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Paints and varnishes — Determination of the resistance to rubbing using a linear abrasion tester (crockmeter)

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Foreword

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This document was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 9, *General test methods for paints and varnishes*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Paints and varnishes — Determination of the resistance to rubbing using a linear abrasion tester (crockmeter)

1 Scope

This document specifies a method for determining the resistance of a coating to rubbing by means of a loaded abrasive material which is linearly moved over the surface to be tested.

The method can also be applied to different material surfaces, such as plastics and metals.

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 edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 105-F09, *Textiles — Tests for colour fastness — Part F09: Specification for cotton rubbing cloth*

ISO 845, *Cellular plastics and rubbers — Determination of apparent density*

ISO 1514, *Paints and varnishes — Standard panels for testing*

ISO 2808, *Paints and varnishes — Determination of film thickness*

ISO 3270, *Paints and varnishes and their raw materials — Temperatures and humidities for conditioning and testing*

ISO 4618, *Paints and varnishes — Terms and definitions*

ISO 23321, *Solvents for paints and varnishes — Demineralized water for industrial applications — Specification and test methods*[1)]

ASTM D2240, *Standard Test Method for Rubber Property — Durometer Hardness*

FEPA-Standard 43-2[2)], *Grains of fused aluminium oxide, silicon carbide and other abrasive materials for coated abrasives microgrits P 240 to P 2500*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4618 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

1) Under preparation. Stage at the time of publication: ISO/FDIS 23321:2019.

2) Federation of European Producers of Abrasives (FEPA). Reference source for FEPA standards: Staatliche Materialprüfungsanstalt Darmstadt, Dr. Ing. P. Hof, Grafenstraße 2, 64283 Darmstadt, Germany, Tel.: +49-6151-16 65 82, Fax: +49-6151-16 60 46, E-Mail: hof@mpa-ifw.tu-darmstadt.de.

4 Principle

A loaded abrasion tool, lined with agreed abrasive material and influenced by an agreed abrasive medium, is moved over the coating using a linear abrasion tester (crockmeter). There are three procedure variations, depending on the agreement and application (see Table 1).

Table 1 — Procedure variations

Abrasion tool	Geometry of abrasion tool	Contact surface to test specimen	Test load	Application
A	Cuboid	Base surface (22 mm × 22 mm)	(22,0 ± 0,5) N	flat test panels
B	Cylinder	Front surface (Ø 16 mm)	(9,0 ± 0,2) N	flat test panels[a]
C		Lateral surface (Ø 44 mm × 25 mm)[b]		flat and curved test specimen

[a] With limitations: Abrasion tool B is the original procedure variation; in most cases abrasion tool A is preferred also for flat test specimen.

[b] The contact surface is a part of the lateral surface, which depends on different parameters, see 5.2.3, Note 3.

The assessment of the friction mark shall be agreed and can be carried out e.g. visually or by means of measuring the change in gloss, haze or brightness.

5 Apparatus and ancillary materials

5.1 Linear abrasion tester (crockmeter)

Linear abrasion tester in accordance with Figure 1, which is specified by the following properties.

5.1.1 The mechanism can be manual (as illustrated in Figure 1) or (electro) motor driven.

5.1.2 For the motoric version, an operation counter for pre-setting the number of double-strokes shall be integrated and the mechanism shall have a stroke frequency of (1,0 ± 0,1) Hz and shall have a constant velocity within the 70 mm measurement area.

