Designation: C 1028 – 07

Standard Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method[1]

This standard is issued under the fixed designation C 1028; 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 test method covers the measurement of static coefficient of friction of ceramic tile or other surfaces under both wet and dry conditions while utilizing Neolite heel assemblies.[2] This test method can be used in the laboratory or in the field.

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

2. Referenced Documents

2.1 *Rubber Manufacturing Association (RMA) Standard:*
HS-3 Method of Test for Evaluating Adhesive Bondability of Shoe Soling Materials (1975)[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *coefficient of friction*—the ratio of the horizontal component of force required to overcome or have a tendency to overcome friction to the vertical component of the object weight or normal force applied through the object which tends to cause the friction.

3.1.2 *friction*—the resistance developed between the physical contacting surface of two bodies when there is movement or tendency for movement of one body relative to the other parallel to the plane of contact.

3.1.3 *static coefficient of friction*—the ratio of the horizontal component of force applied to a body that just overcomes the friction or resistance to slipping to the vertical component of the weight of the object or force applied to it.

4. Significance and Use

4.1 The horizontal dynamometer pull meter and heel assemblies are designed to determine the static coefficient of friction of tile and like materials.

4.2 The measurement made by this apparatus is believed to be one important factor relative to slip resistance. Other factors can affect slip resistance, such as the degree of wear on the shoe and flooring material; presence of foreign material, such as water, oil, and dirt; the length of the human stride at the time of slip; type of floor finish; and the physical and mental condition of humans. Therefore, this test method should be used for the purpose of developing a property of the flooring surface under laboratory conditions, and should not be used to determine slip resistance under field conditions unless those conditions are fully described.

4.3 Because many variables may enter into the evaluation of slip resistance of a particular surface, this test method is designed to evaluate these surfaces under both laboratory and actual site installation conditions.

4.4 The static coefficient of friction is determined under both wet and dry conditions with Neolite heel assemblies over both unprepared and prepared (cleaned) test surfaces.

5. Apparatus

5.1 *Dynamometer Pull Meter*, horizontal capable of measuring 100 lbs.-force (lbf.), accurate to 0.1 lbf., and capable of holding the peak value. (see Fig. 1).

5.2 *Weight*, 50-lb (22-kg) Weight shall be either cylindrical (approximately 6 in. in diameter and approximately 8 in. tall) or of rectangular dimensions with the base measuring approximately 6 by 8 in. Weight must be stable, and have a uniform distribution of weight. (see Fig. 2).

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[1] This test method is under the jurisdiction of ASTM Committee C21 on Ceramic Whitewares and Related Products and is the direct responsibility of Subcommittee C21.06 on Ceramic Tile.

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[2] Neolite or an equivalent has been found satisfactory. Neolite is a registered trademark of the Goodyear Tire and Rubber Co., Shoe Product Division, Windsor, VT 05089 and may be obtained from Smithers Scientific Services, Inc., 425 W. Market St., Akron, OH 44303 (Attn: Technical Director). Specify "Neolite (Break-in Compound)," RMA Spec. HS-3, Size 36 by 44 in., 6 irons, Color: Natural 11, Specific Gravity 1.27 ± 0.02, Hardness Shore A93-96.

[3] Available from Rubber Manufacturers Association, 1901 Pennsylvania Ave., NW, Washington, DC 20006. RMA Specification #HS-3.

(a)

(b)

FIG. 1 Dynamometer Pull Meters

5.3 *Standard Neolite Sled Assemblies*, two, one to be used for each of the wet and dry conditions.

5.3.1 Two assemblies, constructed from 8 by 8 by ¾-in. 6061-T6 aluminum plate or similar material, with 3 by 3 by ⅛-in. Neolite material attached to the aluminum plate with contact adhesive.

5.3.2 Sheen must be removed from the Neolite surface prior to use. To prepare the assembly surface prior to initial use:

5.3.2.1 Place a sheet of 400 grit wet or dry silicon carbide paper (attached to a flat surface, such as a piece of float glass) on a flat and stable surface.

