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Paints and varnishes — Scratch test using a spring-loaded pen

Peintures et vernis — Essai de rayage manuel utilisant un barreau d'essai de dureté

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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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 — Scratch test using a spring-loaded pen

1 Scope

This document specifies a method for determining the resistance of a coating to scratches introduced by a usually hand-held loaded stylus.

The test can be carried out using a point stylus (method A) or using a disc stylus (method B).

Both methods are generally applicable and can be used in the field as well as on curved surfaces. Method A can also be applied on small test specimens (minimum dimensions 30 mm × 50 mm).

The test can be carried out as a "pass/fail" test (test requirement I) or as a classification test (test requirement II).

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

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

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

ISO 13076, *Paints and varnishes — Lighting and procedure for visual assessments of coatings*

ISO 14526-1, *Plastics — Phenolic powder moulding compounds (PF-PMCs) — Part 1: Designation system and basis for specifications*

CEN/TS 13388, *Copper and copper alloys — Compendium of compositions and products*

EN 10027-2, *Designation systems for steels — Part 2: Numerical system*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4618 and the following 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/

3.1
stylus
scratching tool with specified geometry

3.2
writing effect
smoothing of the surface profile of a coating by impact of a loaded *stylus* (3.1) being moved over the surface

3.3
writing mark
gash
scratch with continuous *writing effect* (3.2) damage

3.4
metal marking
writing mark (3.3) which is introduced with a metal *stylus* (3.1) and covered with abraded stylus material

4 Principle

A stylus loaded with a test load between 0,5 N to 20 N is manually moved over the coating surface. The so introduced damage is visually (magnifier) examined and assessed.

The test can be carried out as method A using a point stylus (diameter 0,50 mm, 0,75 mm, or 1,00 mm) or as method B using a disc stylus (made of stainless steel, copper, thermoset, or PMMA [Polymethyl methacrylate]).

5 Apparatus

5.1 Hardness pen, as illustrated in Figures 1 and 2, with the following properties:

5.1.1 The pressure spring, which is compressed by the locking slider, generates the test load exerting on the stylus. This test load can be read in newtons by means of the slider position on the scale.

In order not to change the elastic behaviour of the spring, it shall be relaxed in case the hardness pen is not in use for any length of time.

5.1.2 The range of the test load shall be between 0,5 N to 20 N.

With regard to common hardness pens test load, ranges between 0,5 N to 3 N (graduation 0,1 N), 1,5 N to 10 N (graduation 0,5 N) and 3 N to 20 N (graduation 1 N) are available by means of exchangeable pressure springs.

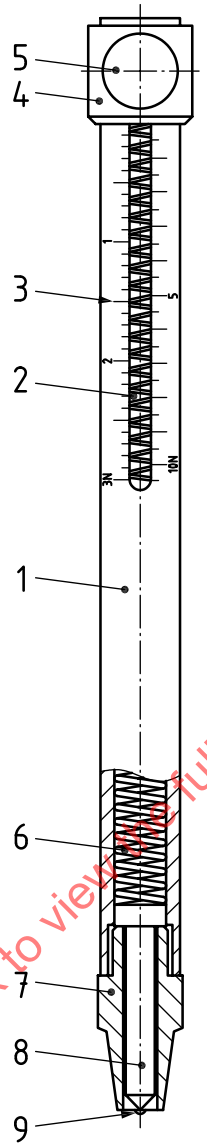
Due to the non-linearity of the spring characteristics and the friction within the hardness pen, the specified lower limits of the test load ranges shall not be underrun.

5.1.3 The removable head piece is the guide bush for the point stylus or the test disc holder respectively. The test load, set by means of the slider, is effective if

— for the apparatus in accordance with Figure 1, the point stylus is pushed into the head piece so that only the tungsten-carbide insert protrudes, and if

— for the apparatus in accordance with Figure 2, the test disc is pushed into the head piece so that both supporting wheels touch the counter surface.

