Designation: D2394 – 17 (Reapproved 2022)

Standard Test Methods for Simulated Service Testing of Wood and Wood-Based Finish Flooring[1]

This standard is issued under the fixed designation D2394; 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 cover procedures for measuring the performance of finish flooring under the following service loadings and conditions:

	Section
Loading Tests	
Concentrated Loading	7
Floor Surface Indentation from Small Area Loads	12
Falling-Ball Indentation	18
Rolling Load	23
Mechanical Tests	
Abrasion Resistance	28
Coefficient of Friction	33
Moisture Tests	
Surface Wetting	38

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *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:*[2]

D1037 Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials

E72 Test Methods of Conducting Strength Tests of Panels for Building Construction

3. Significance and Use

3.1 The test methods presented herein are intended to provide both a factual and comparative means of appraising the suitability of finish flooring. The procedures developed simulate some conditions of use that may require either maintenance beyond that considered normal or replacement of the floor surface material.

3.2 It is important for some of the evaluations that the substrate to be used beneath the finish flooring be duplicated because the type and degree of support will have a direct influence on the value obtained from test. For example, in some present-day construction, low-density materials are used for sound-deadening immediately below the finish flooring. The way this substrate distributes loading and absorbs energy will have an influence on evaluations such as those in rolling and concentrated loads.

3.3 The test methods presented herein may be used to compare different finish floorings as to their resistance to severe and ordinary service loads and also may serve as the means to set specification limits. The properties obtained by these test methods are needed in addition to such basic material properties as stiffness, strength, hardness, and dimensional stability.

3.4 All tests may not be required for any specific investigation. There may be an interrelation between two tests, and when it has been demonstrated what the interrelation is, a complete evaluation is only required as a final stage of a study. In each instance, therefore, it is necessary to determine which evaluations shall be made to fulfill the objectives.

4. Test Specimens

4.1 The number of specimens to be chosen for test and the method of their selection depend on the variability of the finish flooring material and on the purpose of the particular tests under consideration, so no general rule can be given to cover all instances. It is recommended that, whenever possible, sufficient replications be made to establish reliable mean values. Even for the most simple evaluation, a replication of three tests for each property is recommended.

[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] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

5. Control of Moisture Content and Temperature

5.1 Wood and wood-based materials are hygroscopic. The moisture content at time of test will influence values obtained from tests. Therefore, material for test shall be conditioned to essentially constant weight at a condition of 65 ± 5 % relative humidity and a temperature of 68 °F ± 6 °F (20 °C ± 3 °C) (Note 1 and Note 2). If there is any departure from this recommended condition, it shall be so stated in the report. No tests shall be made on any material when it is not essentially stable in moisture content.

NOTE 1—In following the recommendation that the temperature be controlled to 68 °F ± 6 °F (20 °C ± 3 °C) it should be understood that it is desirable to maintain the temperature as nearly constant as possible at some temperature within this range.

NOTE 2—Requirements for temperature and relative humidity vary for different materials and different conditions of use. The condition above meets the standard condition for wood and wood-based materials, and for finish flooring represents the near-maximum seasonal condition for most locations. The amount of damage from the various loadings is usually greater at higher moisture contents than at lower ones.

6. Report

6.1 The data recorded shall include, in addition to the actual test results and data required specifically from each test, a complete description of the material, sampling procedure, and record of any special treatment or conditioning of the flooring material. Any special details concerning the material under test that may have a bearing on the results shall also be recorded.

CONCENTRATED LOADING

7. Scope

7.1 Specimens shall be subjected to the concentrated loading test to obtain a measure of the resistance of the finish flooring to heavy loads produced by such articles of furniture as chests and pianos. This test procedure uses the same equipment and is essentially the same as the one described in Test Methods E72.

