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**Paints and varnishes — T-bend test**

*Peintures et vernis — Essai de pliage en T*

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# Contents

Page

Foreword.....	iv
Introduction .....	v
1 Scope .....	1
2 Normative references .....	1
3 Terms and definitions .....	1
4 Principle.....	1
5 Apparatus .....	2
6 Sampling.....	2
7 Test panels .....	2
7.1 Substrate .....	2
7.2 Preparation and coating.....	2
7.3 Thickness of the coating.....	2
8 Procedure .....	2
8.1 Conditioning of the test panels .....	2
8.2 Test conditions .....	2
8.3 Bending.....	3
8.4 Evaluation.....	5
8.5 T-bend test as a pass/fail test.....	5
9 Supplementary information .....	5
10 Expression of results .....	5
11 Precision.....	6
11.1 General.....	6
11.2 Repeatability, $r$ .....	6
11.3 Reproducibility, $R$ .....	6
12 Test report .....	6
Annex A (informative) Correlation between the ISO rating system and other systems .....	7
Bibliography .....	8

## 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.

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.

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.

ISO 17132 was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 9, *General test methods for paints and varnishes*.

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## Introduction

This International Standard is one of five standards which specify empirical test procedures for assessing the resistance of coatings of paints, varnishes and related products to cracking and/or detachment from the substrate under different conditions of deformation. The other International Standards are ISO 1519, ISO 1520, ISO 6272 and ISO 6860.

The T-bend test has already been standardized in the USA (ASTM D 4145), Europe (EN 13523-7) and Japan (JIS G 3312). The test methods in these standards are basically the same, but differ from each other in details such as

- whether the coated test panel is folded back on itself or is bent round a mandrel or a test panel used as a spacer;
- the way in which the test result is expressed.

In this International Standard, the basic contents common to the US, European and Japanese standards have been adopted, but details in which the US, European and Japanese standards differ, in particular the use of a mandrel or spacer panels, have been made subject to agreement between the interested parties.

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# Paints and varnishes — T-bend test

## 1 Scope

This International Standard describes a method of evaluating the flexibility and adhesion of an organic coating on a metallic substrate by observing the cracking or loss of adhesion when a coated test panel is bent.

The method can be used to confirm whether paints, varnishes or related products meet a given test requirement in a pass/fail test, or to determine the minimum bending diameter at which cracking does not occur.

## 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 1513, *Paints and varnishes — Examination and preparation of samples for testing*

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

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

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

IEC 60454-2, *Specification for pressure-sensitive adhesive tapes for electrical purposes — Part 2: Methods of test*

## 3 Terms and definitions

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

### 3.1

#### **T-bend test**

test designed to determine the flexibility of a paint coating by bending a coated test panel through 180°

### 3.2

#### **T-bend rating**

minimum number of spacers of defined thickness around which a coated test panel can be bent (or, if bent around a mandrel, the number of spacers equivalent to the diameter of the mandrel) without cracking or loss of adhesion (flaking) of the coating occurring

## 4 Principle

Coated panels are bent back on themselves to 180°, with the coated surface on the outside of the bend, at progressively less severe radii of curvature, the radii of curvature being defined by spacers or mandrels. After bending, each panel is examined with a magnifying glass for cracking of the coating and by a tape pull-off test

for loss of adhesion of the coating. The minimum diameter to which the test panel can be bent without cracking or loss of adhesion, i.e. when failures no longer occur, is taken as the T-bend rating.

Visual examination with a magnifying glass can also be used to determine whether there is any loss of adhesion.

## 5 Apparatus

**5.1 Vice**, with flat and smooth jaws. This is used to hold one end of the test piece firmly in place at the start of the bending test.

If the test panel is not bent around itself, a series of bending mandrels with smoothly rounded ends may be used as guides around which the test panel is bent (see Figure 1).

By agreement between the interested parties, one or more uncoated panels may also be used as mandrels.

**5.2 Magnifying glass**,  $\times 5$  to  $\times 10$  magnification.

**5.3 Adhesive tape**, with an adhesive strength between 6 N/25 mm width and 10 N/25 mm width when determined in accordance with IEC 60454-2.