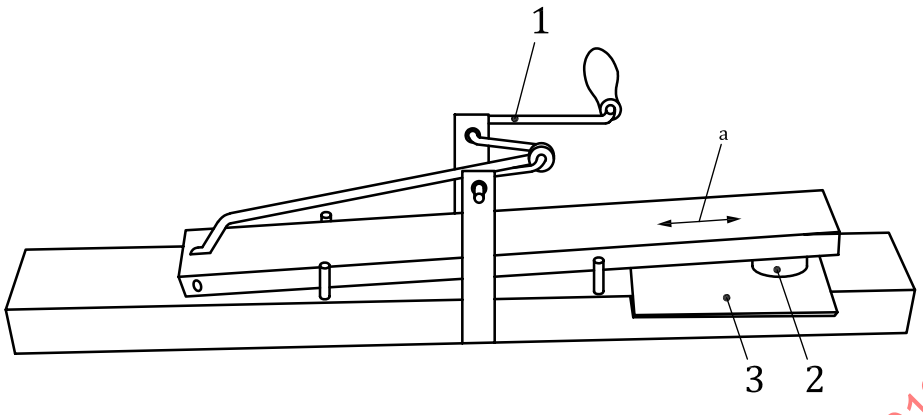
5.1.3 The test load with which the abrasion tool (5.2) is pressed onto the test specimen shall be (9,0 ± 0,2) N (for abrasion tool B and C) and (22,0 ± 0,5) N (for abrasion tool A).

NOTE Test devices intended for a test load of 9,0 N can be converted to a test load of 22,0 N by means of an additional load of 13,0 N (corresponding to an additional weight with a mass of 1,33 kg).

5.1.4 The stroke length shall be selected in such a way that the length of the assessable friction mark is (100 ± 30) mm.

NOTE 1 The assessable friction mark equals the total friction mark, less the expansion of the contact surface of the abrasion tool in the direction of the stroke on both ends (see 7.3.1). Consequently, the stroke length is at least 70 mm + 2 × expansion, in millimetres, of the contact surface of the abrasion tool in the direction of the stroke. For the dimensions of the abrasion tools, see 5.2.

NOTE 2 Some devices exist with a length of the assessable surface less than 70 mm due to technical reasons.



Key

1 crank mechanism (crank handle)

2 abrasion tool B – see 5.2.2

3 test specimen

a Direction of stroke motion.

Figure 1 — Crockmeter (example with manual crank mechanism)

5.2 Abrasion tool

5.2.1 Abrasion tool A, e.g. as shown in Figure 2 a). The felt insert shall have the dimensions (22,0 ± 0,2) mm × (22,0 ± 0,2) mm × 6 mm and a bulk density of 0,44 g/cm^3. The coupling with the crockmeter (5.1) is rigid.

NOTE Despite the rigid coupling a tilting of the front face of the abrasion tool A against the test specimen is impossible due to the elastic felt insert.

5.2.2 Abrasion tool B, designed as a cylinder with a diameter of (16,0 ± 0,1) mm, the front surface of which is facing the test specimen. The coupling with the crockmeter (5.1) is rigid.

NOTE 1 Due to the rigid coupling a tilting of the front surface of the abrasion tool B against the test specimen is generally possible.

NOTE 2 Unlike abrasion tools A and C, abrasion tool B cannot be lined with abrasive material without wrinkling.

5.2.3 Abrasion tool C, e.g. as shown in Figure 2 b). The radius of the tool shall be (19,0 ± 0,5) mm and a width of (25,0 ± 0,3) mm. In the contact area to the test specimen, the lateral surface of the tool shall be covered with a layer of EPDM rubber[3)], e.g. DIM ZK EPDM 21606[4)], with a thickness of (3,0 ± 0,3) mm and a width of (25,0 ± 0,3) mm, and which has the hardness of (60 ± 5) Shore-00 in accordance with ASTM D2240 and a bulk density of (0,16 ± 0,02) g/cm^3 in accordance with ISO 845. The coupling with the crockmeter (5.1) can be moved across the direction of the stroke [see view II in Figure 2 b)].

When lining the abrasion tool with the abrasive material (5.3), the latter is attached tightly to the abrasion tool by means of roll pins which are elastically interconnected by the rubber strips (see view III in Figure 2 b).

