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JIS K 5600-5-4 : 1999

(ISO/DIS 15184 : 1996)

**Testing methods for paints—
Part 5 : Mechanical property
of film—
Section 4 : Scratch hardness
(Pencil method)**

ICS 87.040

Descriptors : paints, film-forming capacity, cross-cut test, painting, membranes,
scratch hardness tests, mechanical testing, pencils

Reference number : JIS K 5600-5-4 : 1999 (E)

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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of International Trade and Industry through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law.

JIS K 5400 corresponding to this Standard will be withdrawn and replaced with this Standard in April 2002, at the time of three years passed after establishment of this Standard.

Consequently it is recommended to comply with this Standard.

JIS K 5600 consists of the following parts.

- JIS K 5600 Part 1 Section 1 to Section 8 *General rule*
- JIS K 5600 Part 2 Section 1 to Section 7 *Characteristics and stability of paints*
- JIS K 5600 Part 3 Section 1 to Section 6 *Film formability*
- JIS K 5600 Part 4 Section 1 to Section 7 *Visual characteristics of film*
- JIS K 5600 Part 5 Section 1 to Section 11 *Mechanical property of film*
- JIS K 5600 Part 6 Section 1 to Section 3 *Chemical property of film*
- JIS K 5600 Part 7 Section 1 to Section 8 *Long-period performance of film*
- JIS K 5600 Part 8 Section 1 to Section 6 *Evaluation of degradation of paint coatings*

JIS K 5600-5 consists of the following sections under the title of "Testing methods for paints—Part 5 : Mechanical property of film".

- JIS K 5600 Part 5 Section 1 *Bend test (cylindrical mandrel)*
- JIS K 5600 Part 5 Section 2 *Cupping test*
- JIS K 5600 Part 5 Section 3 *Falling-weight test*
- JIS K 5600 Part 5 Section 4 *Scratch hardness (Pencil method)*
- JIS K 5600 Part 5 Section 5 *Scratch hardness (Stylus method)*
- JIS K 5600 Part 5 Section 6 *Adhesion test (Cross-cut test)*
- JIS K 5600 Part 5 Section 7 *Adhesion test (Pull-off methods)*
- JIS K 5600 Part 5 Section 8 *Abrasion resistance (Rotating abrasive-paper-covered wheel method)*
- JIS K 5600 Part 5 Section 9 *Abrasion resistance (Rotating abrasive rubber wheel method)*
- JIS K 5600 Part 5 Section 10 *Abrasion resistance (Reciprocating test panel method)*
- JIS K 5600 Part 5 Section 11 *Washability*

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**Testing methods for paints—
Part 5 : Mechanical property of film—
Section 4 : Scratch hardness
(Pencil method)**

Introduction This Japanese Industrial Standard has been prepared based on ISO/DIS 15184 *Paints and varnishes—Determination of film hardness by pencil test* issued in 1996 without changing the technical contents.

The portions underlined with dots in this Standard are not stated in the original International Standard.

1 Scope

1.1 This Standard is one of a series of standards dealing with the sampling and testing of paints, varnishes and related products. It specifies a method for determining the film hardness by pushing pencils of known hardness over the film.

The test can be performed on a single coating of a paint, varnish or related product, or on the upper layer of a multicoat system.

1.2 This rapid, inexpensive test has been found to be useful in comparing the pencil hardness of different coatings.

It is more useful in providing relative ratings for a series of coated panels exhibiting significant differences in pencil hardness.

The method is applicable only to smooth surfaces.

2 Normative references The following standards contain provisions which, through reference in this Standard, constitute provisions of this Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent editions (including the amendment) of the standards indicated below.

JIS K 5600-1-2 Testing methods for paints—Part 1 : General rule—Section 2 : Sampling of products

Remarks : ISO 1512 : 1991 *Paints and varnishes—Sampling of products in liquid or paste form* is identical with the said standard.