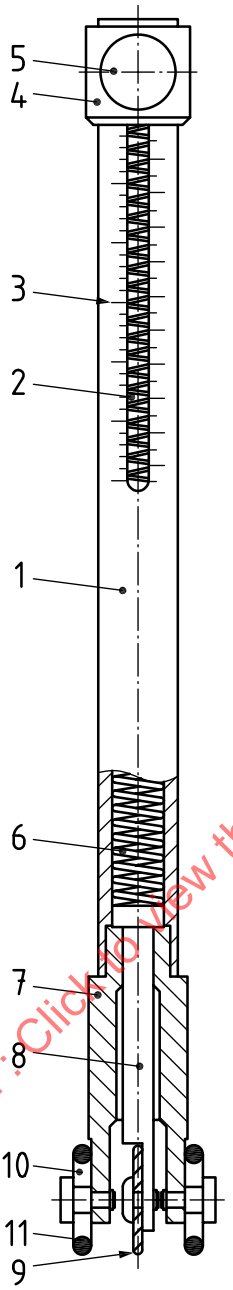
NOTE For the apparatus in accordance with Figure 1, scratches might be introduced unintentionally by the head piece. These scratches hinder the evaluation of the test. Therefore, head piece options with supporting wheels are also available (see Figure 3).



Key

1 metal sleeve
2 slot
3 scale (test load)
4 slider
5 locking screw
6 pressure spring
7 head piece
8 point stylus with (9)
9 spherical tungsten-carbide insert

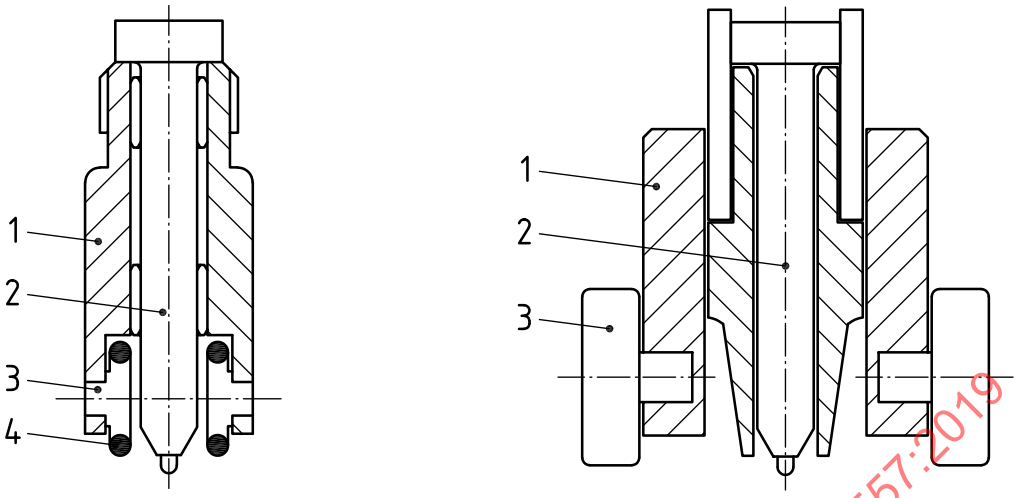
Figure 1 — Hardness pen — Apparatus for method A



Key

1 metal sleeve
2 slot
3 scale (test load)
4 slider
5 locking screw
6 pressure spring
7 head piece
8 disc stylus, consisting of test disc holder and (9)
9 test disc
10 supporting wheel
11 rubber O-ring

Figure 2 — Hardness pen — Apparatus for method B



Key

1 shank of the head piece with slideway
2 point stylus
3 supporting wheel
4 rubber O-ring

Figure 3 — Head piece for method A — Two common apparatuses with supporting wheels

5.2 Styli.

5.2.1 Styli for method A (point styli): Bolt (shape see Figure 3, key 2) with a spherical tungsten-carbide insert.

5.2.1.1 Stylus A1, with a diameter of (0,50 ± 0,01) mm.

5.2.1.2 Stylus A2, with a diameter of (0,75 ± 0,01) mm.

5.2.1.3 Stylus A3, with a diameter of (1,00 ± 0,01) mm.

5.2.2 Styli for method B (disc styli): Disc with polished edge and with the dimensions in accordance with Figure 4.

NOTE The test disc is screwed to the test disc holder so that it can be used several times by rotating it along the periphery. Test discs with segment marking are also available in order to simplify multiple uses.