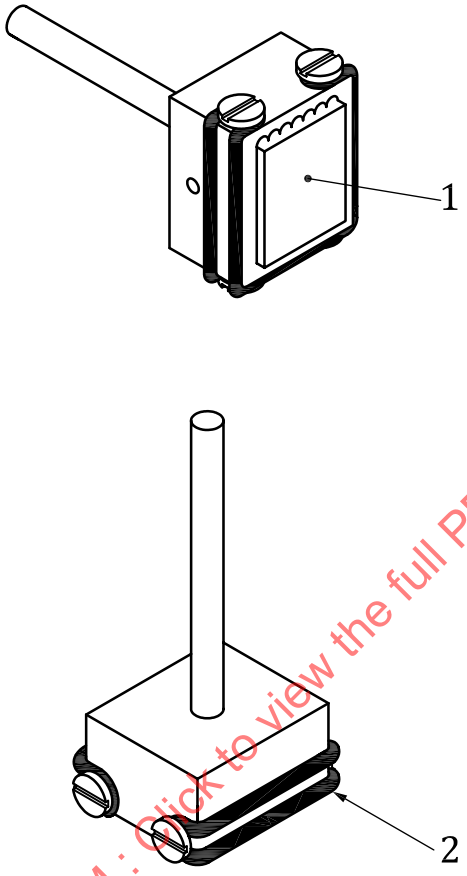
NOTE 1 Due to the EPDM rubber cover the effective diameter of the tool is 44 mm.

3) EPDM: Ethylene-propylene-dien-monomer.

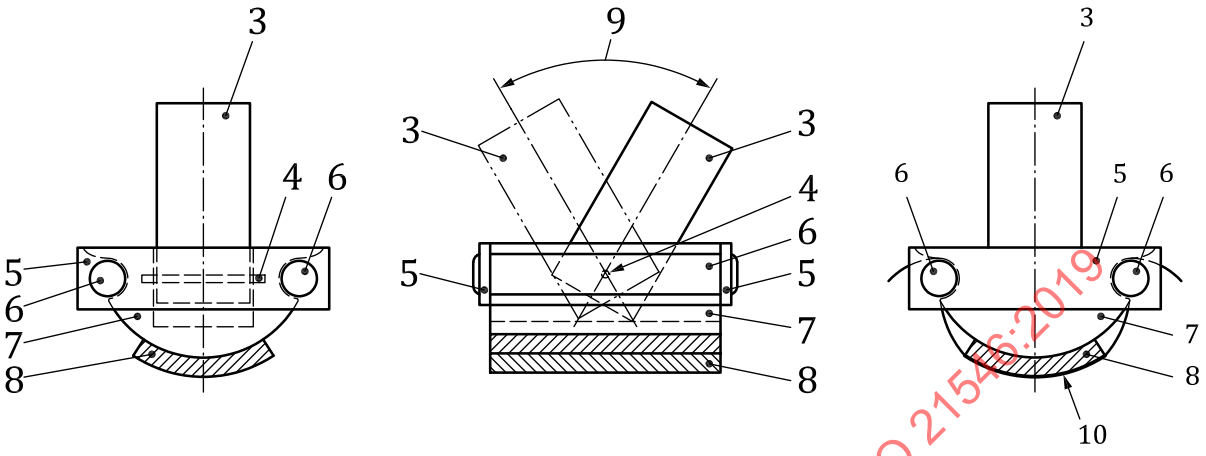
4) DIM ZK EPDM 21606 is the trade name of a product supplied by DIMER. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

NOTE 2 Due to the geometry of the abrasion tool and the movable coupling with the crockmeter, tests can be carried out on curved test specimens by means of abrasion tool C.

NOTE 3 Unlike abrasion tools A and B, the contact surface with the test specimen is geometrically unspecified for abrasion tool C; it is rather defined by the radius of the tool, the elastomer hardness, the test load, and, if applicable, by the properties of the abrasive material.



a) Abrasion tool A



I View across the direction of the stroke (design details)

II View in the direction of the stroke (swivelling range)

III View across the direction of the stroke (lined with abrasive material)

