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**Paints and varnishes — Test method  
for evaluation of adhesion of elastic  
adhesives on coatings by peel test,  
peel strength test and tensile lap-  
shear strength test with additional  
stress by condensation test or  
cataplasma storage**

*Peintures et vernis — Évaluation de l'adhérence des adhésifs élastiques sur les produits de peinture en examinant l'adhérence, la résistance au pelage et la résistance à la traction et le cisaillement en combinaison avec l'exposition à l'eau de condensation ou au cataplasme*



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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*.

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).

# Paints and varnishes — Test method for evaluation of adhesion of elastic adhesives on coatings by peel test, peel strength test and tensile lap-shear strength test with additional stress by condensation test or cataplasma storage

## 1 Scope

This document specifies three methods for testing the peel adhesion, peel strength and tensile lap-shear strength in order to evaluate the adhesive bond as well as the type, location and structure of failures of elastic adhesives on coatings. These methods are used, for example, for testing the assembly with respect to the bond of panes or built-on parts, such as plastic covers, spoilers, instrument panel covers, headlights, with coatings for automobile construction. The two methods of climatic exposure of specimens described herein are the condensation test and cataplasma storage.

This document does not specify requirements for adhesives and coatings.

**NOTE** The peel strength test (method B) for rigid car body construction adhesives is described in ISO 8510-2. The tensile lap-shear strength test (method C) for rigid car body construction adhesives is described in EN 1465. Testing of rigid car body construction adhesives is generally conducted on small joint thicknesses, i.e. <1 mm.

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

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

ISO 6270-2, *Paints and varnishes — Determination of resistance to humidity — Part 2: Condensation (in-cabinet exposure with heated water reservoir)*

ISO 10365, *Adhesives — Designation of main failure patterns*

ISO 17872, *Paints and varnishes — Guidelines for the introduction of scribe marks through coatings on metallic panels for corrosion testing*

DIN 55997, *Solvents for paints and varnishes — Deionized water — Requirements and methods of test*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4618 and the following 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/>

**3.1  
adhesive**

non-metallic substance capable of joining materials by surface bonding (adhesion), where the bond possessing adequate internal strength for force transmission

**3.2  
adherend**

body that is, or is intended to be, held to another body

Note 1 to entry: "Adherend" is a narrower term than "substrate".

[SOURCE: ISO 472:2013, 2.13]

**3.3  
tensile lap-shear strength**

stressing in shear of an overlap specimen between rigid *adherends* (3.2) by applying to the adherends a tensile force which is parallel to the bond area and to the major axis of the specimen

**3.4  
cohesion failure**

cohesive failure

failure of an adhesive bond within the body of the *adhesive* (3.1), i.e. not at the interface

[SOURCE: ISO 472:2013, 2.159]

**3.5  
adhesion failure**

adhesive failure

failure of an adhesive bond in such a way that the separation appears to be at the adhesive/adherend interface

[SOURCE: ISO 472:2013, 2.30]

## 4 Principle

### 4.1 Adhesive strength test method A — Peel adhesion

It describes the peel adhesion test of adhesives on coatings. This method is suitable where a qualitative, i.e. visual, evaluation of an adhesive's behaviour is sufficient or when testing large and voluminous parts.

The adhesive is applied to the test panel in form of a (round or triangular) bead, dried and peeled off the coating using a cutter knife and, if required, pliers. This is followed by a visual evaluation of the failure pattern.

### 4.2 Adhesive strength test method B — Peel strength

It describes the adhesive strength testing of adhesives by determination of the peel force. This method enhances the range of results obtained using method A by additional quantitative measurement values and enables a statement as to which forces are transmitted to the adherend.

The adhesive is applied to the test panel to be bonded in form of a (round or triangular) bead, pressed to the required thickness using a suitable thin plate and cured. A tensile force is applied to the plate thereby peeling it off the bond in a defined angle. The reported result is the maximum force measured for each bond width (see [Figure 20](#)).

### 4.3 Adhesive strength test method C — Tensile lap-shear strength

It describes the adhesive strength testing of adhesives on coatings by determination of the tensile lap-shear strength. This method yields both qualitative and quantitative results. It is suitable for testing complete bonded assemblies as later used in practice. This also includes the use of original adherends.

The tensile lap-shear strength of overlap specimens is determined by stressing in shear of an overlap joint between rigid adherends by applying to the adherends a tensile force which is parallel to the bond area and to the major axis of the specimen. The reported result is the maximum force or maximum tensile shear stress measured for each bond width.

