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Entertainment Technology
Measuring and Specifying the Slipperiness of Floors Used in Live Performance Venues

Floors/2006-8013r3a

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This standard was originally published when the Entertainment Services and Technology Association was operating under the name of PLASA North America.
ESTA has reverted to its original name, and this document has been rebranded with the current corporate name and logo. No changes have been made to the contents of the standard.

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The Floors Working Group, which authored this Standard, consists of a cross section of entertainment industry professionals representing a diversity of interests. ESTA is committed to developing consensus-based standards and recommended practices in an open setting.

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Interest category codes:
[DE] = designer
[DR] = dealer rental company
[G] = general interest
[MP] = mass-market producer
[U] = user

Table of Contents

1 Scope

This standard describes means of measuring and specifying the slipperiness of floor surface materials used by performers in live entertainment venues. The standard is not intended to be applied to normal walking and working surfaces, but only to those floor surface materials used by actors, dancers, and other similar artists when rehearsing or performing.

2 Application

This standard offers two procedures for measuring and specifying the slipperiness of floor surface materials used by performers to address particular measurement problems. The two testing procedures are to address two different uses for measurements of floor slipperiness.

The first testing procedure, the General Testing Procedure, is intended to render a number that can be used in comparing the relative slipperiness of floor materials when the friction materials are the floor surface and stainless steel. It is likely to be useful for marketing purposes and for comparisons between floor materials, but it may not be representative of the slipperiness experienced by a performer in a particular situation, since the performer is unlikely to have footwear with soles and heels made of stainless steel.

The second testing procedure, the Specific Testing Procedure, provides a means of rendering a slipperiness number for a floor surface when specific footwear material is contacting it. This procedure may be useful for helping solving problems when a performer reports that a floor is too slippery or too sticky by allowing objective measurement of the slipperiness. Having an objective measurement can help facilitate finding different floor or footwear materials that are less slippery or sticky to satisfy the performer.

Clauses marked with an asterisk have a corresponding explanatory note in Annex A. The note has the same clause number but has an "A." prefix. All the explanatory notes in Annex A are informational and do not add or remove any requirements from this standard.

3 Basic Test Equipment

The basic test equipment consists of a dragsled, a spring balance or force gauge, and a push stick, which serves as a means of drawing the dragsled across a sample of floor surface material.

3.1 The dragsled

3.1.1* The dragsled shall be a rigid body, approximately 240 mm long by 120 mm wide, with a uniformly distributed mass of 5 kilograms, plus or minus 25 grams.

3.1.2 The dragsled shall be supported on three cylindrical stainless steel feet, each machined at the tip to provide a flat bearing surface of 7 mm diameter and provided with a chamfer of 2 mm radius to allow the test foot to slide unimpeded across the test piece.

3.1.2.1* The stainless steel feet shall be made of type 304, X5CrNi18-10, or 18/8 stainless steel alloy.

3.1.2.2 The test feet shall protrude 19 mm perpendicular to the base of the dragsled, and be set in the form of an isosceles triangle with a base of 80 mm and height of 170 mm.

3.1.3* The leading edge of the dragsled, which is the edge closest to the foot at the apex of the isosceles triangle, shall have a means to attach the sled to a flexible cotton, nylon, or polypropylene multi-strand cord, 2 to 4 mm in diameter.

3.2* The Spring Balance or Tension Gauge

The spring balance or tension gauge shall be able to measure a range of forces from zero up to a force equivalent to the weight of the dragsled with measurement increments equivalent to 50 grams or smaller.

3.3* The Pushstick

The pushstick serves as a means to manually move the dragsled across the floor surface.

3.3.1 The pushstick shall consist of a long handle attached to a freely turning wheel (or wheels) that can roll along the floor. The handle shall be long enough to allow a person to walk upright, pushing the pushstick ahead of him or her, with the handle at about a 45 degree angle from the horizontal.

3.3.2* A freely turning pulley shall be mounted near the wheel (or wheels) at the bottom of the handle. A flexible cotton, nylon, or polypropylene multi-strand cord, 2 to 4 mm in diameter, shall run parallel to the floor from the dragsled to the pulley, through the pulley, and up to the spring balance or tension gauge. The pulley shall have a sheave diameter that is at least 12 times the cord diameter.

