



Designation: **F2913 – 11 F2913 – 17**

Standard Test Method for Measuring the Coefficient of Friction for Evaluation of Slip Performance of Footwear and Test Surfaces/Flooring Using a Whole Shoe Tester¹

This standard is issued under the fixed designation F2913; 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 method² determines the dynamic coefficient of friction between footwear and floorings under reproducible laboratory conditions for evaluating relative slip performance. The method is applicable to all types of footwear, outsole units, heel top-pieces (top-lifts) top lifts and sheet soling materials, also to most types of indoor floorings, including matting and stair nosing, and surface contaminants on the flooring surface, including but not limited to liquid water, ice, oil and grease. The method may also be applied to surfaces such as block pavers, turf and gravel.

1.2 Special purpose footwear or fittings containing spikes, metal studs or similar may be tested on appropriate surfaces but the method does not fully take account of the risk of tripping due to footwear/ground interlock.

1.3 The values stated in the ASTM test method in metrics are to be regarded as the standard. The values in parentheses are for information.

1.4 *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.*

1.5 *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:*³ <http://www.astm.org/catalog/standards/sist/fd2d979d-3ac3-4a9c-a3cc-f8446c15ea3c/astm-f2913-17>
[F1646 Terminology Relating to Walkway Safety and Footwear](#)
[F2508 Practice for Validation, Calibration, and Certification of Walkway Tribometers Using Reference Surfaces](#)

2.2 *Other References:*

[BS EN ISO 4287 Geometrical product specification \(GPS\). Surface texture: Profile method. Terms, definitions and surface texture parameters](#)⁴

[EN 10088-2 Stainless steels - Part 2: Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes](#)⁵

[F2913-11 Slip test training video](#)⁶

[ISO 13287](#)

¹ This test method is under the jurisdiction of ASTM Committee F13 on Pedestrian/Walkway Safety and Footwear and is the direct responsibility of Subcommittee F13.30 on Footwear.

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² This standard is derived from SATRA TM144, Friction {Slip Resistance} of Footwear and Floorings, copyright SATRA Technology Centre, Centre Ltd., Kettering Northamptonshire, NN16 8SD, United Kingdom.

³ 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.

⁴ Available from British Standards Institution (BSI), 389 Chiswick High Rd., London W4 4AL, U.K., <http://www.bsigroup.com>.

⁵ Available from European Committee for Standardization (CEN), Avenue Marnix 17, B-1000, Brussels, Belgium, <http://www.cen.eu>.

⁶ Available at ASTM F13 web page <http://www.astm.org/COMMITTEE/F13.htm>, under Additional Links.

3. Terminology

3.1 For general definitions of terms, refer to the Terminology F1646.

3.2 Definitions:

3.2.1 *footbed (removable), n*—also known as ‘insock,’ a component typically made of a foam material with a leather or fabric cover/sockliner and often shaped or contoured covering the entire insole board which can be inserted between the foot and insole board.

3.2.2 *slider*—*slider, n*—a 76 ± 1 mm flat rectangular specimen used in calibrating test surfaces (see 10.5.1) or a circular test specimen ~~prepared~~ from footwear sheet material-materials (see Note 2), or both.

3.2.1.1 *Discussion*—

Should a shape and/or size of slider other than a 76 mm circular shape be used, it shall be documented within the test report (see 14.1.2.1).

3.2.3 *slider 96—96, n*—a pre-described rectangular test specimen intended for use in calibration of the test surface calibrating test surfaces (see 10.6.10.5.1).

4. Summary of Test Method

4.1 The footwear item and underfoot surface are brought into contact, subjected to a specified vertical force for a short period of static contact then moved horizontally relative to one another at a constant speed. The horizontal frictional force is measured at a given time after movement starts and the dynamic coefficient of friction is calculated for the particular conditions of the test.

