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Determination of slip resistance of pedestrian surfaces - Methods of evaluation

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Foreword

Rwanda Standardsarepreparedby Technical Committees and approved by Rwanda Standards Board (RSB) Board of Directors in accordance with the procedures of RSB, in compliance with Annex 3 of the WTO/TBT agreement on the preparation, adoption and application of standards.

The main task of technical committees is to prepare national standards. Final Draft Rwanda Standards adopted by Technical committees are ratified by members of RSB Board of Directors for publication and gazettment as Rwanda Standards.

DRS542 was prepared by Technical Committee RSB/TC 9, *Civil engineering and Building materials.*

In the preparation of this standard, reference was made to the following standard:

1) BS EN 16165:2021: Determination of slip resistance of pedestrian surfaces - Methods of evaluation

The assistance derived from the above source is hereby acknowledged with thanks.

Committee membership

The following organizations were represented on the Technical Committee on *Civil engineering and Building materials*(RSB/TC 9) in the preparation of this standard.

A+Construction Group Ltd

Africeramics Ltd

Consultants Engineers Group (CEG) Ltd

D&D Resources Ltd

Dutureheza Ltd

Enabel Rwanda

Greenpack Africa Ltd

Integrated Polytechnic Regional Centre (IPRC) - Musanze

Mass Design Group

NP Construction Company (NPCC) Ltd

Road Transport Development Agency (RTDA)

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Standards for Sustainability (SfS)

Stonecraft Industries Ltd

University of Rwanda - College of Science and Technology (UR - CST)

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Introduction

This document describes four test methods commonly used in Europe for the determination of the slip resistance of floorings.

The method in Annex A describes the test method based on the ramp using water as the test liquid and with the operator barefoot. This method cannot be used in situ. It is referred to as the "Barefoot ramp method".

The method in Annex B describes the test method based on the ramp using oil as the test liquid and with the operator wearing specified shoes. This method cannot be used in situ. It is referred to as the "Shod ramp test".

NOTE Oil is used as the test liquid to make the test more sensitive.

The method in Annex C describes the test method based on the pendulum in dry and wet conditions using specified rubber sliders. This method can be used in situ. It is referred to as the "Pendulum test".

The method in Annex D describes the test method based on the tribometer in dry and wet conditions using specified rubber sliders. This method can be used in situ. It is referred to as the "Tribometer test".

The purpose of this document is to harmonize the procedures used when using any of the above test methods. It is not intended to promote any particular test method to Product Group Technical Committees or to limit their choice.

The test methods given in this document cannot be compared with each other. The results can only be compared with results that are obtained with the same test method.

Determination of slip resistance of pedestrian surfaces — Methods of evaluation

1 Scope

This Draft Rwanda standard specifies test methods for determining the slip resistance of surfaces used by pedestrians.

NOTE It is also possible to use this document for measurements where persons might walk on trafficked areas.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the editioncited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

There are no normative references in thisdocument

ISO 868, Plastics and ebonite - Determination of indentation hardness by means of a durometer (Shore hardness) (ISO 868)

ISO 48-2, Rubber, vulcanized or thermoplastic - Determination of hardness - Part 2: Hardness between 10 IRHD and 100 IRHD

ISO 48-4, Rubber, vulcanized or thermoplastic - Determination of hardness - Part 4: Indentation hardness by durometer method (Shore hardness)

ISO 5725-2, Accuracy (trueness and precision) of measurement methods and results - Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method

ISO 572 5-5, Accuracy (trueness and precision) of measurement methods and results - Part 5: Alternative methods for the determination of the precision of a standard measurement method

3 Terms and definitions

For the purposes of this standard, the following terms and definitions apply.

3.1 General terms

3.1.1

pedestrian surface

surface which is designed for people to walk upon

3.1.2

test liquid

standardized liquid applied on the surface for the purpose of the test

3.1.3

friction

resistance to relative motion between two bodies in contact, e.g. the test slider or the footwear sole and the pedestrian surface

Note 1 to entry: The frictional force is the force acting tangentially in the contact area.

3.1.4

slip

loss of traction which can cause the test persons to lose their footing

3.1.5

slip resistance

measure of dynamic friction between two surfaces in contact with or without the presence of a specified test liquid

Note 1 to entry: The frictional force opposing movement of an object across a surface, usually with reference to

the sole (including the heel) of a shoe or to the barefoot contact area on a floor. Slip resistance of a pedestrian surface is the property of the surface which counteracts the relative sliding movement.

3.2 Terms related to ramp tests

3.2.1

angle of slip

lowest angle of the inclined ramp at which the test person reaches the limit of safe walking when slipping occurs

3.2.2

test person

person who walks on the test surface or standard surface

3.2.3

test walk

walk to determine a single angle of slip

3.3 Terms related to pendulum tests

3.3.1

pendulum test value

PTV

standardized value of the slip resistance as measure of the friction between the slider and the test surface obtained with the pendulum friction tester which incorporates a slider manufactured of rubber

3.4 Terms related to tribometer tests

3.4.1

dynamic coefficient of friction

μ

quotient of the horizontal frictional force and the vertically acting force between the slider and the horizontal surface during movement at a constant speed

3.4.2

sliding distance

distance over which the body is pulled during a single measurement

3.4.3

measuring distance

distance over which the sliding friction coefficient is determined

3.4.4

measurement series

series consisting of five single measurements on one measuring distance

4 Test methods

Carry out a test according to Annex A to Annex D. If tests are performed in the laboratory, the room temperature should be (20 ± 5) °c unless otherwise stated.

Annex A
(normative)

Barefoot ramp test

A.1 Principle

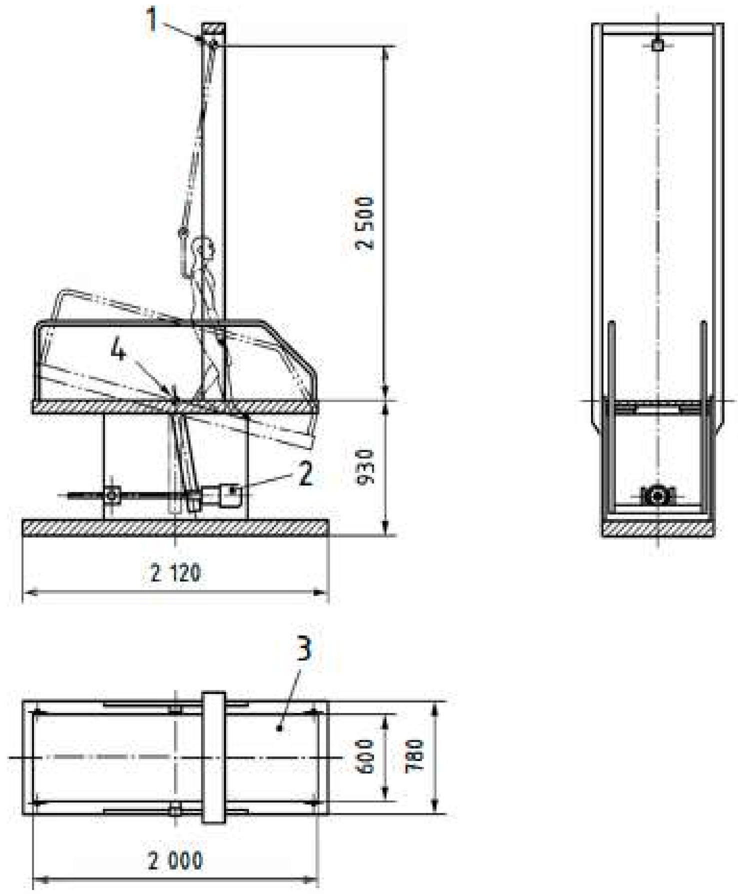
Two bare-foot test persons are used to determine the angle of slip, while the pedestrian surface material being tested is continuously coated with water containing a wetting agent. The test persons, each in turn, facing down the ramp and with an upright posture, move forwards and backwards over the test surface, as they increase their angle of inclination, until the safe limit of walking is reached and a slip occurs. The mean angle of slip obtained is used to express the degree of slip resistance. Subjective influences on the angle of slip are limited by means of a correction procedure.

A.2 Test equipment

A.2.1 Test apparatus with safety devices

The test device (Figure A. l) is a level and torsion-free platform of approximately 600 mm width and 2 000 mm length which can be adjusted longitudinally as a continuous movement to gradients from 0° to approximately 45°. The lifting stroke is controlled by the test person. An angle indicator on the test device shall show the platform tilt away from the horizontal plane at an accuracy of ± 0,2°. The test apparatus shall be rigid such that the angle does not vary by more than ± 0,5° during the walking. The display of the angle measurement system shall be fixed in such a way that the test person cannot read it during the test. The test person is safeguarded by railings along the sides and protected from falling by a safety harness, which shall not cause a hindrance to the test person when walking on the pedestrian surface material under test.

Dimensions in millimetres



Key

1 safety harness and fall arrest system

2 drive unit

3 inclinable walkway area on which the test surface or standard surface is fixed

4 angle indicator

Figure A.1 — Example of a typical test apparatus

A.2.2 Standard surfaces

Three standard surfaces, St-A, St-B and St-C, are used for the training and verification of test persons and the correction of the test results. The angle of slip (a) of these surfaces are given in Table A.l and are specified as angles of slip $a_{s,st\text{-}A}$, $a_{s,st\text{-}B}$ and $a_{s,st\text{-}c}$ of the three standard surfaces. The critical differences of CrD9s are determined for the three standard surfaces for a significance level of 95 % from the comparison and repetition limits according to ISO 5725-2 or ISO 5725-5. [7]

NOTE The critical difference of CrD9s indicates the spreading of measured values during measurements on the same object at various test locations, or coincidental deviations during repeated measurements at the same test location.

Table A.1 — Angle of slip and critical difference values of the three standard surfaces

Standard surface (*n*)	Angle of slip $\alpha_{S,n}$ [°]	Critical difference CrD_{95} [°]
St-A	12,4	3,9
St-B	20,9	4,3
St-C	26,7	4,4

When testing barefoot, the standard surfaces can become contaminated with body fats/oils. This may affect the performance of the surface. It is important to know, when verifying or correcting, that any changes in the surface are due to wear or the operator and not contamination. It is recommended to thoroughly clean the surfaces regularly.

A.2.3 Test liquid

Aqueous solution of a low foaming non-ionic surfactant such as LS45 (CAS-No. 68439-5 1-0) in a concentration of 1 g/1 (aqueous solution: 0,1 % LS45 in water) shall be used as the test liquid. Prior to and during testing the aqueous solution shall be applied at (6,0 ± 1,0) ljmin using appropriate means so as to form a largely uniform distribution of test liquid across the test surface. The temperature range of the solution shall be in between (29,0 ± 2,0) oc.

The test liquid may only be used once and shall not be re-circulated.

A.2.4 Test surface

The test surface shall have a minimum length of 1 000 mm and a minimum width of 400 mm. The test surface shall be either self-supporting, or securely mounted on a suitable flat surface.

The test surface shall be clean.

NOTE The floor manufacturer's instructions can be useful for cleaning.

If the slip resistance differs depending on the direction of walking, then it will be necessary to determine the direction of lowest slip resistance. It is recommended that tests are carried out in at least two directions (longitudinally and laterally) to establish whether there is directionality of the slip resistance of the sample. Once a lack of directionality has been established, it is acceptable to test in a single direction. If the test surface is produced by the customer, they are responsible that the direction of the lowest slip resistance is mounted in the longitudinal direction of the test surface.

Materials designed to be used in one direction should be tested in the intended direction of use.

A.3 Calibration of the test device

The inclination of the inclinable walkway surface shall be calibrated annually and checked periodically.