5.2.2.1 Stylus B1, shall be made of stainless steel, material 1.4301 or 1.4305 in accordance with EN 10027-2.

5.2.2.2 Stylus B2, shall be made of copper, material 2.0065 (new identification: CW004A) or 2.0090 (new identification: CW024A) in accordance with CEN/TS 13388.

5.2.2.3 Stylus B3, shall be made of thermoset, phenolic resin in accordance with ISO 14526-1, formerly type PF 31.

5.2.2.4 Stylus B4, shall be made of PMMA (polymethyl methacrylate), cast and of hardness 85 Shore D in accordance with ISO 868.

Dimensions in millimetres

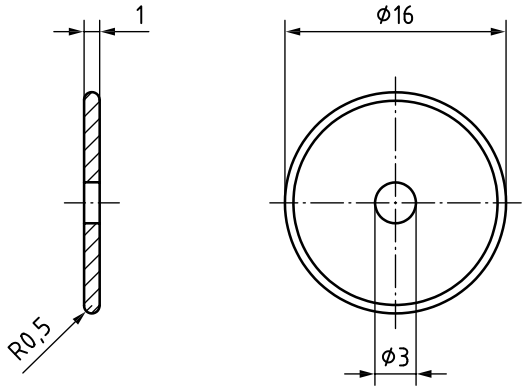


Figure 4 — Dimensions of the test disc (method B)

5.2.3 Application purposes of the styli.

The application purposes of the styli are given in Table 1.

Table 1 — Application purposes of the styli

Stylus type	Stylus material	Application requirement
Point stylus	Tungsten carbide	Mar resistance
Disc stylus	Stainless steel	
	Copper	Resistance to metal marking
	Thermoset	Resistance to writing effects (“gash resistance”)
	Polymethyl meth-acrylate (PMMA)	Resistance to writing effects (“fingernail test”)

6 Test specimens

6.1 General requirements

For carrying out the measurements, the test specimen may only be touched by the tip of the stylus (and, if applicable, by the supporting wheels), however, not by the head piece of the hardness pen (also see 5.1.3, Note). This criterion shall be especially observed in the case of concavely curved test specimens. For method A, this requirement for the surface shall be fulfilled in an area of minimum 30 mm × 50 mm and for method B, of minimum 50 mm × 150 mm.

6.2 Film thickness

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

6.3 Conditioning

Prior to testing, condition the coated test panels at a temperature of (23 ± 2) °C and a relative humidity of (50 ± 5) % (see ISO 3270) for a minimum of 16 h, if not otherwise agreed. Carry out the test as quick as possible, however no later than 30 min after the conditioning phase.

7 Procedure

7.1 Agreements

For the procedure of the test, the following shall be agreed:

— the method: A – test with point stylus or B – test with disc stylus;

— the stylus in accordance with 5.2, in accordance with the application requirement (see Table 1);

— the test requirement: either I ("pass/fail" test with constant test load) or II (classification test with varied test load);

— for test requirement II: the test load, in newtons;

— the assessment criterion: e. g. damage when it is first visible, distinct tangible deformation of the coating, cracking of the coating (see Figure 5).

7.2 Test conditions

Carry out the test at a temperature of (23 ± 2) °C. Measure the relative humidity during the test and record it in the test report.

7.3 General test procedure

7.3.1 Insert the agreed stylus and the spring for the intended range of the test load into the hardness pen.

7.3.2 Adjust the intended or agreed test load by means of the slider, then lock it in this position.

7.3.3 Secure the test specimen onto a support, vertically lower down the hardness pen onto the surface and press down in accordance with 5.1.3.

