Designation: D6205 – 12

Standard Practice for Calibration of the James Static Coefficient of Friction Machine[1]

This standard is issued under the fixed designation D6205; 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 practice covers the testing of the James Machine for repeatability of static coefficient of friction, relative to a standard reference interface consisting of the working surfaces of Borco[2] board and standard leather shoe sole material, or a control polish film and standard leather shoe material. The practice provides basis data on the stability of the James Machine to ensure accurate static coefficient of friction determinations over time and repeated use and for determining if the James Machine is mechanically calibrated and properly aligned.

1.2 This practice is written specifically for James Machines with manual or motorized test table transport. Variations of this practice for the calibration of versions of James Machines which are semi-automated are obvious. Calibration practices suggested by the manufacturer of semi-automatic James Machines should be followed in preference to this practice.

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 *ASTM Standards:*[3]

D2047 Test Method for Static Coefficient of Friction of Polish-Coated Flooring Surfaces as Measured by the James Machine

D2825 Terminology Relating to Polishes and Related Materials

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

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

E178 Practice for Dealing With Outlying Observations

2.2 *Federal Specification:*

KK-L-165C Leather, Cattlehide, Vegetable Tanned and Chrome Tanned, Impregnated, and Soles[4]

3. Terminology

3.1 *Definitions:*For general definitions, see Test Method D2047 and Terminology D2825.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *Borco, n*—special 5-ply vinyl drawing board cover.

3.2.2 *Borco/standard leather reference interface, n*—working interface consisting of the white side of the Borco material, mounted as described in this practice, and the standard leather shoe sole material, mounted on a precision shoe pad as described in Section 7 of Test Method D2047.

3.2.3 *control polish, n*—a reference polish of known or well established Static Coefficient of Friction, as determined by repeated determinations using Test Method D2047 over a long period of time and preferably by determinations on multiple James Machines.

3.2.4 *control polish/standard leather reference interface, n*—working interface consisting of a dried film of control polish, applied according to the procedures of Practice D4103 on standard vinyl composition tile, and the standard leather sole material, mounted on a precision shoe pad as described in Section 7 of Test Method D2047.

3.2.5 *standard test sequence, n*—series of not less than eight consecutive Static Coefficient of Friction (SCOF) determinations made on the Borco/standard leather interface or control polish/standard leather interface in accordance with this practice. The arithmetic average and standard deviation of one

[1] This practice 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] Borco is a registered trademark for a Danish product imported into the United States by Sierra Group, a division of Wallace Leisure Products, Inc. Available from Papyro-Tex A/S, DK-2730, Herlev, Denmark; distributed in North America through drafting and office supply stores under the trade names "Borco," "Vyco," and "Altex" board covers.

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

standard test sequence is the Static Coefficient of Friction (SCOF) of the interface.

4. Summary of Practice

4.1 The performance of the James Machine, in the standard configuration for the determination of Static Coefficient of Friction (SCOF), is tested relative to a standard working interface consisting of the surface of white Borco material in contact with a standard leather shoe pad, or a control polish film in contact with a standard leather shoe pad. The static coefficient of friction values generated provide a basis to establish the repeatability of the mechanical configuration of the James Machine and determine whether the machine remains within the calibration limits.

5. Significance and Use

5.1 This practice is used to calibrate the James Machine for determination of static coefficient of friction of polish surfaces in accordance with Test Method D2047. Over considerable time and repeated use the James Machine may tend to mechanical misalignment, giving self-evident, anomalous readings. The periodic accumulation and comparison of data generated by this practice provides an indication of when the machine is no longer within the calibration limits and can no longer be expected to provide accurate and reliable data.

5.2 Semi-automated James machines may perform an internal calibration/alignment test. These automated tests should be routinely run per the manufacturer's recommendation. If the repeatability tests of this practice indicate that the machine is out of calibration, the manufacturer should be contacted and their suggestions followed. Unqualified disassembly, modification, or adjustment may void the instrument warranty of semi-automated James Machines.