A.4 Training of test persons

The test persons shall be trained for the test (e.g. gait, walking speed, skin condition). The training procedure of the test person shall be carried out as follows :

Each test person} shall walk according to A.S, a) to n) on each standard surface (A.2.2) four times and the average training values are determined out of the last three values:

$$\alpha_{T,St-A,j};\ \alpha_{T,St-B,j};\ \alpha_{T,St-C,j}$$

For each test-person the individual differences according to Formula (A.1):

$$\Delta\alpha_{n,j} = \alpha_{S,n} - \alpha_{T,n,j} \quad (n = \text{St-A, St-B and St-C}) \tag{A.1}$$

are calculated and result in:

$$\Delta\alpha_{St-A,j};\ \Delta\alpha_{St-B,j};\ \Delta\alpha_{St-C,j}$$

If each of the individual differences $\Delta\alpha_{St-A,j};\ \Delta\alpha_{St-B,j};\ \Delta\alpha_{St-C,j}$ are inside of the critical differences, the test person is trained for the test.

$$\left|\Delta\alpha_{n;j}\right| \leq CrD_{95} \quad \text{(see Table A.1)} \tag{A.2}$$

A.5 Test procedure

a) The test surface shall be mounted on the test device so that the direction of the lowest slip resistance is in the direction of walking movement. For determining the slip resistance characteristics of surfaces with directional surface profiles or texture, see A.2.4.

b) The test surface (see A.2.4) shall be clean.

c) The test person j shall soak their feet in water containing the test liquid (see A.2.3) for ten minutes before starting the test.

d) The test person shall put on the harness (see A.2.1). The test person shall then attach to the fall arrest system (see A.2.1).

e) The test person shall mount the ramp (which shall be set to the horizontal position) so as to stand on the test surface.

f) Application of the test liquid (see A.2.3).

g) Facing down the ramp and looking at their feet, the test person, using a half-step gait and using the flat of the foot, shall take a minimum of four steps down the test surface (walking forwards), and then take half-steps up the test surface (walking backwards) to return to their starting position. The test person shall walk up anddown the test surface twice before raising the ramp by a small amount. This continues until a slip occurs. When high angles are achieved, the steps for raising the ramp may be higher in the lower angle area.

h) It is essential to maintain a rhythm of about 144 half steps per minute. A metronome or similar should be used to keep pace. Above a ramp angle of 20°, the pace is less important.

i) Once a slip occurs the walk shall be repeated at the angle of slip and if a further slip occurs then this angle is recorded.

j) If there is no second slip the test is continued, raising the angle by a small amount until two slips occur at the same angle.

k) It is important that around the point of slip the angle is not raised too much in one step. Incremental rises shall therefore be small at this point.

l) If it is suspected that the angle has been raised by too great an amount around the point of slip then the angle shall be lowered to below the angle of slip and the run repeated using smaller increments.

m) If the test person is still able to walk on the test sample at an angle of 30° then the test shall be stopped unless there is agreement between parties to go to higher angles.

n) Record the angle, ao,;,1 with i = 1;2;3;4 rounded to the nearest 0,1 °.

o) Repeat the procedure (steps d) to n)) from the horizontal or from an angle approximately 10° below the angle of slip three more times. Discard the first angle of slip with i = 1 and calculate the mean value ao,1 from the last three angles of slip with i = 2;3;4.

p) Depending on the mean value ao,1 one of the three standard surfaces shall be selected and mounted on the test device for a verification and correction procedure (see Table A.2).

Table A.2 —Selection of a standard surface for correction

Case	Standard surface
$\alpha_{0,j} < 16,7°$	St-A
$16,7° \leq \alpha_{0,j} < 23,8°$	St-B
$23,8° \leq \alpha_{0,j}$	St-C

q) The test steps a) to l) shall be carried out four times on the selected standard surface and given the angles of slip for correction $a_{c,n,i,J}$.. with n = St-A, St-B or St-C and *i* = 1;2;3;4. Discard the first angle, of slip with *i*= 1 and calculate the mean value $a_{c,n,J}$from the last three angles of slip $a_{c,n,i,J}$with *i*= 2;3;4.

The test [test steps a) to q)] shall be repeated by a second test person.

A.6 Verification and correction

A.6.1 General

For every single test surface and test person the verification and correction procedure shall be carried out

A.6.2 Verification

For each test-person the individual difference between the angle of slip of the standard surface (Table A.1) and the angle of slip for correction (see A.5 q)) according to Formula (A.3) is calculated:

$$\Delta\alpha_{n,j} = \alpha_{S,n} - \alpha_{C,n,j} \cdot \ (n = \text{St-A, St-B or St-C}) \quad \text{(A.3)}$$

If the individual difference is inside of the critical difference (see Formula (A.4)) the test person is verified. The correction according to A.6.3 can be made and the result can be used.

$$\left|\Delta\alpha_{n;j}\right| \leq CrD_{95} \ \text{(see Table A.1)} \quad \text{(A.4)}$$

If the individual difference is higher than the critical difference, the result for that test surface from this test person has to be discarded and the test person has to be replaced by another test person.

The results of other tested surfaces on that test day, that was verified correctly, are still valid.

A.6.3 Correction

For two test persons a correction value, D_j (D_1 and D_2) is calculated for each tested surface from the value obtained from the selected standard surface. The calculated correction value, D_j, is added to the mean value of each test surface a_0. giving the corrected value for one test person a_1 (a_1 or a_2). ,j

The calculation of D_j shall be carried out in accordance with one of the three cases given in Table A.3.

Table A.3 — Correction value depending on the size of the mean angle of slip

Case	Correction value D_j for test surface
$\alpha_{0,j} < 16,7°$	$D_j = \left[12,4° - \alpha_{C,St-A,j}\right] \times \frac{1}{\sqrt{2}}$
$16,7° \leq \alpha_{0,j} < 23,8°$	$D_j = \left[20,9° - \alpha_{C,St-B,j}\right] \times \frac{1}{\sqrt{2}}$
$23,8° \leq \alpha_{0,j}$	$D_j = \left[26,7° - \alpha_{C,St-C,j}\right] \times \frac{1}{\sqrt{2}}$

where

$\alpha_{0,j}$ is the mean angle of slip for test person *j*;

D_j is the correction value for test person *j* for the current test surface;

$\alpha_{C,St-A,j}$ is the average correction value for test person *j* walking on standard surface St-A;

$\alpha_{C,St-B,j}$ is the average correction value for test person *j* walking on standard surface St-B;

$\alpha_{C,St-C,j}$ is the average correction value for test person *j* walking on standard surface St-C.

The corrected mean angle of slip of test person 1 (α_1) and test person 2 (α_2) shall be added together and divided by 2 creating the test result $\alpha_{barefoot}$ rounded to the nearest 1°.

A.7 Test report

The following information shall be given in the test report:

a) reference to this European Standard (including its year of publication);

b) method used (i.e. Annex A);

c) test organization and name of the person responsible for the test;

d) date of test;

e) identity of test surfaces or designation, manufacturer, product, where applicable quality class, colour and dimensions of products used for the surface (if this information is known);

f) surface structure (e.g. smooth, profiled, structured);

g) ramp test value, abarefoot, rounded to the nearest 1 degree.

h) any further remarks when appropriate such as, surface conditions tested and cleaning method, regular maintenance procedures, surface treatments and/or the sampling method.

Annex B
(normative)

Shod ramp test

B.1 Principle

Two test persons wearing shoes are used to determine the angle of slip, after the pedestrian surface material being tested has been evenly coated with oil. The test persons, each in turn, facing down the ramp and with an upright posture, move forwards and backwards over the test surface, as they increase

their angle of inclination, until the safe limit of walking is reached and a slip occurs. The mean angle of slip obtained is used to express the degree of slip resistance. Subjective influences on the angle of slip are limited by means of a correction procedure.

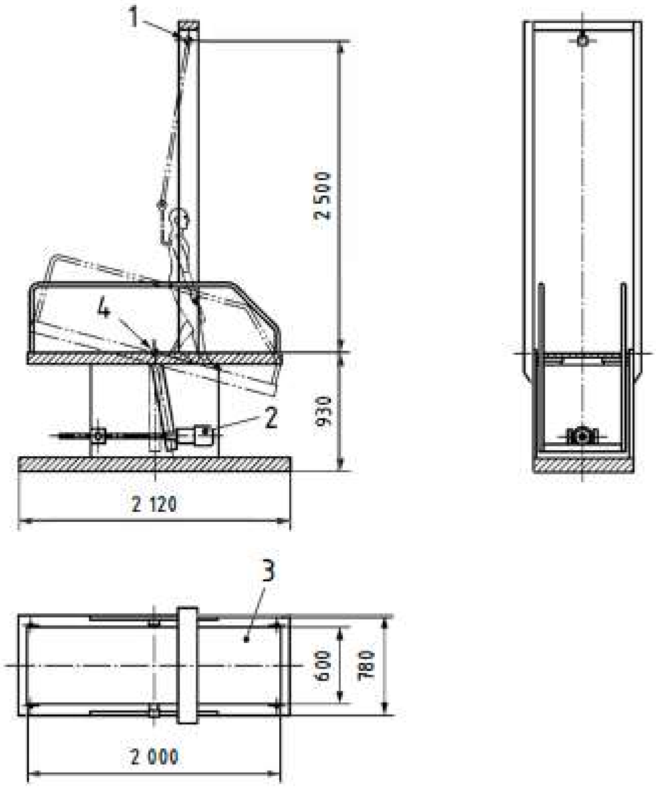
B.2 Test equipment

B.2.1 Test apparatus with safety devices

The test device (Figure B.l) is a level and torsion-free platform of approximately 600 mm width and 2 000 mm length which can be adjusted longitudinally as a continuous movement to gradients from 0° to approximately 45°. The lifting stroke is controlled by the test person. An angle indicator on the test device shall show the platform tilt away from the horizontal plane at an accuracy of ± 0,2°. The test apparatus shall be rigid such that the angle does not vary by more than ± 0,5° during the walking. The display of the angle measurement system shall be fixed in such a way that the test person cannot read it during the test.

The test person is safeguarded by railings along the sides and protected from falling by a safety harness which shall not cause a hindrance to the test person when walking on the pedestrian surface material under test.

Dimensions in millimetres



Key

1 safety harness and fall arrest system

2 drive unit

3 inclinable walkway area on which the test surface or standard surface is fixed

4 angle indicator

Figure B.1 — Example of typical test apparatus

B.2.2 Test surface

The test surface shall have a minimum length of 1 000 mm and a minimum width of 400 mm. The test surface shall be either self-supporting, or securely mounted on a suitable flat surface.

The test surface shall be clean.

NOTE The floor manufacturer's instructions can be useful for cleaning.

If the slip resistance differs depending on the direction of walking, then it will be necessary to determine the direction of lowest slip resistance. It is recommended that tests are carried out in at least two directions (longitudinally and laterally) to establish whether there is directionality of the slip resistance of the sample. Once a lack of directionality has been established, it is acceptable to test in a single direction. If the test surface is produced by the customer, they are responsible that the direction of the lowest slip resistance is mounted in the longitudinal direction of the test surface.

Materials designed to be used in one direction should be tested in the intended direction of use.

B.2.3 Test Liquid

Engine oil of SAE viscosity grade 10 W 30 according to SAE J300 [5] shall be used as the test liquid (200 ± 20) mljm2 oil shall be evenly brushed onto the test surface prior to test walk of the first test person and then re-distributed using a brush prior to the test walk of the second test person. Some surfaces may have an open structure (e.g. grids and gratings) which makes it impossible to determine how much oil to use. In these cases thoroughly brush the contact area with oil.

The oil should be stored in a tightly sealed vessel in order to prevent changes to its viscosity.

B.2.4 Test footwear

The test persons shall wear a test shoe with an outsole which is rubber-based, Shore A hardness 73 ± 5 determined according to EN ISO 868 with a profile according to Figure B.2 [7]. Check the Shore A hardness of the sole before first use and periodically during the boot's lifetime of use to monitor any change over time.

Before first use, the surface of the test shoe soling shall be thoroughly abraded using an orbital sander fitted with P400 grade silicon carbide abrasive paper in order to achieve a consistent, even, reproducible finish over the entire surface. The abrasive paper shall be discarded when noticeable wear or tearing occurs. Freshly abraded soling shall be dusted before testing using a clean, soft brush. After the test, the test shoes soling shall be wiped clean using a paper towel before storing. No solvent or gas oil should be used while cleaning.

A profiled sole is needed to determine the physical-interlock-slip-resistance which is provided by the profile of the test surface.

Figure B.2 — Profiled sole of test shoe

Longer exposure to engine oil and walking on floor coverings with sharp-edged surfaces can lead to changes in the outsole of the test shoes. These changes can be detected optically or during validation.

Grinding the outsole with unused P400 grade silicon carbide abrasive paper eliminates this change. After grinding the grinding dust shall be removed from the sole surface and the validation procedure shall be repeated as in B.3.2.

B.3 Verification

B.3.1 General

The inclination of the inclinable walkway surface shall be calibrated annually and checked periodically. Verification of the data produced by test persons shall be undertaken daily prior to testing. The latter shall be achieved by use of standardized test footwear and an appropriate set of standardized surfaces.

The verification processes as specified below shall be used to select and familiarise the test persons.

B.3.2 Verification of the test person

Three standard surfaces, n = St-I, St-II and St-IIIA, are used for the verification process. The angle of slip (α) of these surfaces are given in Table B.1 and are specified as angles of slip $\alpha_{S,St\text{-}I}$, $\alpha_{S,St\text{-}II}$ and $\alpha_{S,St\text{-}IIIA}$ of the three standard surfaces [7].