3.3.3 The spring balance or tension gauge shall be mounted at the top of the handle in such a manner that it is easily read and easily operated if it has any controls.

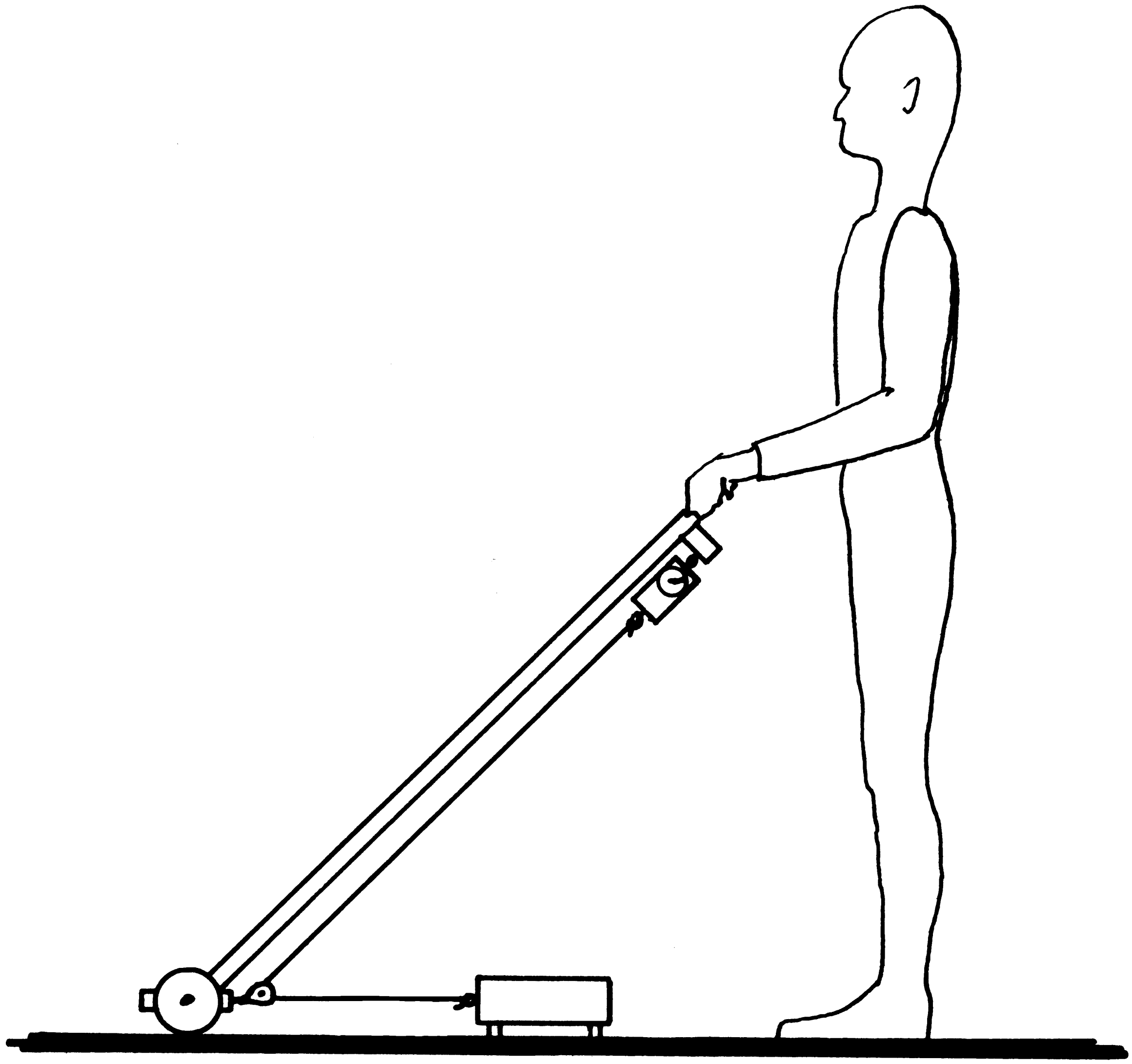

Figure 3.3 One possible implementation of the testing rig, ready for use, with operator

The pushstick is at about a 45 degree angle from the horizontal. The flexible cord runs from the dragsled, through the pulley, up to the spring balance or force gauge. As specified in clause 3.3.2, the cord is parallel to the floor from the dragsled to the pulley. The spring balance or force gauge is near the operator where it can be easily seen and operated.