JIS K 5600-1-3 Testing methods for paints—Part 1 : General rule—Section 3 : Examination and preparation of samples for testing

Remarks : ISO 1513 : 1992 *Paints and varnishes—Examination and preparation of samples for testing* is identical with the said standard.

JIS K 5600-1-4 Testing methods for paints—Part 1 : General rule—Section 4 : Standard panels for testing

Remarks : ISO 1514 : 1993 *Paints and varnishes—Standard panels for testing* is identical with the said standard.

JIS K 5600-1-6 Testing methods for paints—Part 1 : General rule—Section 6 :
Temperatures and humidities for conditioning and testing

Remarks : **ISO 3270** : 1984 *Paints and varnishes and their raw materials—
Temperatures and humidities for conditioning and testing* is identical with the said standard.

JIS K 5600-1-7 Testing methods for paints—Part 1 : General rule—section 7 :
Determination of film thickness

Remarks : **ISO 2808** : 1997 *Paints and varnishes—Determination of film thickness* is equivalent to the said standard.

3 Definition For the purposes of this Standard, the following definition applies:

3.1 pencil hardness The resistance of the surface of a paint film to marking, or the formation of some other defect, as a result of the action of a pencil with a lead of specified dimensions, shape and hardness which is pushed across the surface.

Marking by pencil leads covers a range of defects in the surface of the paint film.

These defects are defined as follows:

- a) **plastic deformation** A permanent indentation in the paint surface without cohesive fracture.
- b) **cohesive fracture** The presence of a visible scratch or rupture in the surface of the paint film, material having been removed from the paint film.
- c) **Combinations of the above** These defects can occur simultaneously.

4 Principle The product or system under test is applied at uniform thickness to flat panels of uniform surface texture. After drying/curing, the pencil hardness is determined by pushing pencils of increasing hardness over the paint film, with the panel in a horizontal position. During the test, the pencil is mounted so that it presses down on the paint surface at an angle of 45° with a load of 750 g.

The hardness of the pencils is increased in steps until the coating is marked by defects of the kind defined in 3.1.

5 Required supplementary information For any particular application, the test method specified in this International Standard needs to be completed by supplementary information. The items of supplementary information are given in Annex A.

6 Apparatus

6.1 Test instrument The test is best performed using a mechanical device. An example of a suitable device is shown in Fig. 1.

The device shown consists of a metal block fitted with two wheels, one on each side. In the middle of the metal block, there is a cylindrical hole inclined at an angle of $(45 \pm 1)^\circ$.

With the help of a clamp, pencils can be fixed in the instrument so that they are always in the same position.

Mounted on the top of the instrument is a level which is used to ensure that the test is carried out with the instrument horizontal.

The instrument shall be designed so that, with the instrument in the horizontal position, the tip of the pencil exerts a load of (750 ± 10) g on the paint surface.

Note 1 Although the test is preferably performed using a mechanical device, it can also be performed by hand. Other types of test instrument may also be used, provided they give similar relative rating results.