5. Significance and Use

5.1 This non-proprietary laboratory test method allows ~~preliminary~~ for the reproducible testing of whole footwear and footwear-related soling materials for evaluating relative slip performance. Other ASTM test methods generally employ a



FIG. 1 Example of Footwear Mounted Using 7° Wedge to Set Proper Contact Angle

standardized test foot primarily for evaluation of flooring materials.

6. Apparatus

6.1 Slip tester capable of performing the required test.

6.2 A means of conditioning the test specimens and the standard reference materials, prior to the test, materials against which the specimens are to be tested, prior to the test at $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ RH relative humidity and of carrying out the test at $23 \pm 2^\circ\text{C}$.

6.3 A means of securely mounting the footwear, ~~outsoles~~ outsole, top lift, or slider.

6.4 A flat rigid horizontal surface mount of minimum width 150 mm and minimum length 450 mm, to which the test underfoot surface, hereafter termed the test surface, shall be securely mounted.

NOTE 1—A device may be used to entrap lubricant within the footwear/surface contact area to ensure that the required depth of lubricant is maintained.

6.5 A means of holding the footwear, sole unit-unit, top lift, or slider clear of the test surface between test measurements without contact with any other surfaces.

6.6 A means of adjusting the angle between the footwear, sole unit-unit, top lift, or slider and the test surface so that the required contact angle can be achieved, and a means of adjusting the contact point horizontally with respect to the line of action of the vertical force when required.

6.7 A rigid wedge of minimum dimensions 80 mm wide by 120 mm long shall be used to set the contact angle of $7.0 \pm 0.5^\circ$ between footwear, sole unit or slider and test surface when required. See Fig. 1.

6.8 A mechanism for lowering the footwear, sole unit, top lift, or slider onto the test surface and applying a steadily increasing downward force, including the weight of the test specimen and its mounting, at a rate that enables the required full force—either 400 ± 20 N or 500 ± 25 N (see Table 1) to be achieved within 0.2 s of reaching 50 N.

6.9 A means of sliding the test surface relative to the footwear, sole unit, top lift, or slider at a speed of 0.3 ± 0.03 m/s commencing within 0.2 s after a vertical load of 50 N is achieved. Sliding shall not start until full vertical force is achieved, see Fig. 2. The footwear test specimen may be constrained while the test floor is moved relative to it, or vice versa.

6.10 A means of measuring time with a resolution of 0.01 s (graph should have tick marks every 0.01 s) or better.

6.11 A means of measuring:

6.11.1 The continuous vertical force exerted on the test specimen, with an accuracy of 2 % or better.

6.11.2 The continuous horizontal frictional force, with an accuracy of 2 % or better, exerted on the test specimen measured in the plane of the surface of the test surface.

6.11.3 The displacement of the moving item, test surface or footwear, sole unit, top lift, or slider, to the nearest 1 mm.

6.12 The apparatus comprising elements 6.2 – 6.10 shall be sufficiently rugged to prevent vibration.

7. Hazards

7.1 Care should be used when working with mechanical equipment. Attention to be given to preventing a pinch hazard while in operation.

8. Sampling and Test Specimens

8.1 For footwear items (footwear, sole units or slider), units, top lifts, or sliders), see 10.10.9. It is suggested that circular sliders used to represent top lifts for everyday footwear should 76 ± 1 mm diameter and minimum thickness of 5 mm. A smaller diameter may be appropriate to represent the top lift of women's fashion footwear. The shape and size of slider used shall be documented within the test report (see 14.1.2.1).

NOTE 2—The term slider refers to sample of soling material generally cut from a larger sample so to fit the apparatus. Such as a piece. Sliders are generally samples of soling material or heel toplift, which is sold in sheets and cut to size as needed for use in footwear from a larger sample.

8.2 For test surfaces, see 10.3 and 10.4; for contaminants/lubricants, see 10.510.4.

NOTE 3—Either the footwear item or the test surface may be the subject of the test. Appropriate flooring items and footwear items respectively are selected as the reference materials against which the test item is to be tested.

9. Preparation of Apparatus, Test Specimens and Test Surfaces

9.1 Prepare and condition standard reference materials (test surfaces and/or test sliders) according to 10.710.6 and Section 11.

