Designation: D 6958 – 03

Standard Test Methods for Evaluating Side-Bonding Potential of Wood Coatings[1]

This standard is issued under the fixed designation D 6958; 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.

1. Scope

1.1 These test methods describe an evaluation procedure for the determination of undesirable side-bonding of coatings for wood flooring. They provide two mechanical properties tests for the quantitative determination of the cohesive strength of wood coatings (tensile and lap shear); they also provide a wood floor simulation test for the qualitative determination of side-bonding potential of wood coatings.

1.2 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 9 Terminology Relating to Wood

D 2370 Test Method for Tensile Properties of Organic Coatings

D 4444 Test Methods for Use and Calibration of Hand-Held Moisture Meters

2.2 *British Standards:*

BS1204 British Standard Test for Synthetic Resin Adhesives[2]

2.3 *Maple Flooring Manufacturers Association (MFMA):*[3]

Guide Specification for Double Plywood Floor System

Guide Specification for Sleeper and Sleeper with Plywood Floor Systems

2.4 *National Oak Flooring Association (NOFMA):*[4]

Cracks in Hardwood Floors

2.5 *National Wood Flooring Association (NWFA):*[5]

Hardwood Floors Trouble Shooting Manual

3. Terminology

3.1 Definitions used in these test methods are in accordance with terminology used in Terminology D 9. A few related terms not covered in these test methods are as follows:

3.1.1 *panelization*—adjacent boards acting as a composite panel instead of individual strips when subjected to changes in temperature and humidity as well as other site conditions.

3.1.2 *panelization failure*—the condition where localized excessive gaps beyond specified limits develop between some strip flooring boards due to panelization.

3.1.3 *percent wood failure*—the rupturing of wood fibers in strength tests on bonded specimens usually expressed as the percentage of total area involved, which shows such failure. The inverse of adhesive failure.

3.1.4 *side-bonding*—the bonding of adjacent strips of wood flooring caused by the floor coating resulting in panelization. This is one possible cause of panelization failure.

3.1.5 *side-bonding wood failure*—the failure of the wood within a strip, as in classic wood failure, when the movement of the strip within the floor is restrained from moisture-related movement by excessive side-bonding. In this situation, the toughness or "work-to-break" of the side-bonding is sufficient to overcome the tensile strength perpendicular to the grain of the wood strip.

3.1.6 *tensile stress (nominal)—as used in Test Method D 2370*, the load per original unit area at which a specimen fails or yields in a tension (pull) test.

SECTION I—MECHANICAL PROPERTIES TESTS

TEST METHOD A—MAPLE BLOCK TENSILE STRENGTH TEST

4. Significance and Use

4.1 This test method was originally designed as a means of quantitatively measuring the level of adhesion of the wood-wood interface caused by a wood coatings system applied to the substrate. The tensile test is useful in measuring bonding strength of coatings, such as gymnasium coatings, in which the wood strip flooring primarily expands or contracts in response to changes across the cross-sectional width of the strip floor.

[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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[2] British Standards Institute (BSI) 389 Chiswick High Rd., London, W4 4AL, UK.

[3] MFMA, 60 Revere Dr., Suite 500, Northbrook, IL 60062.

[4] NOFMA, P.O. Box 3009, Memphis, TN 38173–0009.

[5] NWFA, 111 Chesterfield Industrial Boulevard, Chesterfield, MO 63005.

4.2 This test method was further designed as a means of measuring the side-bonding potential of wood coating systems.

5. Apparatus

5.1 *Tensile Tester*, of the constant rate of jaw separation type, equipped with load cells having capacities of 100 to 1000 lb (445 to 4452 N), and equipped with an indicating device such as an electronic constant speed chart recorder, a digital device that displays numerical values, or a printer that records the numerical values and suitably sized grips to hold the test specimens in place during testing. The machine must be capable of maintaining a cross head velocity during testing of 0.1 in./min (2.54 mm/min) , and if using a strip chart recorder, a chart speed during testing of 10 in./min (254 mm/min).

5.2 *Clamp Assembly*, capable of holding assembled test specimen and maintaining a clamp pressure of 100 psi (690 kPa).

5.3 *Moisture Meter*, meeting the requirements of Test Method D 4444.

5.4 *Foam Polybrushes*, 1 in. (25.4 mm) wide.

6. Procedure

6.1 Material for testing shall be #2 or better, MFMA certified hard maple (Acer saccharum) tongue and groove strip flooring, 2¼ ± 0.03 in. (57.2 ± 0.8 mm) in width by 25⁄32 ± 0.01 in. (19.8 ± 0.3 mm) in thickness.

6.2 Test stock shall be prepared by cutting off the tongue and planing the edge smooth. Blocks for testing shall be cut to a length of 3.00 ± 0.01 in. (76.2 ± 0.3 mm).

6.3 Test blocks shall be conditioned at 75 ± 5°F (24 ± 3°C) and 50 ± 2 % relative humidity for a minimum of 7 days. These conditions equate to an Equilibration Moisture Content (EMC) of ~9 % (see X1.3). After equilibrating, use a moisture meter to determine the EMC of all test blocks, calculate and report the average EMC.

6.4 A minimum of twenty test blocks shall be used to prepare a minimum of ten assemblies for testing of each coating to be evaluated (see Fig. 1).

6.5 Test assemblies consist of two test blocks "edge-glued" using the floor coating as an adhesive (see Fig. 1). The coating to be evaluated shall be applied using a polybrush to the smooth edge of both test blocks at a rate of 500 ± 5 ft^2/gal (12.3 ± 0.1 m^2/L) or as specified by the coating manufacturer. After a 5 min open time the test block pairs shall be assembled by placing the coated surfaces together and clamping the joint at 100 psi (690 kPa) pressure. Test assemblies shall remain clamped for a minimum of 48 h.

6.6 Test assemblies shall be cured at 75 ± 5°F (24 ± 3°C) and 50 ± 2 % relative humidity for a minimum of 7 days including the clamp time. After equilibrating, use a moisture meter to determine the EMC of all test assemblies, and calculate the average EMC.

