INTERNATIONAL STANDARD

ISO 19252

First edition
2008-12-15

Plastics — Determination of scratch properties

Plastiques — Détermination du comportement à la rayure

Reference number
ISO 19252:2008(E)

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Published in Switzerland

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 19252 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 2, *Mechanical properties*.

Plastics — Determination of scratch properties

IMPORTANT — The electronic file of this document contains colours which are considered to be useful for the correct understanding of the document. Users should therefore consider printing this document using a colour printer.

1 Scope

1.1 This International Standard specifies a method for determining the scratch properties of plastics under defined conditions. The method involves making a scratch by moving a hard instrument (scratch tip) of specified geometry under specified conditions of load and speed across the surface of a test specimen and then assessing the result.

1.2 The method is used to investigate the behaviour of specified types of specimen under the scratch conditions defined and for classifying the type of scratch of specimens within the limitations inherent in the test conditions. It can also be used to determine comparative data for different types of material by means of a so-called scratch map in which the types of scratch behaviour for each set of test conditions of test load and test speed are determined using the basic method of constant-load testing, and also by means of the so-called critical normal load (see 3.8) determined using an alternative method of linearly increasing load testing.

1.3 The method is suitable for use with uncoated and unlacquered thermoplastic moulding materials and thermosetting moulding materials.

1.4 The method specifies the preferred dimensions for the test specimen and the preferred scratch-tip geometry.

2 Normative references

The following referenced documents are indispensable for the application 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 291, *Plastics — Standard atmospheres for conditioning and testing*

ISO 294-1, *Plastics — Injection moulding of test specimens of thermoplastic materials — Part 1: General principles, and moulding of multipurpose and bar test specimens*

ISO 3167:2002, *Plastics — Multipurpose test specimens*

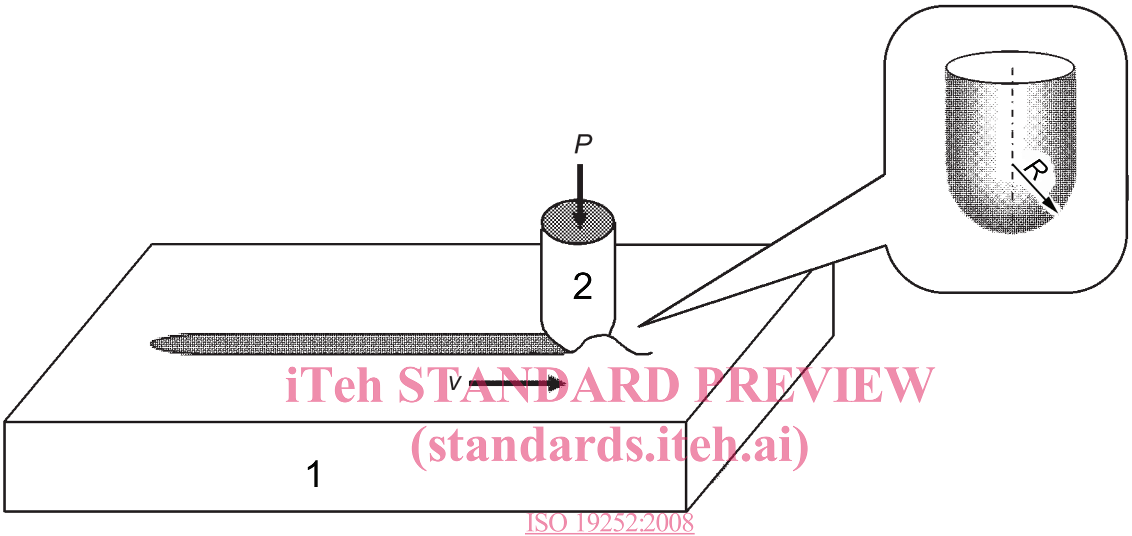
ISO 10724-1:1998, *Plastics — Injection moulding of test specimens of thermosetting powder moulding compounds (PMCs) — Part 1: General principles and moulding of multipurpose test specimens*

3 Terms and definitions

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

3.1
scratch
damage made by a hard instrument (scratch tip) when moved across a test specimen surface under specified conditions of tip geometry, test load and test speed (see Figure 1)

NOTE The term "surface", as used in this definition, applies to the macroscopic surface and not the microscopic surface.



Key
1 test specimen
2 scratch tip
P test load
v test speed

Figure 1 — Schematic representation of a scratch (see 3.1)

3.2
test load
P
load applied by the scratch tip perpendicularly to the test specimen during the test

NOTE It is expressed in newtons.

3.3
test speed
v
relative rate of displacement between the scratch tip and the test specimen during the test

NOTE It is expressed in millimetres per second.

3.4
scratch force
F_s
horizontal force between the scratch tip and the test specimen at any given moment during the test

NOTE It is expressed in newtons.

3.5
scratch-tip displacement
d
vertical displacement of the scratch tip relative to the test specimen surface at any given moment during the test

NOTE It is expressed in micrometres.

3.6
scratch distance
s
horizontal distance travelled by the scratch tip relative to the test specimen at any given moment during the test

NOTE It is expressed in millimetres.