9.2 Prepare and condition footwear, outsole sole unit, top lift, or slider materials according to 10.10.9.

9.3 Fit and secure the prepared test surface onto the rigid surface mount. If more than one test surface specimen is required to achieve a test track of at least 40 mm, position the joint(s) outside the area traversed during the test run.

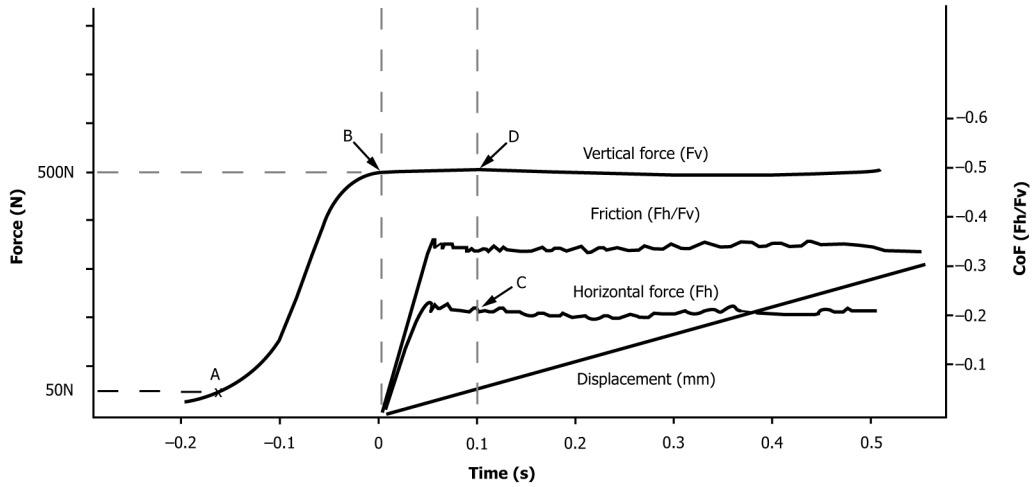
9.4 Securely fit the prepared footwear, sole unit, top lift, or slider to an appropriate mounting.

9.5 Lower the footwear, sole unit, top lift, or slider into contact with the test surface under its own weight. Adjust the alignment and angle of the footwear, sole unit or slider to conform to one of the test modes defined in 12.6.1.

9.6 Fully tighten all mounting adjustments and lift the footwear test specimen—footwear, sole unit, top lift, or slider away from the test surface.

TABLE 1 Vertical Load to be Applied in Slip Test Run

Footwear Item	Full Load to be Applied (N)
Footwear and finished soles of size US size 7.5 men's and 8.5 women's, (Paris Points 40) (UK size 6.5) and above	500 ± 25
Footwear and finished soles of sizes below US size 7.5 men's and 8.5 women's (Paris Points 40) (UK size 6.5)	400 ± 20
Top-pieces and sole materials intended for men's footwear	500 ± 25
Top-pieces and sole materials intended for women's, children's and infant's footwear	400 ± 20



Key:
 A – 50 N reached
 B – Full force achieved and relative movement started within 0.2 s after 'A'
 C – Snapshot value of horizontal force taken at (0.1 ± 0.01) s after the start of sliding movement
 D – Snapshot value of vertical force taken at (0.1 ± 0.01) s after the start of sliding movement