7.3.4 Uniformly move the pressed down hardness pen

— for method A with a speed of about 10 mm/s over a minimum test distance of 10 mm, and

— for method B with a speed of about 100 mm/s over a minimum test distance of 100 mm.

7.3.5 The minimum distance between the test track and the edge of the test specimen shall be 10 mm and the distance to adjacent test track shall be 5 mm.

7.4 Constant test load method (test requirement I – "pass/fail" test)

Carry out scratch tests in triplicate in accordance with 7.3 with the agreed test load. The coating passes the test ("pass"), if the coating is not damaged during each of the three tests. If the coating is damaged during one or several of the three tests, the coating fails the test ("fail").

7.5 Varied test load method (test requirement II – classification test)

Starting with a test load which does not lead to any damage yet, carry out scratch tests in accordance with 7.3. Successively increase the test load until the coating is damaged for the first time. Repeat this method twice on the same test specimen. Record the lowest final test load, in newtons, from the three determinations as result.

7.6 Assessment of the damage

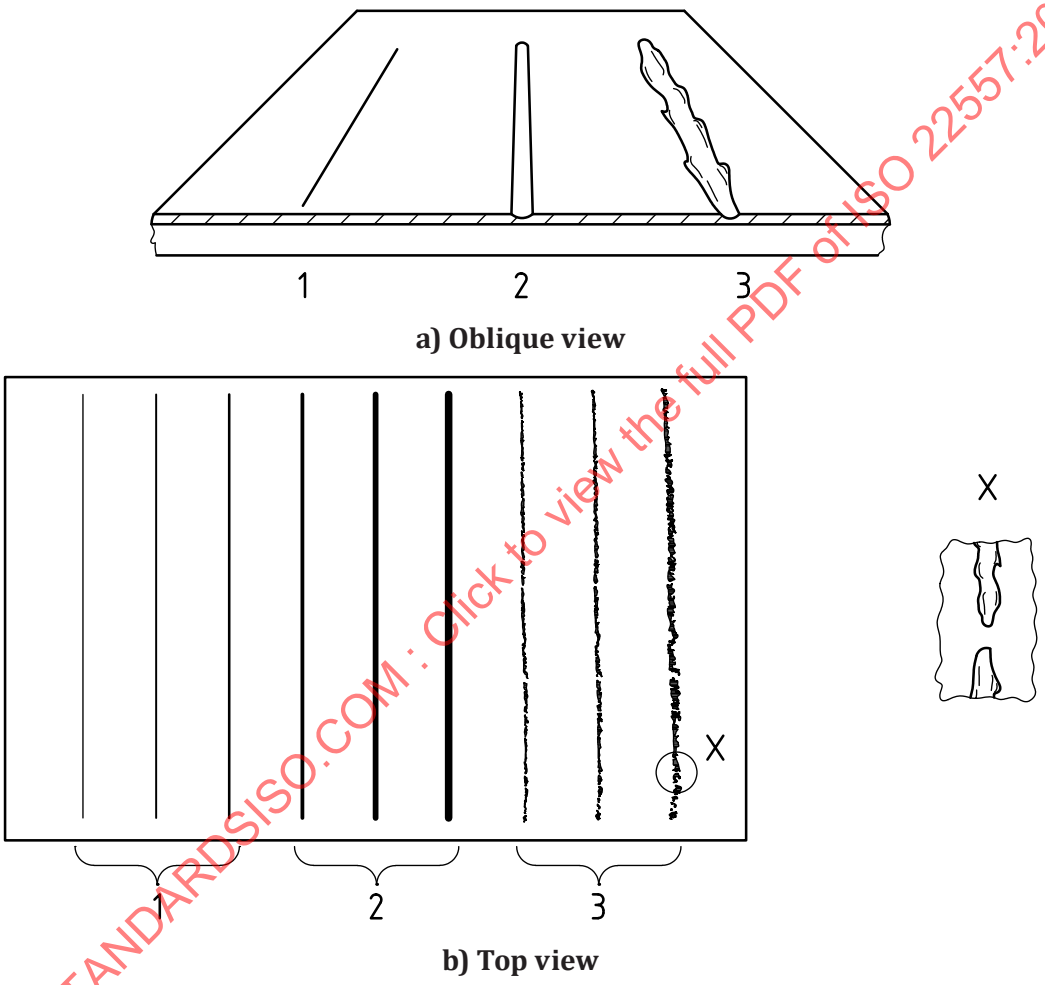
Visually examine the damage, which has been introduced in accordance with 7.4 or 7.5, under the defined conditions in accordance with ISO 13076 and determine the type of damage, e. g. lowest load, for which