### 4.4 Conduction of the test

After complete curing of the adhesive, testing is conducted according to adhesive strength test method A, B or C, either immediately or following subsequent climatic exposure (exposure method 1 or 2).

## 5 Apparatus and test media

Normal laboratory equipment together with the following.

### 5.1 Adhesive strength test method A — Peel adhesion

**5.1.1 Test panel**, e.g. coated plates having dimensions of approximately 200 mm × 100 mm and a thickness of 0,7 mm to 1,2 mm or coated plastic or coated glass (float glass) having a thickness of approximately 4 mm. The thickness shall be sufficient to prevent deformation or fracture of the test panel in combination with the specimen grip under the expected tensile load when peeling off the bead.

Specimen preparation, coating and drying/curing shall be indicated in the test report.

**5.1.2 Adhesive**, as agreed between the interested parties, supplied in a commercially available can.

**5.1.3 Application gun**, for applying the adhesive.

**5.1.4 Doctor blade**, for forming the adhesive beads (see [Figure 1](#)).



**Figure 1 — Example for doctor blade design**

**5.1.5 Vapour barrier**, e.g. strips of PE film or siliconized paper, e.g. baking paper, having dimensions of approximately 200 mm × 25 mm and a thickness of about 0,1 mm.

**5.1.6 Spacer**, according to the agreed bond thickness.

**5.1.7 Cutter knife**, which shall be in accordance with ISO 17872, designed as agreed between the interested parties.

**5.1.8 Commercially available adhesive tape**, approximately 20 mm wide.

**5.1.9 Pliers**, designed as agreed between the interested parties, e.g. needle-nose pliers.

## **5.2 Adhesive strength test method B — Peel strength**

**5.2.1 Test panel**, e.g. coated plates having dimensions of at least 250 mm × 70 mm and a thickness of 0,7 mm to 1,2 mm. The thickness shall be sufficient to prevent deformation of the test panel in combination with the specimen holder under the expected tensile load when peeling off the bead.

Specimen preparation, coating and drying/curing shall be indicated in the test report.

**5.2.2 Adhesive**, as agreed between the interested parties, supplied in a commercially available can.

**5.2.3 Application gun**, for applying the adhesive.

**5.2.4 Strips of PE film or siliconized paper**, e.g. baking paper, having dimensions of approximately 70 mm × 100 mm and a thickness of about 0,1 mm.

**5.2.5 Peeling plate**, just thick enough to enable transmission of the expected tensile forces to the adhesive while allowing bending without using excessive force, e.g. aluminium A1050P, 25 mm × 250 mm × 0,5 mm.

**5.2.6 Spacer**, according to the agreed bond thickness.

**5.2.7 Tensile testing machine**, having a nominal load suitable for the respective adhesive bond, e.g. 10 kN.

The response time of the testing machine shall be sufficiently short to prevent influences on the accuracy when measuring the force at failure. The recorded force shall not deviate from the actually required force by more than 1%. The testing machine shall be capable of applying the required tensile force increasing at a steady rate. It shall be provided with a pair of suitable self-aligning grips to hold the specimen. The grips and attachments shall be constructed such as to move into alignment with the specimen as soon as the force is applied, so that the longitudinal axis of the specimen will coincide with the direction of the required force through the centre line of the grip assembly to avoid bending moment. Grips that operate by bolting through the adherends shall not be used since tearing of the bolting holes is to be expected.

## **5.3 Adhesive strength test method C — Tensile lap-shear strength**

**5.3.1 Test panel**, e.g. coated plates having dimensions of at least 75 mm × 25 mm and a thickness of 0,7 mm to 1,2 mm or coated plastic or coated glass (float glass) having a thickness of approximately 6 mm. The test panel strength shall be sufficient to enable transmission of the occurring tensile forces to the bond.

Specimen preparation, coating and drying/curing shall be indicated in the test report.

**5.3.2 Adhesive**, as agreed between the interested parties, supplied in a commercially available can.

**5.3.3 Application gun**, for applying the adhesive.

**5.3.4 Jig**, for accurately locating adherends during bonding.

**5.3.5 Spacer**, according to the agreed bond thickness or **bonding frame with non-adhesive film or coating**.

**5.3.6 Tensile testing machine**, having a nominal load suitable for the respective adhesive bond, e.g. 10 kN.

The response time of the testing machine shall be sufficiently short to prevent influences on the accuracy when measuring the force at failure. The recorded force shall not deviate from the actually required force by more than 1 %. The testing machine shall be capable of applying the required tensile force increasing at a steady rate. It shall be provided with a pair of suitable self-aligning grips to hold the specimen. The grips and attachments shall be constructed such as to move into alignment with the specimen as soon as the force is applied, so that the longitudinal axis of the specimen will coincide with the direction of the required force through the centre line of the grip assembly to avoid bending moment. Grips that operate by bolting through the adherends shall not be used since tearing of the bolting holes is to be expected.