6. Interferences (Troubleshooting)

6.1 Deviations in calibration data and anomalies in machine accuracy and repeatability are due to the following interferences:

6.1.1 *Contamination of the Test Surfaces*—These are most commonly due to fingerprints or other soils on the working leather surface or the working surface of the Borco board, or the presence of residual materials on the Borco board from use of an improper cleaning solution. Generally, contamination of the working surfaces will result in low readings.

6.1.2 *Irregular Test Table Transport*—This problem is most common on James Machines that derive test table transport from manual cranking, which may not be smooth and uniform, but it may also be caused by localized wear or grit and dirt in the drive mechanism or on the transport guides of the test table. Test table movement that is not smooth and uniform will provide low readings.

6.1.3 *Improper Rate of Test Table Transport*—Even when uniform, the use of an improper rate of test table transport will result in changes in the readings. This is most often seen in manually cranked test table transports, where the rate of travel is difficult to judge subjectively without training and practice. Many motor driven test tables have an electrical motor speed control to adjust the rate of table travel, and this can be inadvertently changed. Too rapid a rate of travel will result in high readings, and too slow a rate of travel will result in low readings.

6.1.4 *Wear or Binding*—Wear or binding at the following bearing surfaces will result in deviations from calibration and loss of machine repeatability: upper strut pivot, upper strut ball bearings, back plate, strut rack and pinion gear assembly, lower strut pivot, and shoe pad cups for lower strut pivots. These problems are most often the result of the normal, repeated use of the James Machine, but they can also be caused by heavy impacts, improper use, improper or inadequate periodic cleaning and lubrication, or inadequate protection of the machine from dirt. Wear resulting in excessive play in the bearing surfaces will cause lower readings. Sporadic binding of the bearing surfaces and pivot points will result in loss of machine repeatability. Consistent binding of the bearing or pivot surfaces can result in high readings.

6.1.5 *Test Table not Flat*—Test tables are warped out of flatness by heavy impacts onto the table, storage of heavy items on the edges of the test table, or storage of the James Machine with the weight and strut in the upright position resting on the test table. Test table flatness may be assessed visually or by use of a machinist's dial gage attached to the strut rack gear and in contact with the traversing test table. Lack of adequate test table flatness will result in poor repeatability of data as a function of the test specimen (tile) placement on the table.

6.1.6 *Test Table not Level*—This is often due to the entire James machine not being level. Otherwise, this problem is usually caused by wear of the table transport guides, an impact on the table, or improper use of the test table for storage. A test table which is not level will result in abnormal readings. The deviation from accurate readings will depend on the magnitude and direction of the deviation of the test table from level. After many adjustments are made to level the Test Table, use the machinist's square to ensure that the plane of strut motion is perpendicular to the Test Table.

6.1.7 *Excess Play or Movement in the Strut Rack Gear*—This results from wear in the strut rack and pinion gear assembly, loss of lubricant, or use of an improper lubricant in the gear box. Care must be taken that there is enough freedom in the movement of the strut rack gear so that the vertical motion of the strut rack gear is not impeded. Excess play in any direction perpendicular to the vertical motion of the strut rack gear will result in low readings.

6.1.8 *Test Table Travel is not in the Plane of Strut Motion*—This is usually caused by excessive movement in the strut rack gear assembly so that the plane of strut motion is rotated (see 6.1.7), binding or excessive movement in at least one of the upper strut pivots (see 6.1.4), or wear of the test table transport guides (see 6.1.6). This problem results in low readings, since the slipping motion of the shoe pad on the test surface is compounded by a skewing action (greater lateral forces are applied at the interface than are recorded by the linear table displacement shown on the chart).

6.1.9 *Chart Board (or Chart) is not in a Plane Parallel to the Plane of the Strut Motion*—This problem is usually due to a heavy impact on the chart board, but it can also be due to the use of a pad of charts (rather than an individual sheet) attached

to the chart board. The magnitude and sign of deviations in readings that result from this problem depend on the magnitude and direction of the deviation of the chart board from a parallel configuration with respect to the plane of strut motion.