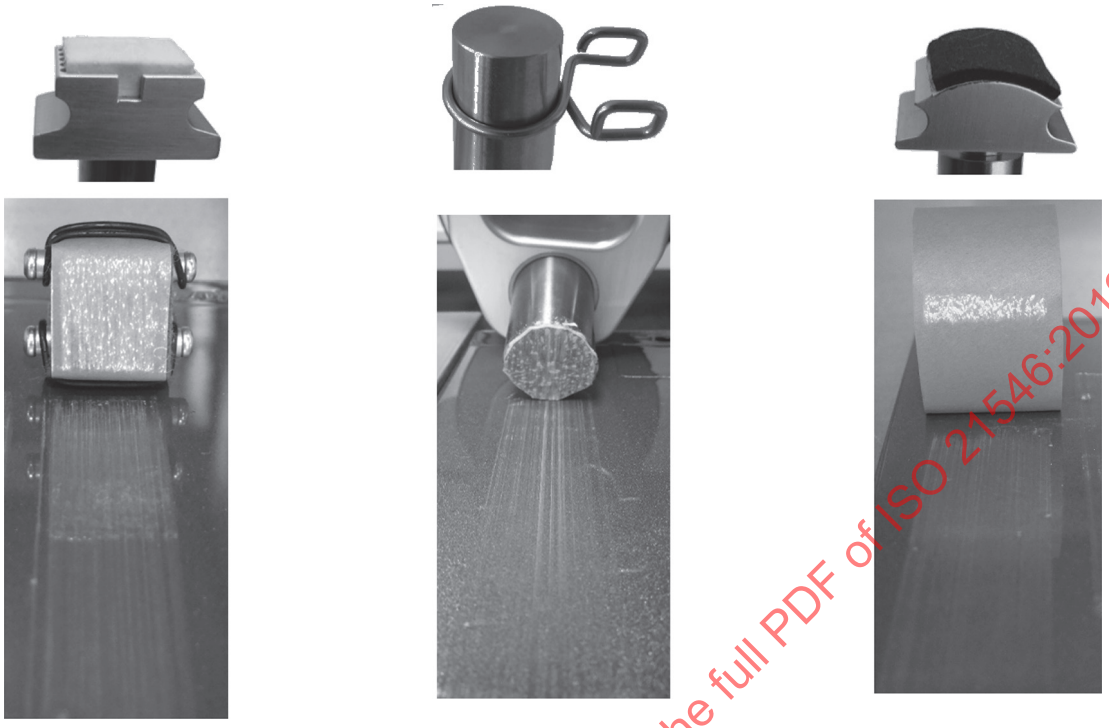
b) Abrasion tool C

Key

1 felt insert
2 o-ring for attaching abrasive material
3 adapter shaft
4 axial pin (swivel axis)
5 rubber strips
6 roll pins (locked in the base 5)
7 base with cylindrical outer contour (radius 19 mm)
8 cellular rubber (20 mm × 25 mm × 3 mm)
9 swivelling range (approximately 60°)
10 abrasive material

Figure 2 — Abrasion tool

5.2.4 Selection of the abrasion tool. The selection of the suitable abrasion tool depends on the type of the sample. Figure 3 shows examples for abrasion tools and the corresponding friction marks.



a) Abrasion tool A b) Abrasion tool B c) Abrasion tool C

Figure 3 — Examples for abrasion tools and the corresponding friction marks

For flat test panels, abrasion tool A is most suitable, because it produces a uniform, homogeneous friction mark which can be assessed easily.

The original abrasion tool B can also be used on flat test panels, nevertheless it produces a transversal inhomogeneous friction mark [see Figure 3 b)] which is difficult to assess. Therefore the abrasion tool A should be preferred.

For curved test specimen, abrasion tool C shall be used in any case. Care shall be taken to ensure that the strokes are located parallel to the curvature of the sample to obtain a maximum contact area and a friction mark that can be assessed clearly (see Figure 4).

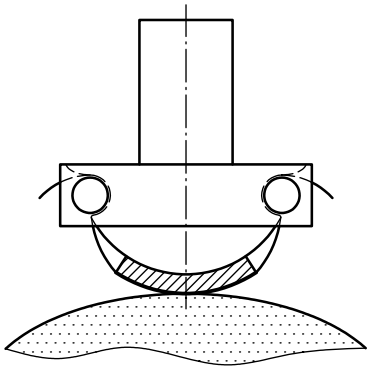


Figure 4 — Position of abrasion tool C on a curved sample surface

5.3 Felt cloth

Felt cloth with a thickness of 1,5 mm and a bulk density of 0,28 g/cm^3, corresponding to the felt hardness DIN 61200 — M5.