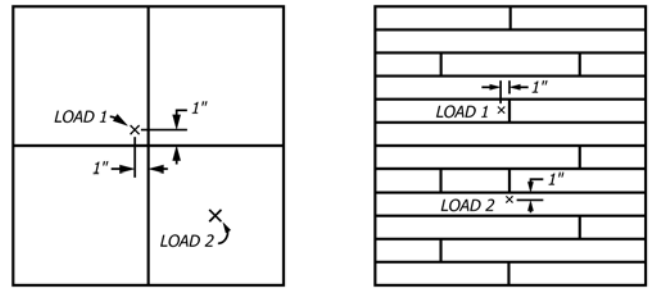
8. Test Specimen

8.1 The size of the test specimen will depend on the size of components making up the finish flooring, but shall be at least 18 in. (457 mm) square. When the finish flooring is prefabricated in parquet or tile form, the specimen shall consist of at least four such tiles attached to an underlayment, subfloor, or other substrate, using the same construction and technique as will be used in the finished construction. When the flooring is manufactured in strip form, the flooring shall be laid in courses over the subfloor and substrate so that end joints occur in the same manner as in actual construction. At least two such end joints shall occur near midwidth in the center one-half of the specimen. Fig. 1 shows the orientation for typical specimens using square and strip configurations of flooring.

9. Apparatus

9.1 The apparatus shall be assembled as shown in Fig. 2 and shall conform in the requirements for component parts as described in 9.1.1 – 9.1.4.

9.1.1 *Steel Disk Loading Tool*—The steel disk loading tool shall be 1 in. (25 mm) in diameter with the circumference of the end rounded to a radius of 0.05 in. (1.3 mm). The loading tool shall be provided with a collar to engage the movable tip of the micrometer dial for measuring deformation under load, and shall be fabricated with a means of fastening it to the platen of the testing machine or loading device.



A. FINISH FLOORING IN PARQUET OR TILE FORM

B. FINISH FLOORING IN STRIP FORM

NOTE 1—One inch equals 25.4 mm.

FIG. 1 Layout of Specimens for Concentrated Load Test

9.1.2 *Deformation Gauge*—The deformation gauge shall consist of a dial micrometer mounted on the three-point supported bridge. The dial micrometer shall be of the kind with divisions of 0.001 in. (0.025 mm). The bridge shall be of sufficient length so that the distance between the single-point support and a line between the pair of point supports is at least 12 in. (305 mm). The bridge support shall have a slot in the center of its span of sufficient opening to clear the loading tool to permit placing the micrometer directly adjacent to the disk loading tool with the stem end in contact with the collar.

9.1.3 *Loading Device*—A testing machine with a platen area sufficiently large to accommodate the 18 in. (457 mm) square or other suitable loading device convenient for loading and measuring the amount of loading to 1000 lb (or 4.45 kN) at the prescribed rate shall be provided.

9.1.4 An indentation measuring tool, as required for the falling-ball indentation test (see 20.1.4) shall be provided for determining the residual indentation from the loading to 1000 lb (4.45 kN) 1 h after removal of load.

10. Procedure

10.1 *Loading Points*—Load points 1 and 2, for both square or rectangular parquet or tile form finish flooring, are illustrated in Fig. 1. Load point 1 for the tile form of flooring is near the corner, so that deformation under load at a corner can be determined. Load point 2 is provided to obtain an index of resistance to concentrated load at a point where the finish flooring can distribute the load because of its inherent stiffness. Load point 2 shall be at the approximate center of the tile area, and when using a 12 in. (305 mm) deformation bridge, the bridge can be placed along the diagonal. Load point 1 for strip flooring is to simulate the loading condition possible when the concentrated load comes at or near an end joint. Load point 2 simulates the condition that exists when loading is on a continuous strip of flooring but there is a joint in the adjacent course of flooring. When strip flooring is less than 2 in. (51 mm) wide, the point of load 2 shall be centered on the strip. For other configurations of finish flooring, load point 1 shall correspond to the one producing maximum deformation under