## 6 Sampling

Take a representative sample of the product to be tested, as described in ISO 15528.

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

## 7 Test panels

### 7.1 Substrate

Unless otherwise agreed, use rectangular steel test panels. The panel surfaces shall be plane.

### 7.2 Preparation and coating

Unless otherwise agreed, prepare each test panel in accordance with ISO 1514 before coating it using the specified application method (see Clause 9) and drying, curing or stoving.

### 7.3 Thickness of the coating

Determine the thickness, in micrometres, of the dry coating by one of the procedures given in ISO 2808.

## 8 Procedure

### 8.1 Conditioning of the test panels

Unless otherwise agreed, condition the coated test panels for at least 16 h at  $(23 \pm 2)$  °C and  $(50 \pm 5)$  % relative humidity before carrying out the test.

### 8.2 Test conditions

Unless otherwise agreed, carry out the test at  $(23 \pm 2)$  °C and  $(50 \pm 5)$  % relative humidity.

## 8.3 Bending

### 8.3.1 General

The bending shall be performed in accordance with one of the procedures given in 8.3.2, 8.3.3 and 8.3.4, as agreed between the interested parties.

Unless otherwise agreed, the bend shall be across the direction of rolling of the panel, except for coil coatings in which case the test panel shall be bent parallel to the direction of rolling.

No bends shall be made closer than 10 mm to the jaws of the vice.

### 8.3.2 T-bend test around a mandrel

Clamp a coated test panel and a mandrel in the vice. Then bend the panel 180° around the mandrel (see Figure 1) in a smooth and uniform manner with the coated side of the panel on the outside of the bend.

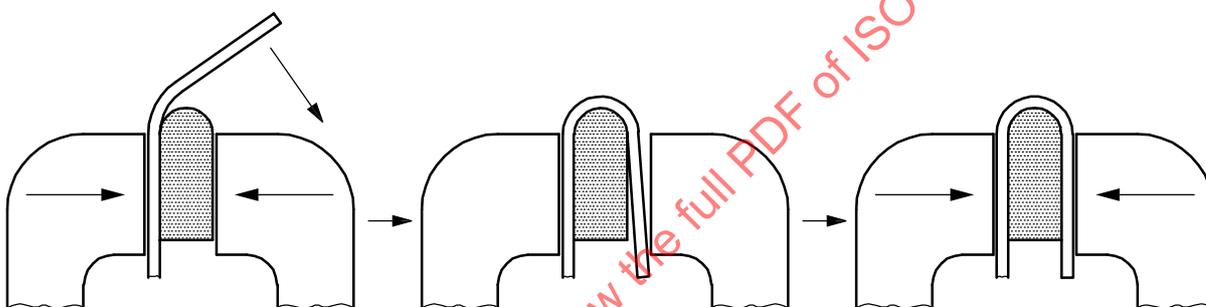


Figure 1 — Bending around a mandrel

Examine the bend for cracking and for loss of adhesion as described in 8.4. Repeat the bending procedure, using a new test panel and a different size of mandrel each time, to determine the minimum mandrel thickness at which no cracking or loss of adhesion occurs.

Express the T-bend rating,  $T_m$ , as the number of panel thicknesses equivalent to the thickness of the narrowest mandrel around which the test panel could be bent without cracking or loss of adhesion occurring, reporting the result as  $1 T_m$  for one panel thickness,  $2 T_m$  for two panel thicknesses, etc. (see also Table A.1).

### 8.3.3 T-bend test with spacer panels

Clamp one end of a coated test panel in the vice and bend it with the coated side of the panel on the outside of the bend. Remove the panel from the vice and bend it further with the fingers until it can be placed in the vice again. Insert one or more uncoated panels as spacers inside the bent panel as shown in Figure 2, fasten the assembly in the vice and bend it quickly to an angle of 180°. Each spacer panel shall have the same thickness as the test panel.

Examine the bend for cracking and loss of adhesion as described in 8.4. Repeat the bending procedure, using a new test panel and a different number of spacers each time, to determine the smallest number of spacers at which no cracking or loss of adhesion occurs.