— scratch mark 1: a first continuous scratch mark is visible, see Figure 5;

— scratch mark 2: a continuous scratch mark is tangible, see Figure 5;

— scratch mark 3: a continuous cracking of the coating occurs, see Figure 5.

NOTE Even if the cracking is not continuous, it can have chatter marks.



Key

1 visible first continuous scratch mark
2 tangible continuous scratch mark
3 continuous cracking of the coating

Figure 5 — Types of damage (scratch marks)

8 Precision

8.1 General

For details on the determination of precision, see Annex A.

8.2 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 can be expected to be with a probability of 95 % (see ISO 5725-1:1994, 3.16). The repeatability limit, *r*, in accordance with this document, calculated with a probability of 95 %, is given in Table 2.

Table 2 — Repeatability limit for scratch marks type a (r_a) and scratch marks type c (r_c)

Substrate	r_a N	r_c N
Wood	0,6	0[a]
Coil	0[a]	0[a]
Plastics	0[a]	0[a]

[a] The value 0 does not mean that the method is extremely good but, amongst others, it results from cancelling effects in the statistical calculation.

8.3 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 can be expected to be with a probability of 95 % (see ISO 5725-1:1994, 3.20). The reproducibility limit, R, in accordance with this document, calculated with a probability of 95 %, is given in Table 3.

Table 3 — Reproducibility limit for scratch marks type a (R_a) and scratch marks type c (R_c)

Substrate	R_a N	R_c N
Wood	3,7	3,8
Coil	1,6	5,1
Plastics	0[a]	3,7

[a] The value 0 does not mean that the method is extremely good but, amongst others, it results from cancelling effects in the statistical calculation.

9 Test report

9.1 Detailed form

The test report shall contain at least the following information:

a) all details necessary for the identification and characterization of the test specimen, i. e. information on

   1) the coating (manufacturer, product identification, batch number, application method, drying/hardening/ageing conditions etc.), and

   2) the substrate (material, thickness, shape, dimensions, curvature etc.);

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

c) a reference to this document (ISO 22557:2019);

d) the method used (A or B);

e) the stylus used in accordance with 5.2;

f) the test requirement (I or II);

g) the agreed test load, in newtons, for test requirement I;

h) the relative humidity, in percentage, during the test;

i) the test result:

   1) "pass/fail" information in accordance with 7.4 or the lowest final test load, in newtons, in accordance with 7.5,

   2) type of damage in accordance with 7.6,

j) any deviation from the specified test method;

k) any unusual observation (abnormalities) during the test;

l) the name of the test person and of the test laboratory;

m) the date of the test.

9.2 Short form

The test result may also be summarized as follows:

Number of this standard – method with stylus – (test requirement) with test load and "pass/fail" information or lowest final test load – type of damage

"Test load" is

— for test requirement I ("pass/fail" test) the agreed test load in newtons with the addition of "pass" or "fail" depending on the result of the test;

— for test requirement II (classification test) the lowest final test load, in newtons, determined in accordance with 7.5.