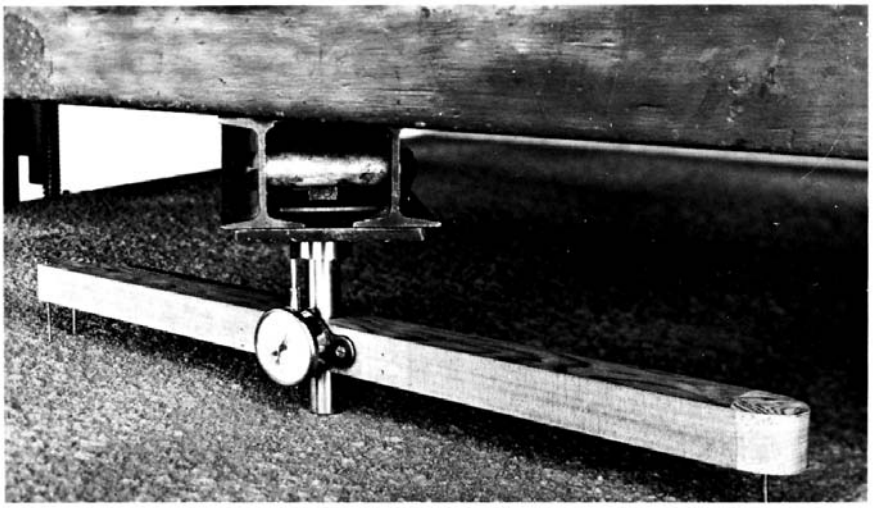


FIG. 2 Assembly for Concentrated Loading Test of Finish Flooring

load and point 2 the more average condition. In each instance, the 1 in. (25 mm) diameter loading disk shall be centered over the dimensioned point.

10.2 *Loading*—Apply the load continuously at a uniform rate of movement of the loading tool of 0.10 in. (2.5 mm)/min (Note 3). Make at least ten simultaneous measurements of load and deformation between zero load and 1000 lb (4.45 kN) (Note 4). After the load of 1000 lb (4.45 kN) has been applied, it shall be removed immediately so that residual deformation can be determined. Record any observed behavior of either the finish flooring or the substrate during test.

NOTE 3—The testing machine speed used shall not vary by more than ±50 % from that specified for a given test. The testing machine speed shall mean the free-running, or no load, crosshead speed for testing machines of the mechanical-drive type and the loaded crosshead speed for testing machines of the hydraulic-loading type.

NOTE 4—For some evaluations of finish flooring where possible use is in commercial buildings, concentrated load evaluations may be desirable for loads greater than 1000 lb (4.45 kN). When this is so, the material shall be loaded first as specified and then, after residual deformation has been obtained, reloaded to the higher maximum load or failure.

10.3 *Residual Deformation*—One hour after the load has been removed, measure the depth of residual indentation to the nearest 0.01 in. (0.25 mm), using the falling-ball indentation measuring tool described in 20.1.4.

11. Report

11.1 The report shall include typical load-deformation curves for load points 1 and 2. Each deformation value for 1000 lb (4.45 kN) loading, and residual after loading was removed, shall be presented. Any observations of behavior of either finish flooring or substrate or failures shall also be reported.

NOTE 5—Photographs showing the nature of residual indentation after loading are beneficial.

FLOOR SURFACE INDENTATION FROM SMALL AREA LOADS

12. Scope

12.1 Specimens shall be subjected to the "indentation damage from small area load test" to obtain a measure of the resistance to sharp-edged small area loadings, such as stiletto heeled shoes, protruding nail heads on other shoes, and indentation damage from small, hard objects on the surface either being stepped on or indented into the floor from rolling loads. In some of these "point" loadings, unit stresses are almost infinite. Some damage to the surface usually occurs. The purpose of this evaluation is to compare by observing the damage from this kind of loading, new finish flooring systems with those of established service performance, or two or more floorings to determine which may have better service possibilities. Results obtained are qualitative rather than quantitative.

13. Test Specimen

13.1 The test specimen shall be a composite of the various floorings being evaluated. When the number of materials being evaluated exceeds the number that can be fabricated in a single specimen, the different materials shall be distributed so that a representative number are included in each sample. Fig. 3 shows the specimen in position for test and the apparatus used for imposing the concentrated loads on the specimen. Specimens shall be approximately 9 in. (229 mm) wide and of any convenient length, so that the number of finish floorings being evaluated can be accommodated. Specimens shall be fabricated with the same substrate and in the same manner as is to be used in the application of the finished floor. When strip floorings are being evaluated, two sets of specimens shall be fabricated; one with the long dimension of the pieces of flooring parallel to, and one with the long direction of the flooring across the