Express the T-bend rating,  $T_p$ , as the minimum number of spacers around which the test panel could be bent without cracking or loss of adhesion occurring, reporting the result as  $1 T_p$  for one spacer,  $2 T_p$  for two spacers, etc. (see also Table A.1).



Figure 2 — Bending with spacers

8.3.4 T-bend test with test panel repeatedly folded back on itself (folding method)

Clamp one end of a coated test panel in the vice and bend it through 90° in a smooth and uniform manner with the coated side of the panel on the outside of the bend. Continue to bend the panel until the bent end can be inserted in the jaws of the vice (see Figure 3). Tighten the vice to complete the 180° bend. Take care to tighten the vice sufficiently so that the surfaces on the inside of the bend are as closely in contact as possible.

Examine the bend for cracking and loss of adhesion as described in 8.4. If cracking or loss of adhesion has occurred, repeat the bending procedure, as shown in Figure 3, until no cracking or loss of adhesion occurs.

Express the T-bend rating,  $T_f$ , as the number of bends, after the initial bend, which could be made in the test panel before no cracking or loss of adhesion occurred, reporting the result as 0  $T_f$  for no bends after the initial one, 1  $T_f$  for one bend after the initial one, etc. (see also Table A.1).

If it is agreed to use test panels in the shape of a right-angled triangle, the lengths of two sides should preferably be equal and in the range 10 cm to 15 cm. This shape leaves part of each bend exposed for later examination and for a permanent record.

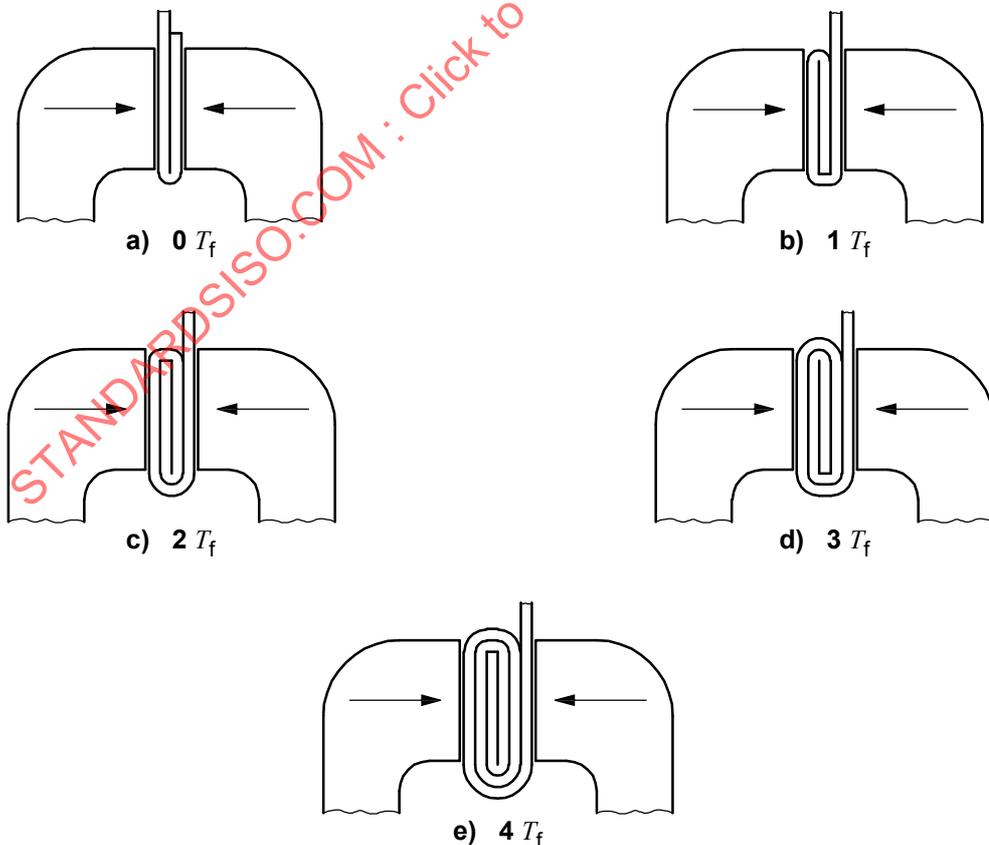


Figure 3 — Folding method

## 8.4 Evaluation

Examine the bend, using the magnifying glass (5.2), immediately after bending for any cracking. Disregard those parts of the bend within 5 mm of each edge of the panel.