## 5.4 Exposure method 1 — Condensation atmosphere with constant humidity

**5.4.1 Apparatus for testing in a condensation atmosphere with constant humidity** shall be in accordance with ISO 6270-2.

## 5.5 Exposure method 2 — Cataplast storage

**5.5.1 Laboratory drying chamber**, capable of maintaining the test temperature within  $\pm 2$  °C (for temperatures up to 150 °C). A laboratory drying chamber with technical ventilation shall be used.

**5.5.2 Freezer**, adjustable to  $(-20 \pm 2)$  °C.

**5.5.3 Aluminium foil**, commercial quality.

**5.5.4 Plastic bag made of polyethylene**, at least 0,22 mm thick, heat resistant and sealable or thermally sealable with an appropriate sealing device.

**5.5.5 Deionized water**, which shall be in accordance with DIN 55997, but with a maximum conductivity of 20  $\mu\text{S}/\text{cm}$ .

**5.5.6 Purified absorbent cotton**, single layer, rectangular, pH neutral.

## 6 Sequence of adhesive strength tests A, B and C

[Table 1](#) gives an overview over the sequence of adhesive strength tests A, B and C.

**Table 1 — Sequence of adhesive strength tests A, B and C**

Process step	Method A: Peel adhesion	Method B: Peel strength	Method C: Tensile lap-shear strength
Preparation of test panels	according to <a href="#">7.1</a>		
Preparation of specimens	according to <a href="#">7.2</a>	according to <a href="#">7.3</a>	according to <a href="#">7.4</a>
Curing of applied adhesive	according to <a href="#">8.1</a>		
Determination of reference values	according to <a href="#">8.2</a>		
Exposure	according to <a href="#">8.3</a>		
Conditioning of test panels	according to <a href="#">8.3</a>		
Test procedure	according to <a href="#">9.1</a>	according to <a href="#">9.2</a>	according to <a href="#">9.3</a>
Expression of results	according to <a href="#">10.1</a>	according to <a href="#">10.2</a>	according to <a href="#">10.3</a>

## 7 Preparation of specimens

### 7.1 Preparation of test panels

Pretreat the substrate to be bonded as agreed between the interested parties (clean with suitable solvent and apply activator/primer, if applicable).

Store the coated test panels ([5.1.1](#), [5.2.1](#) or [5.3.1](#)) at  $(23 \pm 2)$  °C and  $(50 \pm 5)$  % relative humidity in accordance with ISO 3270. The time between completion of the coating and application of the adhesive shall be indicated in the test report.

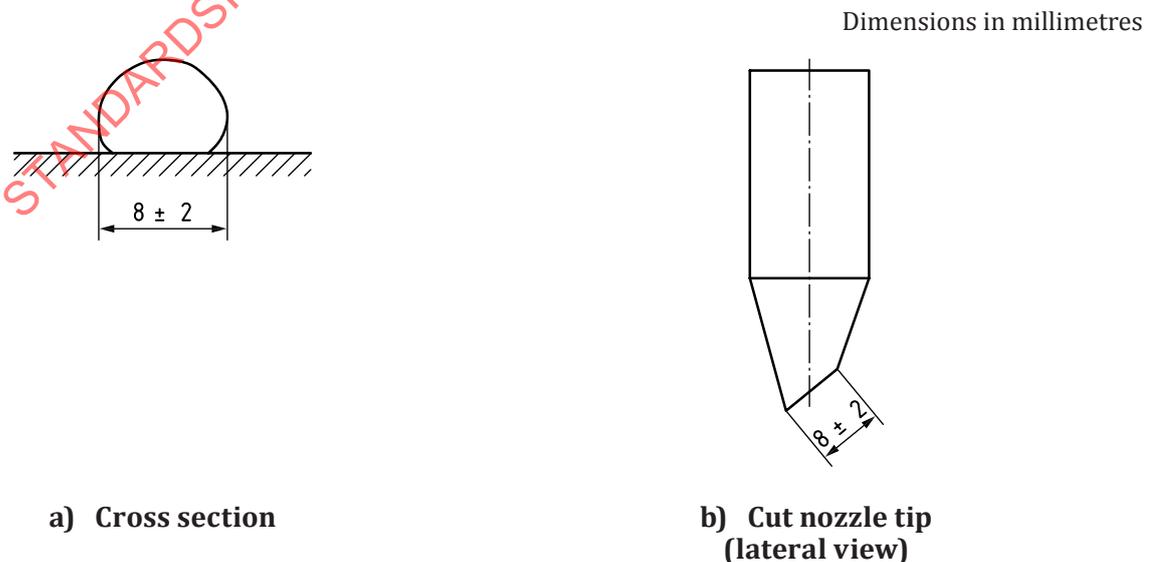
NOTE The adhesive strength of the adhesive can depend on this time span.