On the same day, but prior to testing the test surfaces, each test person j shall walk on each standard surface (n = St-I, St-II and St-IIIA) three times (see B.4) and the mean verification (V) values $\alpha_{V,St-I,j}$; $\alpha_{V,St-II,j}$ and $\alpha_{V,St-IIIA,j}$ shall be determined.

Each individual difference from the verification prior to testing shall be calculated according to Formula (B.1):

$$\Delta\alpha_{n,j} = \alpha_{S,n} - \alpha_{V,n,j} \qquad \text{(B.1)}$$

with n = St-I, St-II and St-IIIA

to give

$\Delta\alpha_{St-I,j}$; $\Delta\alpha_{St-II,j}$ and $\Delta\alpha_{St-IIIA,j}$.

Each of the individual difference shall be less than the corresponding critical differences CrD_{95} that are given in Table B.1, i.e. Formula (B.2):

$$\left|\Delta\alpha_{n;j}\right| \leq CrD_{95} \qquad \text{(B.2)}$$

If one of the absolute values is greater, the test person in question shall be excluded from the test and replaced by another test person for that day.

Table B.1 —Angle of slip and critical difference values of the three standard surfaces

Standard surface (n)	**Angle of slip $\alpha_{S,n}$ [°]**	**Critical difference CrD_{95} [°]**
St-I	8,0	3,0
St-II	19,9	3,0
St-IIIA	25,7	3,0

NOTE The critical difference of C_rD_{59} indicates the spreading of measured values during measurements on the same object at various test locations, or coincidental deviations during repeated measurements at the same test location.

The critical differences of $C_rD_{95}$are determined for the three standard surfaces for a significance level of 9 5 % from the comparison and repetition limits according to ISO 5725-2 or ISO 5725-5.

B.4 Test procedure

a) The test surface shall be mounted on the test device so that the direction of the lowest slip resistance properties is in the direction of walking movement. For determining the slip resistance characteristics of surfaces with directional surface profiles or texture, see B.2.2.

b) The test surface (see B.2.2) and shoe sole (see B.2.4) shall be clean.

c) The test person j wears the test shoes (see B2.4).

d) The test person shall put on the harness (see B.2.1). The test person shall then attach to the fall arrest system (see B.2.1).

e) The test person shall mount the ramp (which shall be set to the horizontal position) so as to stand on the test surface.

f) (200 ± 20) mljm2 of the specified test liquid (see B.3.2) is brushed onto the surface of the sample surface and the soles of the footwear.

g) Facing down the ramp and looking at their feet, the test person, using a half-step gait and using the flat of the foot, shall take a minimum of four steps down the test surface (walking forwards), and then take half-steps up the test surface (walking backwards) to return to their starting position. The test person shall walk up and down the test surface twice before raising the ramp by a small amount. This continues until a slip occurs. When high angles are achieved, the steps for raising the ramp may be higher in the lower angle area.

h) It is essential to maintain a rhythm of about 144 half steps per minute. A metronome or similar should be used to keep pace. Above a ramp angle of 20°, the pace is less important.

i) Once a slip occurs the walk shall be repeated at the angle of slip and if a further slip occurs then this angle is recorded.

j) It is important that around the point of slip the angle is not raised too much in one step. Incremental rises shall therefore be small at this point.

k) If it is suspected that the angle has been raised by too great an amount around the point of slip then the angle shall be lowered to below the angle of slip and the run repeated using smaller increments.

l) If there is no second slip the test is continued, raising the angle by a small amount until two slips occur at the same angle.

m) Record the angle, $a_{o,i,j}$ with i = 1;2;3 rounded to the nearest 0.1 °.

n) Repeat the procedure from the horizontal or from an angle approximately 10° below the slip angle two more times and record all three angles.

o) The test shall be repeated by a second test person following the procedure from c) to e). The oil is then re-distributed using the brush over the test surface and the soles of the shoes before continuing the procedure from g) to n).

p) If the test person is still able to walk on the test sample at an angle of 38° then the test shall be stopped unless there is agreement between parties to go to higher angles.

B.5 Evaluation

For a verified test person, j, determine the mean value from ao,;,J with i = 1;2;3 giving the angle, $a_{o,j}$. For two test persons a correction value, D_1 (D_1 and D_2) is calculated for each tested surface from the values obtained from the standard surfaces. The calculated correction value, D_1, is added to the mean value of each test covering a_{oJ}, giving the corrected value for one test walker a1 ($a_1$or a_2).

The calculation of D1 shall be carried out in accordance with one of the four cases given in Table B.2.

Table B.2 — Correction value depending on the size of the mean angle of slip

Case	Correction value D_j for test surface
$\alpha_{0,j} < \alpha_{V,St-I,j}$	$D_j = \Delta\alpha_{St-I,j} \times \frac{1}{\sqrt{2}}$
$\alpha_{V,St-I,j} \leq \alpha_{0,j} < \alpha_{V,St-II,j}$	$D_j = \left[\Delta\alpha_{St-I,j} + \left(\Delta\alpha_{St-II,j} - \Delta\alpha_{St-I,j}\right) \times \frac{\alpha_{0,j} - \alpha_{V,St-I,j}}{\alpha_{V,St-II,j} - \alpha_{V,St-I,j}}\right] \times \frac{1}{\sqrt{2}}$
$\alpha_{V,St-II,j} \leq \alpha_{0,j} < \alpha_{V,St-IIIA,j}$	$D_j = \left[\Delta\alpha_{St-II,j} + \left(\Delta\alpha_{St-IIIA,j} - \Delta\alpha_{St-II,j}\right) \times \frac{\alpha_{0,j} - \alpha_{VSt-II,j}}{\alpha_{V,St-IIIA,j} - \alpha_{V,St-II,j}}\right] \times \frac{1}{\sqrt{2}}$
$\alpha_{V,St-IIIA,j} \leq \alpha_{0,j}$	$D_j = \Delta\alpha_{St-IIIA,j} \times \frac{1}{\sqrt{2}}$

where

$\alpha_{0,j}$	is the mean angle of slip for test person j;
D_j	is the correction value for test person j;
$\alpha_{V,St-I,j}$	is the mean verification value for test person j walking on standard surface St-I;
$\Delta\alpha_{St-I,j}$	is the individual difference for test person j walking on standard surface St-I (8,0° - $\alpha_{V,St-I,j}$);
$\alpha_{V,St-II,j}$	is the mean verification value for test person j walking on standard surface St-II;
$\Delta\alpha_{St-II,j}$	is the individual difference for test person j walking on standard surface St-II (19,9° - $\alpha_{V,St-II,j}$);
$\alpha_{V,St-IIIA,j}$	is the mean verification value for test person j walking on standard surface St-IIIA;
$\Delta\alpha_{St-IIIA,j}$	is the individual difference for test person j walking on standard surface St-IIIA (25,7° - $\alpha_{V,St-IIIA,j}$).

The corrected mean angle of slip of test person 1 (α_1) and test person 2 (α_2) shall be added together and divided by 2 creating the ramp test value α_{shod} rounded to the nearest 1 degree.

B.6 Test report

The following information shall be given in the test report:

a) reference to this European Standard (including its year of publication);

b) method used (i.e. Annex B);

c) test organization and name of the person responsible for the test;

d) date of test;

e) identity of test surfaces or designation, manufacturer, product, where applicable quality class, colour and dimensions of products used for the surface (if this information is known);

f) surface structure (e.g. smooth, profiled, structured);

g) ramp test value, a_{shod}, rounded to the nearest 1 degree;

h) any further remarks when appropriate such as, surface conditions tested and cleaning method, regular maintenance procedures, surface treatments and/or the sampling method.

Annex C
(normative)

Pendulum test

C.1 Principle

The pendulum friction tester measures the loss of energy as the standard rubber coated slider assembly slides across the test surface. The pendulum friction tester incorporates a spring loaded slider made of a standard rubber attached to the end of the pendulum arm. On swinging the pendulum arm the frictional force between slider and test surface is measured by the reduction of the circular movement of the pendulum arm measured on a graduated scale.

The measuring method can be implemented by using soft or hard rubber (slider 57 or 96, respectively).

The measuring method can be implemented with a test surface in dry condition or a test surface contaminated with water.

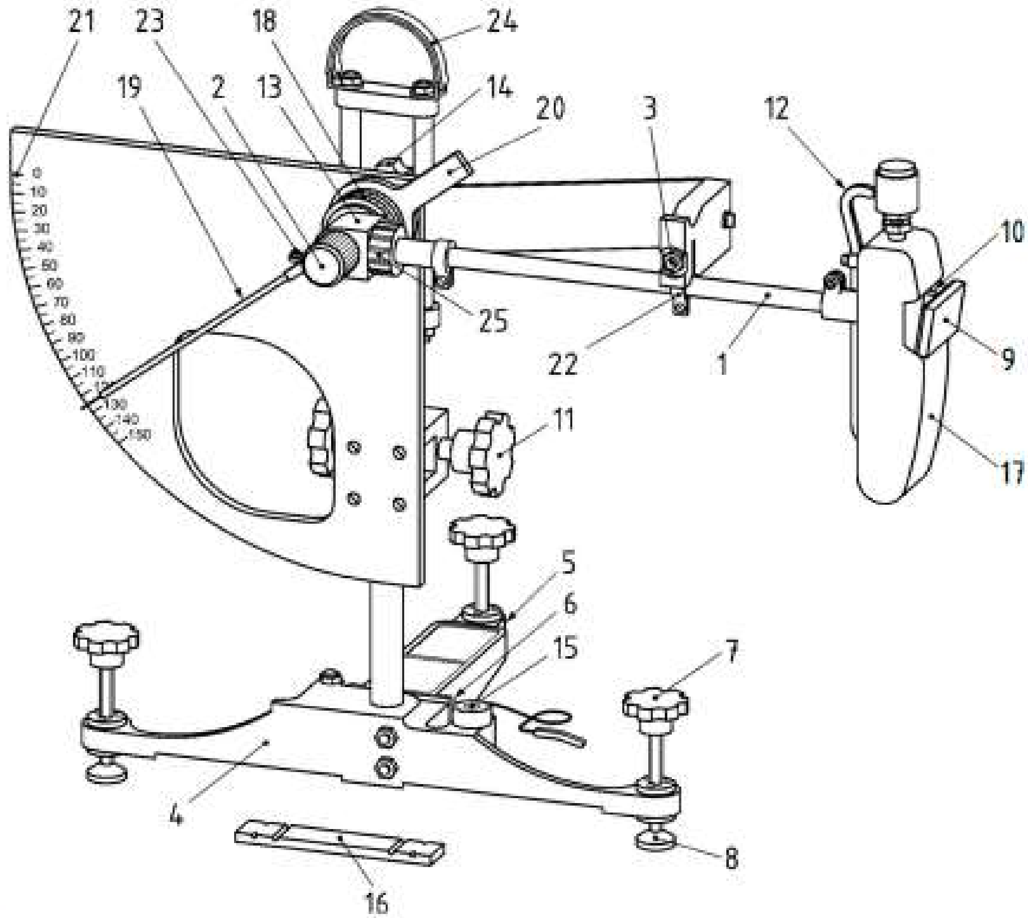
The measuring method can be used for measurements in laboratory conditions as well as for measurements on site.

C.2 Apparatus

C.2.1 Pendulum friction tester

C.2.1.1 General

The pendulum friction tester shall be manufactured generally as shown in Figure C.l. All bearings and working parts shall be enclosed as far as possible, and all materials used shall be treated to prevent corrosion under wet conditions.