3.7
scratch behaviour
type of deformation of the material under the action of the scratch tip

NOTE Scratch behaviour is classified into three types: ploughing (p), wedge formation (w) and cutting (c), as defined in 3.7.1 to 3.7.3.

3.7.1
ploughing
p
scratch behaviour in which the scratch force and scratch-tip displacement are constant over the scratch distance during the test (see Figure 2)

NOTE 1 The surface of the scratch is smooth along its whole length rather than rough.

NOTE 2 A small, inherent level of episodic signal oscillation (of amplitude less than 3 N in the scratch force and 10 µm in the tip displacement) is acceptable.

3.7.2
wedge formation
w
scratch behaviour in which the scratch force and/or scratch-tip displacement oscillate, resulting in a corresponding increase in the actual distance travelled by the scratch tip during the test (see Figure 2)

NOTE The surface of the scratch exhibits a continuous serrated or wedge-like pattern, and stick-slip occurs.

3.7.3
cutting
c
scratch behaviour in which the scratch force and/or scratch-tip displacement vary randomly, resulting in a corresponding increase in the actual distance travelled by the scratch tip during the test (see Figure 2)

NOTE During the test, chips are cut from the surface.

3.8
critical normal load
P_c
minimum normal load at which wedge formation or cutting, whichever occurs first, takes place at a given test speed

NOTE It is expressed in newtons.

4 Principle

A standard test specimen is scratched by a hard tip which applies a load perpendicular to the test specimen and moves lengthwise across the surface at a constant speed along the centreline of the test specimen. During the scratch, the horizontal force between the scratch tip and the test specimen (the scratch force), the vertical displacement of the scratch tip (tip displacement) and the scratch distance are each measured continuously and recorded. The scratch force/scratch distance and tip displacement/scratch distance diagrams thus produced describe the scratch behaviour of the test specimen. Using the basic method of constant-load testing, the type of scratch behaviour can be determined for a series of test conditions (load and speed) and expressed as a so-called scratch map. Using an alternative method of linearly increasing load testing, the critical normal load can be determined at a given test speed (see Table 1). Changes in slope and/or spikes in the scratch force/scratch distance curve indicate transitions from one type of scratch behaviour to another (e.g. from ploughing to wedge formation or to cutting).

5 Apparatus

5.1 Test machine

5.1.1 General

The test machine shall consist essentially of a frame with a specimen support, a scratch tip with its associated fittings, and a device for applying the load (see Annex B), and shall meet the specifications given in 5.1.2 to 5.1.8.

5.1.2 Frame

The frame of the machine shall be capable of being levelled and shall not be deformed by more than 3 µm under the maximum load.

5.1.3 Scratch tip

The scratch tip shall be hardened to at least Rockwell HRC 64 hardness, shall be polished to a roughness of less than 0,20 µm and shall not show any deformation or damage after a test.

The scratch tip shall be hemispherical in shape, with an outside radius R of 0,5 mm ± 0,025 mm.

NOTE Tips made from hardened and polished steel or tungsten carbide have been found to be satisfactory.

5.1.4 Test load

The machine shall be capable of maintaining the test load within a tolerance of ± 1 %, for any test load chosen as specified in 7.2.3, and shall be capable of applying the load perpendicular to the test specimen within a tolerance of ± 5°.

5.1.5 Test speed

The machine shall be capable of maintaining the test speed within a tolerance of ± 1 %, except over the first and the last 10 mm of the scratch distance, for any test speed chosen as specified in 7.2.4 and shall be capable of reaching the test speed within 10 mm and stopping within 10 mm.

5.1.6 Test specimen support

The test specimen support shall be flat, smooth and free of holes in the area where the test specimen will be placed.

The clamping system for holding the test specimen on the support shall be attached to the test machine so that the longitudinal axis of the test specimen coincides with the line of scratch.

The clamping system shall not cause any premature fracture of the test specimen, and the test specimen shall be held in such a way that it cannot slip relative to the specimen support.

5.1.7 Load indicator

The load indicator shall incorporate a mechanism capable of showing the horizontal force between the scratch tip and the test specimen continuously during the test. The mechanism shall be essentially free from inertia lag at the specified test speeds and shall indicate the load with an accuracy equal to or within ± 1 % of the actual value.

5.1.8 Scratch tip displacement gauge

A mechanical or, preferably, an electronic device shall be used which incorporates a mechanism capable of indicating the vertical displacement of the scratch tip to an accuracy of ± 1 µm or better under static conditions. The mechanism shall be essentially free from inertia lag at the specified test speeds and shall be capable of indicating the vertical displacement of the scratch tip to an accuracy of ± 10 µm or better continuously during the test.

5.2 Instruments for measuring the test specimen dimensions

The width b of the test specimen shall be measured using a micrometer or gauge with an accuracy of ± 0,01 mm or better. For measuring the thickness h of the test specimen, a micrometer with a flat circular foot reading to ± 0,01 mm or less shall be used.