The abrasion tool can be lined with the felt cloth beneath the abrasive material. The felt cloth works as a compensating material and ensures that the abrasive material is pressed onto the coating evenly and over the entire surface. By agreement, a different cloth can be used which fulfils the same function.

5.4 Abrasive material, for lining the abrasion tool

5.4.1 Cotton rubbing cloth, in accordance with ISO 105-F09 with a mass per unit area of (110 ± 5) g/m^2 and 36 threads/cm in both directions.

5.4.2 Abrasive paper, with agreed grain size in accordance with FEPA standard 43-2 and preferably self-adhesive.

5.4.3 Abrasive material, with agreed grain size in accordance with FEPA standard 43-2, attached to a soft supporting material.

5.4.4 Felt, made of a material with agreed properties (e.g. bulk density and felt hardness according to DIN 61200).

5.5 Abrasive medium

Abrasive paste, abrasive powder, etc. of agreed type and/or water in accordance with ISO 23321, for sprinkling/wetting the abrasive material and/or the coating prior to rubbing.

5.6 Tools for assessing the friction marks

Depending on the agreed evaluation method, e.g. a measuring device for determining the gloss (see Annex C), the haze, or the brightness, is necessary, in combination with a measuring template (see Annex B) or a set of comparison pictures.

6 Test specimens

6.1 Test specimens

The test specimens shall be plane and prepared, coated, and dried/hardened in accordance with ISO 1514. The width of the test specimens shall allow for the possibility that three tests can be carried out next to each other without edge influence; the lengths of the test specimens depend on the construction of the test device.

NOTE Normal test specimen dimensions are 100 mm × 150 mm.

The surface of the test specimen shall be clean. Clean the surface with a soft, lint-free cloth and, if necessary, use a solvent which does not attack the coating.

6.2 Film thickness

Determine the dry film thickness of the coating, in micrometres, in accordance with one of the methods given in ISO 2808.

6.3 Conditioning

Prior to testing, condition the coated test specimens at a temperature of (23 ± 2) °C and a relative humidity of (50 ± 5) % in accordance with ISO 3270, if not otherwise agreed, for a minimum of 16 h.

7 Procedure

7.1 Test conditions subject to agreement

For the test procedure and the evaluation of the test the following shall be agreed:

— the abrasion tool in accordance with 5.2;

— the abrasive material in accordance with 5.4;

— the abrasive medium in accordance with 5.5;

— the number of double-strokes;

— the evaluation criterion, e.g. measurements of gloss, haze or brightness, visual comparison with reference pictures, etc.;

— the time interval between abrasion and evaluation of the friction marks.

Examples of usual test conditions are given in Annex A.

7.2 Test environment

Carry out the test at a temperature of (23 ± 2) °C. Measure the relative humidity during the test and record in the test report. In case of high relative humidity, be careful that no condensation water forms on the test specimen due to falling below the dew point.

Carry out the test as quick as possible, however, not later than 30 min after the conditioning phase.

7.3 Testing process

7.3.1 If the friction marks are assessed by agreement using optical measurements, e.g. gloss, haze or brightness, determine — preferably using the measuring template (see Annex B) — on the test panel at least three linearly spread measurement points and mark them.

The measurement points shall be determined such that:

— the measuring areas do not overlap;

— they are spread evenly on the (expected) friction mark;

— at the ends of the (expected) friction marks, an area corresponding to the agreed abrasion tool is left blank.

7.3.2 **Align** the agreed abrasion tool (5.2) with the agreed abrasive material (5.4), if necessary in combination with felt cloth (5.5).

7.3.3 Mount the test specimen on the test device. Where appropriate, consider the markings in accordance with 7.3.1, so that the position of the intended friction mark corresponds with the specified measurement points.

7.3.4 If applicable, apply the agreed abrasive medium (5.5) on the abrasive material and/or the coating.

7.3.5 Lower the abrasion tool prepared in accordance with 7.3.2 onto the coating with the specified test load (see Table 1 and 5.1.3) and carry out the agreed number of double-strokes with a frequency of 1 double-stroke/s.

7.3.6 Clean the area of the friction mark in the direction of the marking by means of a soft, lint-free cloth and, if necessary, use a solvent which does not attack the coating. After the agreed period of time, assess the friction mark in accordance with the method specified.

