

INTERNATIONAL STANDARD

ISO 1518-1

Second edition
2019-06

Paints and varnishes — Determination of scratch resistance —

Part 1: Constant-loading method

*Peintures et vernis — Détermination de la résistance à la rayure —
Partie 1: Méthode à charge constante*



Reference number
ISO 1518-1:2019(E)

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Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

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

This second edition cancels and replaces the first edition (ISO 1518-1:2011), which has been technically revised. The main changes compared to the previous edition are as follows:

- [Clause 3](#), Terms and definitions, has been added;
- for the hard-metal tip, styli with tips of diameter 0,75 mm and 3,0 mm have been added;
- a description of the test panels has been added;
- scoring of the surface has been added to the evaluation;
- a requirement to examine the tip of the stylus for damage, contamination and smooth in appearance has been added;
- [Clauses 7](#) and [10](#) have been aligned to ISO 1518-2.

A list of all parts in the ISO 1518 series can be found on the ISO website.

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 scratch resistance —

Part 1: Constant-loading method

1 Scope

This document specifies a test method for determining under defined conditions the resistance of a single coating or a multi-coat system of paint, varnish or related product to penetration by scratching with a scratch stylus loaded with a specified load. Penetration of the stylus is to the substrate, except in the case of a multi-coat system, in which case the stylus can penetrate either to the substrate or to an intermediate coat.

The method specified can be carried out

- a) either as a “pass/fail” test, by testing with a single specified load applied to the stylus to assess conformity with a particular specification, or
- b) as an assessment test by applying increasing loads to the stylus to determine the minimum load at which the coating is penetrated.

NOTE Neither this document nor ISO 1518-2 specifies a method using a curved stylus, which is specified in ISO 12137. The choice between the three methods will depend on the particular practical problem.

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 1513, *Paints and varnishes — Examination and preparation of test samples*

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

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

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

ISO 15528, *Paints, varnishes and raw materials for paints and varnishes — Sampling*

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/>

4 Principle

A scratch stylus loaded with a specified load is drawn over a coating at a constant speed. The following test parameters are specified:

- the geometry of the stylus tip;
- the range within which the test load can lie and the increments by which it can be increased;
- the procedure by which the stylus is lowered on to the coating;
- the speed at which the stylus travels and the minimum length of the scratch.

The scratch is examined to see if the coating has been penetrated to the extent specified for a single specified test load ("pass/fail" test) or to determine the minimum test load required for penetration.

In some cases scoring of the surface of the coating is detected. This evaluation should be repeated after 24 h.

5 Apparatus

5.1 Scratch apparatus, two versions of which are illustrated in [Figure 1](#) and [Figure 2](#), with the following characteristics:

- The test load acting on the scratch stylus fixed to the load beam can be produced either by a weight attached to the stylus (see [Figure 1](#)) or by a weight which slides along a graduated load beam (see [Figure 2](#)).
- The test load shall be 1 N to 20 N, shall be adjustable in increments of 0,5 N and shall be accurate to within 0,2 N.
- The test panel held in a panel holder is moved relative to the stylus by means of a linear actuator driven by a motor. The speed at which the stylus travels shall be (35 ± 5) mm/s and the length of the scratch shall be at least 40 mm. The length of the scratch can affect the result.
- A lowering device with a flat ramp brings the stylus smoothly into contact with the coating at the beginning of the movement of the panel holder. The angle of the ramp shall be $(12,5 \pm 2,5)^\circ$.

Some types of apparatus are designed so that the load beam moves and the test panel is fixed. Such types of apparatus may also be used.

5.2 Scratch stylus A, having a hemispherical hard-metal tip of diameter $(3,00 \pm 0,01)$ mm.

5.3 Scratch stylus B, having a hemispherical hard-metal tip of diameter $(1,00 \pm 0,01)$ mm.

5.4 Scratch stylus C, having a hemispherical hard-metal tip of diameter $(0,75 \pm 0,01)$ mm.

5.5 Scratch stylus D, having a hemispherical hard-metal tip of diameter $(0,50 \pm 0,01)$ mm.

5.6 Scratch stylus E, having a hemispherical synthetic-ruby tip of diameter $(1,00 \pm 0,01)$ mm.

5.7 Scratch stylus F, having a hemispherical synthetic-ruby tip of diameter $(0,50 \pm 0,01)$ mm.

5.8 Indicating device, based on electrical contact between the stylus and the metallic substrate, to show when the coating has been penetrated.

This device is not suitable for paints containing electrically conducting pigments, for non-metallic substrates or if penetration to an intermediate non-conducting coat is required.