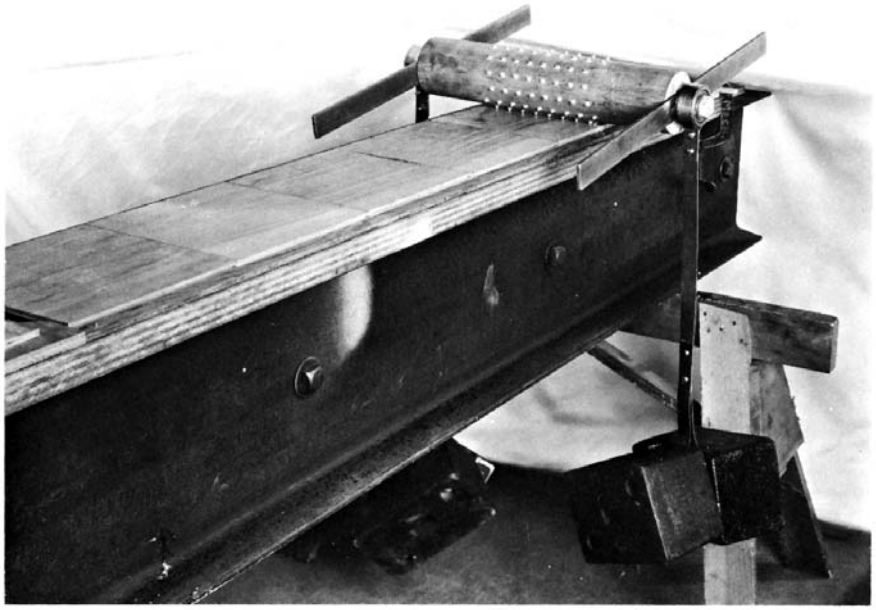


FIG. 3 Assembly for Tests of Floor-Surface Indentation from Small-Area Loads, Showing Loaded Maple Roller Studded with Boot Caulks and Specimens Firmly Supported on Heavy Beam

direction of movement of the studded roller. Cleats shall be provided to prevent sliding of the specimens.

14. Apparatus

14.1 The apparatus shall be assembled as shown in Fig. 3 and shall conform in the requirements for component parts as described in 14.1.1 – 14.1.3.

14.1.1 *Base*—The base shall be a rigid supported unit that will not deflect measurably under the rolling load. The surface of the base shall be slightly wider than the surface of the specimen, as is shown in Fig. 3.

14.1.2 *Roller*—The roller shall be a hard maple (or equivalent) cylinder $3^{13}/_{16}$ in. (97 mm) in diameter and approximately 18 in. (457 mm) long. The roller shall be studded with boot caulks (approximately 0.15 in. (4 mm) in diameter and projecting approximately 0.2 in. (5 mm), including collar, from surface of roller) 1 in. (25 mm) on center around the circumference for an 8 in. (203 mm) width. Alternate rows of studs shall be staggered. The ends of the roller shall be provided with arms for rolling it along the specimen and, either through trunnions or an axle with bearings and straps, provide a means for attaching the superimposed load on the specimen.

14.1.3 *Superimposed Load*—The superimposed load shall total 200 lb (890 N). This shall be in addition to the weight of roller, straps, and bearings and shall be divided equally on both ends of roller.

15. Procedure

15.1 Move the roller over the surface by rotation (force applied to arms) for 100 trips. A trip is defined as a single pass from one end of the specimen to the other. Forward and back are two trips.

16. Interpretation of Results

16.1 At the end of 100 trips, the damage to the different finish flooring samples shall be compared. The amounts of damage shall be classified as none to minor, moderate, severe, and complete. The complete classification would be, in the judgment of the investigator, so severe that replacement would be necessary if that kind of damage occurred in an actual installation.

17. Report

17.1 The report shall include a complete description of the finish flooring, substrate, and method of attaching the finish flooring to the substrate. Any slivering or other disintegration of the flooring surface beyond just denting shall be noted and the classification of the damage shall be reported. Photographs of actual tested specimens (Fig. 4) are desirable and shall be considered in reporting. In Fig. 4, material G can be considered typical of a specimen showing none to minor damage; J is moderate, H severe, and material I probably would be considered to be complete.