Temper the adhesive as indicated by the manufacturer.

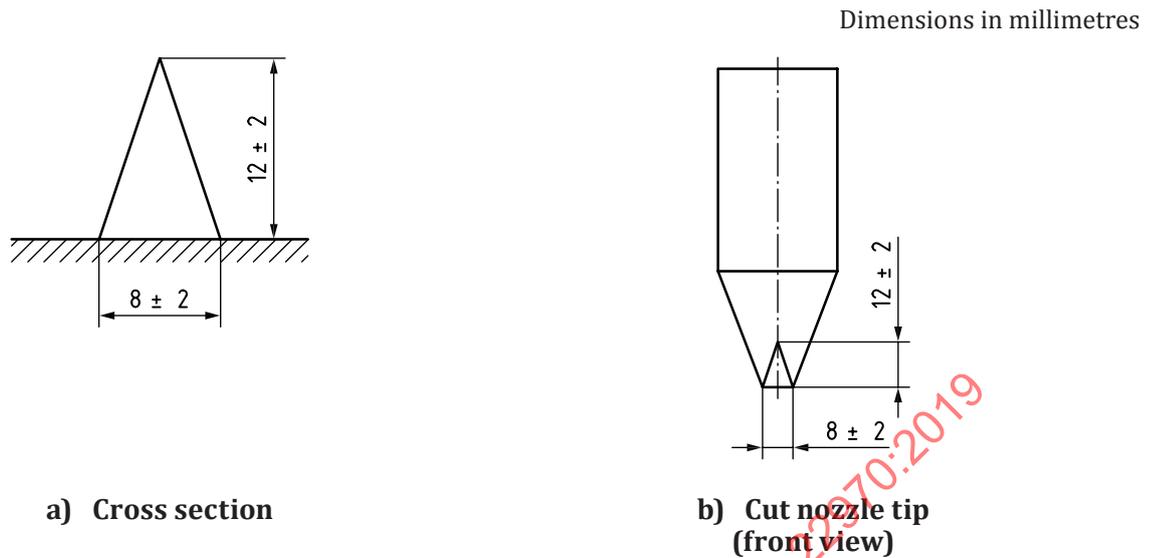
### 7.2 Adhesive strength test method A — Peel adhesion

#### 7.2.1 Bead shape

Cut the nozzle to the base and height of the bead according to the agreed bead shape (round or triangular bead), for example as shown in [Figures 2](#) and [3](#).



**Figure 2 — Round bead**



**Figure 3 — Triangular bead**

For the purpose of paired measurement, apply 2 beads of the appropriately tempered adhesive parallel to each other to the test panel prepared in accordance with 7.1.

Usually, exposures are conducted simultaneously, i.e. one reference test on one pair of beads and only one exposure each.

For elastic bonds, e.g. of windscreens where a clearance of approximately 5 mm is required, a typical bead geometry may be as follows:

Bead length	approximately 180 mm
Bead base	$(8 \pm 2)$ mm
Bead height	$(12 \pm 2)$ mm

When combining several ageing tests on one pair of beads (sequential testing), the sequence, conditions and conditioning between the individual exposures shall be specified for each ageing test. The bead shall be long enough to provide a length of about 5 cm for reference purposes and for each test.