6.1.10 *Warped, or "Out of True" Back Plate, Chart Board, Strut Arm, or Strut Rack Gear*—Though this problem can be the result of heavy impact, it is most commonly the result of not maintaining the James Machine in a controlled temperature environment. The James Machine is a complex assembly of parts that are rigidly held in alignment by bead welds or bolts. Since many of the parts are constructed of different metals, temperature changes (and the different coefficients of thermal expansion) will result in very large forces being applied to the joints or to the components themselves. This can result in a distortion or warping of the parts, particularly those which are large or have at least one long dimension.

7. Apparatus

7.1 *James Machine*[5,6]—See Fig. 1.

7.2 *Standard Reference Leather*[6,7]—Leather sole material conforming to Federal Specification KK-L-165C (Type 1, Class 6).

7.3 *Leather/Shoe Pad Assembly*—Reference leather mounted on the machined shoe pad.

7.4 *Borco Board*[2]—drafting and drawing board working surface cover.

7.5 *Reference Surface*[6,8]—Aluminum plate, 30.48 by 30.48 by 0.3175 cm (12 by 12 by 0.125 in.), which has been machined flat, to which 30.48 by 30.48 cm (12 by 12 in.) Borco board has been mounted, white side up.

7.6 *Chart.* [6,9]

7.7 *Cleaner Solution*—Alcohol and water-based cleaner that does not leave a non-volatile residue, such as household window glass cleaner, or equivalent.

7.8 *Cleaning Cloth*—Clean, lint-free, absorbent cloth or white paper towel.

7.9 *Shoe Pad Stop*—Metal block, approximately 15 cm (6 in.) wide and long enough to fit between the James Machine test table retaining bar and the leading edge of the metal shoe pad when the strut is in the full upright position and the test table is in the start position. The shoe pad stop end shall be constructed so that it contacts only the machined shoe pad and not the leading edge of the leather. See Fig. 2. The shoe pad stop prevents slippage of the shoe pad during movement of the test table during calibration of the James Machine.

7.10 *Spring Clips or Drafting Tape.*

7.11 *Machinist's Square.*

8. Test Surface

8.1 For James Machine calibration the test surface assembly will consist of the working interface between the standard reference leather, mounted on the shoe pad, and the mounted Borco board reference surface, or between the mounted standard reference leather and the control polish applied and equilibrated on a Vinyl Composition Tile as described in Test Method D2047 and Practice D4103.

8.2 The test surfaces shall not be altered, adulterated, or contaminated in any matter, except for the cleaning procedure which begins each test sequence. When not in use, the reference surface and leather/shoe pad assembly shall be stored in individual, sealed, dust-proof plastic bags, and protected from impacts, contamination, and scratches. A single tile of the control polish shall be freshly prepared per Test Method D2047 and Practice D4103 for each test sequence. Cleaning solution is not to be used with the control polish.

9. Procedure

9.1 *Preliminary:*

9.1.1 Remove the reference surface from its protective plastic bag.

9.1.2 Clean the bottom aluminum surface and the Borco surface with cleaning solution and a clean, lint-free cloth or soft paper towel. Wipe dry and set the clean reference surface aside in a dust-free environment to thoroughly dry (do not heat) for a minimum of 30 min before using it in the test procedure. Do not touch the cleaned reference surface or allow it to contact other objects. If the reference surface is a control polish, prepare and handle it in accordance with Practice D4103 and Test Method D2047.

9.1.3 Mount a chart on the chart board with the spring clip. Load the pen holder with a fine tipped ballpoint pen or HB lead pencil that has been sharpened to a non-fragile point.

9.1.4 Visually and physically inspect all the bearing points for wear, binding, excessive play, soil, and proper lubrication.