7.3.7 If the friction marks are assessed by agreement using optical measurements, e.g. gloss, haze or brightness, repeat the measurements in accordance with 7.3.1 using the same measuring direction.

7.3.8 Only uniform and continuous friction marks shall be evaluated.

7.3.9 If it is agreed to assess several friction marks, repeat the procedure described in 7.3.1 to 7.3.7 accordingly.

8 Evaluation

The evaluation method of the friction marks shall be agreed between the interested parties.

9 Precision

9.1 Repeatability limit, *r*

The repeatability limit, *r*, is the value less than or equal to which the absolute difference between two test results obtained under repeatability conditions may be expected to be with a probability of 95 % (see ISO 5725-1:1994, 3.16). For gloss measurements as an example for a test criterion the repeatability limit, *r*, in accordance with this document, calculated with a probability of 95 %, is given in Table 2.

Table 2 — Repeatability limit, *r*, for gloss measurements

Measurement angle abrasion tool	*r* GU
A20-A	8
A20-B	8
A20-C	9
A60-A	8
A60-B	7
A60-C	8

9.2 Reproducibility limit, *R*

The reproducibility limit, *R*, is the value less than or equal to which the absolute difference between two test results obtained under reproducibility conditions may be expected to be with a probability of 95 % (see ISO 5725-1:1994, 3.20). For gloss measurements as an example for a test criterion the reproducibility limit, *R*, in accordance with this document, calculated with a probability of 95 %, is given in Table 3.

Table 3 — Reproducibility limit, *R*, for gloss measurements

Measurement angle abrasion tool	*R* GU
A20-A	14
A20-B	11
A20-C	15
A60-A	13
A60-B	10
A60-C	11

For more details on precision, see Annex D.

10 Test report

The test report shall contain at least the following information:

a) all details necessary to identify and characterize the test specimen;

b) the film thickness, in micrometres, in accordance with 6.2;

c) a reference to this document (i.e. ISO 21546);

d) the relative humidity during testing, as percentage;

e) the abrasion tool (A, B, or C) used;

f) the agreed abrasive material in accordance with 5.4 and information whether the felt cloth (5.3) was used;

g) the agreed abrasive medium in accordance with 5.5 (type of abrasive paste, abrasive powder, etc. and/or quantity and type of water);

h) the agreed number of double-strokes;

i) the stroke length, in millimetres;

j) the agreed test criterion;

k) the agreed time interval between abrasion and assessment of the friction mark;

l) the test result for the agreed test criterion;

m) any deviation from the test method specified;

n) any unusual observation (deviation) during testing;

o) the name of the operator and the testing laboratory;

p) the date of the test.

Annex A
(informative)

Usual test conditions

Usual test conditions are given in Table A.1.

Table A.1 — Usual test conditions

Coating system	Compensating material	Abrasive material	Abrasive medium
Automobile clear coating material	Felt cloth in accordance with 5.3	Abrasive material in accordance with 5.4.3	—
Automobile interior coating material	—	Cotton rubbing cloth in accordance with 5.4.1 or felt in accordance with 5.4.4	Without abrasive medium or various test liquids
Interior wall coating	—	Cotton rubbing cloth in accordance with 5.4.1	Without abrasive medium or water
Industrial coating material	—	Abrasive paper in accordance with 5.4.2	—

Annex B
(informative)

