an orientation of the constituent materials, keep separate records for cuts in each direction.

21. Routing/Shaping

21.1 The machine shall be a commercial size computer numeric controlled (CNC) router with a feed system capable of at least 250 in./min (6350 mm/min) speed and a spindle speed of at least 15 000 revolutions per minute. However, a hand router shall be permitted as an acceptable alternative for the dado routing tests.

21.2 The test specimen shall be 3-in. by 2-ft strips (76 mm by 0.6 m), cut as shown in Fig. 3. The same specimens shall have one long edge shaped per 21.3 and then be routed per 21.4. Both operations may be completed using multiple passes of the router while the specimen remains locked in position.

21.3 *Edge Routing/Shaping:*

21.3.1 As illustrated by Nos. 2 and 3 in Fig. 13, the bits used for the edge router/shaping tests may be either a tongue or quarter round. An ogee bit or alternative pattern may also be used if they are more representative of the end use.

21.3.2 The spindle speed shall be at least 15 000 revolutions per minute. The feed speed shall be at least 250 in./min (6350 mm/min). The actual feed and spindle speeds used for the test shall be recorded.

21.3.3 Make a preliminary roughing cut down one of the specimen long edges. The cut shall be straight and parallel to the edge.

21.3.4 Make the final cut 1⁄16 in. (1.6 mm) deep down the same edge.

21.3.5 Examine the cut and grade it for smoothness of cut, chipping, and fuzzing. Record the results.

21.4 *Dado Routing:*

21.4.1 As illustrated by No. 4 in Fig. 13, the bit used for the dado routing test shall be a standard ¼ in. (6.4 mm) single fluted type without a spiral.

21.4.2 With a CNC router, the spindle speed shall be at least 15 000 revolutions per minute and the feed speed shall be at least 250 in./min (6350 mm/min). The actual feed and spindle speeds used for the test shall be recorded regardless of whether a CNC or hand router is employed.

21.4.3 Make a preliminary roughing cut down the specimen long edge that was not used for the edge routing/shaping test. The cut shall be straight and parallel to the edge.

21.4.4 Use the router to cut a single groove ¼ in. (6.4 mm) inboard from and parallel to the preliminary cut. Make the groove ¼ in. (6.4 mm) wide by ¼ in. (6.4 mm) deep. The groove shall be a straight line cut for the full length of the specimen.

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

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

22. Drilling

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

22.2 Use a ⅜-in. (9.5-mm) twist drill with a 120° point.

22.3 The test specimen shall consist of five 3 in. by 2-ft strips (76 mm by 0.6 m), cut as shown in Fig. 3.

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

22.5 In hardboard, drill the holes through each specimen at ¼ in. (6.4 mm) from the edge into a hardwood backing.

22.6 The spindle speed shall be 3500 r/min.

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

22.8 For wood-base panels made with an orientation of the constituent materials, keep separate records for holes bored in each direction.

23. Evaluation of Machining Defects

23.1 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 12 – 22 (Note 25). Record all results on prepared forms (see sample form in Fig. 6).

NOTE 25—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 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.

24. Precision and Bias

24.1 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.

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