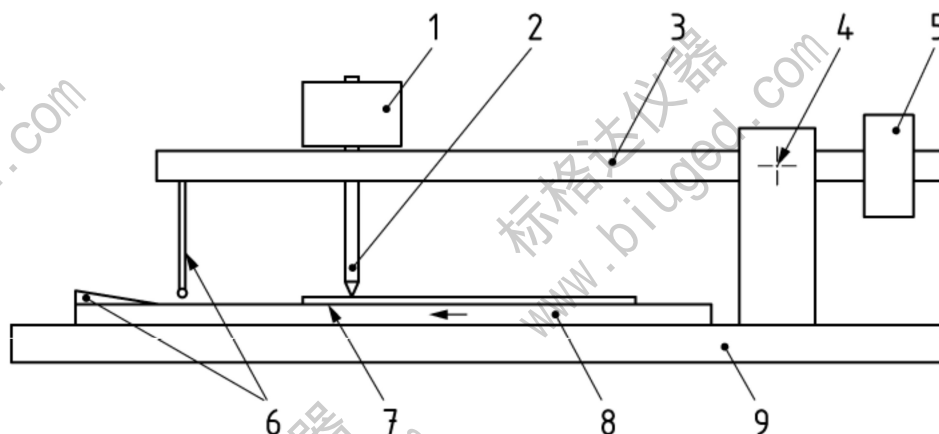
NOTE The indicating device can only be used when certain parts of the scratch apparatus are electrically insulated and a stylus with hard-metal tip is used.

5.9 Magnifying lens, with at least $\times 4$ magnification.

6 Sampling

Take a representative sample of the product to be tested (or of each product in the case of a multi-coat system), as described in ISO 15528.

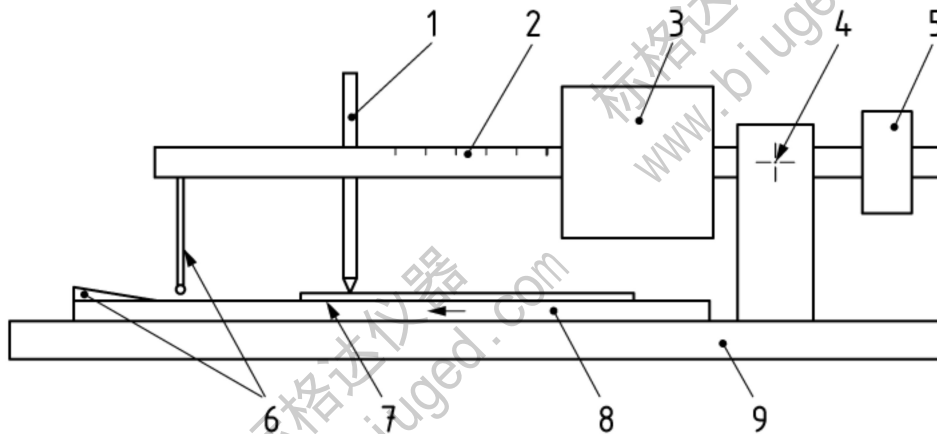
Examine and prepare each sample for testing, as described in ISO 1513.



Key

- 1 weight
- 2 scratch stylus
- 3 load beam
- 4 pivot bearing for load beam
- 5 tare weight
- 6 lowering device (ramp and guide pin)
- 7 test panel
- 8 test panel holder (designed to be driven by a motor to move in the direction of the arrow)
- 9 baseplate

Figure 1 — Scratch apparatus — Version with the weight attached to the stylus



Key

- 1 stylus
- 2 load beam with scale
- 3 sliding weight
- 4 pivot bearing for load beam
- 5 tare weight
- 6 lowering device (ramp and guide pin)
- 7 test panel
- 8 test panel holder (designed to be driven by a motor to move in the direction of the arrow)
- 9 baseplate

Figure 2 — Scratch apparatus — Version with a sliding weight

7 Test panels

7.1 Substrate

The test panels shall be conductive with a thickness of 0,7 mm to 1,0 mm and shall conform to the requirements of ISO 1514. The panels should preferably have a size of 200 mm × 100 mm.

7.2 Preparation and coating

Prepare each test panel in accordance with ISO 1514 and coat it according to the specified method with the product or system under test.

The method of application of the coating shall be as specified by the manufacturer or agreed between the interested parties and shall be included in the test report [see [Clause 10](#), c) 2)].

7.3 Drying and conditioning

Dry (or stove) and age, if applicable, each coated test panel for the specified time and under the specified conditions. Before testing, condition the coated panels at $(23 \pm 2)^\circ\text{C}$ and a relative humidity of $(50 \pm 5)\%$ (i.e. in accordance with ISO 3270) for a minimum period of 16 h. Carry out the test procedure immediately after the removal of the test panels from the conditioning chamber.

The drying (or stoving) and ageing time and conditions shall be as specified by the manufacturer or agreed between interested parties and shall be included in the test report [see [Clause 10](#), c) 3)].

The coated panels shall be stored and handled so as to avoid contamination by fingerprints and dust.

NOTE Fingerprints, dust or other contamination on the surface will result in a lower accuracy.