4 General Testing Procedure

4.1 Preparation of the floor surface material to be tested and the stainless steel test feet

4.1.1 If the test is to be conducted at the manufacturing quality-control stage of a floor surface material, ensure the area of the floor surface to be tested is wiped clean with a dry cloth to remove any dirt, dust, or other contaminants.

4.1.2 If the test is to be conducted on floor surface material as it is used in the field, do not clean the material but test it as it is in the field.

4.1.3 The floor surface material to be tested shall be mounted or held in a horizontal position.

4.1.4 If the floor surface material to be tested is flexible, it shall be supported by a rigid, flat, horizontal surface.

4.1.5 Ensure that the stainless steel test feet are clean. Also ensure that the solution used to clean the feet is removed.

4.2* Weighing the dragsled

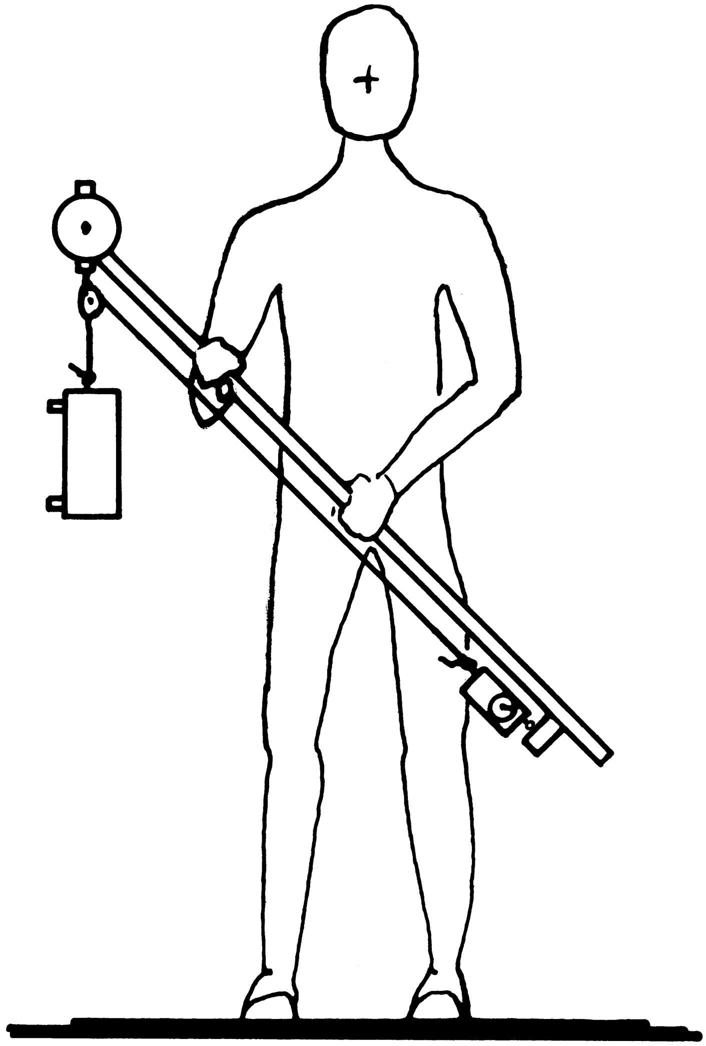

Figure 4.2 Weighing the dragsled

Notice that the angle between the cord running from the sled to the pulley and from the pulley to the spring balance or force gauge is the same as the angle shown in Figure 3.3.