Unless otherwise agreed, also examine each bend for loss of adhesion by the following test. Place a piece of adhesive tape (5.3) on the coating at the bend in the test panel. Rub the tape flat to ensure good contact with the coating. Then pull off the tape with a rapid movement. If no coating residues can be seen on the adhesive tape, there is no loss of adhesion.

If agreed, the magnifying glass (5.2) can be used instead to examine the bend for loss of adhesion of the coating.

## 8.5 T-bend test as a pass/fail test

The T-bend tests described in 8.3.2, 8.3.3 and 8.3.4 can also be used as a pass/fail test, the bend being evaluated, as before, in accordance with 8.4.

If the results of several determinations differ, additional tests shall be carried out.

## 9 Supplementary information

For any particular application of the test method specified in this International Standard, the following information needs to be specified, in addition to that given in the preceding clauses, 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 coating material under test.

- a) The material, shape, thickness and surface preparation of the test panels.
- b) The method of application of the coating material under test to the panels, including duration and conditions of drying between coats in the case of a multi-coat system.
- c) The duration and conditions of drying (or stoving) and ageing (if applicable) of the coating before testing.
- d) The temperature and relative humidity of conditioning of the coated panels before starting the test, if different from those indicated in 8.1.
- e) The thickness, in micrometres, of the dry coating and the method of measurement used, and whether it is a single coat or a multi-coat system.
- f) The test temperature and relative humidity, if different from those indicated in 8.2.
- g) The type of test to be carried out, i.e. whether it is a classification test or a pass/fail test.

## 10 Expression of results

Report the test result as the greatest extent to which the test panel can be bent without cracking or loss of adhesion, expressed as specified in 8.3.2, 8.3.3 or 8.3.4 for the method used and indicating, in addition, if cracking took place without loss of adhesion or *vice versa*.

EXAMPLE      1  $T_p$  (no loss of adhesion); 2  $T_f$  (no cracking).

## 11 Precision

### 11.1 General

The precision statements below are based on results obtained from round-robin testing using spacers (i.e. the method described in 8.3.3). The test conditions were  $(20 \pm 1)$  °C and  $(65 \pm 5)$  % RH and the bends were evaluated visually both with and without a magnifying glass.

### 11.2 Repeatability, $r$

The repeatability  $r$  is the value below which the absolute difference between two single test results, each the mean of duplicates, can be expected, with 95 % probability, to lie when this method is used under repeatability conditions, i.e. same material, same operator, same apparatus and results obtained within a short interval of time. For examination with a magnifying glass,  $r$  was found to be  $\pm 0,66$ ; for unaided visual examination,  $r$  was found to be  $\pm 0,57$ .

### 11.3 Reproducibility, $R$

The reproducibility  $R$  is the value below which the absolute difference between two single test results, each the mean of duplicates, can be expected, with 95 % probability, to lie when this method is used under reproducibility conditions, i.e. same material but operators in different laboratories. For examination with a magnifying glass,  $R$  was found to be  $\pm 1,09$ ; for unaided visual examination,  $R$  was found to be  $\pm 1,12$ .

## 12 Test report

The test report shall contain at least the following information:

- a) all information necessary for identification of the coating material tested;
- b) a reference to this International Standard (ISO 17132:2007);
- c) the items of supplementary information referred to in Clause 9, including a reference to the international or national standard, product specification or other document supplying the information referred to;
- d) the method used (mandrel, spacers, folding), as indicated in Clause 8;
- e) the direction of bending, i.e. perpendicular or parallel to the direction of rolling;
- f) the results of the test, including the results of the individual determinations, expressed as specified in Clause 10;
- g) any deviations from the procedure specified;
- h) any unusual features (anomalies) observed during the test;
- i) the date of the test.