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## Paints and varnishes — Pull-off test for adhesion

*Peintures et vernis — Essai de traction*

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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](http://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](http://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](http://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*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 139 *Paints and varnishes*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This fourth edition cancels and replaces the third edition (ISO 4624:2016), which has been technically revised.

The main changes are as follows:

- [Clause 3](#) on terms and definitions has been added;
- for the use of this method on concrete, larger dolly of up to 100 mm have been added to [5.2](#);
- requirement concerning the adhesive in relation to substrate or coating material has been added in [Clause 6](#) (last sentence).
- additional information has been added to the single dolly method in [9.4.2](#);
- the normative references have been updated.

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](http://www.iso.org/members.html).

## Introduction

This document describes methods for assessing the adhesion of a single coating or a multi-coat system of paint, varnish or related product by measuring the minimum tensile stress necessary to detach or to rupture the coating in a direction perpendicular to the substrate.

The test result is influenced not only by the mechanical properties of the system under test, but also by the nature and preparation of the substrate, the method of paint application, the drying conditions of the coating, the temperature, the humidity and other factors like the type of test instrument which has been used.

ISO 2409 can also be used for the evaluation of adhesion characteristics.

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# Paints and varnishes — Pull-off test for adhesion

## 1 Scope

This document specifies three methods for determining the adhesion by carrying out a pull-off test on a single coating or a multi-coat system of paint, varnish or related product.

These methods include:

- method A: using two dollies, suitable for testing both rigid and deformable substrates;
- method B: testing from one side only, using a single dolly, suitable for rigid substrates only;
- method C: using dollies, one as a painted substrate.

These test methods have been found useful in comparing the adhesion behaviour of different coatings. It is most useful in providing relative ratings for a series of coated panels exhibiting significant differences in adhesion.

The test can be applied using a wide range of substrates. Different procedures are given according to whether the substrate is deformable, e.g. thin metal, plastics and wood, or rigid, e.g. thick concrete and metal plates. To avoid distortion of the substrate during the tensile test, it is common to use a sandwich construction. For example, for special purposes, the coating can be applied directly to the face of a test dolly.

## 2 Normative references

[ISO/FDIS 4624](#)

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 3270, *Paints and varnishes and their raw materials — Temperatures and humidities for conditioning and testing*

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 terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

## 4 Principle

The product or system under test is applied at uniform thickness to flat panels of uniform surface texture.

After drying/curing the coating system, dollies are bonded directly to the surface of the coated and cured panel using an adhesive.

After curing the adhesive, the bonded dolly assemblies are placed in a suitable tensile tester. The bonded assemblies are subjected to a controlled tensile test (pull-off test), and the force required to break the coating/substrate bond is measured.

To avoid possible distortion of the substrate during the tensile test, dollies with a diameter smaller than the 2 cm diameter used for steel substrates may be used to reduce the force introduced.

The test result is the tensile stress necessary to break the weakest interface (adhesive failure) or the weakest component (cohesive failure) of the test assembly. Mixed adhesive/cohesive failures may also occur.

## 5 Apparatus

**5.1 Tensile tester**, suitable for carrying out the chosen procedure specified in [Clause 9](#). The tensile stress shall be applied in a direction perpendicular to the plane of the coated substrate and shall be increased at a substantially uniform rate, not greater than 1 MPa/s<sup>1)</sup> such that failure of the test assembly occurs within 90 s. Suitable designs for applying the tensile stress are shown in [Figures 1](#) and [2](#).