FIG. 2 Test Chart Showing Sequence of Events in a Typical Test Run

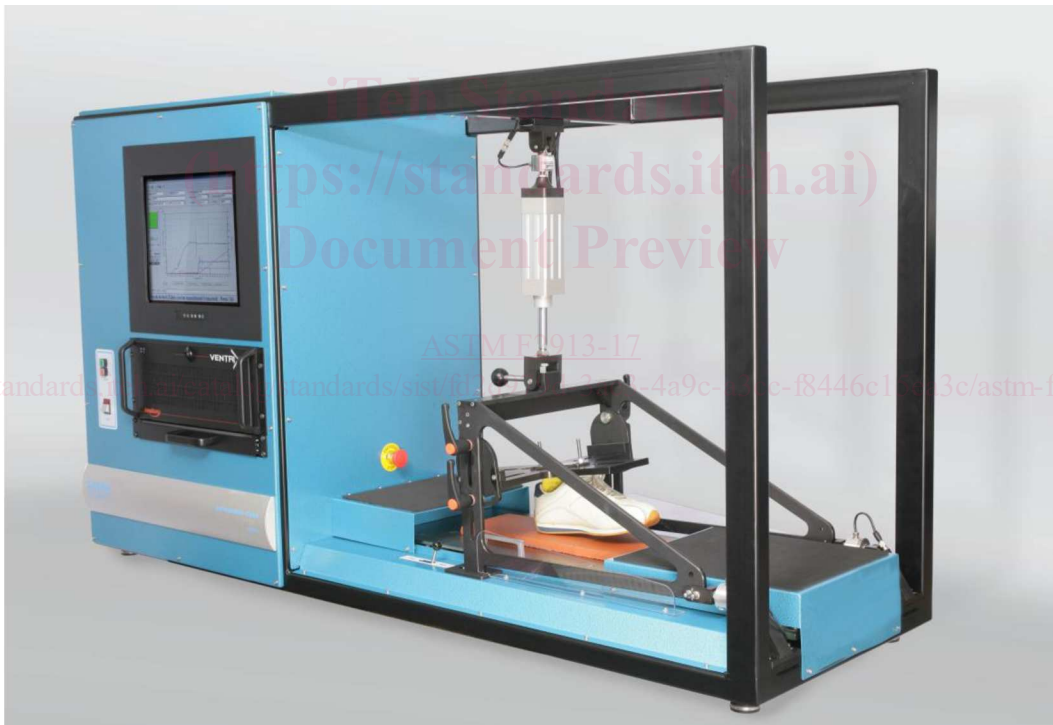


FIG. 3 Example of Test Apparatus

9.7 Apply contaminant if required (see 10.5).

9.8 Activate the data recording system.

TABLE 2 Coefficient of Friction Range for Calibrated Quarry Tiles

	Dry COF	Wet COF
Minimum	0.57	0.43
Maximum	0.63	0.49

9.9 Bring the footwear test specimen—footwear, sole unit, top lift, or slider into contact with the test surface and apply the required vertical force as specified in [Table 1](#).

10. Calibration and Standardization—Test Surfaces (Floorings) and Lubricants

10.1 General Information:

10.1.1 Any type of test surface and lubricant may be used provided it can be ~~securely~~ mounted without interfering with the action of the test.

10.1.2 Test ~~specimens~~surfaces shall be of uniform mean thickness, allowing for any surface pattern, and have minimum dimensions of 220 by 120 mm.

10.1.3 When evaluating an extruded or rolled product, where possible, cut ~~specimens~~the surface material either:

10.1.3.1 Parallel to the process direction,

10.1.3.2 Perpendicular to the process direction, or

10.1.3.3 At 45° to the process direction.

NOTE 4—Where the process direction is not known, the directions should be referenced in relation to some other distinguishing feature on the flooring.

10.1.4 When evaluating worn surfaces it may be appropriate to ~~measure~~evaluate these items in directions aligned with any patterns of wear in addition to the normal modes of testing.

10.1.5 When preparing ~~specimens~~the surfaces to be used as reference materials for testing footwear or footwear materials, the ~~specimens~~surfaces shall be calibrated in the direction in which they are to be ~~used by either~~evaluated.

10.1.5.1 Determination of standard COF test values against a Slider 96 slider in ~~10.6~~10.5, or

10.1.5.2 Specification of surface roughness in ~~10.9.2~~10.8.2.

10.1.6 Other floors used for comparing performance of footwear or footwear materials should be characterized by testing against Slider 96 rubber to establish the nominal performance level of the flooring for future reference.²

10.1.7 Transient surfaces such as natural grass and ice should be characterized by other means as appropriate, describing in full detail ~~how they were made~~in the report how the surface was made, prepared, and characterized. In general such surfaces will be damaged or changed by the action of the test so it may not be practicable to quantify their friction against a standard slider nor to perform multiple measurements on the same sample.