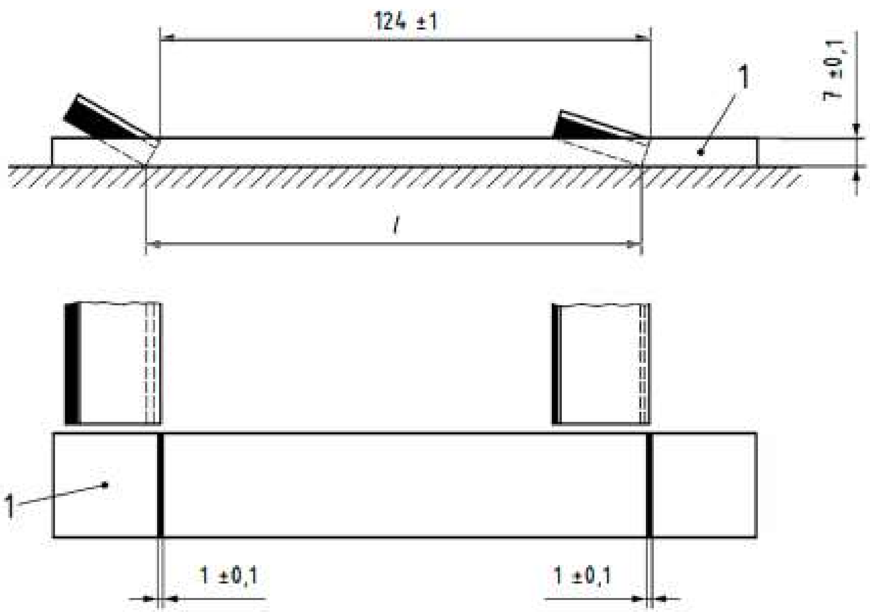
Key

1	pendulum arm	10	slider support rod	19	pointer
2	mark (in the centre of rotation, indicating the axis of suspension)	11	vertical screw (for vertical adjustment)	20	pointer counterbalance
3	release mechanism (knob)	12	slider lifting handle	21	scale (see C.8)
4	frame/base	13	pendulum head	22	release catch
5	rear support foot	14	clamp for vertical adjustment	23	pointer adjustment screw
6	screw for rear support foot	15	spirit level	24	handle
7	levelling screw	16	gauge (see Figure C.2)	25	lock nut
8	bottom plate (hinged)	17	pendulum foot		
9	slider assembly	18	friction and locking ring		

NOTE Individual testers might have a slightly different configuration or appearance.

Figure C.1 — Pendulum friction tester

Dimensions in millimetres



Key

l actual sliding length

1 measuring gauge

Figure C.2 — Sliding length gauge

C.2.1.2 Further features

C.2.1.2.1 Spring loaded rubber coated slider, as specified in C.2.1.2.10 to C.2.1.2.17.

This slider shall be mounted on the end of a pendulum arm with the slider not in contact with the surface so that the sliding edge is (514 ± 3) mm from the axis of suspension.

C.2.1.2.2 Bubble spirit level, as a means of setting the support column of equipment vertical.

C.2.1.2.3 Frame/base of sufficient mass, to ensure that the equipment remains stable during the test containing three levelling screws.

NOTE A mass of the frame/base (rear support foot included) of not less than 3,5 kg has been found suitable.

C.2.1.2.4 Vertical screw mechanism, as a means of raising and lowering the axis of suspension of the pendulum arm, so that the slider can:

a) swing clear of the surface of the specimen;

b) be set to traverse a surface over a fixed length.

The sliding length shall be measured, aligning the marks with the aluminium backing as shown in Figure C.2. A sliding length measured this way of (124 ± 1) mm gives an actual sliding length of about 126 mm. This actual sliding length is influenced by the worn width of the striking edge, and the positioning points from where to where the actual sliding length is being measured. For this reason, it is necessary to measure at fixed points at the aluminium backing of the slider.

C.2.1.2.5 Release mechanism that holds the pendulum arm and can release it so that it falls freely from a horizontal position.

C.2.1.2.6 Pointer, of nominal length of 300 mm, balanced about the axis of suspension, indicating the position of the pendulum arm throughout its forward swing and moving over the circular scale. The mass of the pointer shall be not more than 85 g.

C.2.1.2.7 Adjustable friction ring, so that, with the pendulum arm swinging freely from a horizontal position, the outward tip of the pointer can be brought to rest on the forward swing of the arm at a point (10 ± 1) mm below the horizontal. This is the zero reading.

C.2.1.2.8 Scale, marked from 0 to 150 at intervals of five or whole units, see C.8.

C.2.1.2.9 The mass of the pendulum arm, including the slider assembly, shall be (1,50 ± 0,03) kg. The centre of gravity shall be on the axis of the arm at a distance of (410 ± 5) mm from the axis of suspension.

C.2.1.2.10 The slider assembly shall consist of a rubber slider with a width of (76,2 ± 0,5) mm, a length of (25,4 ± 1,0) mm (in the direction of swing) and a thickness of (6,4 ± 0,5) mm mounted to an aluminium base; the combined mass of slider and aluminium base shall be (32 ± 5) g. The thickness of the rubber slider including the aluminium base shall be in between (9,5 ± 0,5) mm. [7]

C.2.1.2.11 The rubber slider shall be fastened over the full area (by vulcanizing or using a cyanoacrylate-based adhesive which does not affect the rubber properties) on a flat, rigid aluminium base with a centre pivoting axis. This shall be mounted on the end of the pendulum arm in such a way that, when the arm is at the lowest point of its swing with the trailing edge of the slider in contact with the test surface, the plane of the slider is angled at (26 ± 3)0 to the horizontal. In this configuration the slider can turn about its axis without obstruction to follow unevenness of the surface of the test surface as the pendulum swings.

C.2.1.2.12 The slider assembly shall be spring-loaded against the test surface. The static force on the slider assembly as set by the equipment calibration procedure shall be (22,2 ± 0,5) N when deflected 4,5 mm measured upside down (see C.9.5). The change in the static force on the slider shall be not greater than 0,2 Njmm deflection of the slider (see C.9.6).

C.2.1.2.13 The initial rebound resilience (in accordance with the Pendulum method of ISO 4662 [4]) and IRHD (International Rubber Hardness Degree in accordance with ISO 48-2) hardness of the Slider 96 shall comply with Table C.l. The compliance shall be proved with a certificate of conformity including the name of the manufacturer and date of manufacture. Slider assemblies shall be discarded 24 months after the certificate date.

For a long-time storage of the sliders, it is recommended to keep the sliders in dark and at a temperature below 10 oc.

Table C.1 — Initial properties of the slider 96 rubber

Temperature °C	Initial rebound resilience %	Hardness IRHD
5	19 to 23	-
23	21 to 26	94 to 98
40	26 to 30	-

C.2.1.2.14 The initial rebound resilience (in accordance with the Pendulum method of ISO 4662 [4]) and IRHD (International Rubber Hardness Degree in accordance with ISO 48-2) hardness of the Slider 57 shall comply with Table C.2. The compliance shall be proved with a certificate of conformity including the name of the manufacturer and date of manufacture. Slider assemblies shall be discarded 24 month after the certificate date.

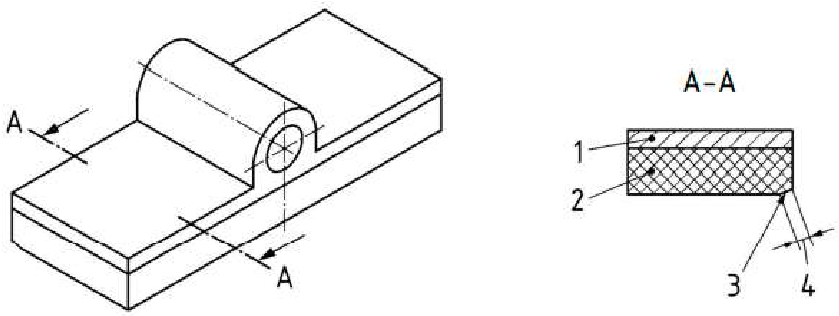
For a long-time storage of the sliders it is recommend to keep the sliders in dark and at a temperature below 10 °c.

Table C.2 — Initial properties of the slider 57 rubber

Temperature °C	Initial rebound resilience %	Hardness IRHD
0	43 to 49	-
10	58 to 65	-
20	66 to 73	-
23	-	53 to 59
30	71 to 77	-
40	74 to 79	-

C.2.1.2.15 The edges of the slider shall be square and clean-cut, and the rubber free from contamination by, for example, abrasive or oil.

C.2.1.2.16 The width of the striking edge as shown in Figure C.3 shall be 2,5 mm maximum for slider 57 and 4,0 mm for slider 96. The slider edge shall be discarded when the striking edge is greater than this value or when it becomes excessively scored or burred. The slider can be reversed to expose a new edge, which will need to be conditioned (see C.3.2).



Key

1 aluminium base

2 rubber slider

3 striking edge

4 width of striking edge

Figure C.3 — Slider assembly, also illustrating the worn width of the striking edge

C.2.1.2.17 The slider assembly shall be at ambient temperature when used (see C.5.1 and C.6.1).

C.2.1.2.18 The apparatus shall be calibrated after manufacture and re-calibrated on its performance when verification demonstrates non-conformity. This shall be done by an approved body or part of the organisations certificated quality assurance system. The calibration procedure is described in C.9.

C.2.2 Additional items required for testing

C.2.2.1 Thermometer, capable of measuring temperatures, with an accuracy of ± 0,5 oc.

C.2.2.2 400 grade waterproof abrasive paper.

C.2.2.3 Abrasive film, 3M 261X ImperialTM Lapping Film Grade 3MIC 1.

C.2.2.4 Slider preparation plates (A and B). Each plate shall comprise a piece of hard, flat, smooth faced material such as glass, and shall have a surface area dimension of not less than 100 mm x 150 mm. Plate A is for the affixing of P400 paper (see C.3.2.1.2). Plate B is for the affixing of abrasive film (see C.3.2.1.3).

C.2.2.5 Test liquid: Potable water, and a dispenser.

C.2.2.6 Gauge or graduated scale, in millimetres, for setting the slider contact length (see Figure C.2).

C.2.2.7 Calliper, able to measure with an accuracy of ± 0,1 mm.

C.3 Preparation

C.3.1 General preparation (laboratory and on-site measurements)

C.3.1.1 Carry out a visual check of the pendulum tester to ensure that it has been assembled correctly and there is no obvious damage that requires repair prior to use. Swing the pendulum arm to see if there are any obvious mechanical defects.

C.3.1.2 Using the thermometer, measure and record, to the nearest degree, the ambient temperature.

C.3.1.3 Position the pendulum over the surface to be tested so that the pendulum swings over the particular area that is required for testing. When testing samples in the laboratory, position the pendulum on a rigid surface that includes a suitable means of restraining the test sample in a horizontal position. The adjustable feet, which should be set as low as possible, are used in conjunction with the built-in spirit level to ensure that the base of the instrument is horizontal. It is important that the bubble lies exactly in the centre of the spirit level. Once set the locking nuts should be tightened. If there is any movement between the feet of the pendulum tester and the test surface during a full swing of the pendulum, weight(s) should be placed on the rear leg (ensuring that the base remains level), or high friction pads under the feet should be used, in order to prevent any such movement.

The pendulum may be used on a sloping surface on site provided that the slope can be accommodated within the adjustment range of the feet (see also C.6.9). When testing verification specimens, or when testing samples in a laboratory, it is important that the plate/specimen is firmly fixed so that it cannot move horizontally, nor can it rock about any axis. Solid and stable contact should be obtained between the underside of the specimen or plate and the laboratory bench or test location. The use of any form of resilient intermediate layer will invalidate the results.

NOTE A plywood or metal intermediate layer used as a specimen holder is acceptable and can be regarded as non-resilient.

C.3.1.4 Whenever the head of the tester is raised or lowered, ensure that the mechanism is firmly clamped afterwards to hold the head securely in position.

C.3.1.5 Set the pendulum arm in the horizontal position such that it engages the release mechanism. Level the base, using the spirit level and the three levelling screws on the base-frame. Raise the head of the tester such that the pendulum arm swings clear of the surface to be tested. Ensure that the base of the instrument remains stable, relative to the test surface, during a full swing of the pendulum and that neither the arm nor the pointer make contact with any part of the frame, e.g., the scale or the carrying handle.

C.3.1.6 Check that the slider is correctly fitted to the pendulum and that its working edge is undamaged and the slider has been suitably prepared as specified in C.3.2.

C.3.1.7 Adjust the zero setting as follows:

a) raise the head of the tester to ensure that the slider swings clear of the test surface;

b) raise the swinging arm to the horizontal release position on the right-hand side of the tester, such

c) that it is locked automatically in the release catch;

d) bring the pointer round to its stop in line with the pendulum arm;

e) release the pendulum arm;

f) catch the pendulum arm on its return swing and record the pointer reading;

g) return the pendulum arm to the release position;

h) correct the zero setting as necessary by adjustment of the friction rings;

i) repeat steps b) to g) until three consecutive zero readings are obtained.

If the pointer swings past the zero position, screw the rings up a little more tightly. If the pointer does not reach zero, unscrew the rings a little. Ensure that the locking ring is tight before further use.

C.3.1.8 Set the contact length of the rubber slider (the distance between two points where the slider edge of the rubber touches the test surface) by gently lowering the pendulum arm until the slider just touches the surface, first on one side of the vertical, and then on the other. The measured sliding length at the aluminium backing shall be between 123 mm and 125 mm. This is normally accomplished in a series of small steps, using the gauge (see C.2.1) as follows:

C.3.1.8.1 Move the pendulum foot to the right and lower the head so that the slider starts to contact the test surface with its rear corner (aluminium base) level with the right mark on the gauge. Manually hold the gauge in that position.