9.1.5 Test the table transport for smooth operation and even, uniform motion. If the test table transport mechanism is motor driven, test and adjust the rate of table transport to be 152.4 cm/min or 2.54 cm/s (60.0 in./min or 1.0 in./s).

9.1.6 Remove the leather/shoe pad assembly from its protective plastic bag. Do not touch the leather surface.

9.1.7 Place the leather/shoe pad assembly on a clean, lint-free cloth or paper towel on the test table, block the weight and strut in the upright position, and engage the lower strut pivots in the shoe pad pivot cups. Inspect the lower strut pivots for wear, binding, and excessive play in the shoe pad pivot cups. (Do not touch the leather surface.)

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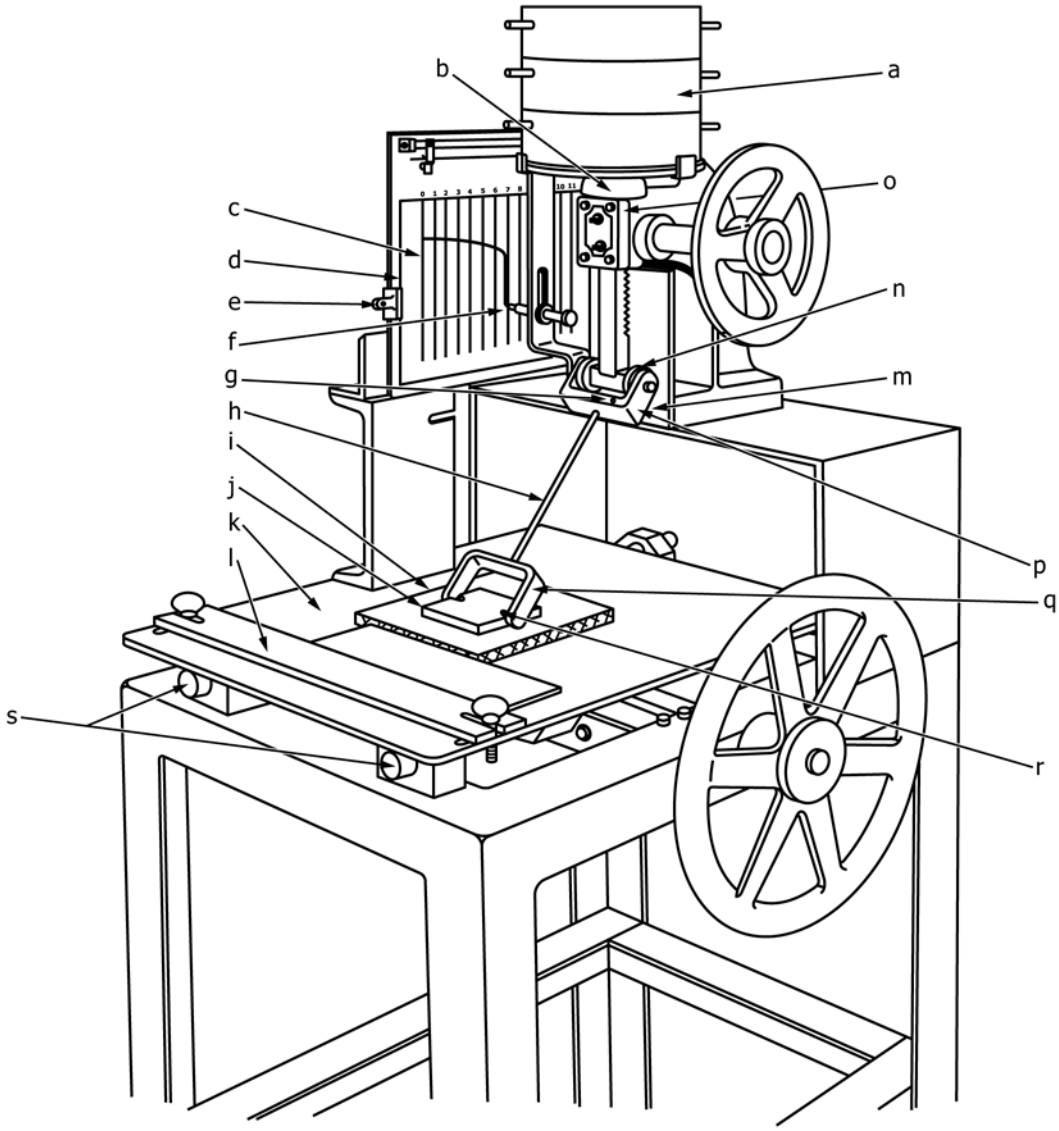
[5] The sole sources of supply for the apparatus known to the committee at this time are as follows: assembled, motorized machines are available from Michelman, Inc., 9080 Shell Road, Cincinnati, OH 42536-1229. Assembled, non-motorized machines are available from Quadra, Inc., 1810 Renaissance Blvd., Racine, WI 53177-1743. Engineering/machinist drawings for motorized and manual transport James machines are available from Consumer Specialty Products Association, 1667 K Street, Suite 300, Washington, DC 20006.