5.3 Monitoring and inspection devices (optional)

5.3.1 Monitoring device

A monitoring device, such as a video camera equipped with a recording system and a magnifying mechanism, is useful for monitoring the area around the scratch tip during the test (see 7.2.9, 8.2 and 8.4).

The device shall not have any thermal effect on the specimen.

5.3.2 Scratch inspection device

In addition to inspection with the naked eye, a device such as a magnifying glass, microscope, flatbed scanner or interferometer is useful for observing the appearance of the surface of the scratch after the test (see 7.2.9, 8.2 and 8.4).

The device shall not have any thermal effect on the specimen.

NOTE When testing using a linearly increasing load (the alternative method), an image of the surface of the scratch at the critical normal load can be generated with the aid of computer software using, for instance, a “grey-level threshold” programme (see Figure 4).

6 Test specimens

6.1 Shape and dimensions

Type A multipurpose test specimens as specified in ISO 3167:2002 shall be used.

6.2 Preparation

6.2.1 Moulding

Test specimens shall be directly injection-moulded in accordance with ISO 294-1 or ISO 10724-1, as appropriate, under conditions defined in the relevant standard for the material under examination.

The specimens shall be suitably marked outside the test area to indicate the melt-flow direction, the particular cavity from which the specimen came (when using a multi-cavity mould) as well as the side of the mould (cavity-plate side or fixed-plate side) on which a particular specimen face was formed (see e.g. ISO 10724-1:1998, Annex B).

NOTE Certain types of material may show different scratch behaviour depending on the face of the specimen which is tested and/or the melt-flow direction.

Strict control of all conditions during specimen preparation is essential to ensure that all test specimens are in the same state.

6.2.2 Inspection of specimens and measurement of specimen dimensions

Test specimens shall be free of twist. The faces and edges shall be free from scratches, pits, sink marks, flash and other imperfections.

Test specimens shall be checked for conformity with these requirements by visual observation, using straight edges, squares and flat plates, and by measuring the dimensions (thickness and width) of the parallel-sided section to the nearest 0,01 mm with instruments as specified in 5.2.

Specimens showing measurable or observable departure from any of these requirements shall be rejected.

With injection-moulded specimens, it is not necessary to measure the dimensions of each specimen. It is sufficient to measure one specimen from each set. When using multi-cavity moulds, measure the dimensions of a specimen from each cavity. If the difference in dimensions between mould cavities is greater than 0,02 mm, the specimens from each cavity shall be treated as different batches.

6.3 Number of test specimens

For determining the type of scratch behaviour as specified in 8.2, a single specimen is required for each set of test conditions if only one type of scratch behaviour occurs during a single test. Three specimens are required for each set of test conditions when several types of scratch behaviour occur during a single test.

In order to obtain a scratch map as specified in 8.3, it is recommended that at least 25 different sets of test conditions (for example, five different constant test loads and five different test speeds), and hence a total of at least 25 specimens, be used.

To determine the critical normal load as specified in 8.4, three specimens are required for each set of test conditions (i.e. for each test speed).

6.4 Conditioning

Unless otherwise specified in the standard for the material under test or agreed upon by the interested parties, specimens shall be conditioned for at least 16 h in one of the standard atmospheres specified in ISO 291.

7 Procedure

7.1 Test atmosphere

The atmosphere used for the test shall be the same as that used for conditioning, unless otherwise agreed upon by the interested parties, e.g. for testing at high or low temperatures. It is recommended that one of the standard atmospheres specified in ISO 291 be used.

The test temperature shall be measured and recorded during the test.

7.2 Scratch test

7.2.1 General

The scratch test shall be conducted on each specimen in turn in accordance with the procedure and conditions specified in 7.2.2 to 7.2.9.

7.2.2 Scratch tip

Use the scratch tip specified in 5.1.3.

Before the test, check that the baseline against which vertical scratch-tip displacement will be measured along the intended scratch line is constant to within 10 µm.

NOTE 1 The scratch-tip displacement baseline can be checked using, for example, a flat metal bar, whose thickness is known to within a few microns, clamped on to the test specimen support.

Before testing each specimen, check under at least × 10 magnification that the surface of the scratch tip is not coated with any plastic filings and is not damaged in any way.

NOTE 2 The scratch tip can be checked using, for example, a microscope, a magnifying glass or the monitoring or inspection device (see 5.3).

7.2.3 Test load

7.2.3.1 General

Before the test, verify that the test loads to be used are applied within the tolerance limits specified in 5.1.4.

Depending on the method to be used (see Table 1), select the test load in accordance with 7.2.3.2 or 7.2.3.3.

7.2.3.2 Constant load (basic method)

To determine the type of scratch behaviour (see 8.2) and to obtain a scratch map (see 8.3), use a constant load produced by means of weightpiece.

It is recommended that the test load for determining the type of scratch behaviour be chosen from the six following loads:

1 N, 2 N, 5 N, 10 N, 20 N, 50 N (constant to within ± 1 %).

To obtain a scratch map (see Figure 3), select at least five different constant test loads from the series above. The preferred loads are the following:

1 N, 5 N, 10 N, 20 N, 50 N (constant to within ± 1 %).