Designation: D2047 – 11

Standard Test Method for Static Coefficient of Friction of Polish-Coated Flooring Surfaces as Measured by the James Machine[1]

This standard is issued under the fixed designation D2047; 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 This laboratory test method covers the use of the James Machine for the measurement of the static coefficient of friction of polish-coated flooring surfaces with respect to human locomotion safety. Further, this test method also establishes a compliance criterion to meet the requirement for a nonhazardous polished walkway surface. The test method is not intended for use on "wet" surfaces or on surfaces wherein the texture, projections, profile or clearance between the sculptured pattern of the surface does not permit adequate contact between the machine foot and the test surface.

1.2 This test method is the only method appropriate for testing polishes for specification compliance with the floor polish static coefficient of friction criterion.

1.3 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.

1.4 *This standard does not purport to address all of the safety problems, 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:*[2]

C1028 Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method (Withdrawn 2014)[3]

D1436 Test Methods for Application of Emulsion Floor Polishes to Substrates for Testing Purposes

D1630 Test Method for Rubber Property—Abrasion Resistance (Footwear Abrader)

D2825 Terminology Relating to Polishes and Related Materials

D4103 Practice for Preparation of Substrate Surfaces for Coefficient of Friction Testing

D6205 Practice for Calibration of the James Static Coefficient of Friction Machine

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E456 Terminology Relating to Quality and Statistics

2.2 *Federal Specification:*

KK-L-165C Leather, Cattlehide, Vegetable Tanned and Chrome Retanned, Impregnated, and Soles.[4] Type 1–Factory (for Shoe Making), Class 6–Strips

3. Terminology

3.1 *Definitions*—See also Teminologies D1436 and D2825.

3.1.1 *friction, n*—the resistance to relative motion developed between two solid contacting bodies at, and parallel to, the sliding plane.

3.1.2 *coefficient of friction, n*—the ratio of the horizontal (shear) component of force required to overcome friction, to the vertical (normal) component of force applied.

3.1.3 *static coefficient of friction, n*—the ratio of the horizontal component of force applied to a body that just overcomes the friction or resistance to sliding, to the vertical component of force applied.

3.1.4 *dynamic coefficient of friction, n*—the ratio of the horizontal component of force required to cause a body to continue to slide at a constant velocity, to the vertical component of force applied.

3.1.5 *slip resistance, n*—the frictional force opposing movement of an object across its surface, usually with reference to the sole or heel of a shoe on a floor. A surface having a static coefficient of friction of 0.5 or greater as measured by this test method is considered to have adequate slip resistance. That is,

[1] This test method is under the jurisdiction of ASTM Committee D21 on Polishes and is the direct responsibility of Subcommittee D21.06 on Slip Resistance.

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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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

it will provide the required traction for preventing or markedly reducing the probability of slipping while walking.

4. Significance and Use

4.1 Test Method D2047 establishes a compliance criterion relating static coefficient of friction measurements of flooring surfaces with human locomotion safety. The compliance criterion is based on extensive experiential data from residential, commercial, industrial and institutional walkway surfaces since 1942.

4.2 Polishes and other floor maintenance coatings having a static coefficient of friction of not less than 0.5, as measured by this test method, have been recognized as providing nonhazardous walkways.

NOTE 1—The value of 0.5 meets the requirements for compliance with Rule 5 on "The use of terms slip retardant, slip resistant, or terms of similar import," of the Proposed Trade Practice Rules for the Floor Wax and Floor Polish Industry as issued by the Federal Trade Commission on March 17, 1953.

4.3 The 0.5 static coefficient of friction compliance criterion of this test method is only appropriate for polish-coated surfaces tested in accordance with this machine and test method. The use of this compliance criterion with other test methods, other test instruments, and other surfaces is improper, because they are not a part of the body of experiential data upon which the conformance criterion is based.

NOTE 2—The conformance criteria of this test method may be valid for other surfaces and surface coatings tested by this test method, but this has not been substantiated by correlation with experiential data.

5. Apparatus

5.1 *James Machine*[5]—See Fig. 1.

5.2 *Shoe Material*[6]—For interlaboratory and specification testing the shoe material shall be leather, conforming to Federal Specification KK-L-165C. Other materials commonly employed as footwear sole or heel material may be used. However, it should be understood that the 0.5 static coefficient of friction compliance criterion value is not relevant when such materials are substituted for the specification leather (Notes 2 and 3). To date, compliance criterion values for polish interfaces with other shoe materials have not been determined with respect to establishing minimum requirements for nonhazardous walkways. If a standard rubber shoe material is required, the test rubber should be in accordance with Test Method D1630.