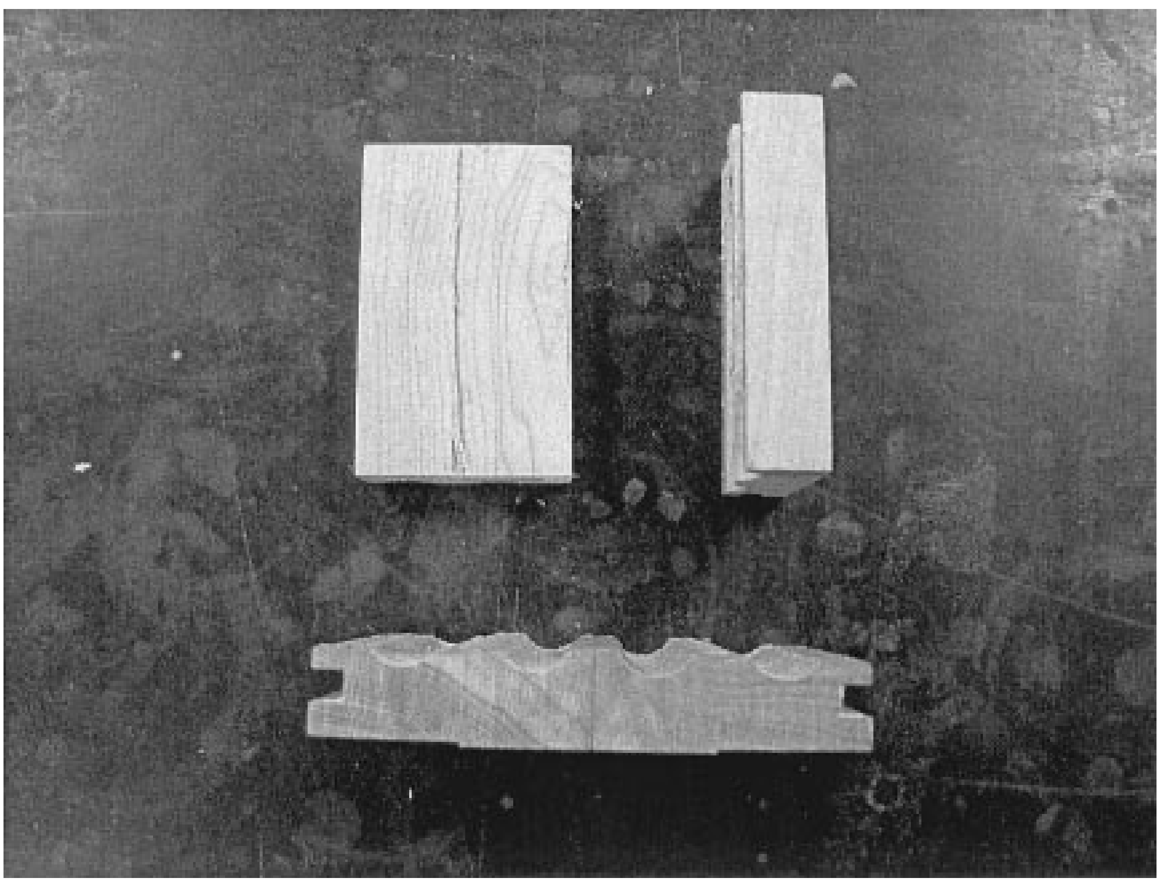

FIG. 1 Test Method A, Maple Block Tensile Strength Test-Test Blocks (top), Test Assembly (bottom)

6.7 Measure and record the length and width of the test assembly to the nearest 0.01 in. (0.3 mm). Calculate the test area of each test assembly.

6.8 Test assemblies shall be secured in a test machine (see Fig. 2) and pulled apart in tension at a rate of 0.1 in./min (2.54 mm/min).

6.9 Record the ultimate load, location of failure (coating-coating interface, coating-wood interface, within wood), an estimate of the percent wood failure and the average EMC.

7. Report

7.1 Report the number of samples tested, the location of failure (coating-coating interface, coating-wood interface, within wood), an estimate of the percent wood failure, and the average EMC.

8. Precision and Bias

8.1 Until sufficient data are available as a result of performing these tests, no specific precision and bias statement can be expressed.

TEST METHOD B—MAPLE STRIP LAP SHEAR TEST

9. Significance and Use

9.1 This test method was originally designed as a means of quantitatively measuring the level of adhesion of the wood-wood bond interface caused by a wood coatings system applied to the substrate. The lap shear test is useful for measuring bonding strength of coatings used on parquet or other similar types of flooring, where longitudinal movement of the flooring