FALLING-BALL INDENTATION

18. Scope

18.1 Specimens shall be subjected to the falling-ball indentation test to obtain a measure of the resistance of a finish flooring to impacts from dropped objects. In this procedure, the indentation-heights of drop data are plotted and a line drawn through the plotted points. The slope of this line, amount of indentation for a prescribed height of drop, and damage to the surface beyond indentation are values used as criteria. Each drop is made at a different location on the surface.

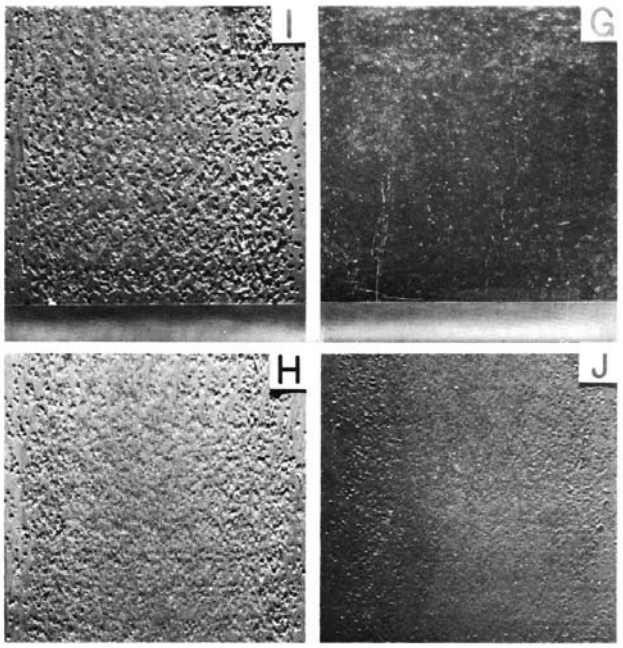


FIG. 4 Appearance of Finish Flooring Specimens After 100 Trips with Caulk-Studded Roller

FIG. 5 Apparatus for Falling-Ball Indentation Test for Wood or Wood-Based Finish Flooring

19. Test Specimen

19.1 The specimen shall be of any convenient size, in the same thickness as is to be used in the finished floor, but large enough (Note 6) so that twelve drops of the falling ball may be made without the value for indentation for one height of drop being influenced by another, or by being too close to the edge of the specimen. This means that a minimum area of about 100 in.^{2} (0.065 m^2) is required. In this test, the specimens are not backed by the underlayment or other substrate. The indentation is obtained with a minimum of energy absorption by any other component than the finished flooring.

NOTE 6—These impact points should be approximately 2 in. (51 mm) apart. When flooring is in strip form or in small tile, it may be necessary to use two or more pieces to satisfy that requirement. If so, they should be selected to be as nearly alike as possible.

20. Apparatus

20.1 The equipment suitable for measuring the falling-ball impact resistance is shown in Fig. 5. Essential parts are described in 20.1.1 – 20.1.4.

20.1.1 *Ball*—The impacting unit is a 2 in. (51 mm) diameter steel ball weighing 1.18 lb (535 g) (Note 7).

NOTE 7—A suitable ball may be a bearing ball of that diameter.

20.1.2 *Base*—The base shall be flat and smooth, of heavy mass, rigidly supported, oriented so the top surface is horizontal, and preferably of steel.

20.1.3 *Holding and Release Mechanism*—The mechanism for positioning and holding the steel ball until released at desired height of drop shall be such that at release of the ball no horizontal motion is imparted. The free fall of the ball must be vertical. Shown in Fig. 5 is an electromagnetic unit with an electric switch that releases when the magnetic head unit reaches a preset height. If such a unit is not provided, some means must be provided to accurately measure and set the distance from the surface of the specimen to the bottom of the ball at the desired increments of 6 in. (152 mm).

20.1.4 *Indentation Measuring Device*—The measuring device shall be assembled from the components listed in 20.1.4.1 – 20.1.4.3. An example is shown in Fig. 5.