## 7.2.2 Application of the adhesive bead

### 7.2.2.1 Application to the coating, curing without pressing

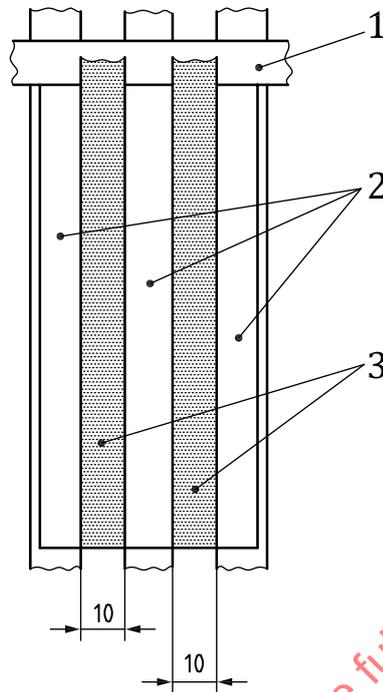
This method allows quick execution (“screening”) by applying round beads directly to the coating thus causing them to cure faster due to the lack of a vapour barrier. Testing may also be conducted on uneven surfaces of original parts.

Following cleaning and application of the pretreatment layer, adhesive tape may be applied to one of the shorter sides of the test panel. This will later facilitate initial lifting of the adhesive bead. As an alternative, the bead may initially be cut to peel it off the coating.

During bead application, the nozzle tip shall be placed carefully on the substrate without damaging the surface. If damage cannot be excluded, application is done near to the surface without touching it. For this purpose, the drawing speed of the application gun and the adhesive discharge rate shall be coordinated such as to neither stretch nor compress the adhesive in order to ensure a uniformly good contact with the substrate surface.

As an alternative, beads of any geometry may be applied to test areas defined by taping; excess material may be removed by means of a shaping doctor blade. See [Figure 4](#).

Dimensions in millimetres



**Key**

- 1 one strip of adhesive tape
- 2 three strips of adhesive tape
- 3 adhesive bead

**Figure 4 — Application of two adhesive beads directly to the coating**

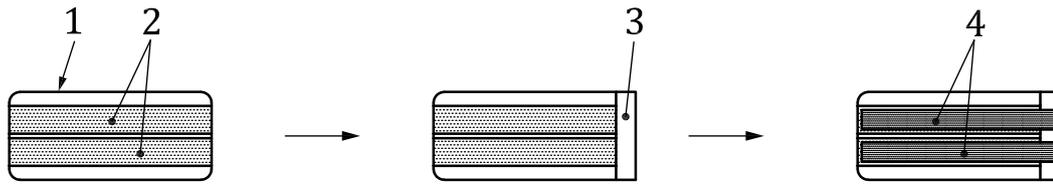
**7.2.2.2 Application to the coating including pressing**

The advantage of applying the adhesive bead directly to the coating including pressing is that this ensures good contact of the adhesive with the surface. This is the method most commonly used by laboratories. This specimen preparation simulates the curing process under real conditions where curing will occur from two sides. A typical example is the bonding of panes.

Following the cleaning and the application of the pretreatment layer, adhesive tape may be applied to one of the shorter sides of the test panel. This will later facilitate initial lifting of the adhesive bead. As an alternative, the bead may initially be cut to peel it off the coating.

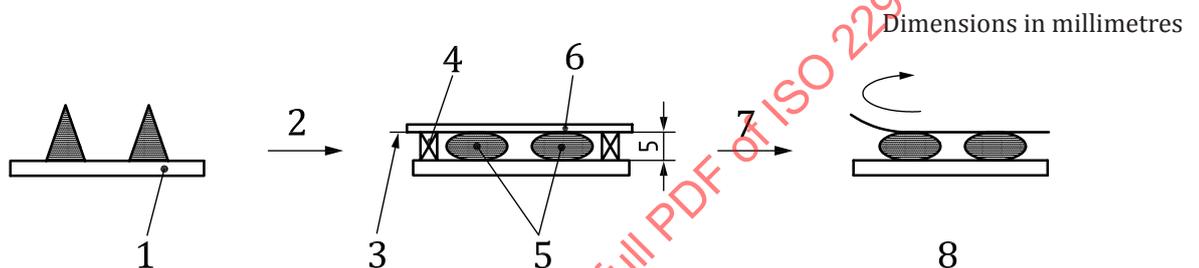
During bead application, the nozzle tip shall be placed carefully on the substrate without damaging the surface. If damage cannot be excluded, application is done near to the surface without touching it. For this purpose, the drawing speed of the application gun and the adhesive discharge rate shall be coordinated such as to neither stretch nor compress the adhesive in order to ensure a uniformly good contact with the substrate surface.

Immediately after placing the spacers ([5.1.6](#)) and applying the vapour barrier ([5.1.5](#)), press the adhesive bead to the coating by means of a rigid contact aid in order to produce a bond thickness of  $(5 \pm 1)$  mm (see [Figure 5](#) and [Figure 6](#)).