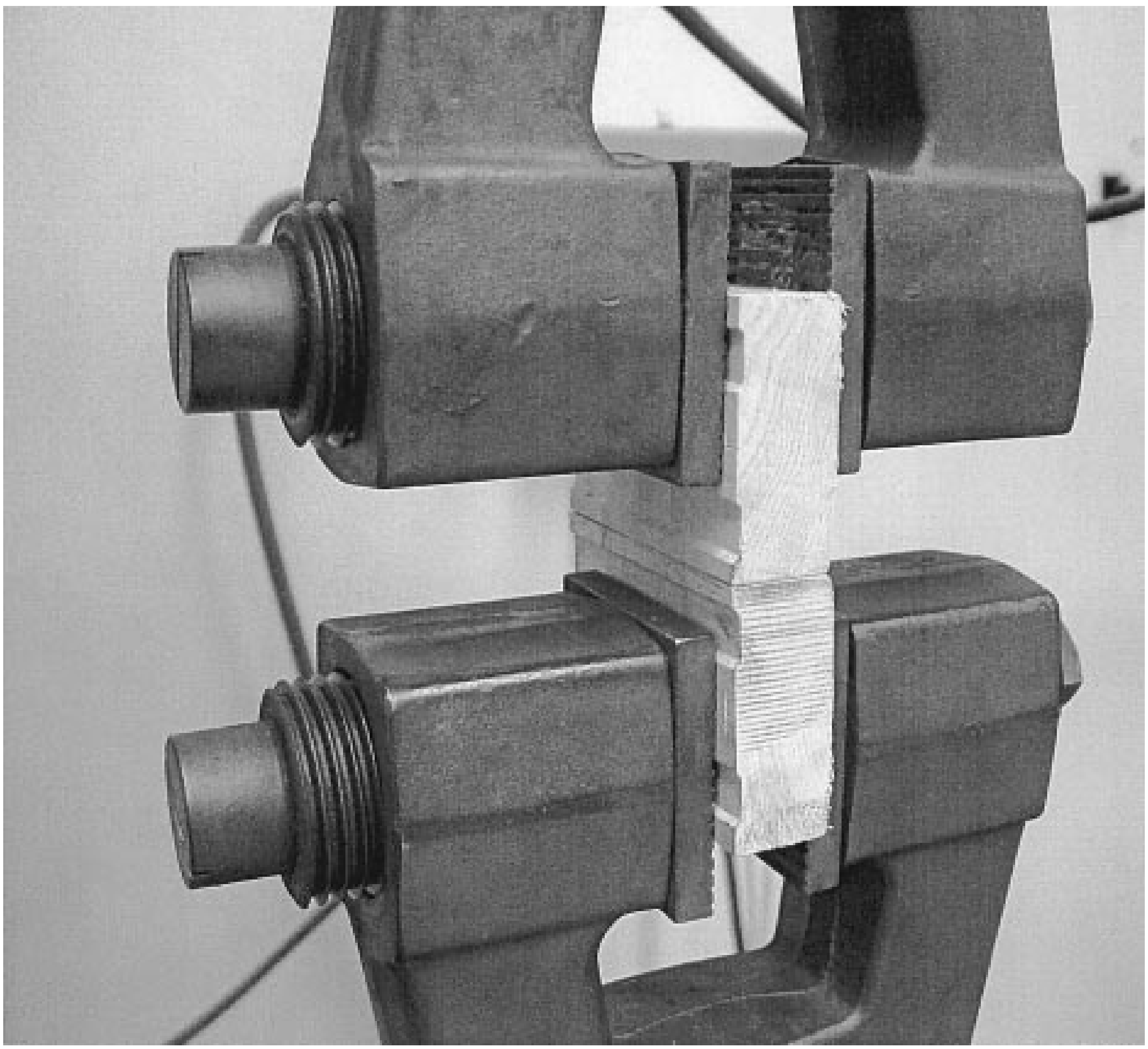

FIG. 2 Assembly Secured in Testing Machine

is a concern (for example, the shear force as the individual wood pieces slide past each other).

9.2 This test method was further designed as a means of measuring the side-bonding potential of wood coating systems.

10. Apparatus

10.1 *Tensile Tester*, of the constant rate of jaw separation type, equipped with load cells having capacities of 100 to 1000 lb (445 to 4452 N), and equipped with an indicating device such as an electronic constant speed chart recorder, a digital device that displays numerical values, or a printer that records the numerical values as well as suitably sized grips to hold the test specimens in place during testing. The machine must be capable of maintaining a cross head velocity during testing of 0.1 in./min (2.54 mm/min), and if using a strip chart recorder a chart speed during testing of 10 in./min (254 mm/min).

10.2 *Clamp Assembly*, capable of holding assembled test specimen and maintaining a clamp pressure of 100 psi (690 kPa).

10.3 *Moisture Meter*, meeting the requirements of Test Method D 4444.

10.4 *Foam Polybrushes*, 1 in. (25.4 mm) wide.

11. Procedure

11.1 Material for testing shall be #2 or better, MFMA certified hard maple (Acer saccharum) tongue and groove strip flooring, 2¼ ± 0.03 in. (57.2 ± 0.8 mm) in width by 25⁄32 ± 0.01 in. (19.8 ± 0.3 mm) in thickness.

11.1.1 Test stock shall be prepared by cutting off the tongue and planing the edge smooth. Strips for testing shall be planed from this test stock to a width of 1.0 ± 0.01 in. (25.4 ± 0.3 mm), a length of 4.5 ± 0.01 in. (114 ± 0.3 mm) and a thickness, 0.125 ± 0.006 in. (3.18 ± 0.15 mm). (See Appendix X2.)

11.1.2 Test strips shall be conditioned at 75 ± 5°F (24 ± 3°C) and 50 ± 2 % relative humidity for a minimum of 7 days. These conditions equate to an Equilibration Moisture Content (EMC) of ~9 % (see X1.3). After equilibrating, use a moisture meter to determine the EMC of all test strips, and calculate the average EMC.

11.1.3 A minimum of twenty test strips shall be used to prepare a minimum of ten assemblies for testing of each coating to be evaluated (see Fig. 3).

11.1.4 Test assemblies consist of two test strips "face-glued" using the floor coating as an adhesive. The coating to be evaluated shall be applied using a polybrush on a one-inch overlap test area on the ends of the test strips at a rate of 150 ± 5 ft^2/gal (3.7 ± 0.1 m^2/L) or as specified by the coating manufacturer (see Fig. 3). After a 5 min open time the test strip pairs shall be assembled by placing the coated surfaces