NOTE 3—The static coefficient of friction measured with elastomeric compositions are frequently as much as 0.3 to 0.5 higher than leather.

5.3 *Substrate*—For interlaboratory and specification testing, OVCT[7], wood panels[8], or standard ceramic tiles[9] shall be used.

5.3.1 If substrates other than the above standards are to be used, they should be of uniform porosity and free of surface irregularities which would interlock the shoe material with the surface or otherwise impede smooth sliding of the shoe over the film surface.

6. Test Surface

6.1 For interlaboratory and specification testing of floor polishes, films on OVCT, wood panels, or ceramic tiles shall be prepared in accordance with Practice D4103 or Test Method C1028, respectively.

7. Test Shoe Material

7.1 The size of the shoe material used by the apparatus is 3 by 3 in. square by 0.25 in. thick (76.2 by 76.2 by 6.4 mm).

7.2 For interlaboratory and specification testing, the shoe material shall be leather manufactured in accordance with Federal Specification KK-L-165C. Cut the 3 by 3-in. (76.2 by 76.2 mm) specimen from the center portion of the hide by any suitable method. Mark the direction of the grain fibers for later reference. The alignment of the sides of the test specimen shall be along the length and width of the hide. Do not compress the leather during cutting. Dress the edges square.[6]

7.3 Before use, the specification leather should be equilibrated at 50 %(±5 %) relative humidity for one week. Between uses, the leather shoe material should be stored under these same constant humidity conditions.

7.4 Other shoe materials may be used for individual and specific testing purposes. If rubber is used, a standard rubber compound conforming to Test Method D1630, Section 7.1, is recommended. It is further recommended that the thickness of the shoe material not be greater than 0.25 in. (6.4 mm) or less than 0.20 in. (5.1 mm).

7.5 Gently sand the inside (flesh) surface of the leather to produce a uniform thickness. The final sanding in this process should be done by using 400 grit waterproof silicon carbide paper[10] affixed to a flat surface to produce a uniform surface for mating with the shoe holder. The inside (flesh) and outside (grain) faces of the leather should be parallel to within 0.01 in. (0.25 mm). The inside surface should be free of loose shreds of leather, grit, and dust.

7.6 Cement the flesh side of the leather to the metal shoe (3-in. square flat steel plate) using any suitable adhesive or

[5] Assembled, motorized machines are available from Michelman, Inc., 9080 Shell Road, Cincinnati, OH 45236–1229. Assembled, non-motorized machines are available from Quadra, Inc., 1833 Oakdale Ave., Racine, WI 53405. Engineering/machinist drawings are available from Consumer Specialty Products Association, 900 17th Street NW, Washington, DC 20006.

[6] Precut specification leather material is available from Consumer Specialty Products Association , 900 17th Street NW, Washington DC 20006.