20.1.4.1 A hollow cylinder with approximately the following dimensions: outside diameter of barrel 1 15/16 in. (49 mm), base 1 11/16 in. (43 mm), height of base, outside ½ in. (12 mm), inside ¼ in. (6 mm); inside diameter of barrel ⅜ in. (9.5 mm) (to accommodate collar of micrometer), base 1 3/16 in. (30 mm); and overall height 2⅛ in. (54 mm).

20.1.4.2 A dial micrometer of the type with graduations of 0.001 in. (0.025 mm), with a stem of sufficient length so indentations of about ¼ in. (6 mm) can be measured.

20.1.4.3 The tip (anvil) of the micrometer shall be the standard rounded one, 13/64 in (5 mm) diameter, with the spherical end surface of 11/64 in. (4.4 mm) radius.

21. Procedure

21.1 *Increments of Drop*—The height of the drops shall progress in increments of 6 in. (152 mm). Make the initial drop from 6 in. (152 mm) (measured from the surface of the specimen to the bottom of the steel ball). Make each drop at a fresh, undisturbed location on the surface of the specimen at least 2 in. (51 mm) from any previous indentation. Catch the steel ball on the rebound after each drop, so that each indentation is the result of a single impact. Make drops up to a height of 6 ft (1.8 m).

21.2 *Indentation Measurements*—Set the dial of the indentation measuring tool at zero by placing it at about five different

places on the surface of the specimen and averaging the differences in surface irregularity as indicated by the readings of the dial. Measure the depth of indentation after each drop by placing the center of the indentation-measuring device over the center of the impact area (Note 8).

NOTE 8—A piece of tissue-thin carbon paper is useful in locating the center of each impact area. When used, place it on the surface of the specimen, carbon side down, before each drop and then remove before each measurement.

21.3 *Interpretation of Results*—Plot the values of indentation measured for each drop as shown in Fig. 6, with height of drop as the ordinate and depth of indentation as the abscissa. Draw a smooth curve through the plotted points. Take the intercept of the curve for a height of drop of 72 in. (1.8 m) as the index of indentation resistance. Also use comparisons of the curves for different materials, as is done in Fig. 6.

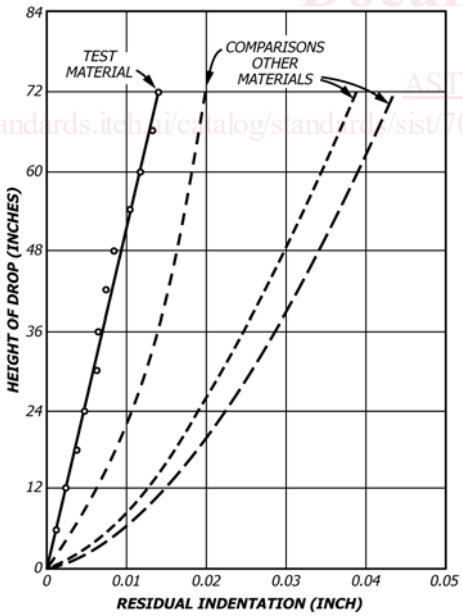
22. Report

22.1 The report shall include a complete description of the finish floor, the curve of indentation obtained, and description of any fracture of surface or interior material.

ROLLING LOAD

23. Scope

23.1 Specimens shall be subjected to the rolling load test to obtain a measure of the damage to surface and to the finish flooring material from repeated rolling forces, such as are produced from heavy castered loads of chests, beds, pianos, and appliances. In this procedure, a unit simulating a caster is rolled back and forth along the surface of the flooring. The total direct load on the caster is 200 lb (890 N). The depth of indentation produced by repeated passes of the caster is the index of resistance to the rolling load.