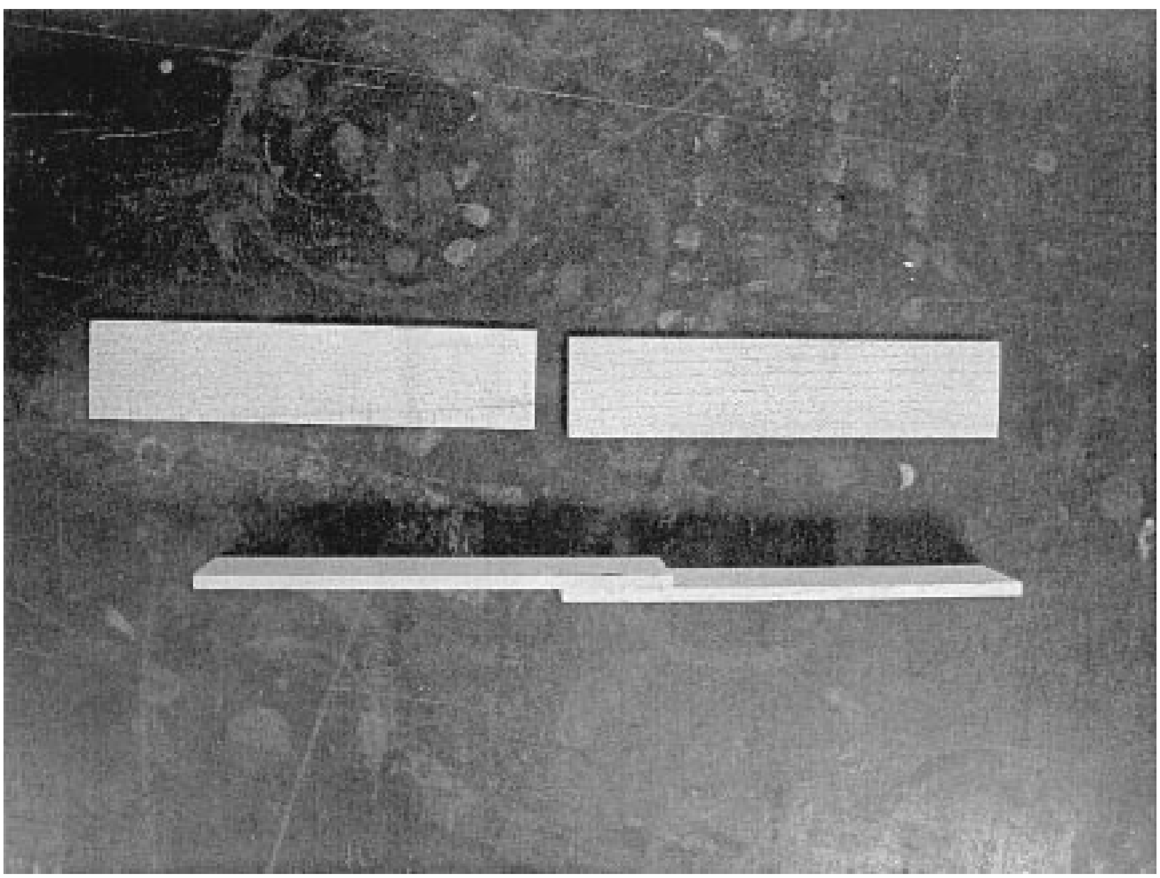

FIG. 3 Test Method B, Maple Strip Lap Shear Test-Test Strips (top), Test Assembly (bottom)

together and clamping the joint at 100 psi (690 kPa) pressure. Test assemblies shall remain clamped for a minimum of 48 h (see Figs. 4 and 5).

11.1.5 Test assemblies shall be cured at 75 ± 5°F (24 ± 3°C) and 50 ± 2 % relative humidity for a minimum of 7 days including the clamp time. After equilibrating, use a moisture meter to determine the EMC of all test assemblies, calculate and report the average EMC.

11.1.6 Measure and record the length and width of the test area to the nearest 0.01 in. (0.3 mm). Calculate the test area of each test assembly.

11.1.7 Test assemblies shall be secured in a test machine (see Fig. 2) and pulled apart in tension at a rate of 0.1 in./min (2.54 mm/min).

11.1.8 Record the ultimate load, location of failure (coating-coating interface, coating-wood interface, within wood), an estimate of the percent wood failure and the average EMC.

12. Report

12.1 Report the number of samples tested, the location of failure (coating-coating interface, coating-wood interface, within wood), an estimate of the percent wood failure, the average EMC and the average shear strength.

13. Precision and Bias

13.1 Until sufficient data are available as a result of performing these analyses, no specific precision and bias requirements can be expressed.

SECTION II

TEST METHOD C—FLOOR SIMULATION TEST

14. Significance and Use

14.1 This test method was designed as a means of qualitatively measuring the side-bonding potential of wood coating systems. The flooring simulation test is helpful in giving a visualization of the significance of the tensile/lap shear strength numbers generated. Dependent on the specific end use of the coating, other flooring types, for example, plank, parquet, could also be evaluated under this test method.

15. Apparatus

15.1 *Moisture Meter*, meeting the requirements of Test Method D 4444.

15.2 *Face Nailing Machine*, capable of face nailing 2 in. (50.8 mm) nail cleats.

15.3 *Side Nailing Machine*, capable of nailing 2 in. (50.8 mm) nail cleats into tongue and groove 2¼ in. (57.2 mm) wide, 25⁄32 in. (19.8 mm) thick, maple strip flooring.

15.4 *Foam Polybrushes*, 2 in. (50.8 mm) wide.

15.5 *120 Grit Sandpaper*.

15.6 *Test Panels*, (prepared as described in Section 16).

16. Floor Simulation Test Panels

16.1 The panel design (see Fig. 6), simulates the installation pattern observed on most gymnasium floors. Information regarding the installation of wood floors may be found in the