[6] If you aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

[7] The sole source of supply of precut leather, ready to mount on the test shoe pad, is available from Consumer Specialty Products Association, 1667 K Street, Suite 300, Washington, DC 20006.

[8] The sole source of supply of a mounted reference surface known to the committee at this time is Technical Products Co., 264 Park Avenue, North Caldwell, NJ 07006.

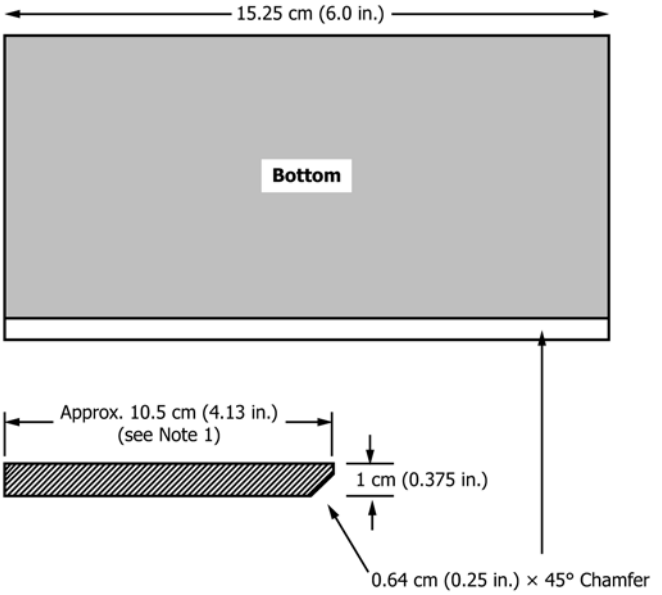
[9] The sole source of supply known to the committee at this time is Consumer Specialty Products Association, 1667 K Street, Suite 300, Washington, DC 20006.



a—Weights
b—Cushion
c—JSCOF Chart
d—Chart Board
e—Spring Clip
f—Recording Pencil
g—Set Screw
h—Strut Arm
i—Specimen
j—Shoe Pad
k—Test Table
l—Retaining Bar
m—Back Plate
n—Upper Strut Pivot and Ball Bearing Rollers
o—Gear Box (Rack and Pinion Gear, Strut Rack Gear)
p—Upper Strut
q—Lower Strut
r—Lower Strut Pivot and Shoe Pad Pivot Cups
s—Transport Guides

FIG. 1 James Machine

9.1.8 Lower the weight and strut so that the shoe pad assembly rests on the clean cloth or paper towel. Place the shoe pad stop between the leading face of the leather/shoe pad assembly and the retaining bar.



NOTE 1—Exact dimension to be determined for the individual machine configuration. Dimension will vary depending on the width of the retaining bar and length of the test table.