Metric Equivalents

in.	12	25	36	48	60	72	84
mm	305	635	914	1219	1524	1829	2134
in.	0.01		0.02	0.03	0.04	0.05	
mm	0.25		0.51	0.76	1.02	1.27	

FIG. 6 Plot of Height of Drop versus Indentation for Falling-Ball Indentation Test

24. Test Specimen

24.1 The specimen shall be a composite built up of pieces of finish flooring laid in the manner that will normally be used in installations. The substrate for the finish flooring shall be duplicated insofar as possible. If the finish floor is to be applied over concrete, this shall be duplicated. If it is to be applied to a plywood subfloor, then plywood shall be installed underneath the finish flooring material. Usually, the flooring is installed on the diagonal, as shown in Fig. 7. End joints in strip flooring and corners of tile floor shall be placed in the center of the width so that the caster will roll across corners as shown. The test specimen shall be of any convenient length so that as many individual flooring materials can be evaluated at a time as practicable.

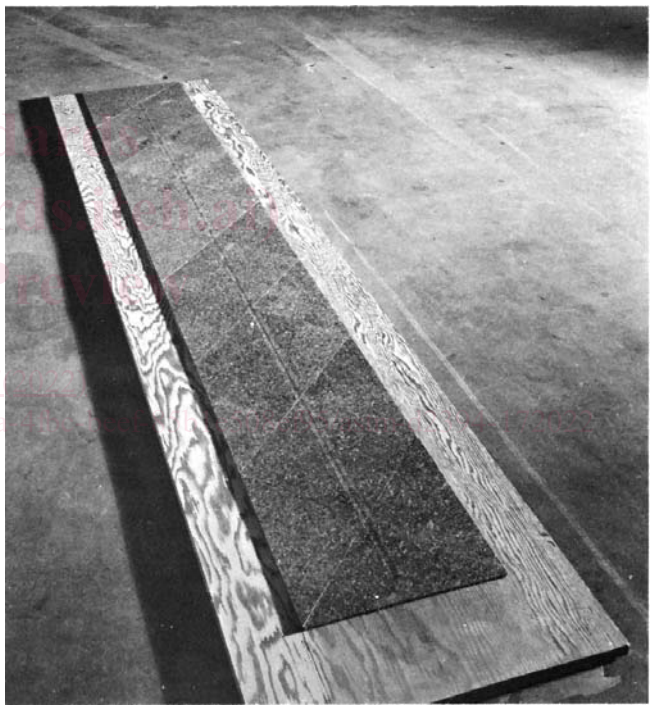


FIG. 7 Wood-Based Finish Floor Applied to Plywood with Tile Oriented so that Loaded Caster will Roll Across Corner

25. Apparatus

25.1 The apparatus for making the rolling load test shall be assembled as shown in Fig. 8. Pertinent parts are described in 25.1.1 – 25.1.4.

25.1.1 *Carriage and Load*—The tri-wheeled carriage shall be constructed so that the single front caster rolls over the center of the specimen and the two rear casters roll along the outsides of the two longitudinal guides to keep the carriage in position. The carriage shall be constructed also so that weights may be placed on it until the total force on the front caster is 200 lb (890 N). The front of the carriage shall be provided with

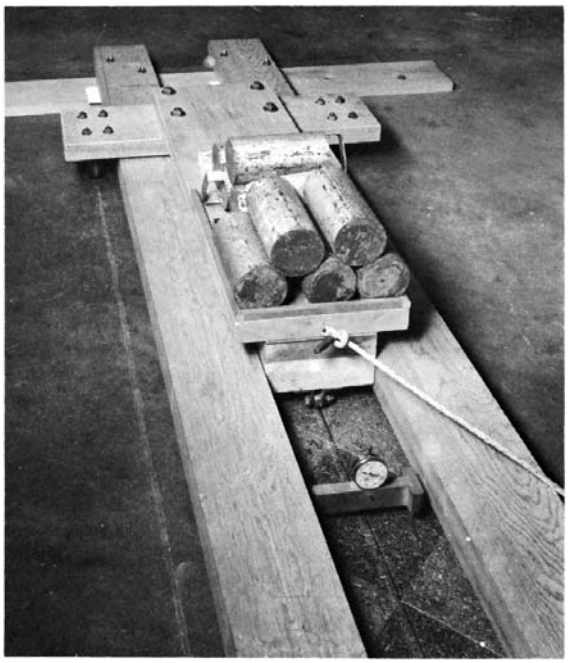


FIG. 8 Apparatus for Simulated Rolling Caster Test

a guide block not more than ⅛ in. (3 mm) less in width than the distance between longitudinal guides, so that repeated passes over the specimen will be along the same path.