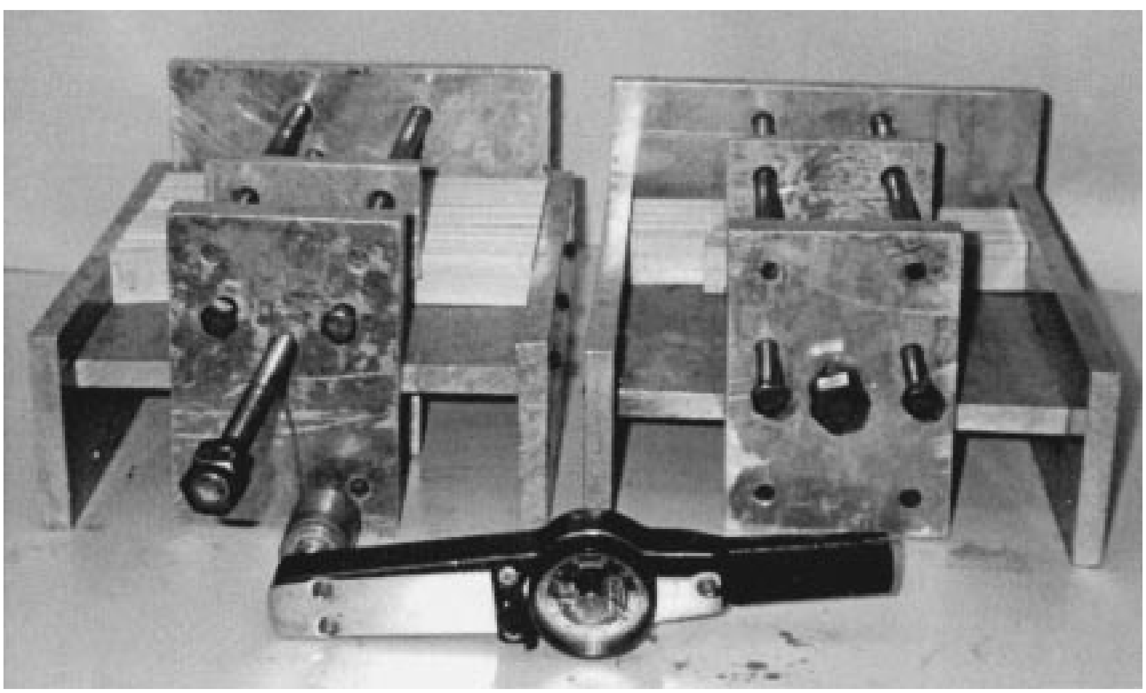

FIG. 4 Front View of Clamp Assembly

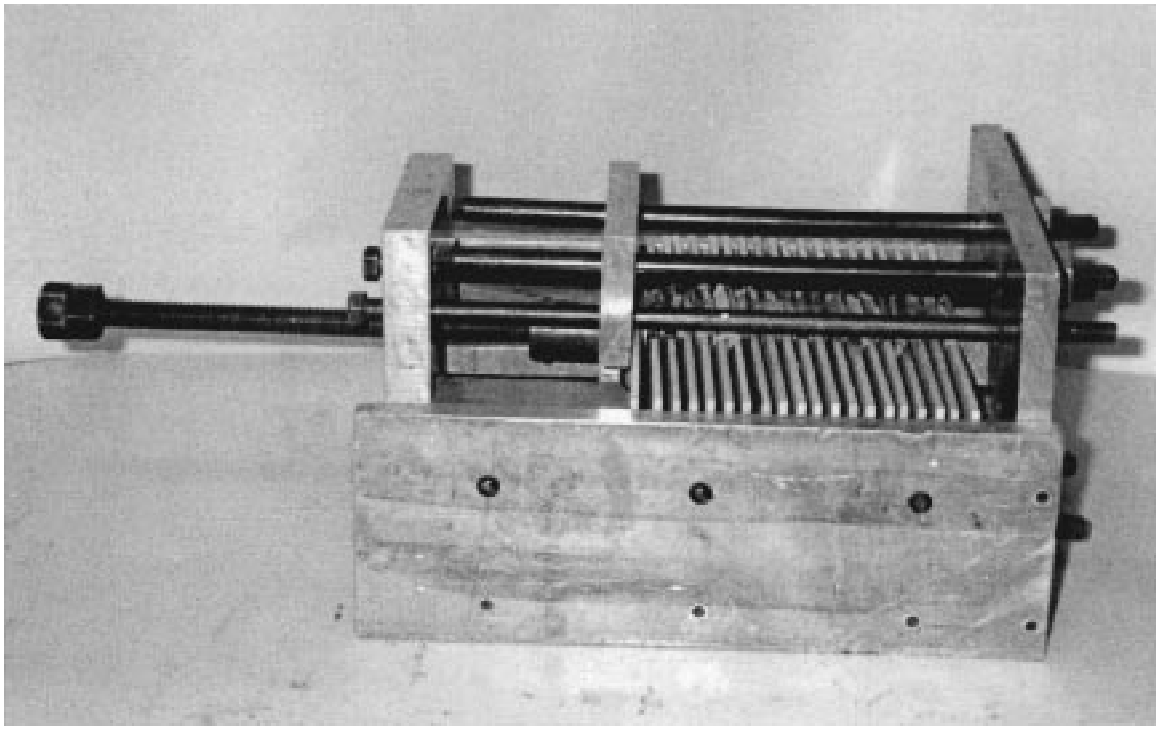

FIG. 5 Side View of Clamp Assembly

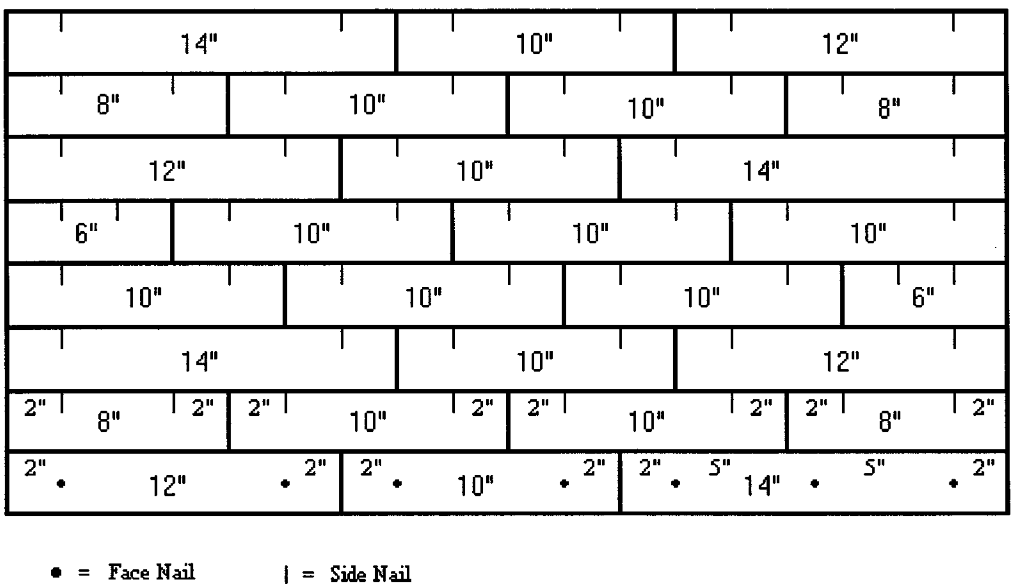

FIG. 6 Nailing Pattern for Maple Strip Flooring

MFMA publications MFMA Guide Specification for Double Plywood Floor System and MFMA Guide Specification for Sleeper and Sleeper with Plywood Floor Systems.