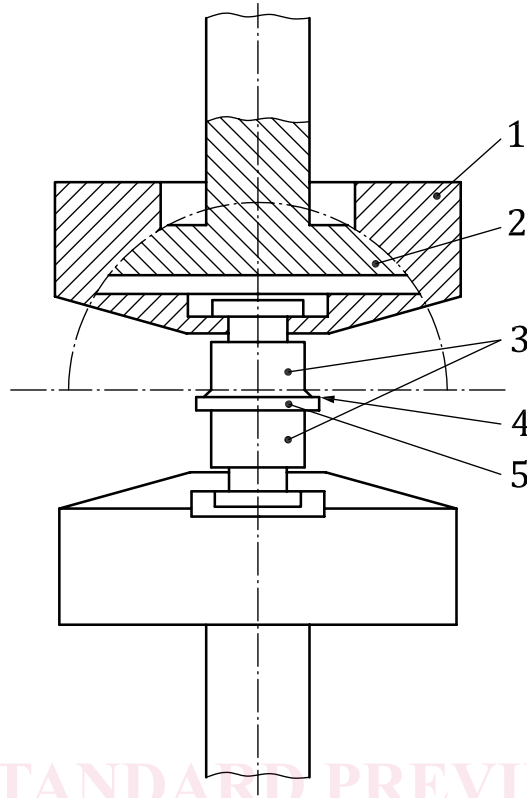
Instead of a tensile tester, other types of pull-off adhesion testers (mechanically, pneumatically, hydraulically or hand-driven) may be used provided that they give similar results. The type of instrument shall be reported in the test report, because hand-driven/mechanical/hydraulic instruments are reported to produce widely different results.

**NOTE** The results can be influenced by the test assembly used. Furthermore, the results are not reproducible unless coaxial alignment of the tensile forces is ensured.

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1) 1 MPa/s = 1 MN/(m<sup>2</sup>·s).





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**Key**

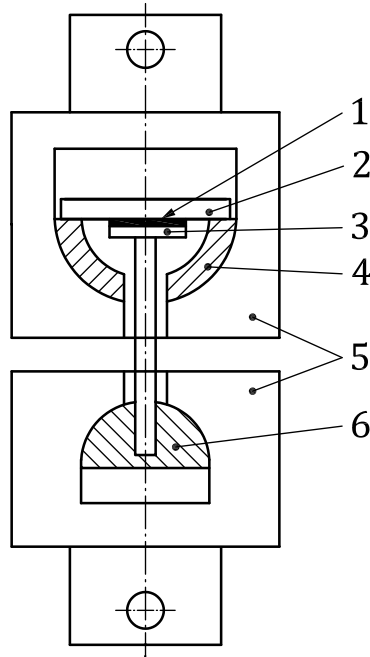
- 1 support
- 2 ball joint
- 3 dollies
- 4 coating
- 5 substrate

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NOTE These methods are described in [9.4.1](#) and [9.4.3](#).

**Figure 1 — Example of a suitable test apparatus for the two-dolly methods (methods A and C)**



**Key**

- 1 coating
- 2 test piece
- 3 dolly
- 4 ball-and-socket sliding joint
- 5 support (suitably designed to allow for joint assembly)
- 6 ball-and-socket sliding joint

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NOTE [https://standards.iteh.ai/catalog/standards/sist/a115607f-2dd8-43fb-b618-f94978ef2214/iso-fdis-4624](#) This test apparatus is described in 9.4.2.

**Figure 2 — Example of a suitable test apparatus for the one-dolly method (method B)**

**5.2 Test dollies**, each consisting of a steel or aluminium cylindrical-faced testing body, specifically designed to be used with the tensile tester. Each dolly has a rigid, flat face for bonding the adhesive/coating at one end and a facility for connecting the pull-off tester at the other. Each dolly has a nominal diameter of 20 mm and sufficient thickness to ensure freedom from distortion during the test. It is recommended that the length of each dolly is not less than half its diameter. The faces of each dolly shall be machined perpendicular to its axis before use.

Dollies with a diameter of 7 mm for example, may be used when the method for testing adhesion from one side only is used and when there is a danger of distortion of the substrate (see 9.4.2). If dollies smaller in diameter are used, more measurements shall be made to improve the precision. When using 7 mm dollies, 10 measurements have been shown to be practicable. The diameter of the dollies shall be recorded in the test report.