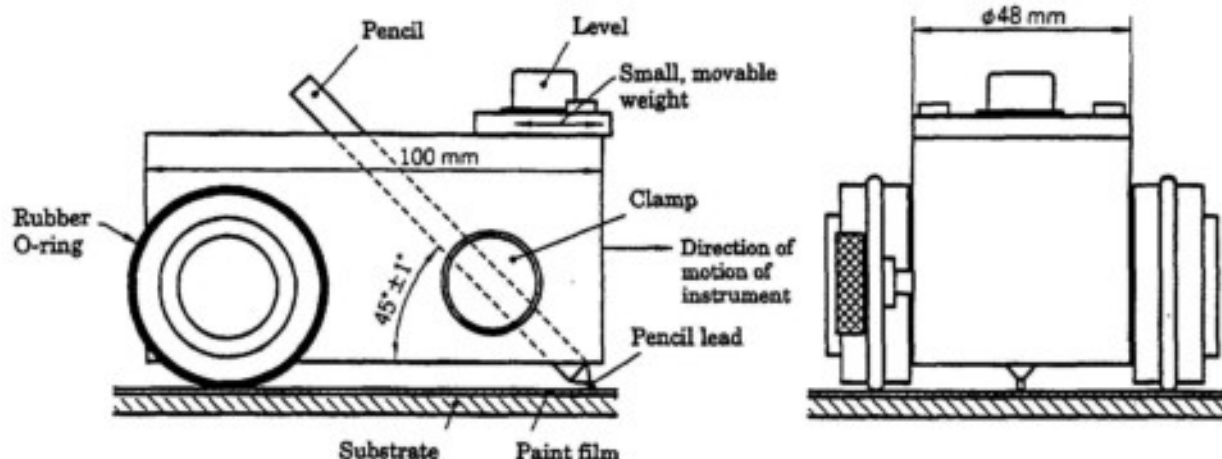


Fig. 1 Schematic diagram of test instrument

6.2 Set of wood drawing pencils The following hardnesses (see Note 2):

6B · 5B · 4B · 3B · 2B · B · HB · F · H · 2H · 3H · 4H · 5H · 6H

Softer ← ————— → Harder

Note 2 Pencils made by various manufacturers may be used by agreement between the interested parties, provided they give similar relative rating results.

Some examples of pencil makes and manufacturers which have been found suitable are as follows:

Microtomic,	manufactured by Faber Castell;
Turquoise T-2375,	manufactured by Empire Berol, USA;
KOH-I-NOOR, type 1500,	manufactured by Hardtmuth AG;
Uni,	manufactured by the Mitsubishi Pencil Co.

For comparative testing, it is recommended that pencils from the same manufacturer be used. Variations may be found between manufacturers and between batches from the same manufacturer.

6.3 Special mechanical sharpener It will remove the wood only, leaving the cylindrical pencil lead intact (see Fig. 2).

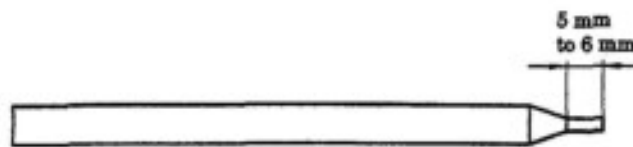


Fig. 2 Schematic view of pencil after sharpening

6.4 Abrasive paper 3M-P1000.

6.5 Soft cloth or swab of cotton wool To clean the panel after the test, using a solvent to which the coating is inert.

7 Sampling

7.1 Take a representative sample of the product to be tested (or of each product in the case of a multicoat system), as described in **JIS K 5600-1-2**. Examine and prepare each sample for testing, as described in **JIS K 5600-1-3**.

8 Test panels

8.1 Substrate Unless otherwise agreed, select the substrate from one of those described in **JIS K 5600-1-4**, using, where possible, the same type of material as will be used in practice.

The substrate panels shall be plane and free from distortion.

8.2 Shape and dimensions The shape and dimensions of the test panels shall be such that, during the test, the panel will stay in the horizontal position.

8.3 Preparation and coating Unless otherwise agreed, prepare each test panel in accordance with **JIS K 5600-1-4** and then coat it by the specified method with the product or system under test.

8.4 Drying and conditioning Dry (or stove) and age, if applicable, each coated test panel for the specified time under the specified conditions. Before testing, condition the coated panels at $(23 \pm 2)^\circ\text{C}$ and a relative humidity of $(50 \pm 5)\%$, unless otherwise agreed, for a minimum period of 16 h.

8.5 Thickness of coating The thickness of the coating shall be as specified or as agreed between the interested parties. Determine the thickness of the coating by one of the procedures specified in **JIS K 5600-1**.

9 Procedure

9.1 Carry out the test at a temperature of $(23 \pm 2)^\circ\text{C}$ and a relative humidity of $(50 \pm 5)\%$, unless otherwise agreed (see **JIS K 5600-1-6**).