C.3.1.8.2 Raise the slider with the slider lifting handle and move the pendulum foot to left hand side sufficiently to ensure the slider is clear of the surface when the slider is lowered.

C.3.1.8.3 Allow the pendulum foot to gently drop back so that the slider contacts the test surface.

C.3.1.8.4 The rear edge (aluminium base) of the slider should lie on the left-hand mark of the gauge (Figure C.2). If it does not, raise or lower the pendulum head so that the slider moves about 50 % of the distance towards the correct setting.

C.3.1.8.5 Reposition the gauge so that the corner of the slider is level with the left-hand gauge mark and then move the pendulum foot over to the right-hand side and check if it lines up with the right-hand gauge mark. If not, repeat the process, backwards and forwards until the pendulum head is set at the correct height to give a (124 ± 1) mm measured sliding length.

To prevent undue wear of the slider when moving the pendulum arm through the arc of the contact, the slider should be raised off the test surface by means of the slider lifting handle.

C.3.2 Preparation of the slider

C.3.2.1 General

C.3.2.1.1 To obtain consistent results correct preparation and conditioning of the slider is essential.

C.3.2.1.2 A sheet of fresh 400 grade abrasive paper (C.2.2.2) shall be fixed to the clean upper surface of plate A (C.2.2.4).

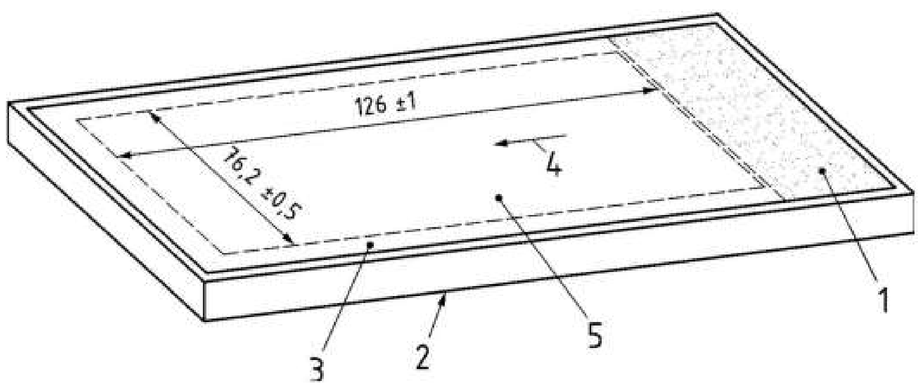
C.3.2.1.3 A sheet of abrasive film (C.2.2.3) shall be fixed to the clean upper surface of plate B (C.2.2.4). These sheets shall be secured to the plate using tape along one of its edges only, and such that beyond the fixing the slider pad is able to make contact over at least 127 mm of the attached sheet (see Figure C.4).

The matt surface of the abrasive film is the surface to be used.

C.3.2.1.4 For each of the preparation procedures the pendulum tester shall be set up with the slider to be preparedjre-preparedjrestored as if to test the slider preparation plates. The swept length, measured using the gauge (see Figure C.2), shall be (124 ± 1) mm.

C.3.2.1.5 The slider preparation plate shall be suitably restrained during the operation.

Dimensions in millimetres



Key

1 area of adhesion
2 slider preparation plate
3 verification film
4 direction of testing
5 swept area

Figure C.4 — Fixing of sheet to plate

For both dry and wet measurements, the slider preparation method is the same.

C.3.2.2 Procedure

C.3.2.2.1 Preparation of a new slider pad

A new slider pad shall be prepared by carrying out 20 swings across plate A in dry conditions, resetting the footprint after 10 swings. This shall be followed by 20 swings across plate B in wet conditions after removing the burr from the slider edge with soft paper.

C.3.2.2.2 Re-preparation of a worn slider pad

The working edge of a worn, contaminated or damaged slider pad shall be re-prepared using 3 swings across plate A in dry conditions, so that a clean, uniform and smooth working edge to the slider is obtained. This shall be followed by 20 swings across plate B in wet conditions.

The working edge shall be re-prepared every time the surface type changes from the one preceding.

C.3.2.2.3 Discarding worn slider pads

When the width of the working edge of the slider pad exceeds 2,5 mm for slider 57 and 4,0 mm for slider 96, this edge shall no longer be used. The edge shall be suitably disfigured to prevent its further use, and the other long edge of the slider pad shall be adopted as the working edge. When the width of this edge also exceeds 2,5 mm or 4,0 mm respectively, the slider pad shall be discarded.

C.3.2.2.4 Use of wet and dry sliders

Sliders used for wet testing shall not be used for dry testing without drying using a towel.

C.3.3 Surface area and small units

The surface area shall be at least 150 mm x 85 mm. When not it is necessary to form a new equivalent area by bonding two or more units together using a construction adhesive in such a fashion that one flat surface is realized and the glued joints have minimal thickness. This can be realized by taking two or more units and, when necessary, sawing and/or grinding flat one or more sides of each unit perpendicular to the visible side. These units are then placed on a flat surface with the visible side facing downwards. Sides which have been ground flat are then glued to each other creating a new equivalent surface with sufficient size.

C.3.4 Flatness of the surface

If the measurement surface is not sufficiently flat, it will not be possible to carry out a reliable measurement. In that case, a different section of the surface should be measured or else a different sample should be selected that does comply with the flatness criterion.

The measurement surface should be rejected if the deviation from a straight line over the length of the surface exceeds 2,0 mm (concave or convex) or if the deviation from a straight line over the width of the surface exceeds 0,5 mm. This should be checked in the middle of the measurement surface with the help straight edges and a feeler gauge set over the appropriate length (135 mm) or width (80 mm).

C.4 Verification

C.4.1 General

The reliability of a measurement result is largely linked to the following aspects:

a) The configuration and actual condition of the pendulum device used and the spring curve attached to the slider (see C.9);

b) The condition of the slider used (see C.2.1.2.13 - C.2.1.2.16 and C.3.2);

c) The positioning and setting of the slider contact length by the operator (C.3.1.8).

A self-check with unique materials should be performed as described in C.4.2.

C.4.2 Setup for control (Verification)

A check on the correct operation of equipment, the configuration of sliders and the execution of the measurement shall be done immediately prior to testing using a set of verification surfaces as indicated in Table C.3.

Table C.3 — Property values of the verification surfaces

Pendulum verification surface (PVS)[a]	Assigned value of the verification surface (PTV, in wet conditions)	Acceptance criteria between verification surface and measured value for Pendulum (PTV, in wet condition)	
		Slider 96 (C.2.1.2.13)	Slider 57 (C.2.1.2.14)
PVS-1	0 to 15	± 2	± 3
PVS-2	25 to 40	± 2	± 3
PVS-3	50 to 75	± 3	± 3
[a] PVS-1 has traditionally been float glass; PVS-2 a reference tile such as a preconditioned Portuguese tile known as *'Pavigres'* characterised by the UK Slip Resistance Group (UKSRG); PVS-3, a single use pink Lapping Film for fibre optic connector polishing comprising graded aluminium oxide particles coated on a 3-mil polyester film produced by 3M (product code: 261X 3 MIC - 8 1/2" X 11") (C.2.2.3).			

Each verification material for multiple use shall have a hard and stable surface and should be not sensitive to mechanical changes. Some surfaces may need to be conditioned prior to initial use to ensure that stable verification values are subsequently obtained.

The assigned value of each verification surface (this also means for surfaces of different batches of the same surface type) shall be established immediately after equipment calibration (C.9) and prior to testing from the median value from at least 10 tests according to C.S on different days by at least two operators. The slider shall be reconditioned between each test.

NOTE 1 Where two or more operators are not available the verification can be done with measurements of the same operator.

NOTE 2 Two different sets of equivalent verification surfaces, one set for working references and one set for incidental check, can be helpful to monitor a possible drift in PTV of the working reference due to changes in the surface properties by repeated measurements.

NOTE 3 Two different sets of equivalent verification surfaces may also overcome the problem to organize a new verification surface in between two calibrations when a reference material has broken.

Verification materials and their assigned values may also originate from certified reference material.

In the situation that the acceptance criteria are not met the equipment/slider combination or the operator is considered unreliable and adequate measures shall be taken to get the PTV values in line with the assigned values.

C.5 Conducting the test

C.5.1 Procedure in general

The procedure can be performed in the laboratory or on-site in dry or in wet conditions. When performed in the laboratory the room temperature shall be controlled at (20 ± 5) oc for at least 2 h before the test begins and for the duration of the test The surface or specimens to be tested shall be held for a minimum of 30 min at room temperature before testing. When tested under laboratory conditions with slider 57 in wet conditions, the PTV value needs a temperature correction according to C.5.3 when measured outside a temperature range of (20 ± 2) ^{o}c.

To test in wet conditions, follow a) to k). Omit instruction g) when testing in dry state.

a) select the appropriate slider;

b) check that all operations described under 'General preparation' (see C.3.1) have been carried out;

c) prepare or re-prepare the slider edge every time the sample changes (see C.3.2);

d) clean the test area, unless specifically testing the as-found state (see C.6.5 and C.6. 7);

e) place the pendulum arm in its release position such that it is held by the release catch;

f) bring the pointer round to its stop. With a proper adjustment of the stop the pointer in that situation will be horizontal, parallel to the pendulum arm;

g) wet the surface which is to be tested (flooring or specimen) and the slider rubber with a copious supply of potable water. Some porous surfaces may readily absorb water. Take care to ensure the surface is thoroughly wetted before and during the test If the material to be tested consists of porous units, this can be accompanied by immersing the units in water for at least half an hour to ensure adequate water is retained on the surface during the test

   On surfaces typical found on roads, at least 100 ml of water can be required to the slider contact surface to ensure the wet slider is passing over the wet surface. Applying too little water will have a significant effect on the results if any part of the swept length is dry;

h) release the pendulum arm and catch it on the return swing before the slider strikes the test surface;

i) record the reading;

j) return the arm and pointer to the release position, keeping the slider clear of the test surface by means of the lifting handle;

k) repeat steps e) to j) to give eight readings;

l) if the dimensions allow repeat at 90° and 45° to the original direction to determine whether the slip properties are isotropic. If the sample is non-isotropic and there are differences in PTV values then take the PTV according C.5.3 taken in the direction of lowest value. Specimens can be tested as specified in the relevant product standard or by agreement between parties.

If the dimensions are too small to carry out testing in three directions it can be possible to butt two samples of the same product together.

Some product specifications require testing at 180° to the original direction. In this case follow the relevant standard for the product being tested.

NOTE For additional information for measurements on site, see C.6.

Specimens may be tested in a laboratory as taken from a site, as manufactured (unpolished) or after a polishing regime.

C.5.2 Checking for error

C.5.2.1 After conducting the test in accordance with C.5.1, check the measuring length using the gauge again to make sure that the measuring length is still (124 ± 1) mm.

C.5.2.2 If the measuring length is not correct, discard the results and move the pendulum to move in another path. Proceed according to C.S. l.

C.5.2.3 After conducting the test in accordance with C.5.1, raise the head of the instrument such that it swings clear of the test surface and check the free swing to determine whether the zero setting is still correct (see C.3.1.7).

C.5.2.4 If the zero setting is not correct, adjust it in accordance with C.3.1.7, repeat the appropriate test procedure (see C.5.1) and then check the free swing again to determine whether the zero setting is correct If it is not, the instrument shall be taken out of service.

C.5.3 Calculating the pendulum test value (PTV)

The measured Pendulum Test Value PTV is the median of the last five recorded readings. If a slider 57 rubber is being used performing measurements on site in wet conditions, correct the median for rubber temperature to the reference temperature of 20 oc using Formula (C.1).

$$PTV_{20} = \frac{PTV_t}{1 - [0,0059 \times (t - 20)]} \quad (C.1)$$

where

PTV_{20} is the PTV value corrected to 20 °C, rounded to whole PTV units;

PTV_t is the PTV value (median of last five recorded readings);

t is the rubber temperature, to be measured as ambient temperature (°C).

NOTE This correction is only valid for rubber temperatures in between 5 °C and 40 °C.

No temperature correction is required for PTV when using slider 96 rubber.

C.6 Pendulum measurements on-site, additional information

C.6.1 The slider assembly and the whole equipment shall be at ambient temperature when used. Once the equipment is assembled, wait 30 min. Record the ambient temperature to the nearest 1 oc.

C.6.2 The pendulum should be transported in a manner which is appropriate and such as to ensure the instrument is not damaged.