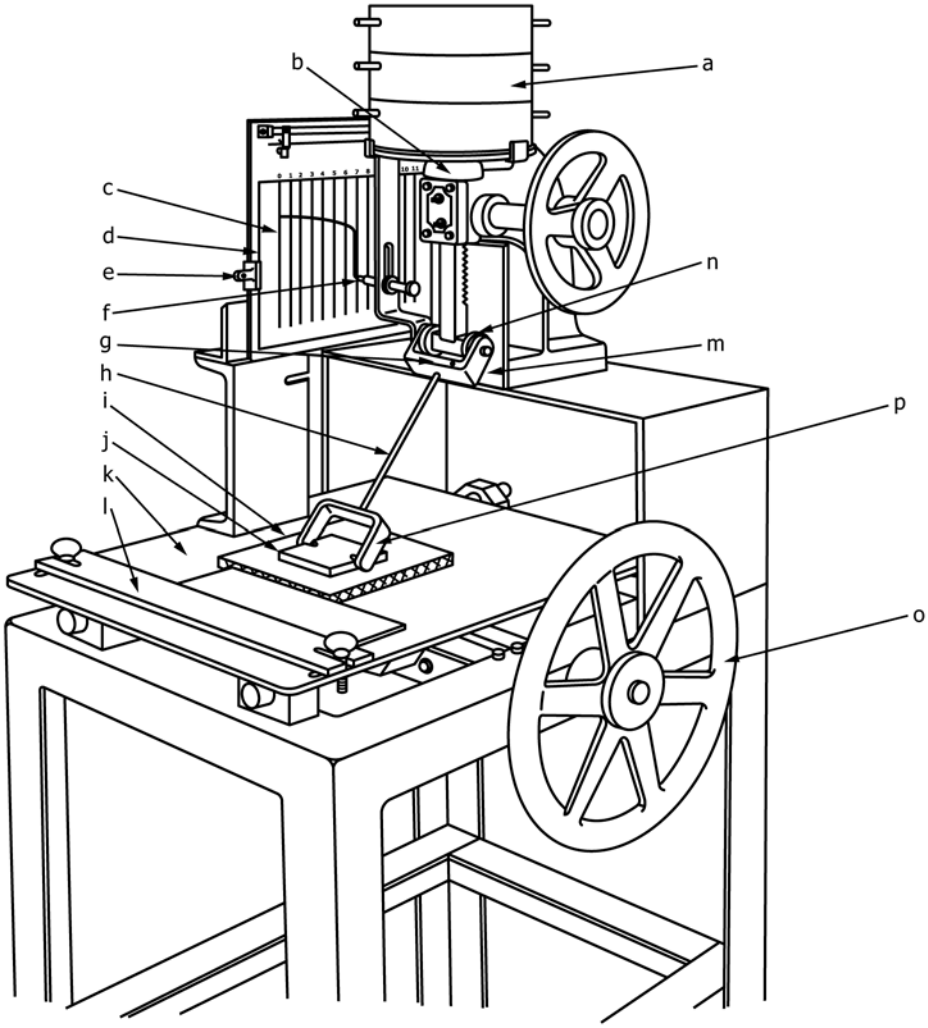
[7] OVCT, Official Vinyl Composition Tile, is available from Consumer Specialty Products Association, 900 17th Street NW, Washington, DC 20006.

[8] Wood panels may be constructed from assembled Rock Maple shorts (Second Grade, or better), available from Robbins, Inc., 4777 Eastern Ave., Cincinnati, OH 45226, or from local distributors for Bruce Hardwood Floors, or Harris-Tarkett Floors. Alternatively, panels may be cut from 3/4 in. (19.1 mm) furniture grade maple veneer plywood, available from local lumberyards or millworks.

[9] Available from the Tile Council of America, P.O. Box 1787, Clemson, SC 29633. The tiles should be prepared for coating in accordance with the procedure in Test Method C1028.

[10] 3M-413Q, available from 3M Co., St. Paul, MN; C414W, available from Carborundum Abrasives Co., Niagara Falls, NY; T421, available from Norton Co., Stephenville, TX.

NOTE 1—The schematic is of a hand driven model. Motorized models do not have a table transport hand wheel (o). For clarity, this depiction of the James Machine does not show guards in place; pinch points should be guarded in accordance with recognized safety engineering standards.



a—Weights
b—Cushion
c—Chart
d—Chart Board
e—Spring Clip
f—Recording Pencil
g—Set Screw
h—Strut
i—Specimen
j—Shoe
k—Test Table
l—Retaining Bar
m—Back Plate
n—Ball Bearing Rollers
o—Table Transport wheel
p—Shoe holder

FIG. 1 James Machine

double-sided tape. Orient the leather on the shoe so that the original grain of the leather is parallel to the direction of shoe travel.

7.7 To prepare the face of the leather-shoe for interlaboratory and specification testing, sand the grain face of the leather with 400 grit paper using four passes, two parallel to the direction of shoe travel followed by two perpendicular to the direction of shoe travel. Remove all dust from the leather surface using a brush, vacuum, blower, or woodworking "tack" cloth. Test the surface to be certain it is free of dust by wiping with green felt cloth and observing the cloth for dust.

7.8 Lightly sand the grain face of the leather shoe with the 400-grit paper before each reading, as described in 7.7.

NOTE 4—Discontinue use of the leather material when sanding has reduced the thickness by 0.05 in. (1.3 mm).

8. Procedure (See Fig. 1)

8.1 Thoroughly check the James Machine is level in all directions, and correct any mechanical malfunctions to ensure reliable results (see Practice D6205).

8.2 Attach the chart[11] to the chart board.

8.3 Raise the weights until the strut is perpendicular to the table and attach the prepared test shoe in the shoe holder.

8.4 Before starting the actual test, make a test run in four mutually perpendicular directions using a panel of known coefficient of friction. Follow the procedure in 8.8. The test results shall differ by no more than 5 % from the known coefficient of friction. A greater deviation indicates the necessity to check the alignment of the machine (Practice D6205). Repeat this process until specified results are obtained.