9.2 Remove approximately 5 mm to 6 mm of wood from the point of each pencil using the special mechanical sharpener (6.3), being careful to leave an undisturbed, unmarked, smooth cylinder of pencil lead.

9.3 The tip of the lead shall be squared by holding the pencil in a vertical position and moving the pencil back and forth over abrasive paper (6.4), maintaining an angle of 90°. Continue until a flat, smooth, circular cross-section is obtained, free from chips or nicks in the edges.

Repeat this procedure each time a pencil is used.

9.4 Place the coated panel on a level, firm, horizontal surface. Insert a pencil in the test instrument (6.1) and clamp it in position so that the instrument is horizontal with the tip of the pencil resting on the surface of the paint film (see Fig. 1).

9.5 Immediately after the tip of the pencil has come to rest on the coating, push the test panel, in the direction away from the operator, at a speed of 0.5 mm/s to 1 mm/s for a distance of at least 7 mm.

9.6 Unless otherwise agreed, inspect the coating after 30 s with the naked eye for marking of the kind defined in 3.1 (see Note 3).

Note 3 The damage can be assessed more easily after cleaning all fragments of pencil lead from the paint surface using a soft cloth or swab of cotton wool (6.5) and an inert solvent.

If this is done, take care that the solvent does not affect the hardness of the coating in the test area.

By agreement, a microscope may be used to assess the damage. If a microscope is used, this shall be reported in the test report. If no marking has occurred, repeat the test (9.3 to 9.6) without overlap of the test areas, moving up the hardness scale until marking occurs over a distance of at least 3 mm.

If marking has occurred, repeat the test (9.3 to 9.6) down the hardness scale until marking no longer occurs.

Determine which of the defects of the kind defined in 3.1 has been produced.

The hardness of the hardest pencil which does not mark the coating is the so-called pencil hardness.

9.7 Carry out the test in duplicate. If the two results differ by more than one unit of pencil hardness, discard them and repeat the test.

10 Precision Use the following criteria, based on ASTM D 3363-92a, to judge the acceptability of results (confidence level 95 %):

Repeatability Two results obtained by two different operators within the same laboratory using the same pencils and panels should be considered suspect if they differ by more than one pencil unit on the scale given in 6.2.

Reproducibility Two results, each the mean of at least two determinations, obtained by operators in different laboratories using the same pencils and panels, or different pencils and the same panels, should be considered suspect if they differ by more than one pencil unit on the scale given in 6.2.

Bias Since there is no acceptable material suitable for determining the bias for the procedure in this test method, bias cannot be determined.

11 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 Standard;
- c) the items of supplementary information referred to in Annex A;
- d) a reference to the international or national standard, product specification or other document supplying the information referred to in c);
- e) the make and manufacturer of the pencil used;
- f) the result of the test, including, if agreed between the interested parties, a description of the kinds of defect defined in 3.1 which actually occurred;
- g) any deviation from the test method specified;
- h) the date of the test.

Annex A (normative)
Required supplementary information

The items of supplementary information listed in this Annex shall be supplied as appropriate to enable the method to be carried out.

The information required should preferably be agreed between the interested parties and may be derived, in part or totally, from an international or national standard or other document related to the product under test.

- a) The material, dimensions and surface preparation of the substrate.
- b) The method of application of the test coating to the substrate.
- c) The duration and conditions of drying (or stoving) and ageing (if applicable) of the coating before testing.
- d) The thickness, in micrometres, of the dry coating and method of measurement in accordance with **JIS K 5600-1-7**, and whether it is a single coating or a multi coat system.
- e) The temperature and relative humidity of the test, if different from those specified in **9.1**.

Errata for JIS (English edition) are printed in *Standardization Journal*, published monthly by the Japanese Standards Association, and also provided to subscribers of JIS (English edition) in *Monthly Information*.

Errata will be provided upon request, please contact:
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