**Key**

- 1 substrate
- 2 activator + primer
- 3 adhesive tape
- 4 adhesive bead

**Figure 5 — Application and pressing of the adhesive bead to the test panel (top view)**

**Key**

- 1 test panel/adherend
- 2 pressing
- 3 vapour barrier
- 4 spacer
- 5 adhesive bead
- 6 glass plate
- 7 curing
- 8 removal of vapour barrier

**Figure 6 — Pressing of the adhesive bead to the test panel (front view)**

After the prescribed curing time of the adhesive, remove the vapour barrier from the beads.

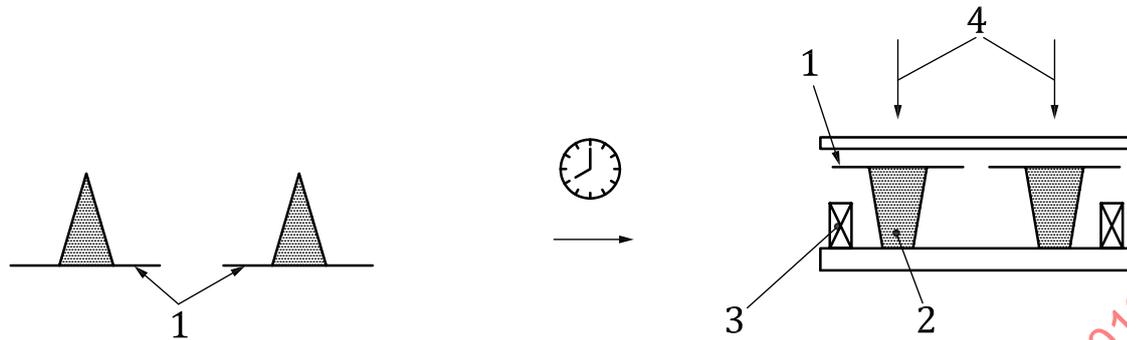
### 7.2.2.3 Application to the vapour barrier including pressing

Unilateral application of the adhesive to the substrate surface is, due to process related reasons, not always followed by immediate bonding with the second adherend. Consequently, the adhesive will be exposed to ambient conditions for some time and start to cure which is why it is tested for its open time behaviour. The open time is the maximum permissible time between application and bonding.

During bead application, the nozzle tip shall be placed carefully on the substrate without damaging the surface. If damage cannot be excluded, application is done near to the surface without touching it. For this purpose, the drawing speed of the application gun and the adhesive discharge rate shall be coordinated such as to neither stretch nor compress the adhesive in order to ensure a uniformly good contact with the substrate surface.

Following the cleaning and the application of the pretreatment layer, adhesive tape may be applied to one of the shorter sides of the test panel. This will later facilitate initial lifting of the adhesive bead. As an alternative, the bead may initially be cut to peel it off the coating.

The beads are applied separately to the vapour barrier and, following the specified open time at defined climatic conditions, pressed to the coating by means of a rigid contact aid (see [Figure 7](#)).



**Key**

- 1 PE film/baking paper
- 2 adhesive bead
- 3 spacer
- 4 pressing

**Figure 7 — Transfer and pressing of the adhesive bead to the test surface (front view)**

The bead application method and, if applicable, the open time conditions shall be indicated in the test report.

**7.3 Adhesive strength test method B — Peel strength**

Prepare at least three bonded test panels/adherends for each test.

Following the cleaning and the application of the pretreatment layer, the front part of the adherend shall be entirely masked (see [Figure 8](#) and [Figure 9](#)). This will later facilitate initial lifting of the adhesive area.

Apply a bead of appropriately tempered adhesive to the accordingly prepared adherend.

During bead application, the nozzle tip shall be placed carefully on the substrate without damaging the surface. If damage cannot be excluded, application is done near to the surface without touching it. For this purpose, the drawing speed of the application gun and the adhesive discharge rate shall be reduced such as to apply a sufficient amount of adhesive.

Press the bead to the desired thickness by using the peeling plate conditioned according to [7.1](#). For this purpose, the amount of the previously applied adhesive should have been chosen such as to ensure an excess of adhesive on each side of the test panel/adherend. Remove the excess by means of a spatula.