FIG. 2 Shoe Pad Stop

9.1.9 With a machinist's square, check to ensure that the strut is exactly vertical and square to the plane of the test table. Adjust the shoe pad stop so that the shoe pad will not move during operation (transport of the test table) of the James Machine during the calibration procedure.

9.2 *Calibration:*

9.2.1 With the strut blocked in the vertical, upright position, adjust the chart so that the pen point rests at the upper left intersection of the horizontal and vertical axes of the chart. Fix the chart to the chart board with spring clips or drafting tape.

9.2.2 Remove the shoe pad stop. Lift the strut to a horizontal position (do not touch the leather surface), unblock, and gently lower the weight to rest on the cushion collar. Adjust the chart so the pen point rests on the lower left intersection of the horizontal and vertical axes of the chart. Fix the chart to the chart board with spring clips or drafting tape.

9.2.3 Repeat the chart adjustments of 9.2.1 and 9.2.2 until the left vertical axis of the chart is exactly superimposed under the pen line. If any part of the pen line deviates from the chart vertical axis line, check for distortion or wear on the back plate, binding of the upper strut ball bearings, and excess play in the strut rack and pinion gear. Fix the chart to the chart board with spring clips or drafting tape.

9.2.4 With the weight in the lowered position, resting on the cushion collar, adjust the pen point to rest at the lower left intersection of the vertical and horizontal axis of the chart, and lift the strut to a horizontal position (do not touch the leather surface). Transport the test table to the end of its travel. Adjust the test table travel stop so that the pen point is at the lower right intersection of the horizontal and vertical axes of the chart.

9.2.5 Raise the weight and block it. The pen should scribe a line exactly colinear with the right vertical axis of the chart, ending at the upper right intersection of the horizontal and vertical axes. If it does not, check for warping or bending of the chart board, wear on the test table transport guides, and check that the test table travel is level.

9.2.6 With the weight blocked in the raised position, return the test table to its start position. The pen should scribe a line which exactly coincides with the upper horizontal axis of the chart. If it does not, or if the line scribed in 9.2.4 does not exactly coincide with the bottom horizontal axis, then check the table transport guides and their alignment to see that the table transport is level and parallel to the normal movement of the strut.

9.2.7 Gently lower the weight to rest on the cushion collar. The line scribed on the chart should exactly coincide with the line scribed in 9.2.1 – 9.2.3. If it does not, check for excessive play in the test table transport mechanism and in the upper strut pinion gear.

9.2.8 Remove the leather/shoe pad assembly from the lower strut, and set it aside on a clean, lint-free cloth or paper towel. With a soft bristle paint brush, remove all loose dust and foreign matter from the test table. If necessary, clean the test table with cleaning solution, using a clean, lint-free cloth, and wipe dry. Place the tile coated with the control polish, or the clean reference interface, Borco side up, on the test table with the leading edge against the retaining bar (do not touch the Borco surface). Raise the weight to the upright position and block it. Replace the leather/shoe pad assembly on the strut, and put the shoe pad stop in place.

9.2.9 Position the pen point at the upper left intersection of the vertical and horizontal axis of the chart. Unblock the weight and transport the test table smoothly and uniformly, in the normal matter, at a rate of exactly 2.54 cm (1.0 in.) per second. The pen should scribe a smooth arc which intersects the SCOF = 1.0 line at exactly the midpoint between the upper and lower horizontal axes of the SCOF chart. If the arc is not smooth, check for excessive play in the strut rack and pinion gear assembly, warp or soil on the back plate, or faults in the test table drive mechanism that would cause jerky motion. If the intersection with the SCOF = 1.0 line is not exactly at the midpoint of the line height, check for warped strut, worn upper strut bearings, worn lower strut pivots, worn shoe pad pivot cups, worn or soiled back plate, and excess play in the strut rack and pinion gear box.