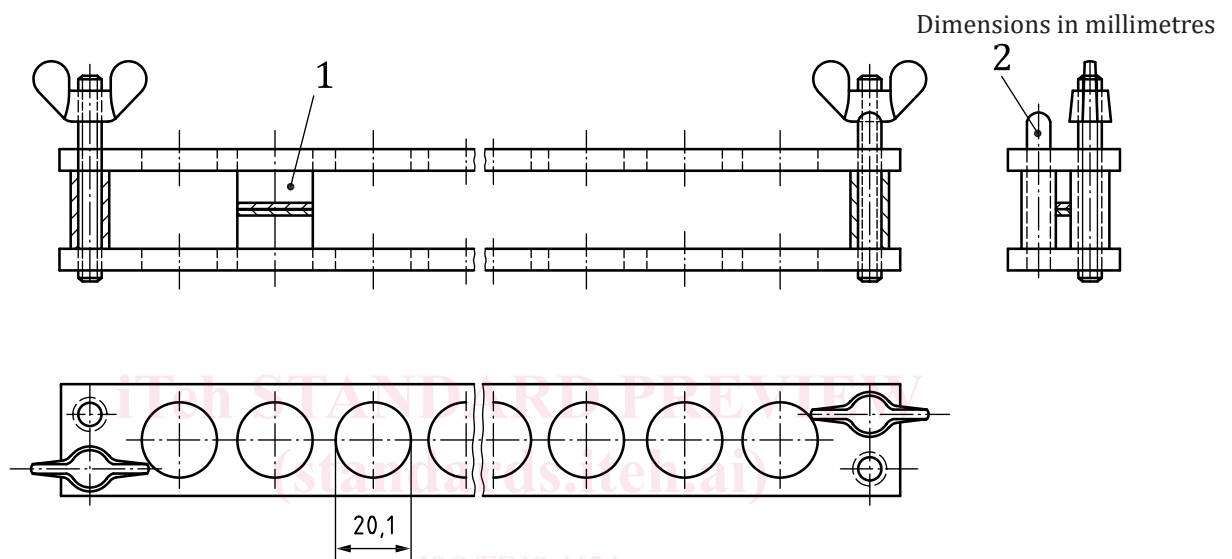
Use of this method on concrete typically uses a larger dolly of up to 100 mm. Use of a larger dolly is beneficial on concrete coatings as the force applied during the test provides values closer to the maximum tensile strength of most concrete.

**5.3 Centring device**, for ensuring proper coaxial alignment of the test assembly during the adhesion process of the two-dolly methods described in 9.4.1 (method A) and 9.4.3 (method C). A suitable design is shown in Figure 3.

**5.4 Cutting device**, such as a sharp knife, for cutting through the cured adhesive and the paint coating to the substrate, round the circumference of the dolly.

Depending on the mechanical properties of the paint system (e.g. brittleness), cutting through the cured adhesive and the paint film to the substrate can have a big influence on the adhesion of the paint system. It is permitted, if specified or agreed between the interested parties, not to cut when the paint systems are less than 150 µm in layer thickness. If cuts around the dolly have been made, this shall be mentioned in the test report and the type of cutting tool shall also be mentioned.

When using small dollies, cutting often is difficult and is normally not carried out. Experience has shown that an increasing number of small dollies has an advantage concerning precision compared to the cut combined with the 20 mm dollies.



- Key**
- 1 test assembly aligned for adhesion process (see 5.3)
  - 2 centring pin

**Figure 3 — Example of a suitable centring device for 20 mm-diameter dollies**

## 6 Adhesives

Special attention is required in selecting suitable adhesives to be used in the test. To produce failure of the coating, it is essential that the cohesive and bonding properties of the adhesive are greater than those of the coating under test.

Preliminary screening of adhesives shall be carried out in order to determine their suitability for use. Suitable adhesives and, if applicable, their unmixed components, shall cause little or no visible change in the coating under test when left in contact with the coating for a period equivalent to the curing time of the adhesive.

Adhesives which give the highest results, which means the most coating-substrate adhesive failure or coating failure, are preferred.

In most cases, cyanoacrylate, two-component solventless epoxide and peroxide-catalysed polyester adhesives have been found suitable. In special tests under highly humid conditions, the curing time of the adhesive should be as short as possible. The use of two-pack quick-drying epoxy adhesive is preferable in these situations.

Where failure is mainly associated with the adhesive at tensions less than 5 MPa, the use of another type of adhesive can enable more useful results to be obtained.