7.4 Thickness of coating

Determine the thickness, in micrometres, of the dried coating by one of the procedures specified in ISO 2808.

The dry-film thickness shall be as specified by the manufacturer or agreed between the interested parties and shall be included in the test report [see [Clause 10](#), c) 4)].

8 Procedure

8.1 Test conditions

Carry out the test at $(23 \pm 2)^\circ\text{C}$ and a relative humidity of $(50 \pm 5) \%$.

8.2 General test procedure

8.2.1 Clamp a coated test panel on the panel holder with the coating facing upwards. Position the test panel so that the distance between the scratches to be made will be at least 5 mm and the distance from the scratches to the edge of the test panel will be at least 10 mm.

8.2.2 Examine the tip of the stylus for damage, contamination and smooth in appearance. Fix the scratch stylus in the load beam so that, when in position on the test panel, the stylus will be perpendicular to the panel.

8.2.3 With the stylus unloaded, balance the load beam by means of the tare weight.

8.2.4 Adjust the test load to the required value by placing a weight on the stylus or by moving the sliding weight, depending on the type of apparatus used.

8.2.5 Activate the indicating device, if used, and check that it is functioning correctly.

8.2.6 Start the motor of the apparatus and allow the scratch to be made in the coating. Observe the indicating device during the test, if appropriate, to determine whether electrical contact occurs between the stylus and the substrate.

8.2.7 Remove the panel and immediately examine the scratch, with the aid of the magnifying lens, for penetration to the extent specified.

8.3 Procedure for a single specified load ("pass/fail" test)

Carry out the procedure specified in [8.2](#) three times on each of two test panels. If the coating has not been penetrated beyond the specified extent in any of the six test runs, report the result as "pass". If the coating has been penetrated beyond the specified extent in one or more of the six test runs, report the result as "fail".

8.4 Procedure for determination of the minimum load to cause penetration

Carry out the procedure specified in [8.2](#), starting at a load which is somewhat less than that expected to cause penetration of the coating. Progressively increase the load on the stylus in suitable increments until the coating is penetrated. Record the minimum load at which the stylus penetrates the coating to the extent specified. Repeat the procedure on a further two panels. Report the lowest result, in newtons, of the three determinations.

8.5 Evaluation of the scribe

Lower forces result in scoring of the surface only. The load required can also be determined by gradually increasing the load. An evaluation should be carried out directly after the procedure and should be repeated after 24 h.

9 Precision

In order to determine the precision of the test method, an interlaboratory test was carried out. Four participants tested three different coating systems.

Using the procedure specified in this document, the minimum load was recorded at which penetration of the stylus to the next layer, as determined by visual examination.

A repeatability limit, r , as defined in ISO 5725-1, could not be determined for this type of destructive test.

The visual inspection of the scratch has a considerable influence on the test result. The visual examination of scratches on "poor" coatings is easy whereas, with scratch-resistant coatings, the onset of scratching is significantly more difficult to observe.

It was agreed by the participants in the interlaboratory test that only the reproducibility limit, (R) ($\approx 30\%$), should be stated in this document to give an approximate indication of the precision.

10 Test report

The test report shall contain at least the following information:

- a) all details necessary to identify the product tested;
- b) a reference to this document (i.e. ISO 1518-1:2019);
- c) all details of the preparation of the test panels, including the following:
 - 1) the material, thickness and surface preparation of the substrate (see 7.1),
 - 2) the method of application of the test coating to the substrate, including the duration and conditions of drying between coats in the case of a multi-coat system (see 7.2),
 - 3) the duration and conditions of drying (or stoving) of the coating, and the conditions of ageing, if applicable, before testing (see 7.3),
 - 4) the thickness, in micrometres, of the dry coating and the method of measurement in accordance with ISO 2808, and whether it is a single coating or a multi-coat system (see 7.4);
- d) the scratch stylus used (A, B, C, D, E or F);
- e) the specified load applied to the stylus during the test, if applicable ("pass/fail" test);
- f) the specified depth of penetration of the stylus (penetration to the substrate or to an intermediate coat);
- g) the results of the test:
 - either, for each determination, whether or not the coating was penetrated under the specified conditions ("pass/fail"),
 - or the minimum load at which the stylus penetrated the coating;
- h) any deviation (by agreement or otherwise) from the test method specified;
- i) any unusual features (anomalies) observed during the test;

j) the date of the test.

Bibliography

- [1] ISO 1518-2, *Paints and varnishes — Determination of scratch resistance — Part 2: Variable-loading method*
- [2] ISO 3270, *Paints and varnishes and their raw materials — Temperatures and humidities for conditioning and testing*
- [3] ISO 5725-1, *Accuracy (trueness and precision) of measurement methods and results — Part 1: General principles and definitions*
- [4] ISO 12137, *Paints and varnishes — Determination of mar resistance*

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