16.2 *Side-Bonding Test Panel Design*:

16.2.1 Test panels shall be constructed using two pieces of plywood 23⁄32 by 18 by 36 in. (18.3 by 457 by 914 mm) Exterior Grade A/C) and maple gymnasium flooring boards (2¼ in. (57.2 mm) wide, 25⁄32 in. (19.8 mm) thick; cut to 6 in. (152 mm), 8 in. (203 mm), 10 in. (254 mm), 12 in. (305 mm), 14 in. (356 mm) lengths as necessary to assemble the panels as shown in Fig. 6; No. 2 grade or better). Prior to test panel assembly, the maple boards and plywood are conditioned at 70 ± 5°F (21 ± 3°C) and 80 ± 5 % relative humidity for two weeks.

16.2.2 Join the plywood pieces together with screws (Fig. 7). Attach the first row of maple boards to the plywood using face nails (see Fig. 6). Face nail using 2 in. (50.8 mm) nail cleats. The remaining rows of boards are attached to the panel using a side nailer using 2 in. (50.8 mm) nail cleats. Following construction, the panels are equilibrated at 70 ± 5°F (21 ± 3°C) and 80 ± 5 % relative humidity for two weeks. (Typically

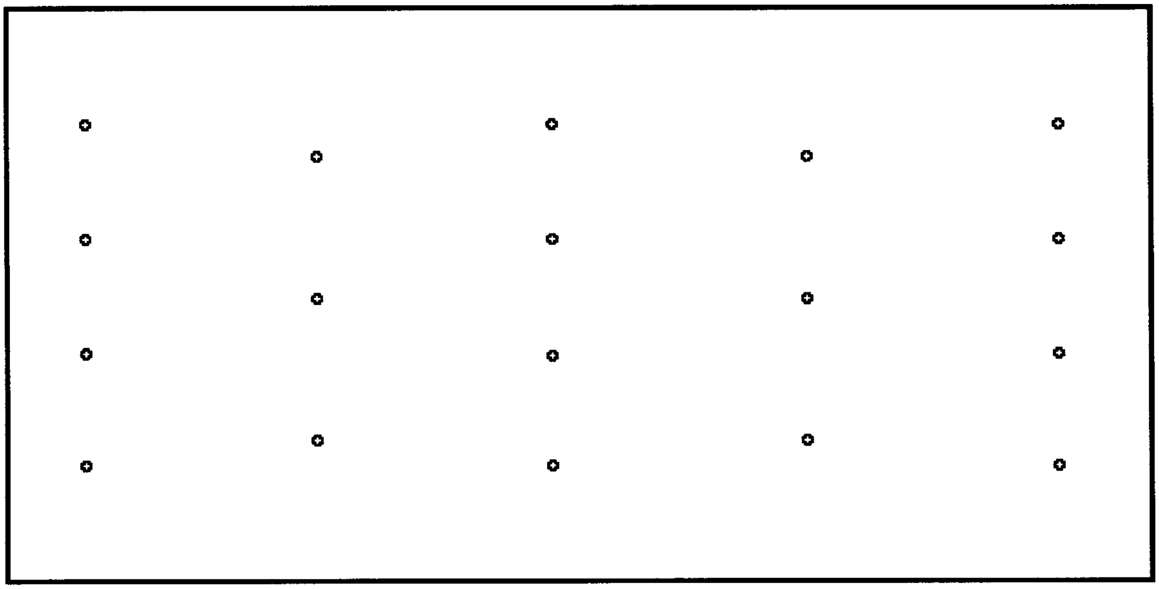

FIG. 7 Preparation of Test Panels for the Floor Simulation Test—Wood Screw Pattern for Plywood Subfloor

for the woods used, the equilibrium moisture content (EMC) will be approximately 16 % EMC (see X1.3). The total number of panels evaluated per test is a function of the available space with temperature and humidity control. It is recommended that a minimum sample size of two be used.

17. Procedure

17.1 After equilibration and prior to coating, a moisture meter is used to determine the initial moisture content of the test panel, by taking ten random readings and determining the average EMC.

17.2 Coat the test panels per the coating manufacturer's application instructions. In the case that such instructions are not available; apply four coats of a test finish to the test panels at a coverage rate of 500 ± 5 ft^2/gal (12.3 ± 0.1 m^2/L); allow a twelve to eighteen-hour cure time between coats, abrading in between coats with 120 grit sandpaper.

17.3 Following coating, examine the test panels for any gaps, cracked or split boards, or other surface abnormalities prior to the start of testing. These observations shall be recorded as initial appearance of the test panels.

17.4 Condition the test panels at 70 ± 5°F (21 ± 3°C) and a relative humidity of 80 ± 5 % for a two-week period (see X1.3).

17.5 At the end of the two-week period, observations shall be made on the test panels. These observations should include any gaps, cracks, split boards, or other anomalous appearances. Photographs should be taken at this time to provide documentation of the recorded observations. The observations shall be appropriately recorded as the high humidity cycle. A moisture meter shall be used to determine the moisture content of the wood at this time, taking ten random readings and determining the average EMC.

17.6 Place the test panels in a 125 ± 5°F (52 ± 3°C) oven for a two-week period. The relative humidity in the oven should measure 35 ± 2 % during this phase of testing (see X1.6).

17.7 At the end of the two-week period, observe the test panels for gaps, cracks, split boards, or other anomalous appearances. Photographs shall be taken at this time to provide documentation of the recorded observations. The observations shall be appropriately recorded as the low humidity cycle. Use a moisture meter to determine the moisture content of the wood at this time by taking 10 random readings and determining the average EMC. Measure the width of any cracks (see Figs. 8 and 9).

18. Report

18.1 Reporting shall include the initial, visual observations recorded for the test panels before testing begins; similar observations after each cycle of testing shall likewise be recorded. The initial moisture content of the wood shall be reported along with the moisture content of the wood after each cycle of testing. The report shall include the temperature and relative humidity of each test cycle and photographs taken during testing evaluations.