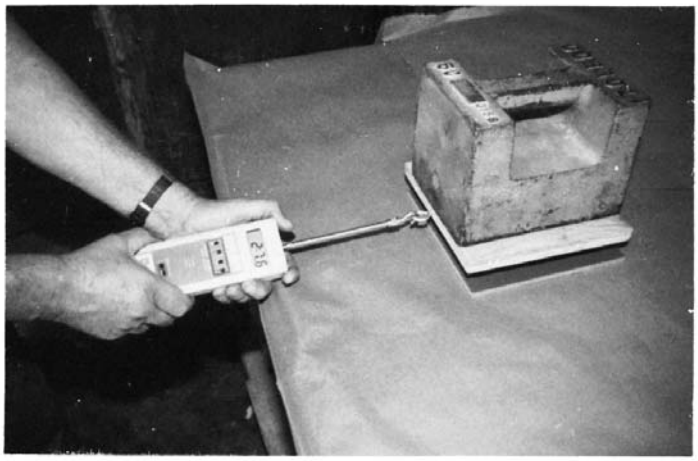

FIG. 2 Test Assembly

5.3.2.2 Sand Neolite material by moving the assembly once across the sandpaper towards the operator for a distance of about 4 in. (102 mm) while applying between 15-20 lbs-force to the assembly,

5.3.2.3 Remove the sled assembly and brush off any accumulated Neolite dust from the silicon carbide paper and sled assembly using a dry brush; brush to be such that it effectively removes the Neolite dust but causes no damage to the silicon carbide paper or the Neolite on the sled assembly.

5.3.2.4 Rotate the sled 90° (clockwise) and sand the Neolite again with the same procedure (one single pull towards the operator followed by removing the Neolite dust is considered one stroke).

5.3.2.5 Repeat sanding in this fashion (rotating the sled assembly by 90°, clockwise, and brushing off the Neolite dust each time between strokes) for a total of eight (8) strokes. Eight strokes equals one (1) resurfacing cycle.

5.3.2.6 Continue sanding the Neolite until all the sheen (glossy surface produced during the manufacturing process) is removed, usually no more than 500 strokes.

5.4 *Standard Tile.* Standard tiles were manufactured under controlled conditions, assigned a unique identifying number and are available from the Tile Council of North America.[4]

6. Reagents and Materials

6.1 *Silicon Carbide Paper*, wet or dry, 400 grit.

6.2 *Renovator,*

6.3 *Neolite,*[2] Standard Neolite Cement Liner (see 2.1).

6.4 *Rags, Sponge, or Paper Towels*.

6.5 *Water*, distilled.

7. Calibration (Dry)

7.1 Because many variables are associated with this test procedure, it is important that the operator calibrates the

[4] The sole source of supply of the standard tile known to the committee at this time is Tile Council of North America, 100 Clemson Research Blvd. Anderson, SC 29625. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

Neolite Heel Assembly surface with the Standard Tile each time the test is performed.

7.2 For uses other than the initial use, resurface the assembly with 400 grit wet or dry silicon carbide paper, four cycles.

7.3 Determine the total weight, *W*, of the 50-lb (22-kg) weight plus the Neolite Heel Assembly.

7.4 Clean the Standard Tile with a renovator.

7.5 Place the Neolite Heel Assembly and the 50-lb (22-kg) weight on the Standard Tile surface. Using a dynamometer, determine the force required to set the test assembly in motion. Record the highest reading.

7.6 Make a total of four pulls, each perpendicular to the previous pull.

7.7 Calculate the dry calibration factor as follows:

$$X_D = 0.86 - \frac{R_D}{NW} \quad (1)$$

where:

X_D = dry calibration factor,
R_D = sum of the four recorded dry force readings, lb (kg),
N = number of pulls (4), and
W = weight of heel assembly plus 50-lb (22-kg) weight, lb (kg).

NOTE 1—The 0.86 factor is the static coefficient of friction value as determined by the Tile Council of North America for the standard tile (see 5.4) and confirmed by ASTM ILS in February 2007.

8. Test Procedure (Dry)

8.1 Test the following surfaces:

8.1.1 The test area or separate test specimens shall not be less than 4 by 4 in. (102 by 102 mm). Bond the separate test specimens of small-sized tile, such as 1 by 1 in. (25 by 25 mm) and 2 by 2 in. (51 by 51 mm) to a suitable surface to provide the 4 by 4 in. or larger size.

8.1.2 Test the surface in the as-received condition.

8.2 Place the 50-lb (22-kg) weight assembly with Neolite material attached on the test surface. Using a dynamometer, determine the force required to set the test assembly in motion. Record the highest reading.

8.3 Four pulls perpendicular to the previous pull on each of three surface areas or three test specimens constitute the twelve necessary readings to calculate the static coefficient of friction.

8.4 Record all readings.

8.5 Under no conditions should additional tiles be tested without performing a new calibration.

9. Calibration (Wet)

9.1 Immerse the Neolite portion of the sled assembly in water for a minimum of 5 min. after resurfacing the sled per 7.2. (See 5.3.)

9.2 It is important that the operator calibrates the assembly surface each time the test is performed. Repeat the procedure in 7.2-7.5 with one exception: Saturate the surface with distilled water and repeat the calibration with the surface wet, keeping the surface saturated.