NOTE 5—Finishes of known coefficient of friction are those which have undergone repeated evaluation by this test method, including round robin tests, and which have amassed considerable exposure to pedestrian traffic. Most commerical finishes meet these requirements. Samples and corresponding coefficient of friction values are available from many formulating manufacturers, polymer manufacturers, and other floor finish raw material suppliers.

8.5 Use three tiles or panels for each test, obtaining four readings on each panel. Rotate the panels 90° between each of the four readings so that a fresh surface is tested each time and directional effects, if any, are cancelled. If there is insufficient floor finish to coat three panels, tests on one or two panels may be run, though with the expectation of reduced precision.

8.6 Place the panel on the test table in firm contact with the retaining bar. Lightly dust the test panel to remove any extraneous matter.

8.7 Carefully place the leather-shoe into the strut yoke and gently lower the entire assembly into contact with the test panel. Disengage the small hand wheel.

8.8 Release the recording pen, making sure it is on the zero line of the chart.

8.9 Move the test table forward at a uniform rate of 60 in./min (1524 mm/min), ± 3 in./min (±76 mm/min), until the shoe slips and the vertical column drops.The table movement should be started within 5 s after the contact in 8.7 has been made.

8.10 After each determination, lift the strut and return the test table to the start position. Rotate the test panel 90°, sand the leather shoe material in accordance with 7.8, vertically offset the recording pen, and repeat steps 8.6 through 8.9.

8.11 Record as the static coefficient of friction the point at which the horizontal curve made on the chart by the recording pen changes to a vertical line. If this point is not sharply defined at the top of the vertical line, it may be necessary to draw a standard curve with the shoe braced to prevent slippage. Overlay the standard curve on the test curve, and record the point at which the test curve first deviates from the standard curve. Estimate the readings to the nearest 0.01

NOTE 6—If panels thicker than 0.5 in. (12.7 mm) are to be tested (for example, concrete or terrazzo slabs), a shim may be required underneath the gear box frame. The shim shall be cut to the contours of the frame and horizontal support and may be of any thickness necesary to accommodate the panel. When in position it shall maintain the strut and weights perpendicular to the test table and shall not impede the free fall of the weighted vertical gear through the gear box. Holes should be cut in the shim to accomodate bolts so that the unit may be bolted down before operation.

9. Report

9.1 The completed CSPA chart shall constitute the report of testing. It shall include the following:

9.1.1 The static coefficient of friction as the arithmetic average of all twelve readings obtained on the three panels. For interlaboratory testing or external reporting, round off the average to one significant digit using the rounding-off method of Practice E29. For intralaboratory data analysis, two significant digits may be retained.

9.1.2 The calculated standard deviation from the mean of the readings, or the range (lowest and highest) readings in the test.

9.1.3 The name or other identifier of the polish, and the date tested.

9.1.4 If other than the standard leather, identity and specifications for the test foot material used.

9.1.5 The temperature and humidity under which the tests were conducted.

9.1.6 If other than two coats of polish were applied, report the number of coats and the application procedure used (see Test Method D1436 and Practice D4103).

9.1.7 The polish substrate, if other than the standard OVCT tile, wood, or ceramic tile.

9.1.8 Name of the operator.

10. Precision[12]

10.1 The following criteria should be used for judging the acceptability of results (95 % confidence):

10.1.1 *Repeatability*—Duplicate determinations of the mean static coefficient of friction of a polish film, by the same operator and on the same James machine, should be considered suspect if they differ by more than 0.02.

10.1.2 *Reproducibility*—The mean static coefficient of friction of films from a liquid polish determined by two laboratories should be considered suspect if they differ by more than 0.07.

11. Bias

11.1 The procedure in Test Method D2047 for measuring the static coefficient of friction of polish-coated surfaces by the James Machine has no bias because the value of the static coefficient of friction of polish-coated surfaces is defined only in terms of this test method.

[11] Suitable charts are available from the Consumer Specialty Proucts Association, 900 17th Street NW, Washington DC 20006. Only use originals of these charts, not copies. Even the best copying machines will not duplicate exactly, and small deviations in the distance between coefficient of friction lines on the chart could lead to inaccurate results.

[12] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D21-1000.

12. Keywords

12.1 coefficient of friction; finishes; flooring; footwear; heel; James Machine; polishes; sole