EXAMPLES

— ISO 22557:2019, A1 (I) 10,0 fail

The test in accordance with ISO 22557 has been carried out as "pass/fail" test using a point stylus with a radius of 0,50 mm and an agreed test load of 10,0 N – the coating failed the test in accordance with 7.4;

— ISO 22557:2019, B3 (II) 8,5 – c

The test in accordance with ISO 22557 has been carried out as classification test using a thermoset disc stylus – the lowest test load in accordance with 7.5, for which the coating was visibly damaged (type of damage c in accordance with 7.6), is 8,5 N.

Annex A
(informative)

Details on the interlaboratory comparison for the estimation precision

A.1 General notes on the interlaboratory comparison

An interlaboratory comparison (ILC) has been carried out for the determination of precision using spring-loaded pen.

12 Laboratories participated in the round-robin with different types of spring-loaded pen.

A.2 Samples

For the interlaboratory comparison, 16 different coatings, claddings or foils on different substrates were prepared (see Table A.1).

Table A.1 — Samples of the interlaboratory comparison

Sample number	Substrate	Coating, cladding or foil
1	Wood with foil	UV-coating rolled
2	Wood with foil	Coating moulded and cured by electron beam
3	Coil	Base coat with clear coat
4	Coil	Textured coating
5	Coil	Automotive filler
6	Coil	Base coat with clear coat
7	Plastics	Soft coating for car interiors semi haptic
8	Plastics	Soft coating for car interiors semi haptic
9	Plastics	Soft coating for car interiors hard
10	Steel	Powder standardized polyester coating
11	Steel	Polyurethane powder coating
12	Steel	Silver foil 90 µm
13	Steel	White foil 120 µm
14	Steel	Powder coating
15	Steel	Powder coating
16	Steel	Powder coating

A.3 Spring-loaded pens

For the interlaboratory comparison, various types of new spring-loaded pens from four different suppliers were used.

The scratch tests were carried out with a spring-loaded pen with a point stylus in accordance with method A (see Figure A.1).

For the scratch tests were used different types of spring-loaded pens (method A) with two various point stylus and in three different test load ranges were used for the scratch tests (see Table A.2).

The spring-loaded pens were pulled over the surface of the coating either direct without holder or with supporting wheels (F) and/or with a trolley (H).

Table A.2 — Spring-loaded pen

Type of spring-loaded pen	Description of spring-loaded pen	Point stylus mm	Test load N	Reading accuracy N
Type 1	Spring-loaded pen	0,75	0 to 10	0,5
Type 2	Spring-loaded pen	0,75	0 to 3 0 to 10	0,1 0,5
Type 2-F	Spring-loaded pen with supporting wheels	0,75	0 to 3 0 to 10	0,1 0,5
Type 3	Spring-loaded pen	0,75	0 to 3 0 to 10 0 to 30	0,1 0,5 1,5
Type 3-F	Spring-loaded pen in a holder	0,75	0 to 10	0,5
Type 4	Spring-loaded pen	0,75	0 to 3 0 to 10	0,1 0,5
Type 4-1	Spring-loaded pen	1,00	0 to 10 0 to 20	0,5 1,0
Type 4-FH	Spring-loaded pen with supporting wheels and trolleys	0,75	0 to 3 0 to 10	0,1 0,5
Type 4-FH-1	Spring-loaded pen with supporting wheels and trolleys	1,00	0 to 10	0,5

NOTE For precision calculation only the indicated spring-loaded pens are taken into account.

A.4 Assessment of the damage

Before starting the round robin, the criteria of the assessment were agreed:

— scratch mark a: a first continuous scratch mark is visible including deformation, see Figure 5;

— scratch mark c: a continuous cracking of the coating occurs, see Figure 5.

One of the results of the round robin was to evaluate the damage of the coating under standardized light conditions, see also ISO 13076.

A.5 Number of determinations

For determining the repeatability limit, a second or a third scratch and visual assessment under standard light were carried out on every sample.

A.6 Evaluation

The calculation of the precision could be done based on a sufficient number of measurement results obtained from coatings on wood, coil and plastics with the parameter for the point stylus 0,75 mm and a test load of 10 N – for details, see Table A.3.