9.3 Calculate the wet calibration factor as follows:

$$X_W = 0.51 - \frac{R_W}{NW} \quad (2)$$

where:

X_W = wet calibration factor,
R_W = sum of the four recorded wet force readings, lb or kg,
N = number of pulls (4), and
W = weight of heel assembly plus 50-lb (22-kg) weight, lb (kg).

NOTE 2—The 0.51 factor is the static coefficient of friction value as determined by the Tile Council of North America for the standard tile (see 5.4) and confirmed by ASTM ILS in February 2007.

10. Test Procedure (Wet)

10.1 Repeat the procedure in 8.2 and 8.3 with one exception: Saturate the surface with distilled water and repeat the test with the surface wet, keeping the surface saturated.

10.2 Record all readings.

11. Test Procedure Using Prepared Test Specimens

11.1 Test the prepared test specimens, both wet and dry, after cleaning the test specimens with a renovator.

12. Calculation

12.1 Calculate the static coefficient of friction as follows:

12.1.1 *Dry*:

$$F_D = (R_D/NW) + X_D \quad (3)$$

12.1.2 *Wet*:

$$F_W = (R_W/NW) + X_W \quad (4)$$

where:

F_D = static coefficient of friction for dry surface,
F_W = static coefficient of friction for wet surface,
R_D = total of the 12 dry force readings, lb (kg),
R_W = total of the 12 wet force readings, lb (kg),
N = number of pulls (12),
X_D = dry calibration factor,
X_W = wet calibration factor, and
W = total weight of the heel assembly plus 50-lb (22-kg) weight, lb (kg).

13. Report

13.1 Report the following information:

13.1.1 Type of tile or surface and

13.1.2 The individual and average static coefficient of friction for:

13.1.2.1 dry surfaces (both as-received and after cleaning) and

13.1.2.2 wet surfaces (both as-received and after cleaning).

14. Precision and Bias

14.1 *Precision*— The precision of this test method is based on an interlaboratory study of C1028-06, Standard Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method, conducted in 2006. Each of seven laboratories tested five different materials. Every "test result" is

TABLE 1 Static Coefficient of Friction for Dry Surfaces

Surface	Average	Standard Deviation	Repeatability Standard Deviation	Reproducibility Standard Deviation	Repeatability Limit	Reproducibility Limit
	$\bar{x}$	Sx	sr	sR	r	R
1	0.7971	0.0351	0.0242	0.0391	0.0678	0.1093
2	0.8093	0.0479	0.0183	0.0496	0.0513	0.1390
3	1.0007	0.0379	0.0228	0.0412	0.0639	0.1154
4	0.8700	0.0328	0.0173	0.0350	0.0485	0.0980
5	0.8543	0.0493	0.0093	0.0497	0.0259	0.1392

calculated using twelve individual force readings. The laboratories obtained two replicate test results for each material, under both wet and dry conditions.[5]

14.1.1 *Repeatability*—Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the "*r*" value for that material; "*r*" is the interval representing the critical difference between two test results for the same material, obtained by the same operator using the same equipment on the same day in the same laboratory.

14.1.1.1 "*Sr*" represents the repeatability standard deviation

14.1.2 *Reproducibility*—Two test results shall be judged not equivalent if they differ by more than the "*R*" value for that material; "*R*" is the interval representing the difference between two test results for the same material, obtained by different operators using different equipment in different laboratories.

14.1.2.1 "SR" represents the reproducibility standard deviation

14.1.3 Any judgment in accordance with these two statements would have an approximate 95 % probability of being correct.

14.2 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method, therefore no statement on bias is being made.

14.3 The precision statement was determined through statistical examination of 140 results, from seven laboratories, on five materials. Descriptions of the surfaces tested follow:

Surface 1: unglazed porcelain

Surface 2: glazed porcelain, lightly textured

Surface 3: glazed ceramic, lightly textured

Surface 4: unglazed porcelain, lightly textured

Surface 5: Standard Tile, glazed

To judge the equivalency of two test results, it is recommended to choose the surface closest in characteristics to the test surface.

15. Keywords

15.1 dynamometer; friction

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: C21–1005.

TABLE 2 Static Coefficient of Friction for Wet Surfaces

Surface	Average	Standard Deviation	Repeatability Standard Deviation	Reproducibility Standard Deviation	Repeatability Limit	Reproducibility Limit
	$\bar{x}$	Sx	sr	sR	r	R
1	0.6757	0.0113	0.0093	0.0131	0.0259	0.0367
2	0.5129	0.0269	0.0220	0.0311	0.0617	0.0871
3	0.3200	0.0338	0.0196	0.0365	0.0550	0.1023
4	0.7321	0.0269	0.0191	0.0301	0.0534	0.0843
5	0.4993	0.0137	0.0144	0.0170	0.0403	0.0477