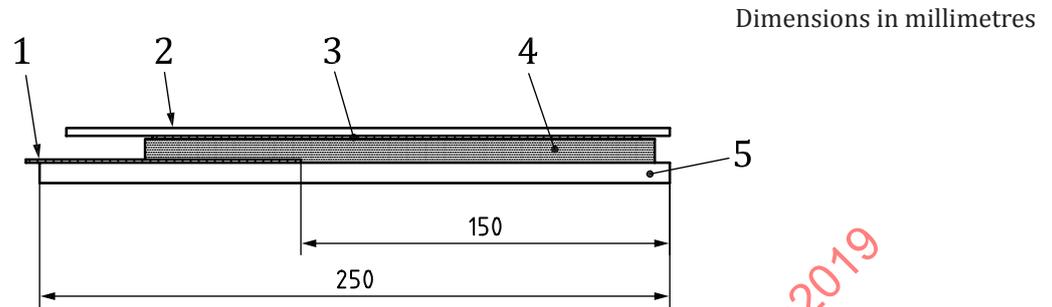
For elastic bonding, e.g. of windscreens where a clearance of approximately 5 mm is required, a typical specimen geometry may be as follows:

Bead length	min 200 mm
Width of peeling plate and applied adhesive	(25 ± 2) mm
Bond thickness	(5 ± 1) mm

When combining several ageing tests on one pair of beads (sequential testing), the sequence, the conditions and the conditioning between the individual exposures shall be specified for each ageing test. The bead shall be long enough to provide a length of about 5 cm for reference purposes and for each test.

In order to ensure complete curing, the curing time for this specimen geometry is approximately 14 days at  $(23 \pm 2) ^\circ\text{C}$  and  $(50 \pm 5) \%$  relative humidity in accordance with ISO 3270.

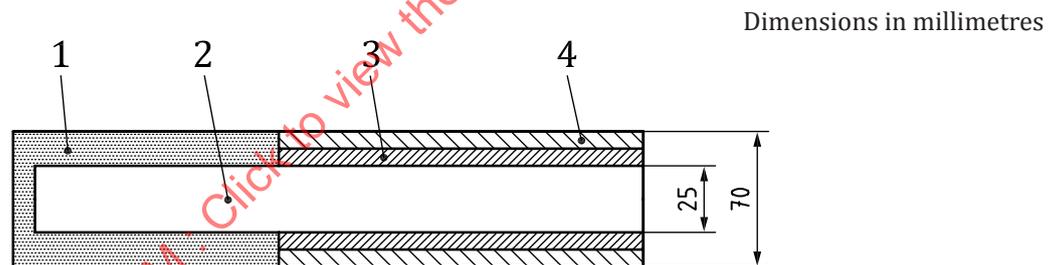
For the peel strength specimen assembly see [Figure 8](#) and [Figure 9](#).



**Key**

- 1 PE film/baking paper
- 2 peeling plate
- 3 activator/primer
- 4 adhesive
- 5 test panel/adherend

**Figure 8 — Peel strength specimen assembly (lateral view)**



**Key**

- 1 PE film/baking paper
- 2 peeling plate
- 3 activator/primer
- 4 test panel/adherend

**Figure 9 — Peel strength specimen assembly (top view)**

#### 7.4 Adhesive strength test method C — Tensile lap-shear strength

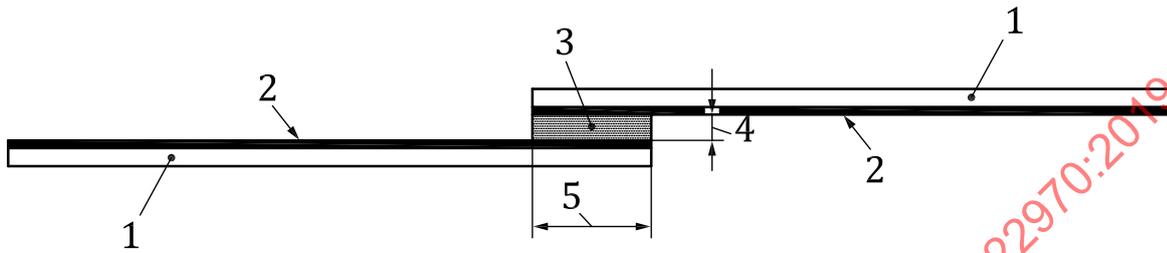
Prepare at least three bonded test panels/adherends for each test.

The lower and the upper adherend equal two coated test panels prepared according to [7.1](#).

For elastic bonding, e.g. of windscreens where a clearance of approximately 5 mm is required, a typical test panel geometry may be as follows:

Specimen length	min 75 mm
Specimen width	(25 ± 1) mm
Overlap	(12 ± 1) mm
Bond thickness	(5 ± 1) mm

Figure 10 shows the assembly of bonded adherends.