25.1.2 *Front Caster*—The front roller, simulating a hard-wheeled caster, shall be a standard ball bearing assembly with an outer race 1.18 in. (30 mm) in diameter and width of 9⁄16 in. (14.3 mm), with rounded edges so that the flat surface is about ½ in. in width (13 mm).[3]

25.1.3 *Longitudinal Guide*—Guides shall be provided so that repeated passes of the caster will be along the same path over the center of the specimen. The means of providing this guidance is optional, but one suitable system is shown in Fig. 8.

25.1.4 *Deformation-Measuring Bridge*—A three-point supported bridge with a micrometer measuring dial (smallest division 0.001 in. (0.025 mm)) shall be provided for measuring the depth of indentation produced by repeated passes of the roller across the specimen. The tip (anvil) of the micrometer shall be the standard rounded one as described in 20.1.4.3. The length of the bridge may be of any convenient amount but shall be long enough so that the supports clear the area adjacent to the indentation produced by the roller (Note 9).

NOTE 9—With some flooring materials the surface adjacent to the groove produced by the roller may be pushed up by the indentation in the roller track.

26. Procedure

26.1 Secure the specimen in place on a firm, smooth base with the guides secured in relation to the specimen. Take initial readings of the bridge at points where deformation is to be determined. Position the carriage at one end of the specimen, and either push or pull over the specimen until ten trips have been completed. Measure the amount of indentation produced by the ten trips (Note 10). One trip is defined as movement of the carriage from one end of the specimen to the other. A pass from one end to the other and return to the starting point is two trips. Repeat this procedure for a total of 25 trips, and then if the floor surface is still essentially intact and the indentation produced by the roller is no more than 0.01 in. (0.25 mm), continue the test until the total number of trips has been 50.

NOTE 10—It is the purpose of this procedure to obtain the maximum and average amount of indentation produced by the small-castered wheel. For the average results, approximately three sets of readings per material should be used. Where damage is not uniform, areas of maximum damage may be determined visually when apparent or by sliding the bridge along the length of the specimen.

27. Report

27.1 The report shall present the average measured values of indentation for 10 and 25 trips, and for 50 trips if the test was continued that long. The maximum indentation value shall be presented separately from those used in averaging, unless it happened to be at one of the points selected for measurement at the beginning of the test. Any fracturing of the surface shall be noted, with the cycle number that the fracture was first noted.

NOTE 11—Photographs illustrating the kind of damage produced by the rolling load are beneficial.

ABRASION RESISTANCE

28. Scope

28.1 Proper maintenance of a finish film on the surface of wood or wood-based finish flooring improves its performance against abrasive forces, but the abrasion resistance of a finish flooring is an important property in assessing the possibilities of use in heavy traffic areas and possible service performance if a continuous wax or other film is not maintained by ordinary applications. The Navy-Type Wear Tester[4] (Note 12) shall be used to measure the abrasion resistance of finish floor wearing surfaces. This machine simulates the abrasive action of the human foot when walking. The action is a combination of sliding and twisting that produces uniform wear. When flooring samples are nonuniform in depth or the surface is finished with a particularly heavy coating, wear may not be uniform. Otherwise, the slope of the wear versus cycles curve is the index of abrasion resistance.

NOTE 12—Other test methods have been used to measure abrasion resistance of other materials. The method here delineated has been used extensively for measuring the resistance of wood and other wood-based materials, like plywood, to surface abrasion, so values are available for comparing results.[5] This method is also described in Test Methods D1037.

29. Test Specimens

29.1 The area of the specimen to be abraded shall be 2 in. by 3 in. (51 mm by 76 mm) and the specimen shall be fabricated

[3] A ball bearing 5200 series satisfies the described bearing unit.

[4] This machine may be constructed from drawings available at the Forest Products Laboratory, 1 Gifford Pinchot Drive, Madison, Wisconsin 53726.

[5] U.S. Forest Products Laboratory Report 1732, "The Abrasion Resistance of Wood as Determined with the U.S. Navy Wear Test Machine," 1948.