18.2 Finishes are to be judged as side-bonding contributors if the wood of the test panels cracks or shows excessive or uneven gapping between boards. This is considered indicative of side-bonding.

18.2.1 (Per NOFMA/NWFA Troubleshooting Guide, hairline cracks can be considered to be normal if, in strips 2¼ in. (57.2 mm) wide or less:

18.2.1.1 They close up during non-heating months

18.2.1.2 They are not wider than 0.045 in. (1.14 mm) (the thickness of a U.S. dime) in some locations, and vary from the thickness of 0.0087 in. (0.22 mm) (a piece of stationery) in

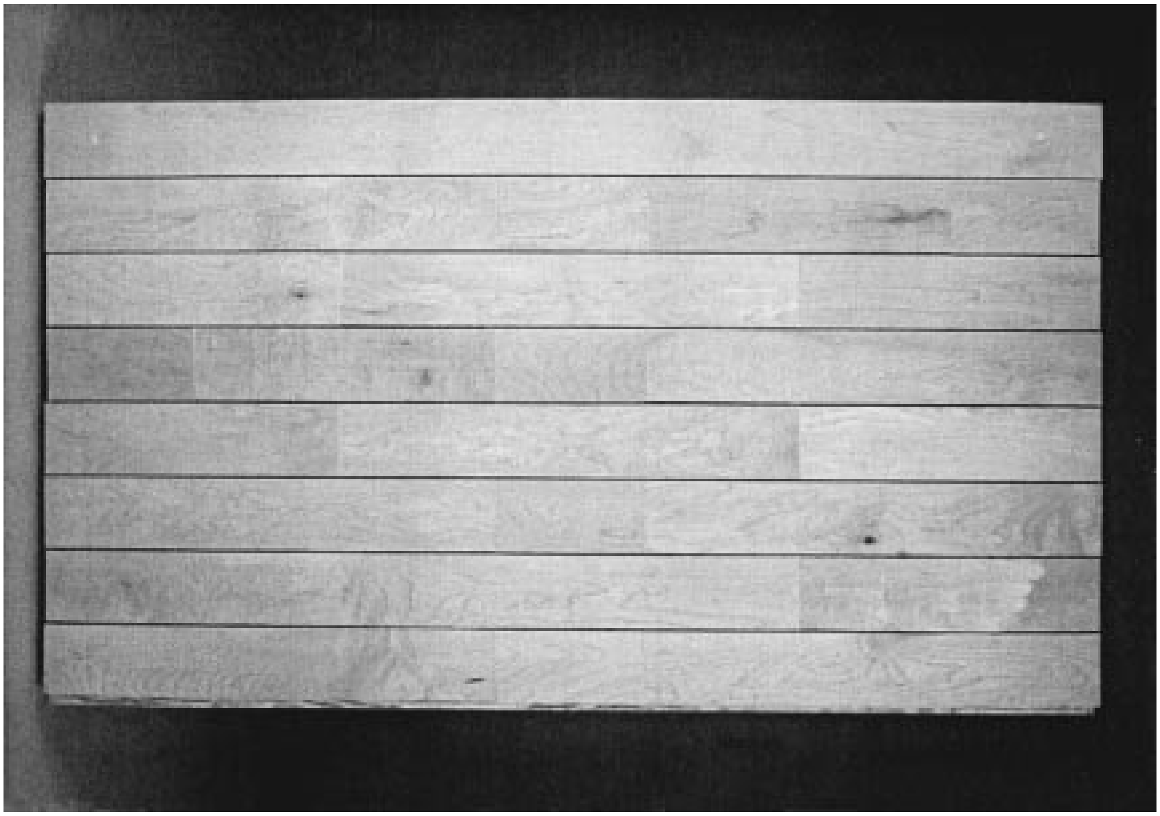

FIG. 8 Test Finish Not Exhibiting Side-Bonding

most areas to scattered larger cracks up to 0.045 in. (1.14 mm) (the thickness of a U.S. dime).

NOTE 1—It is normal for gapping to occur in an even, non-excessive fashion, with no wood failure or rupture. In such cases, these phenomena are not to be considered as indicators of sidebonding.

18.2.1.3 During the manufacturing process, due to kiln drying, end checks along the wood grain may occur that are not observed during the grading process for the flooring. Consequently, anomalous end or edge splitting may be observed that is not indicative of side-bonding.

19. Precision and Bias

19.1 No information is presented about either precision or bias of this test method for measuring side-bonding potential since the test result is nonquantitative.

20. Keywords

20.1 cohesive strength; elongation; gapping; panelization; shear strength; side-bonding; spread rate; tensile strength