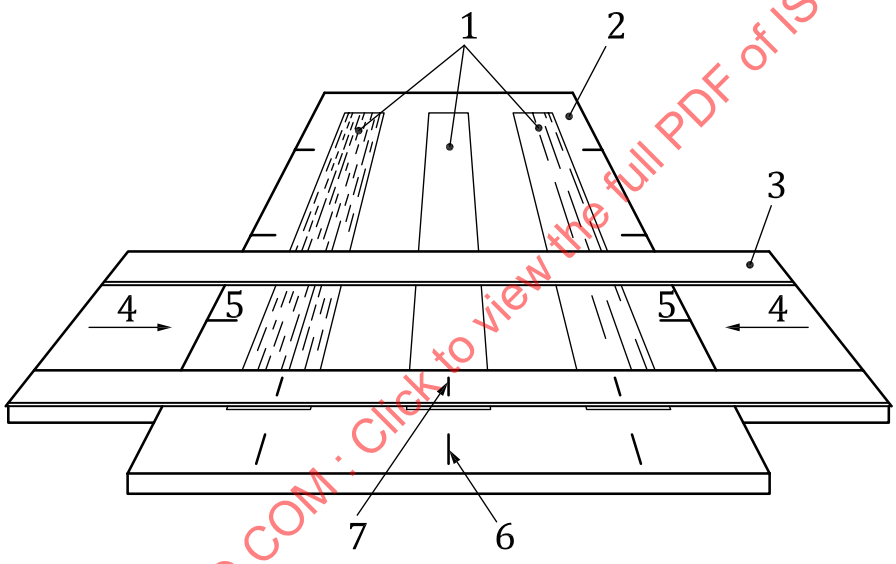
Measuring template

If the friction marks are assessed by agreement using optical measurements, e.g. gloss, haze or brightness, it shall be ensured that:

— the measuring surface of the measuring device considering the measuring direction lies within the intended friction mark;

— the measurement points are in the same position prior to and after abrading.

For these purposes, it can be helpful to use a measuring template (see Figure B.1) in order to carry out process steps 7.3.1, 7.3.3 and 7.3.7 correctly.



Key

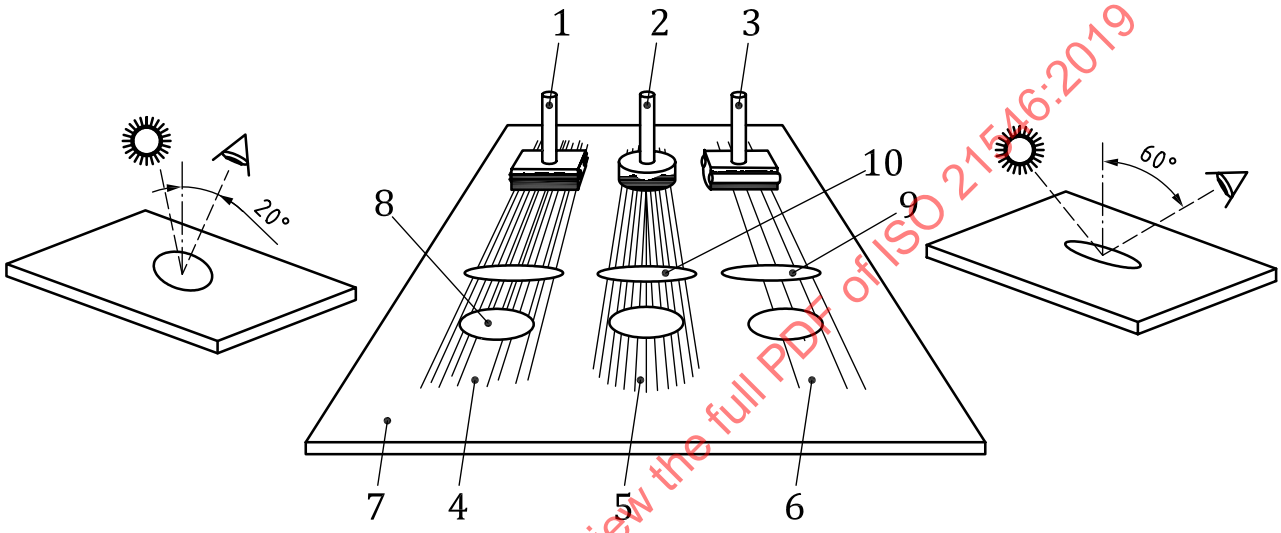
1 friction mark
2 test specimen
3 measuring template (mask)
4 cross marking on the mask
5 cross marking on the test specimen
6 longitudinal marking on the test specimen
7 longitudinal marking on the mask

Figure B.1 — Measuring template (example)

Annex C
(informative)

Evaluation of gloss as test criterion

The evaluation of gloss as test criterion is influenced by the width of the friction mark. In most cases, the measuring spot of the 60° geometry is larger than the width of the friction mark. See Figure C.1.