9.2.10 Remove the shoe pad stop. Raise the weight and block it in the upright position. Lift the strut and leather/shoe pad assembly to a horizontal position (do not touch the leather surface) and return the test table to the start position. Position the leather/shoe pad assembly on the reference surface and check that the lower strut pivots are both evenly and actively engaged in the shoe pad pivot cups. Position the shoe pad stop.

9.2.11 Repeat the procedure of 9.2.9 and 9.2.10 at least twice. The line scribed in each repetition should exactly coincide with the previously traced arcs.

9.3 *Repeatability Test Procedure:*

9.3.1 Position the control polish or Borco reference surface on the test table, against the retaining bar.

9.3.2 Position the leather/shoe pad assembly on the reference surface, and actively engage the lower strut pins securely in the shoe pad pivot cups. Unblock the weight.

9.3.3 Transport the test table smoothly and uniformly at a rate of 2.54 cm (1.0 in.) per second.

9.3.4 After slip has occurred, stop the test table transport and disengage the pen from contact with the chart. Lift the strut and leather/shoe pad assembly to a horizontal position (do not touch the leather surface) and return the test table to the start position. Raise the weight to the upright position and block it. Reposition the pen so that it is about 0.6 cm (0.25 in.) below the previous trace, and engage the pen against the chart. Turn the control polish tile or Borco test surface 90° and reposition it against the retaining bar. Repeat the steps in 9.3.2 – 9.3.4.

9.3.5 Run a total of 8 drops to complete the test sequence.

9.3.6 Remove the chart from the chart board and fill in the required information. Return the Borco reference surface to its dust-proof plastic bag. Seal the bag, and place it in proper storage. Return the leather/shoe pad assembly to its dust-proof plastic bag. Seal the bag, and place it in proper storage. (Do not touch the leather surface.) If a control polish is used as the reference, strip the control polish film from the tile so that the tile may be reused in other SCOF determinations.

9.3.7 Read and tabulate the static coefficient of friction determined with each drop, and record this on the SCOF chart. Calculate the mean and the standard deviation of the mean of the determinations from this test sequence.

9.3.8 Repeat the entire procedure of 9.1 – 9.3 at least every 90 days. Greater frequency of calibration may be warranted if the James Machine is heavily used.

10. Calculation

10.1 Arithmetic mean of standard test sequence:

$$\bar{X} = \frac{\left(\sum_{1}^{n} x_i\right)}{n} \tag{1}$$

where:

x_i = the datum of an individual determination, and
n = the number of determinations in the standard test sequence, usually 8. See also Practices E29 and E178.

10.2 Standard deviation of the mean (*sd*):

$$sd = \left\{ \frac{\sum_{1}^{n} \left(x_i - \bar{X}\right)^2}{(n-1)} \right\}^{\frac{1}{2}} \tag{2}$$

10.3 Grand Mean, the arithmetic mean of all of the means of previous determinations on the reference interface.

11. Report

11.1 A tabular record of test results (average and standard deviation of the average) from the determinations of the standard test sequences should be maintained by the laboratory with each James Machine. The record should be reviewed, and historic data compared with most recent data, each time that the test sequence is run.

12. Precision and Bias

12.1 The following precision limits provide a reasonable basis for judging the accuracy and calibration of the James Machine:

12.1.1 *Accuracy*—The arithmetic mean of the readings for a standard test sequence with a given James Machine and Borco/standard leather reference interface shall be 0.65, with a standard deviation of the mean of less than 0.03. Failure of the mean to fall within this limit indicates a malfunction or misalignment of the James Machine, or an operator error in following the calibration procedure.

12.1.2 *Repeatability*—Comparisons of the mean readings from previous standard test sequences with a given James Machine and standard reference interface shall be within ±0.02 of the Grand Mean. Failure of the means to fall within this limit indicates a malfunction or misalignment of the James Machine, or an operator error in following the calibration procedure.

13. Keywords

13.1 Borco board; control polish; James Machine; reference interface; SCOF chart; slip resistance; standard reference leather; standard test sequence; static coefficient of friction