C.6.3 The pendulum should be validated with the appropriate slider once it has been assembled to check that it is functioning correctly (see C.3). It is important to choose a flat smooth area of surfacing to carry out this test to ensure stability of the float glass plates.

C.6.4 When conducting a test on site, the equipment and operator being well below normal eye level are not always noticeable to pedestrians. Adequate safety measures should be in place to maintain a safe working area.

C.6.5 The test of an on-site surface can take several forms including:

a) dry (as found), wet (as found);

b) dry (clean), wet (clean), cleaning according the manufacturers or customers instruction.

C.6.6 It should be noted that the two surface conditions mentioned can give very different test results. The condition(s) under which the surface was tested (temperature included) should be clearly stated in the report, together with the method used to achieve cleaning.

C.6.7 If the "as found" condition is tested or other test liquids other than water are used, it should be recognized that the slider could become contaminated. For this situation the slider should be wiped clean and be re-prepared according C.3.2.2.2 before it is being used again.

Alternatively separate sliders may be used.

C.6.8 The pendulum should be placed on a firm surface with the pendulum swinging in the general direction of traffic. When the area permits on any given surface type, tests should also be conducted at 90° to this direction in the immediate location in order to determine whether the slip properties are isotropic. A further test at 45°should be made to confirm this. If the surface is isotropic only test in one direction in other locations on that surface. If the surface is clearly not isotropic three tests will be required in each location. In this case report the lowest PTV.

C.6.9 The pendulum can be used to test slopes. The reading obtained will be the same whether the test is conducted up the slope or down the slope. The available adjustment in the feet is such as to allow the instrument to be set up on all normal internal sloping surfaces, i.e. up to a gradient of approximately 6° or 1 in 10. It is important that the base of the instrument is horizontal as indicated by the built-in spirit level.

C.6.10 On profiled surfacing values of PTV will often be found to be dependent on the angle between the direction of test and the direction of the main profile axis and several tests at different angles can be necessary in order to determine the minimum slip resistance offered by that surface. When setting the measurement length of 124 mm it is important that the slider should start on the top of the profile -this can mean moving the instrument.

C.6.11 On tiled surfaces or surfaces with many joints, the minimum value of PTV will be found in a direction of about 10° to 20° to the longer joint line. On timber surfaces, the minimum value of PTV will generally be found along the grain.

C.6.12 When testing outdoors it can be necessary to protect the instrument from the effects of wind, or movement of air caused by passing trains or traffic.

C.6.13 On certain porous surfaces, it can be necessary to use significant amounts of water to saturate the surface in order to simulate the worst operating conditions. If the pores of the material are not fully saturated, then the water in the lubricating film is pushed by the action of the slider into the pores and becomes ineffective. It only requires a very small residual capacity in the material's pore structure to absorb the lubricating film.

C.6.14 When assessing a site it is important to obtain as much information about the surface as possible. As a guide, measurements should be taken from areas that are trafficked regularly such as entrances, the middle of corridors or at the bottom of stairs and areas where there is no or little traffic such as in corners, at the edges of corridors and under stairs or benches. It is useful to test the floor as found and again after cleaning. Measuring these parameters can tell you if the problem is the floor itself (is it slippery when contaminated, has it worn etc.) or is it another issue (contamination, incorrect cleaning etc.) The amount of areas will depend on the size and use of the area and should be agreed between relevant parties. It is also important to remember that when assessing the area the slip resistance of the floor is only one contributor to the slip risk.

C.7 Test report

The test report shall include at least the following information:

a) reference to this European Standard (including its year of publication);

b) method used (i.e. Annex C);

c) name of the person responsible for the test and of the test organization;

d) date of test;

e) when appropriate, location of the site and a drawing showing the positions of the test(s);

f) identity of reference test surfaces or designation, manufacturer, product, where applicable quality class, colour and dimensions of products used for the flooring (if this information is known);

g) description of the surface (or sample) tested and its condition (e.g. smooth, profiled, structured);

h) indication whether the test(s) was (were) carried out under dry or wet conditions;

i) slider material used (slider 57 or slider 96);

j) PTV at each position and direction tested as PTVs7 for slider 57 measurements and PTV96 for slider 96 measurements;

k) when appropriate (on site measurements with slider 57 rubber) rubber temperature and temperature corrected PTV20;

l) any further remarks when appropriate such as, surface conditions tested and cleaning method, regular maintenance procedures, surface treatments and/or the sampling method (see C.6).

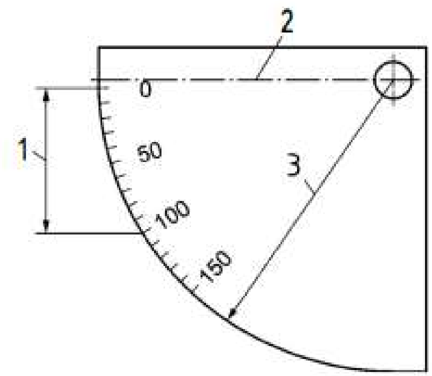
C.8 Pendulum scale dimensions

The pendulum scale dimensions are given in Table C.4.

Table C.4 — Pendulum scale dimensions (see Figure C.5)

Graduation	Drop (mm)	Below horizontal (mm)
0	0,00	10,16
5	7,13	17,29
10	14,26	24,42

Graduation	Drop (mm)	Below horizontal (mm)
15	21,39	31,55
20	28,52	38,68
25	35,65	45,81
30	42,78	52,94
35	49,91	60,07
40	57,04	67,20
45	64,17	74,33
50	71,30	81,46
55	78,43	88,59
60	85,56	95,72
65	92,69	102,85
70	99,82	109,98
75	106,95	117,11
80	114,08	124,24
85	121,21	131,37
90	128,34	138,50
95	135,47	145,63
100	142,60	152,76
105	149,73	159,89
110	156,86	167,02
115	163,99	174,15
120	171,12	181,28
125	178,25	188,41
130	185,38	195,54
135	192,51	202,67
140	199,64	209,80
145	206,77	216,93
150	213,90	224,06



Key

1 drop (between 0 and 100 PTV units)

2 horizontal line through axis of rotation

3 scale radius, 305 mm

NOTE 1 The drop is the distance between a horizontal line through the zero on the scale to the edge of the scale.

NOTE 2 The zero is 10,16 mm below a horizontal line through the axis of rotation of the pendulum.

Figure C.5 — Scale

C.9 Calibration procedure for the pendulum friction tester

C.9.1 General

Calibration should be performed under laboratory conditions. When carrying out the calibration, the pendulum tester shall be operated in accordance with the procedure as specified in C.5.1.

Any damage or misalignment observable should be rectified by the manufacturer and recorded and/or simple repairs may be carried out by the calibration laboratory prior to calibration.

C.9.2 Pre-calibration verification

C.9.2.1 General

The purpose of the initial verification is to assess and record the condition of the pendulum tester prior to calibration.

C.9.2.2 Visual and mechanical check

Carry out a visual check of the assembled pendulum tester to determine whether there is any obvious damage that requires repair prior to calibration. Swing the pendulum arm to see if there are any obvious mechanical defects.

C.9.2.3 Performance check

Check the PTVs of the reference materials in wet condition as described in C.4.

C.9.3 Detailed condition check

Examine the pendulum tester carefully and record any defects found prior to calibration, following a) to p) of the following recommended list of items to be checked:

a) there is no damage to main frame and main tube support;

b) levelling screws are easy to operate and when extended by 7 5 % of their travel not so loose as to cause the pendulum tester to move laterally relative to the surface on which it stands by more than 1 mm in total under a reasonable lateral hand pressure;

c) the rear support foot is attached firmly to the main frame and when the locking nut is tightened there is no free play between it and the main frame;

d) the level glass is firmly fitted, undamaged and readable, and check the horizontal display for its horizontality in line with the level glass;

e) the head raising and lowering mechanism (vertical screw) is secure and without significant play;

f) the release mechanism (knob) securely locks the head when normal hand clamp force is applied;

g) the release mechanism (knob) operates correctly and the release catch does not rub or snag in the catch;

h) the pointer is straight/undamaged and swings with uniform frictional restraint round the full normal movement;

i) the friction and locking ring operates correctly;

j) the main pendulum arm fits correctly to the bearing assembly and is not damaged;

k) the pendulum foot swings in line with the frame, i.e. when hanging vertically the front and rear of the pendulum foot are equidistant from the frame;

l) the main bearing is smooth in operation throughout its normal travel;

m) the counterweight on the rear of the foot is complete and secure;

n) the slider lifting handle raises and lowers the slider smoothly and freely; with the pendulum arm hanging vertically, raise the slider using the slider lifting handle, manually support the raised slider and release the handle. It should drop back down freely;

o) the plate on the underside (when present) of the pendulum foot is secured with all the required screws;

p) the slider support rod is provided with the requisite washers, spring and securing pin and allows the slider backing plate to rotate easily.

C.9.4 Checking/setting the centre of gravity of the pendulum arm and slider assembly

C.9.4.1 Apparatus

C.9.4.1.1 Laboratory balance, capable of weighing up to 2 kg to an accuracy of ± 1 g.

C.9.4.1.2 Knife edge, set horizontally to an accuracy of 1 in 120 (0,5°).

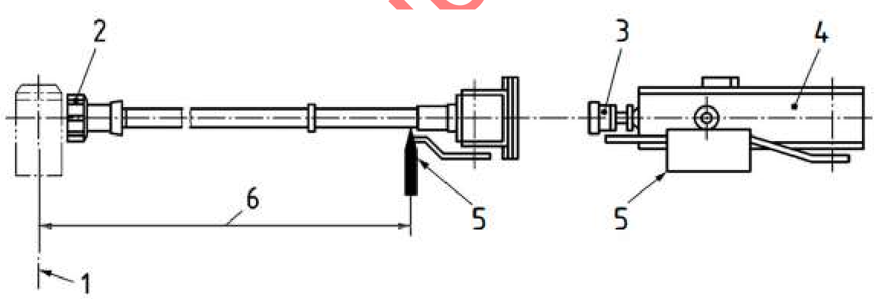
C.9.4.2 Mass of the arm

Remove the pendulum arm, complete with slider assembly and slider 96 attached, from the main frame of the apparatus and weigh it using the balance (C.9.4.1.1). Record this value. If the mass is not (1,50 ± 0,03) kg, consult the manufacturer.

C.9.4.3 Longitudinal position of the centre of gravity

Place the tubular part of the arm across the knife edge (C.9.4.1.2) such that the arm balances. Mark the position of the point of balance on the arm (see Figure C.6).

The longitudinal centre line of the arm should be at right angles to the horizontal axis of the knife edge and the lock nut (2) located as far from the foot as possible.



Key

1 centre of rotation
2 lock nut
3 counter balance weight
4 pendulum foot
5 knife edge
6 distance to centre of gravity

Figure C.6 — Pendulum arm, showing the location of the centre of gravity

C.9.4.4 Lateral position of the centre of gravity

Place the tubular part of the pendulum arm on, and at right angles to the horizontal knife edge (C.9.4. 1.2).

The arm should be free to roll along the knife edge.

Fully tighten the counter balance weight assembly.

If there is a tendency for the foot part of the pendulum arm assembly to rotate, adjust the counter balance weight on the rear of the pendulum foot to obtain the correct balance.

NOTE If correctly balanced, the foot part of the arm assembly lies in a horizontal plane with no tendency to rotate.

Mark the centre of gravity on the pendulum arm with a pencil or similar marker.

C.9.4.5 Distance of centre of gravity to centre of rotation

Reassemble the arm onto the main frame and measure the distance from the marked point of balance as specified in C.9.4.3 to the axis of suspension. Record this distance. If the measured distance is not (410 ± 5) mm, consult the manufacturer.

C.9.5 Checking/setting the effective spring tension

C.9.5.1 General

This procedure enables the spring tension to be adjusted to the configuration of the pendulum arm.

C.9.5.2 Apparatus

C.9.5.2.1 Pendulum arm holder, a means to hold the pendulum arm vertical with the foot at the top.

C.9.5.2.2 Balance, capable of measuring up to 3 kg, accurate to ± 0,5 g.

C.9.5.2.3 Means of applying a vertical force, a hanger attached to the screw (see C.9.5.3.1) containing weights sufficient to apply a force of at least 30 N.

C.9.5.2.4 Ruler or callipers, to mark on the backing plate the downward movement of the screw.

C.9.5.3 Procedure

C.9.5.3.1 Assemble the pendulum vertically in the holder. Expose the threaded hole in the slider lifting handle. Screw a 6BA screw into the tapped hole in the slider lifting handle (see Figure C. 7).

For some designs, unscrew the small plate to the side of the slider lifting handle.