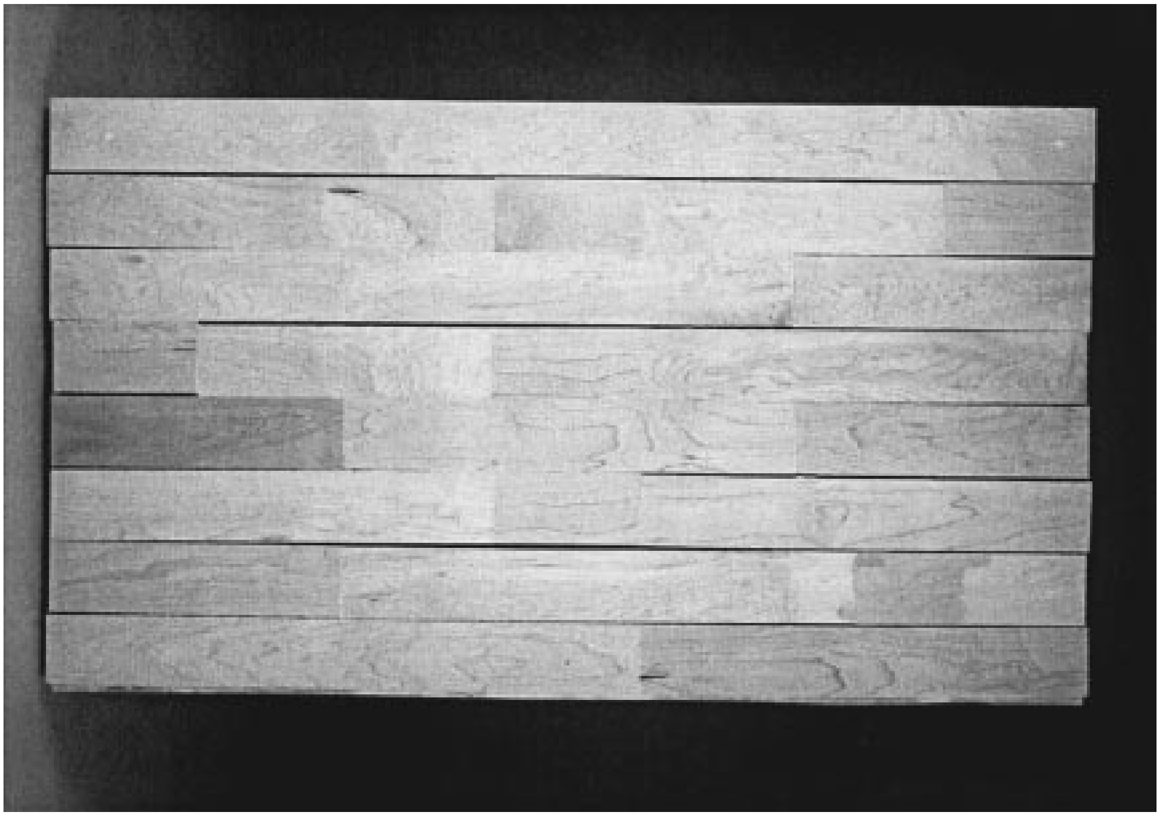

FIG. 9 Test Finish Exhibiting Sidebonding

APPENDIXES

(Nonmandatory Information)

X1. COMMENTARY

X1.1 These test methods address the possibility of coating induced panelization failure (side-bonding) of wood floors. However, there are numerous non-coating related factors that can cause panelization on wood floors. Improper installation techniques, inadequate nail spacing, foundation settlement, large changes in moisture content of the wood, improper subfloor materials, and over-drying of the floor are contributing causes of flooring panelization.

X1.2 In 6.5, the wood block adhesion test uses 500 ft^2/gal (12.3 m^2/L), while in 11.1.4, the maple strip lap shear test uses 150 ft^2/gal (3.7 m^2/L). The higher level used in the maple strip lap shear test is to simulate the pooling of the coating between individual boards within the tongue and groove or between the wood strip and the subfloor.

X1.3 Other methods of conditioning (such as saturated salt solutions in an enclosed chamber) as well as other conditions may be specified depending on the desired testing parameters provided they are documented.

X1.4 No sanding of the block/strip is done prior to assembly of the test specimen as this test simulates the joint formed by adjacent wood flooring pieces. This surface is planed to form the tongue and groove joint, but is not sanded in practice.

X1.5 The floor simulation test may also be designed to evaluate other contributing factors that affect panelization, such as nailing pattern interval and frequency, fastener type (staples, nails, channel and clip, etc.), tightness of the fit of the interlocking tongue and groove joints, amount of space present between the edges of boards when the finish is applied, and floor adhesives. Panel size can be modified, appropriate to the aforementioned contributing factors, including use of straight-edged wood in place of tongue and groove to minimize frictional points.

X1.6 The purpose of the oven for drying the floor simulation panels is to simulate the extreme fluctuations in EMC, which are typical of the environmental conditions that result in panelization failure. Other means of reducing the EMC may be employed including ambient conditions that will result in a rapid moisture loss of greater than 8 % in EMC.

X1.7 Test Methods A and B are laboratory tests that measure the level of adhesion of a wood coatings substrate, whereas Test Method C simulates what happens to flooring systems when changes in RH or EMC occur. Test conditions for Test Methods A and B stabilize the wood substrate to produce consistent test results. The test conditions described for Test Method C promote a wood expansion and wood shrinkage cycle giving a visual tool to evaluate a coatings side bonding potential.

X1.8 The lap shear test is also useful for measuring bonding strength of coatings used on strip flooring where the coating is pooled in the tongue and groove or between the wood strip and the subfloor. Here it is appropriate to measure the shear force relative to the tongue and groove or subfloor, or both, as the wood strip flooring primarily expands or contracts in response to changes across the cross- sectional width of the strip floor.

X2. SELECTION OF THE MAPLE TEST STRIPS
(Modified from British Standard B.S. 1204:1964, p. 11)

X2.1 *Test Strips*—Prepare the test strips from hard maple (Acer saccharum) 1 ± 0.01 in. (25.4 ± 0.3 mm) wide and 0.125 ± 0.006 in. (3.18 ± 0.15 mm) thick. The lengths for close joints are 4.5 ± 0.01 in. (114 ± 0.3 mm). The growth rings may be at any angle, from 0 to 90° inclusive, relative to the face. One face of the strip should be planed; the other may be planed or smoothly sawn.

NOTE X2.1—5/4 in. quarter-sawn hard maple (Acer saccharum) lumber planed to 1 in. is an acceptable alternative to the 2¼ by 35⁄32 in., 2 or better, MFMA certified strip flooring.

X2.2 It is essential that the strips shall be flat and free from splits, knots, whorls and decay, that the angle of inclination of the grain across the face of each test strip shall be not greater than 1 in 9, and that the grain shall not be obviously inclined to the face.

X2.2.1 Inclination of grain across the face can be judged by two factors:

X2.2.1.1 The long lines formed by the junctions of the growth rings which are to be seen most clearly on quarter-cut strips, (that is, strips cut with the growth rings at 90° to the faces).

X2.2.1.2 The small rays, which can be seen as dark flecks and most prominent, on slash-cut or tangentially cut strips, (that is, strips cut with growth rings parallel to the faces).

X2.2.2 Strips with growth rings at other angles at the surface show both characteristics with varying degrees of prominence.

X2.2.3 Inclination of the grain to the face of the strips is viewed on the edges. It is best shown by the same two factors in reverse, that is, by the growth ring junctions for tangential strips and by the ray flecks on quarter cut strips.