10.1.8 All test surfaces should be stored carefully: do not stack specimens on top of each other. When handling test surface samples, hold them by the edges and ~~also~~ do not touch the test surface of the tiles.

10.1.9 Cleaning procedures for test materials are given in ~~10.11~~10.10.

10.2 Additional Apparatus:

10.2.1 For retaining friable, weak or loose surfaces such as natural grass or gravel, a walled tray that will locate on the horizontal surface of the friction test apparatus and is sufficiently large that no part of the footwear or footwear materials being tested will come into contact with the tray during the test. A flat rigid plate 5 mm less in length and in width than the tray that is used for consolidating friable, weak or loose surfaces such as natural grass or gravel.

10.2.1.1 A means of applying a vertical load to the center of the plate shall be laid on the surface, which should be evenly distributed in the tray, and a vertical load applied through the center of the plate. The area of the plate and the total load applied should be recorded.

10.3 Test Surface Specifications—~~Calibrated Clay Quarry Tile: Surface:~~

10.3.1 ~~Flat unglazed clay quarry tile~~^{7,8}Flat unglazed clay quarry tile that is wider than the test specimen and long enough to allow a sliding distance of at least 75 mm without crossing a joint.

10.3.1.1 Sufficiently flat to allow it to be secured on the mounting table such that no movement occurs between the tile and mounting table during the test.

10.3.1.2 Has a ribbed profile or directional marking on the underside to identify the direction in which the tile should be aligned (with the ribs parallel to the sliding direction).

10.3.1.3 Conforms to the values specified in [Table 2](#) when calibrated by the Slider 96 method (see ~~10.6~~10.5).

NOTE 5—Calibration figures could differ as supplied by the tile provider and should be reported within the test document.

10.3.1.4 Calibration of the tiles should be checked, after every 10 tests or prior to each day of testing whichever is the less frequent, to ensure that they are not being worn smooth or otherwise damaged. However, if experience shows that the friction properties of the test floor are not strongly influenced by repeated testing then calibration intervals may be extended.

10.3.2 Ceramic Tile, such as Eurotile 2 as defined in EN ISO 13287 or the reference surfaces defined in Practice [F2508](#).

10.3.3 Stainless Steel Plate:

⁷ The sole source of supply of the slip tester (STM603) tile (reference STM 603 Quarry Tile) known to the committee at this time is SATRA Technology Centre, Kettering, Northamptonshire, NN16 8SD, United Kingdom.

⁸ 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.

10.3.3.1 Such as steel Number 1.4301, Type 2G (cold rolled, ground) conforming to EN 10088-2 or AISA Type 304.^{9,8}

10.3.3.2 That when calibrated by the roughness method which gives an overall mean value of R_z from all 10 locations of between 1.6 μm and 2.5 μm , as described in 10.8.

10.3.4 *Other Test Surfaces*, including such commonly found flooring materials as vinyl, wood, carpet, GRP (glass reinforced plastic), concrete, etc., shall consist of a flat sheet of material or set of tiles wider and longer than the test specimen and long enough to allow a sliding distance of at least 75 mm. The test surface may be calibrated or characterized as appropriate by the Slider 96 method (see 10.5), surface roughness where possible and then shall be checked at appropriate regular intervals. A full description of the surface should be given in the test report (14.1.2.2).

10.4 *Test Surface Specifications—Stainless Steel:*

10.4.1 *A Stainless Steel Plate:*

10.4.1.1 Such as steel Number 1.4301, Type 2G (cold rolled, ground) conforming to EN 10088-2 or AISA Type 304.^{10,7}

10.4.1.2 That when calibrated by the roughness method which gives an overall mean value of R_z from all 10 locations of between 1.6 μm and 2.5 μm , as described in 10.9.