The dragsled shall be weighed with the spring balance via the cord and pulley on the pushstick, with the dragsled hanging below the pulley. The angle between the cord running from the sled to the pulley and from the pulley to the spring balance or force gauge shall be equal to the angle when the pushstick is used with the wheel on the floor, as shown in Figure 3.3, within the tolerances shown in Table 4.2:

Angle with wheel on floor, pulling the dragsled	Angular range when weighing the dragsled
60 degrees	49 to 69 degrees
58 degrees	47 to 68 degrees
56 degrees	44 to 66 degrees
54 degrees	41 to 64 degrees
52 degrees	39 to 63 degrees
50 degrees	36 to 61 degrees
48 degrees	33 to 60 degrees
46 degrees	30 to 58 degrees
45 degrees	28 to 57 degrees
44 degrees	26 to 57 degrees
42 degrees	23 to 55 degrees
40 degrees	19 to 54 degrees
38 degrees	14 to 52 degrees
36 degrees	6 to 51 degrees
34 degrees	0 (parallel cord runs) to 49 degrees
32 degrees	0 to 48 degrees
30 degrees	0 to 47 degrees

Table 4.2

4.3 Conducting the test

4.3.1 The dragsled and pushstick shall be positioned on the test floor surface material. The pushstick shall be pushed ahead of the operator, thus dragging the dragsled across the floor surface. The pace should be a normal walking pace, which is about one meter per second.

4.3.2 As the dragsled is drawn along the test floor surface material, the readings of the spring balance or force gauge shall be observed and recorded, starting from a point 500 mm from the start of its travel. Three or more readings shall be taken, at points at least 1 meter apart.

4.3.3 A minimum of three test runs shall be completed in one direction, and then an equal number of test runs shall be done on the floor surface in a direction perpendicular to the original test runs.

4.3.4 The mean of the spring balance or force gauge readings over the runs shall be calculated. Obviously spurious readings may be rejected, but the cause of the spurious readings should be investigated.

5 Specific Testing Procedure

5.1 Preparation of the floor surface material to be tested

Prepare the floor surface as described in 4.1.

5.2* Preparation of the sled's test feet

5.2.1 Samples of the footwear sole or heel material shall be fitted under the bottoms of the test feet. They shall be secured so that the material does not come off or change position on the test feet.

5.2.2* The footwear sole or heel samples shall be in a condition similar to their condition when worn by the performer. That is, if they are clean when worn by the performer, they shall be clean; if they are dirty when worn by the performer, they shall be dirty with the same kind and similar quantities of dirt.

5.2.3 The edges of the footwear sole and heel samples shall be slightly rounded with a chamfer of 1 mm radius or more.

5.3 Conducting the test

5.3.1 Weigh the dragsled with the specially prepared test feet, using the procedure described in 4.2.

5.3.2 Conduct the test as described in 4.3, starting with clause 4.3.1 and finishing with the calculations described in 4.3.4.

6 Calculating and reporting the test results

6.1 The coefficient of sliding friction for the floor surface material shall be computed by dividing the average force shown on the spring balance, as determined in clause 4.3.4, by the weight of the dragsled. The units shall be adjusted so that the result is a unitless number.

6.2 The coefficient of sliding friction, as determined by clause 6.1, shall be reported as the "slipperiness" of the floor surface material.

Annex A
(informational, not mandatory)

This annex is informational only. It contains no requirements.

A.3.1.1 The dragsled can be made of anything, but it should be rigid so that the test feet don't wiggle or vibrate along the floor surface.

A.3.1.2.1 "Type 304," "X5CrNi18-10," and "18/8" are all designations for a common stainless steel alloy. Sometimes the specification is written "18-8."

A.3.1.3 The cord needs to be flexible, but also not so elastic that the dragsled, as it is pulled along the floor by the cord, oscillates between stopping and sliding. Cord of cotton, nylon, or polypropylene, 2 to 4 mm in diameter, has been chosen because flexible, multi-strand cord of these materials in this size range is readily available and should meet the requirements of flexibility and limited elasticity.

A.3.2 The spring balance or force gauge can be calibrated in kilograms, grams, newtons, pounds-force, or ounces-force, but it must be able to measure the weight of the dragsled, which can be as massive as 5,025 grams, which is 11.055 pounds, or 49.28 newtons. To accurately measure a dragsled this heavy, the measuring device must not be at its limit when measuring this load. That is, it must be able to measure the weight of something a little heavier than 5,025 grams.