NOTE The 6BA screw contains a non-preferred thread. The screw is provided by the manufacturer of the pendulum.

C.9.5.3.2 Mark a location in pencil or similar marking device on the backing plate (4,5 ± 0,1) mm below the initial location of the screw, to indicate the lower position of the screw after the application of load. Alternatively use a micrometer to measure the movement of the slider assembly.

NOTE Marking from the lower edge of the screw is easier.

When using a micrometer a slider 96 shall be used and the micrometer should not push down the slider assembly.

C.9.5.3.3 Attach the hanger and increase the weights until the screw moves downward 4,5 mm to indicate the lower position (see Figure C.7).

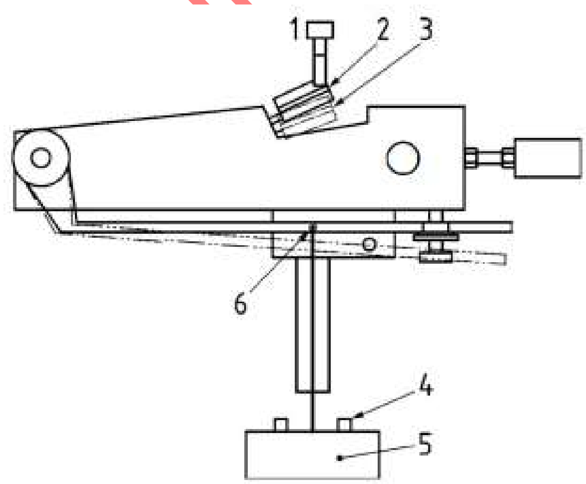
C.9.5.3.4 Note the mass (M) of the weights and hanger in kilograms to calculate the (measured) force Fm in Newtons on the hanger, using Formula (C.2).

$$F_m = M \times g \tag{C.2}$$

where

M is mass of the total weight in kilograms;

g is acceleration of gravity in metres per square second (9,81 m/s²).



Key

1 micrometer
2 position 1
3 position 2
4 small weights
5 weight
6 tapped hole

Figure C.7 — Drawing demonstrating the calibration of the spring tension

C.9.5.4 Calculating the correct spring tension force

Calculate the correct (upside down) spring tension force, Fu, in N, using Formula (C.3).

$$F_u = \frac{F_N \times W_p \times L_p}{W_N \times L_N} - 2,3 \qquad (C.3)$$

where

F_u is the correct vertical tension force, in N, when the slider is deflected 4,5 mm;

F_N is the nominal vertical compression force (24,5 N), when the slider is deflected 4,5 mm;

W_p is the mass of the pendulum arm as determined in accordance with C.9.4.2, in grams;

W_N is the nominal mass of the pendulum arm (1 500 g);

L_p is the distance to the centre of gravity as determined in accordance with C.9.4.3, in millimetres;

L_N is the nominal distance to the centre of gravity (410 mm).

NOTE 2,3 is the weight, in N, of the slider fitting and lifting handle multiplied by 2.

If the force Fm applied, determined from mass M, is not within the range (Fu ± 0,5) N, undo the clamp at the bearing end of the pendulum arm and rotate the top section relative to the tubular arm until the correct tension is achieved.

Reassemble the arm onto the main frame and adjust the foot so that it is parallel to the frame and remains parallel during its swing. Fully tighten the clamp screws.

C.9.6 Checking/setting the slider force/deflection characteristics

C.9.6.1 Apparatus

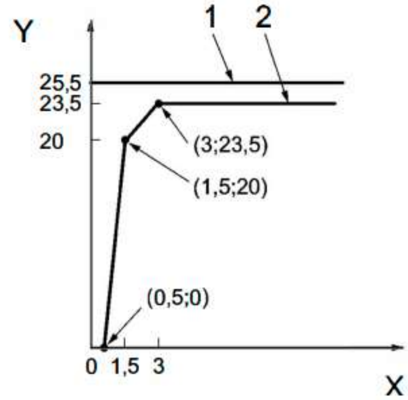
C.9.6.1.1 Means of measuring the vertical force on the slider

The instrument should be accurate to within 0,1 N and should be able to measure a range of at least 30 N. Its stiffness, i.e. its deflection under a load of 25 N, should be known or, alternatively, monitored by a dial gauge during the test.

C.9.6.1.2 Dial gauge or similar device (e.g. an Linearly Variable Differential Transformer, LVDT, electronic displacement measuring sensor), with a minimum 10 mm full scale deflection and 0,01 mm divisions.

C.9.6.2 Force-deflection limits

For the upper and the lower force limits see Figure C.B.



Key

Y force, in N

X deflection, in mm

1 upper force limit

2 lower force limit

Figure C.8 — Envelope for slider force/deflection characteristics

C.9.6.3 Procedure

i) Set up the pendulum tester fitted with a slider 96 in the normal manner such that the pendulum arm/slider hangs over and just clear of the balance/load cell/force gauge. When lowered on to the balance/load cell/force gauge, the slider should be supported over its full width of 76 mm. When using a balance use Formula (C.2) to calculate the load in Newtons.

j) Set up the dial gauge (C.9.6. 1.2) to monitor the anticipated 10 mm, vertically downwards, movement of the pendulum foot, correcting for the displacement of the balance plate measured with a second dial gauge.

k) Lower the pendulum arm until the slider working edge just makes contact with the load measuring device and gives a reading of between 1 N and 10 N. Record the load and the dial gauge reading.

l) Lower the pendulum arm by four further movements of approximately 0,5 mm followed by a further six movements of 1,0 mm. At each stage record the load and dial gauge readings.

m) Raise the pendulum arm, stopping at approximately the same dial gauge readings as in d) to record the load and dial gauge readings.

n) Plot the load/ deflection curve, assuming that:

1. lowering the pendulum arm gives a positive deflection; and

2. the true deflection of the first reading taken in c), in millimetres, is 0,025 multiplied by the load in Newtons.

o) Compare both curves with the envelope shown in Figure C.8.

NOTE 1 If the curves do not lie within the envelope, the cause might be one or more of the following, in which case appropriate remedial action might be necessary:

1. the main spring is incorrectly tensioned or requires replacement;
2. the knife edges (axes of rotation) within the foot have become displaced;
3. the interstices of the foot require cleaning, especially around the roller, which applies the load onto the slider support arm;
4. there is friction in the bearings, and/or in the slider lifting handle assembly.

If the tension of the main spring needs to be adjusted, undo the clamp at the bearing end of the pendulum arm and rotate the top section relative to the tubular arm until the correct tension is achieved. Reassemble the arm onto the main frame and adjust the foot so that it is parallel to the frame and remains parallel during its swing. Fully tighten the clamp screws.

Repeat the procedure according to a) to g) to ensure that the correct force/deflection characteristics have been established.

NOTE 2 The force/deflection curve can also be determined with a tensile test machine or similar device where a continuous graph could be determined.

C.9.7 Checking/setting the levelness of the frame

C.9.7.1 Apparatus

C.9.7.1.1 Spirit level, accurate to within four minutes of arc (0,06°) or 1 in 1 000, or other equivalent means of checking verticality.

C.9.7.2 Levelling the frame

Set the pendulum frame up with the arm now attached to the main frame. Adjust the feet such that the pendulum tester is level according to the built-in level.

Using the spirit level (C.9.7. 1.1) check the verticality of the main upright tube in two directions at right angles. Record the extent of any non-verticality in excess of 0,5° (1 in 120) and either adjust the built in level or consult the manufacturer. Similarly, check that when the pendulum arm with the release catch is engaged in the release mechanism (knob) that its longitudinal axis lies in a horizontal line. Record the extent of any deviation from the horizontal in excess of 0,5° (1 in 120) and either adjust the catch block or consult the manufacturer.

Measure the vertical distance between the arm centre of rotation and the zero mark on the scale. Record the extent of any deviation in excess of (10 ± 1) mm and either adjust the scale or consult the manufacturer.

C.9.7.3 Adjusting the pointer

Allow the pendulum arm to hang freely. Place the pointer alongside it in its "following" position. Turn the pointer adjustment screw such that the pointer longitudinal axis is precisely in line with the axis of the pendulum arm.

The longitudinal axes of the upright tube on the frame, the pendulum arm and the pointer shall all be in line and vertical.

C.9.8 Final calibration

Repeat the procedure specified in C.9.2.3. Check that the PTVs are within the corresponding limits specified in C.4.2.

If the PTV is outside these limits, investigate and correct the cause of the deviation and then repeat the procedures specified in C.9.3 to C.9. 7 as necessary.

C.9.9 Calibration report and marking (external calibration)

C.9.9.1 Calibration report

The pendulum tester calibration report shall include at least the following information:

a) reference to this European Standard (i.e. EN 16165 :2021);

b) name of the calibration laboratory;

c) serial number of the pendulum tester;

d) organization for whom the calibration has been carried out;

e) date of calibration;

f) laboratory temperature during calibration;

g) pre-calibration verification results;

h) final calibration results;

i) authorized signature of the calibration laboratory test personnel;

j) calibration certificate number, if relevant;

k) slider force/deflection curve.

C.9.9.2 Marking

A label shall be affixed to the pendulum tester stating the following:

a) number and date of this document;

b) name of the calibration laboratory;

c) serial number of the pendulum tester;

d) calibration certificate number, if relevant;

e) date of calibration.

Annex D
(normative)

Tribometer test

D.1 Principle

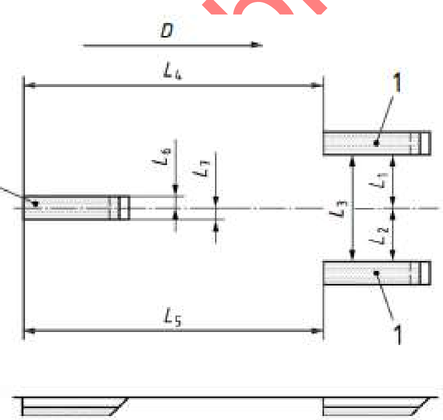
A test apparatus equipped with sliders is chosen such that a given pressure acts on the surface. The sliders are made of a defined material and exhibit a certain shape. The test apparatus is pulled at a constant speed and parallel to the surface. The force required to pull the test apparatus is determined over the length of the measuring distance. In order to determine the sliding friction coefficient, this force is divided by the vertically acting force. The test can be carried out in wet or in dry conditions.

The measuring method can be used for measurements in laboratory conditions as well as for measurements on site.

D.2 Apparatus

D.2.1 The test apparatus weight including the slider assembly weight shall be (10 ± 0,1) kg.

D.2.2 Slider assembly consisting of three sliders with the dimensions given in Figure 0.1.

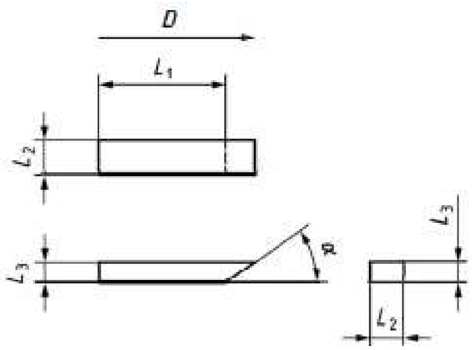


Key

1	slider
D	sliding direction
L_1 minus L_2	(0 ± 0,3) mm
L_3	(46 ± 2) mm
L_4	(130 ± 3) mm
L_4 minus L_5	(0 ± 0,3) mm
L_6 minus L_7	(0 ± 0,3) mm

Figure D.1 — Slider assembly

The slider dimensions are given in Figure D.2.



Key

D sliding direction

L_1 length (37,5 ± 2,5) mm

L_2 width (10 ± 0,5) mm

L_3 thickness of 2 mm to 6 mm

α angle (35 ± 5)°

Figure D.2 — Slider dimensions

D.2.3 Device used to pull the test apparatus including the sliders over a measuring distance of at least 0,5 m at a constant speed in the range 0,2 mjs to 0,25 mjs.

The device shall maintain the speed constant over this measuring distance with a tolerance of ± 0,02 mjs.

D.2.4 Measuring device, capable of measuring the tensile force with a measurement uncertainty of maximum ± 1% of the pulled test apparatus's weight.

D.2.5 Balance to determine the mass of the pulled test apparatus including the sliders with a measurement uncertainty of maximum ± 0, 1 %.

D.2.6 Force meter (e.g. spring balance) with a range of 10 N to 100 N and an accuracy of max. ± 0,5 % within that range.

D.3 Test equipment

D.3.1 Slider materials.