10.4.2 *Other Test Surfaces*—These test surfaces may include such materials as vinyl, wood, carpet, GRP (glass reinforced plastic), concrete, etc., shall consist of a flat sheet of material or set of tiles wider and longer than the test specimen and long enough to allow a sliding distance of at least 75 mm. The test surface may be calibrated or characterized as appropriate by the Slider 96 method (see 10.6), surface roughness or equivalent means and then shall be checked at appropriate regular intervals.

10.4 *Use of Optional Surface Lubricants: Test Surface Condition:*

10.4.1 *Dry:*

10.4.2 *Wet—Lubricant*—Distilled or deionized water shall be applied to the flooring to thoroughly wet the surface unless otherwise specified and make a pool at least as wide and long as the footwear, sole unit or slider test specimen in the area of initial contact: test surface.

NOTE 6—A trough or similar device may be used to entrap lubricant within the footwear/surface contact area to ensure that the required minimum depth of lubricant is reached.

10.5.2 *Distilled or de-ionized water:*

10.4.3 *Detergent*—Detergent solution, containing a mass fraction of 0.5%–0.5 % sodium lauryl sulphate in demineralized water: sulfate in distilled or deionized water. Shall be applied to the flooring to thoroughly wet the test surface.

10.4.4 *Oily*—0.5 \pm 0.02 g (approximately 20 drops) of vegetable oil. Type of vegetable oil must be detailed in the test report examples include corn, soy, canola etc. Shall be applied by smearing the vegetable oil over a 150 by 150 mm area of the flooring.

10.4.5 *Other Lubricants—Oily Wet*—The surface may be covered with other substances such as oils, fats and dust as required. The method of application of such substances and the amount applied should be appropriate to the particular application of interest. The volume or mass applied per unit area should be recorded. 0.2 \pm 0.02 g (approximately 8 drops) of vegetable oil with distilled or deionized water. Type of vegetable oil must be detailed in the test report examples include corn, soy, canola etc. Shall be applied by smearing the vegetable oil over a 150 by 150 mm area of the flooring and thoroughly wet the oily test surface with distilled or deionized water.

10.5.4.1 An oily/wet condition may be produced using a 50/50 mix of water with corn oil, shaken together before application using a spray bottle.

10.5.4.2 Alternatively a sprayed on uniform film of water may be applied on top of 0.2 \pm 0.02 g (approximately 8 drops) of corn oil which has been smeared on the surface as a thin film.

10.4.6 *Other Lubricants*, as might be found on pedestrian or workplace underfoot surfaces. A full description of the lubricant and application method shall be given in the test report (14.1.2.2).

10.5 *Calibration Procedure for Test Surfaces by Slider 96 Method—Materials and Apparatus:*

10.5.1 Material ‘Slider 96’ of calibrated hardness: 96 \pm 2 IRHD measured value at 23 \pm 2°C and specified resilience (Lupke BS903-A8:1990) of 24 \pm 2 % at 23°C. Required specimen size: 25.4 mm wide, at least 50 mm long and greater than 5 mm thick. The walls shall be vertical and the edges square.

NOTE 5—Storage of Slider 96 rubber: storage temperature should be below 25°C and preferably below 15°C; moist conditions should be avoided, and conditions should be such that condensation does not occur; protect from light, particularly direct sunlight and strong artificial light; protect from circulating air by wrapping or storing in air tight containers (paper and polythene are both suitable; however, plasticized PVC film must not be used). It is recommended that Slider 96 sliders are discarded 12 months after issue.

⁸ The sole source of supply of the “Slider 96” material (formerly known as Four S rubber) known to the committee at this time is RAPRA Technology Ltd., Shrewsbury, Shropshire, SY4 4NR, United Kingdom.

⁹ The sole source of supply of the tile plate (reference STM 603 Quarry Tile) 603S known to the committee at this time is SATRA Technology Centre, Centre Ltd., Kettering, Northamptonshire, NN16 8SD, United Kingdom.