Key

1 abrasion tool A
2 abrasion tool B
3 abrasion tool C
4 friction mark obtained with abrasion tool A
5 friction mark obtained with abrasion tool B
6 friction mark obtained with abrasion tool C
7 test panel
8 measuring spot for gloss measurements with 20° geometry
9 measuring spot for gloss measurements with 60° geometry
10 gloss measurements perpendicularly to the friction mark

Figure C.1 — Gloss measurements on friction marks

Annex D
(informative)

Details on precision

D.1 General

An interlaboratory comparison test has been carried out for the determination of precision using linear abrasion tester (crockmeter) and three different types of abrasion tools (see Table D.1).

The friction marks were assessed by measuring the gloss.

D.2 Crockmeter and abrasion tool

Ten laboratories participated in the interlaboratory test with their own linear abrasion testers (crockmeters).

The different types of abrasion tools (5.2) were used with the crockmeters.

Abrasion tool A

The abrasion tool A has been specifically developed for use with this document. It has a square shape with a square contact area of 22 mm × 22 mm. Thus, the rubbed area is large enough to use the portable glossmeter with the measurement angles of 20° and 60°. Nevertheless, this area is not large enough for gloss measurements of matt areas using the measurement angle of 85°.

Abrasion tool B

The cylindrical abrasion tool B with a diameter of 16 mm was implemented from ISO 105-X12. This tool is mainly used for textiles, but also used for other material surfaces.

This small diameter of the cylinder results in a small friction mark which can hardly be measured with a measurement angle of 20°. It is not possible to measure with the angle of 60° or 85°. All measurements will include the non-rubbed edge area and will give erroneously high gloss values.

Abrasion tool C

The abrasion tool C is a new development with the movable transverse cylindrical abrading the surface. This construction can also be used for curved samples. Only a small area of the cylinder is touching the surface.

The purpose of the interlaboratory comparison was to clarify the following:

— are the three abrasion tools A, B and C comparable;

— advantage and disadvantage of the different abrasion tools;

— applicability of gloss measurements to the evaluation of rubs;

— precision of the test method including the differences between spatially resolved and non-spatially resolved measurements.

Table D.1 — Crockmeter and test conditions

Crockmeter-ID	Crockmeter	Abrasion tool A N	Abrasion tool B N	Abrasion tool C N
C01	Crockmeter A	22,4	9,0	9,6
C02	Crockmeter A	22,8	9,0	8,9
C03	Crockmeter A	22,8	9,4	9,8
C04	Crockmeter A	22,2	8,8	9,0
C05	Crockmeter A	22,8	8,7	9,0
C06	Crockmeter B	22,4	9,0	8,8
C07	Crockmeter C	22,0	9,0	9,0
C08	Crockmeter A	22,4	9,0	9,2
C09	Crockmeter A	22,2	8,8	8,8
C10	Crockmeter A	22,0	9,0	9,0

D.3 Samples and abrasion materials

Four different coatings on three different substrates were tested in the interlaboratory comparison (see Table D.2).

For three samples, polishing paper 9 µm was used as abrasion material and for the coated plastic substrate the felt cloth was used for abrasion (5.3 and 5.4).

Table D.2 — Samples

Sample number	Substrate	Coating	Abrasion material	Double strokes	Angle
P01	polycarbonate	red automotive coating with reflow effect, measurement after 10 min	polishing paper 9 µm	10	20°/60°
P02	steel	black automotive coating +2 component clear coat	polishing paper 9 µm	10	20°
P03	plastics	mat soft coat	dry felt cloth	100	60°/85°
P04	steel	black powder coating, high gloss	polishing paper 9 µm	10	20°/60°

Two friction marks were produced on each sample.

D.4 Determination of the abrasion using gloss measurements

Only one glossmeter was used for all measurements.

For samples P01 and P04 measurements with 20° and 60° were made, to determine which measurement angle is the most suitable for high changes in gloss after abrasion.

Gloss measurements were taken perpendicularly to the tracks.

D.5 Multiple determinations

All gloss measurements, before and after abrasion were taken using a measurement template for defining the three measurement points on each of the two friction marks.