D.3.1.1 Slider assembly with slider materials for wet and dry conditions: Three sliders of SBR rubber in accordance to EN 15307 with a density of (1,23 ± 0,02) gjcm3 and a Shore D hardness 50 ± 3 in accordance with ISO 48-4. Slider materials shall be discarded 3 years after the production. [7]

D.3.1.2 Slider assembly with slider materials for dry conditions: The back slider consists of SBR rubber (0.3.1.1). The two sliders in the front consist of pit-tanned leather of density (1,0 ± 0,1) gjcm3 and a Shore D hardness 60 ± 10 in accordance with ISO 48-4. Slider materials shall be discarded 3 years after the production. [7]

D.3.2 Test liquid: Solution of 0,1 % sodium lauryl sulphate (purity ≥ 99 %) in deionized or distilled water.

D.3.3 New abrasive papers, abrasive: silicon carbide, 120 grade (for removal of contaminations) and 320 grade, attached to the plane solid carrier plate.

D.3.4 Plane, solid carrier plate, wider than the slider assembly and at least 1 000 mm long with an attachment device for the abrasive paper.

NOTE It is also possible to fix the abrasive paper with adhesive tape on a flat and solid table.

D.3.5 Ethanol solution with a mass fraction of (50 ± 5) % ethanol in deionized or distilled water, for cleaning the surfaces.

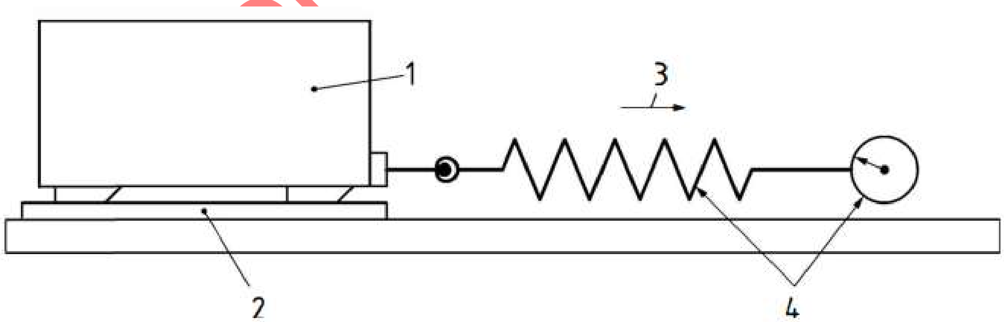
D.4 Verification and checking

D.4.1 Verification of the load cell

Verification shall be carried out as given below. The test device shall be placed in a horizontal fixed mounted position. In static state (static load on the load cell < 1 N) the readout shall display the zero point. After it the load cell of the test device should be connected to a calibrated force meter (like a spring balance; D.2.6) to verify the pull force shown on the readout of the test device (see Figure D.3).

The verification of the forces should be checked at the levels 15 N, 30 N, 45 N and 60 N. The readout should not have a difference of more than ± 2 N on each level between the test device and the force meter.

When verifying no parts of the force meter system should touch the surface.



Key

1 test device with load cell and read out

2 fixing

3 force direction

4 force meter (e.g. spring balance)

Figure D.3 — Schematic view of pull force verification set-up

D.4.2 Verification of the slider material and test apparatus

D.4.2.1 General

The reliability of a measurement result is largely linked to the following aspects:

a. The configuration and condition of the measurement-device used (see D.2 and D.4.1);

b. The condition and preparation of the slider used (see D.7).

D.4.2.2 Setup for control (Verification)

A check on the correct operation of equipment, the condition and preparation of sliders, and the execution of the measurement shall be performed under laboratory conditions prior to testing using a set of verification surfaces as indicated in Table 0.1.

NOTE An additional check immediately before testing is not necessary.

Table D.1 — Property values of the verification surfaces

Tribometer verification surface (TVS)	Assigned value of the verification surface (Dynamic coefficient of friction, μ)	Acceptance criteria between verification surface and measured value (μ)	
		Slider-assembly according D.3.1.1 (SBR-rubber), wet conditions (D.3.2)	Slider-assembly according D.3.1.2 (mixed SBR-rubber and leather), dry conditions
TVS-1	0,20 to 0,40	± 0,03	± 0,04
TVS-2	0,40 to 0,60	± 0,03	± 0,04

Each verification material shall have a hard and stable surface and should be not sensitive to mechanical changes. Some surfaces may need to be conditioned prior to initial use to ensure that stable verification values are subsequently obtained.

The assigned value of each verification surface (this also means for surfaces of different batches of the same surface type) shall be established immediately after equipment calibration by the manufacturer and/or verification of the load cell (0.4. 1) from the median value from at least 10 measurements on different days by at least 2 operators

NOTE 1 Where 2 or more operators are not available the verification can be done with measurements of the same operator.

NOTE 2 Two different sets of equivalent verification surfaces, one set for working references and one set for incidental check, can be helpful to monitor a possible drift in dynamic coefficient of friction of the working reference due to changes in the surface properties by repeated measurements.

NOTE 3 Two different sets of equivalent verification surfaces may also overcome the problem to organize a new verification surface in between two calibrations when a reference material has broken.

Verification materials and their assigned values may also originate from proficiency testing where values were obtained under the above conditions or, where available, may be certified reference samples.

In the situation that the acceptance criteria are not met the equipment/slider combination or the operator is considered unreliable and adequate measures shall be taken to get the values of the dynamic coefficient of friction in line with the assigned values.

D.5 Preparation of the test surface area for laboratory tests

The test surface area shall be minimum 1 000 mm x 400 mm in the lowest direction of slip. The test surface shall be either self-supporting, or securely mounted on a suitable flat surface.

If the direction of the slip resistance of the test surface is not known, it is recommended that tests are carried out in at least three directions (longitudinally, laterally and approximately 45 o between the two) to establish whether there is directionality of the slip resistance of the sample. Once a lack of directionality has been established, it is acceptable to test in a single direction.

The test surface area shall be clean. If necessary e.g. the ethanol solution according to 0.3.5 can be used.

In certain situations, the test surface is measured as it is.

The test sample is conditioned at room temperature for at least 12 h prior to testing.

For measurements in wet conditions: The test liquid shall act on the surface for at least 5 min prior to the measurement Wet the surface with the test liquid in order to create a thin film, as uniform as possible, over the test area using a clean brush or spray bottle.

NOTE On slopes and on flooring material with higher water absorption it might not always be possible to create a proper water film. This might influence the measurement results.

D.6 Measurements on-site

D.6.1 General aspects

The Tribometer should be transported in a manner which is appropriate and such as to ensure the instrument is not damaged.

When testing outdoors it can be necessary to protect the instrument from the effects of wind, or movement of air caused by passing trains or traffic.

When conducting a test on site, the equipment and operator being well below normal eye level are not always noticeable to pedestrians. Adequate safety measures should be in place to maintain a safe working area. The slider assembly and the whole equipment shall be at ambient temperature when used.

D.6.2 Preparation of the test surface for on-site tests

For on-site tests the test surfaces are determined depending on the utilization situation of the surface. In accordance with the question to be investigated, it is necessary to test the surface for instance as follows:

— carry out a standard test (e.g. verification of product testing), the test surface area shall be clean. If necessary e.g. the Ethanol solution according to 0.3.5 can be used. For testing the test liquid given in 0.3.2 shall be used;

— in the operating state determined on site (as found, wetting material from on-site situations or dry, with or without contamination, e.g. for risk assessments);

— cleaned, according the manufacturers or customers instruction;

— with other test liquids commonly used in the test area.

The wetting agents shall act on the surface to be tested for at least 5 min prior to the measurement. For tests with wetting agents a uniform thin film is prepared on the surface.

D.6.3 Additional information for on-site tests

When assessing a site it is important to obtain as much information about the surface as possible. As a guide, measurements should be taken from areas that are trafficked regularly such as entrances, the middle of corridors or at the bottom of stairs and areas where there is no or little traffic such as in corners, at the edges of corridors and under stairs or benches. It is useful to test the floor as found and again after cleaning. Measuring these parameters can tell you if the problem is the floor itself (is it slippery when contaminated, has it worn etc.) or is it another issue (contamination, incorrect cleaning etc.) The amount of areas will depend on the size and use of the area and should be agreed betweenrelevant parties. It is also important to remember that when assessing the area the slip resistance of the floor is only one contributor to the slip risk. [6]

D.7 Preparation of the sliders

For the purposes of cleaning and obtaining a flat slider surface with a defined roughness, the surfaces of the sliders are abraded in a planar direction using 320 grade abrasive paper on the plane solid carrier plate in accordance with D.3.4, and any dust is removed. The abrading process shall be performed using the test apparatus with one full stroke in dry conditions by using the pulling device at a constant speed as defined in D.2.3 with no additional load. The abraded particles on the abrasive paper shall be removed regularly. This preparation is repeated prior to each measurement series (of five singlemeasurements). If stick-slip occurs the abrasion shall be checked.

The abrasive paper can be used as long the readout of the device during the preparation procedure shows similar values. If this values get significant lower, new abrasive paper shall be used.

For wet testing: Apply the test liquid to each slider surface.

Contamination of the sliders resulting from on-site tests on very dirty surfaces can be removed using the 120-grade abrasive paper. Afterwards the abrading process shall be carried out using the 320-grade abrasive paper, performing at least 2 full-strokes of the test apparatus.

Sliders contaminated by measurements using sliding agents deviating from D.3.2 (e.g. oils or fats) are not suitable for further use with the sliding agent water.

D.8 Procedure

The test equipment including the sliders used shall be conditioned to the ambient climate for at least 30 min prior to measuring. For on-site measurements and for laboratory measurements with doubts what the direction with the lowest slip resistance is that tests shall be carried out in three directions (longitudinally, laterally and approximately 45° between the two) to establish whether there is directionality of the slip resistance of the sample. If a lack of directionality can been established it is acceptable to test the surface in any single direction. If the slip resistance property is directional, then test in the direction of the lowest slip resistance. During the test, the measuring device is pulled over the test surface at a constant speed as defined in D.2.3. The mean value of the frictional force is calculated over the measuring distance of at least 0,5 m not taking into account the acceleration and braking down parts of the sliding distance.

NOTE When carrying out measurements in accordance with this document, in rare cases vibrations (stick slip) occur. These result in increased measurement uncertainties. By design measures and/or by guiding the measuring device by hand during the starting phase, this behaviour can be reduced.

One measurement series consists of five single measurements in the direction of the lowest slip resistance in one trace.

To evaluate a floor (e.g. for product testing), three measurement series in different traces should be determined.

When performing on-site tests, the number of the test surfaces and measurement series, the sliding directions and the sliders are specified in accordance with the utilization situation of the surface and the question to be investigated.

D.9 Calculation and expression of results

For each slider material and sliding agent the mean value of the sliding friction coefficient μ is calculated for each measuring distance to two decimal positions, in accordance with Formula (0.1):

$$\mu = \frac{F_f}{N_N} \tag{D.1}$$

where

F_f is the mean value of the frictional force, in Newtons;

N_N is the weight of the pulled test apparatus including the sliders, in Newtons.

The mean value of a measurement series is calculated from the results of the third to the fifth single measurement, to two decimal positions.

D.10 Test report

The test report shall contain the following information:

a) reference to this European Standard (including its year of publication);

b) method used (i.e. Annex D);

c) complete description of the tested product, including the type, origin, colour and the manufacturer's reference marks and/or an identification of the test site for the on-site test;

d) test organization and name of the person responsible for the test;

e) five individual values for each measurement series and the calculated average (measurement 3 to measurement 5) to the nearest 0,01;

f) mean values of the sliding friction coefficient, μ;

g) other quantities which could have influenced the results (e.g. temperature, humidity);

h) slider materials and wetting agent or test liquids used;

i) any other appropriate remarks, such as, surface conditions tested and cleaning method, usual maintenance procedures and cleaning products used, surface treatments of the tested pavement and the sampling method.

Bibliography

[1] EN 360, Personal protective equipment against falls from a height - Retractable type fall arresters

[2] EN 361, Personal protective equipment against falls from a height - Full body harnesses

[3] EN 1 5307:2014, Adhesives for leather and footwear materials - Sole-upper bonds - Minimum strength requirements

[4] ISO 4662, Rubber, vulcanized or thermoplastic - Determination of rebound resilience

[5] SAE }300:2015, Engine Oil Viscosity Classification

[6] DGUV Information 208-041, Bewertung der RutschgefahrunterBetriebsbedingungen (Evaluation of the risk of slip under operating conditions)

[7] Supplier-list for testing-materials, Deutsche gesetzlicheUnfallversicherung, Fachbereich Handel und Logistik, https ://www.dguv.de/medien/fb-handelundlogistik/pdf-dokumente/supplierlist.pdf [viewed 2020-12-14]

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