The minimum measurement increment for the spring balance of force gauge need to be 50 grams or less, which is 0.11 pound (about 1 3/4 ounces) or 0.49 newtons. This minimum increment with a load of nominally 5 kg implies an accuracy of 1%, but, since the sled may be slightly heavier than 5 kg, the full-scale reading of the balance or gauge will need to be more than 5 kg (11 pounds). Balances and gauges are readily available that have full-scale readings of 10 kg or 20 pounds, and a 50 gram increment with these implies an accuracy of about 0.5% of full scale. Lab-quality force gauges with this accuracy are available for less than $1,000; fish scales that are claimed to be able to weigh with this accuracy are available for less than $100.

Since the same scale is used to weigh the sled and to measure the force needed to draw it across the floor, the absolute accuracy of the scale is not important, nor are the units. It is only important that its response be linear across its measurement range. Be careful if the scale uses two ranges and the weight of the sled is measured with one and the draw force is measured with another; the scale reading might only be linear within a range and not across ranges.

A.3.3 There are walking tape measures on the market that can serve as the basic structure for the pushstick. These are devices with a wheel and a revolution counter on the end of a long handle.

A.3.3.2 The cord running from the pulley to the dragsled is required by clause 3.3.2 to be parallel to the floor. If it is not, and runs down from the pulley toward the dragsled, tension in the cord will tend to raise the front of the sled, reducing the friction. If it is not parallel and runs up from the pulley to the dragsled, tension in the cord will tend to pull the front of the sled toward the floor, increasing the friction. If raising or lowering the handle of the pushstick tends to raise or lower the height of the pulley above the floor, this can change the measured amount of force needed to move the sled. There are (at least) three possible remedies for this source of error, and they can be used together.

(1) Simply ensure that the operator holds the handle at a particular height, and does not raise and lower it, so that the pulley stays at its optimal position.

(2) Construct the pushstick so that raising or lowering the handle does not move the pulley. If the pulley is attached at or very close to the axle, moving the handle will have no or little effect on the pulley height.

(3) Have the length of cord from the pulley to the dragsled be long to minimize the angular change caused by the pulley rising or falling a few millimeters. Of course, the cord must not be so long that the dragsled is under the feet of the walking operator.

A.4.2 Running the cord over a pulley introduces the effect of the pulley on the tension measurements. That is, any drag in the pulley will lower the readings on the spring balance or force gauge. However, the drag will have no effect on the final calculated coefficient of friction for the floor in our testing procedure as long as the drag as a proportion of the tension on the cord is the same when the sled is weighed and when the dragsled is pulled. It will be the same if the angle between the lengths of cord going into the pulley and coming out of the pulley is exactly the same in both instances. This is difficult to do in real life, so some tolerance must be allowed.

The tolerances shown in Table 4.2 are calculated based on the pulley having a friction factor of 10%, and allowing the friction in the pulley to affect the force readings no more than 0.5%. A friction factor of 10% is common for a pulley with a plain sheave bearing. A sheave with a pressure-lubricated bronze bearing might have a friction factor of 5%. A sheave with ball bearings or properly adjusted roller bearings might have a friction factor of 3%.

An informative discussion of friction factors with block and tackle can be found in Jay O. Glerum's *Stage Rigging Handbook*, third edition. The friction factors of 10%, 5%, and 3% stated in the previous paragraph were taken from that book.

A.5.2 The samples of the footwear sole or heel material could be attached with adhesive, or folded up around the test feet and tied in place. The important points are that the samples don't slip, that the mounting material (e.g., the adhesive) does not contaminate the sliding surface, and that area of the bearing surface is not much larger than the area of the bare stainless steel feet. The sled weight per unit of contact area with the stainless steel feet is approximately that of a 75 kilogram (165 pound) person standing on the ball of his foot. Theoretically the coefficient of sliding friction is not dependent on the contact surface area, but it is thought that the test procedure should roughly duplicate the situation when a performer is standing on the ball of one foot so that there is not significantly more or less deformation of the floor surface due to the load in the test situation.

A.5.2.2 Make sure that the feet are not contaminated with dirt from a previous test.