**Key**

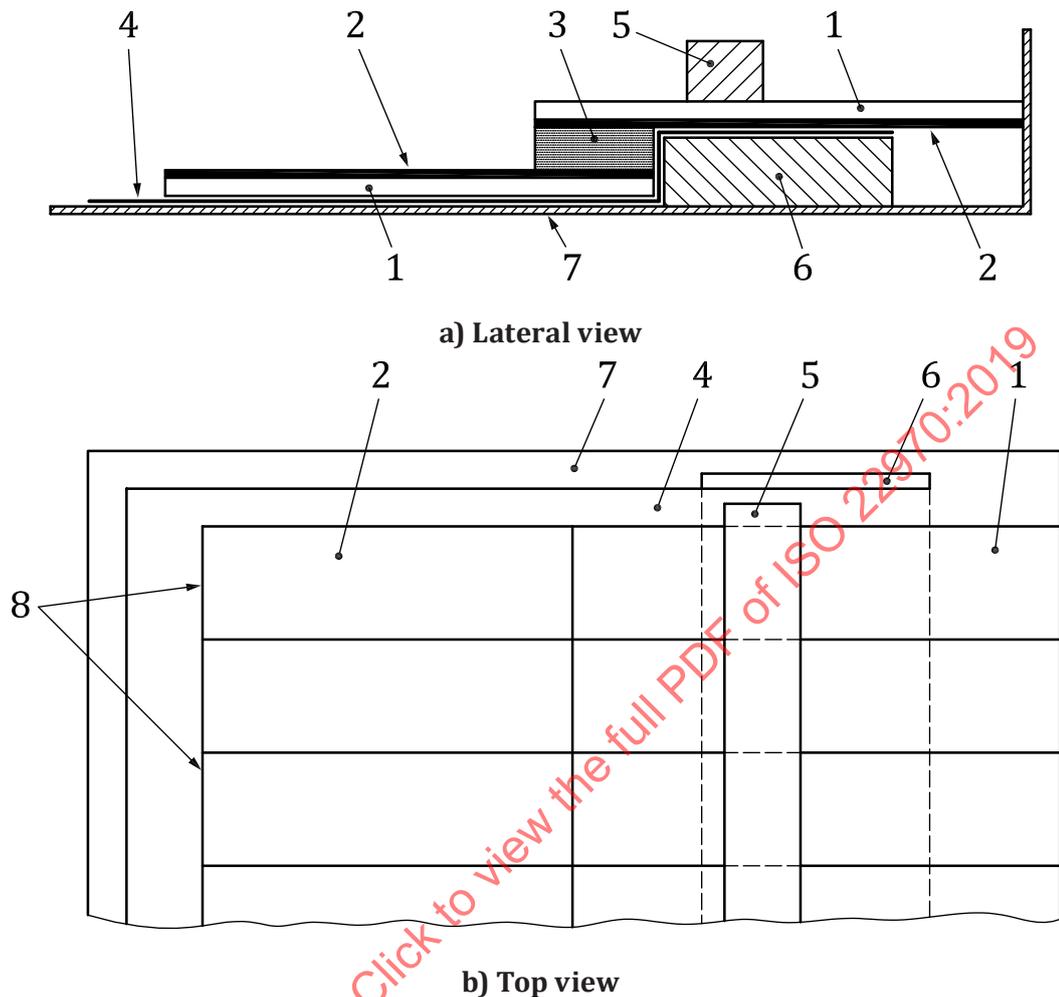
- 1 substrate
- 2 coating
- 3 adhesive
- 4 bond thickness
- 5 overlap area

**Figure 10 — Assembly of bonded adherends**

Apply a sufficient, i.e. slightly excessive, amount of appropriately tempered adhesive to a coated test panel prepared according to 7.1. Press the bonding surface using a second coated test panel while observing the defined overlap area and the bond thickness. Dimensions shall be kept constant during bonding in order to obtain comparable measurement values. In addition, carefully ensuring the correct alignment of parts is essential. Reproducibility of specimen preparation is best achieved by using a bonding frame (see Figure 11); alternatively, it is also permissible to only use spacers (see Figure 12 and Figure 13).

Fix the adherends, e.g. by means of adhesive tape or clamps, and remove excess adhesive with a spatula.

NOTE When using a bonding frame, several adherends can be prepared simultaneously.

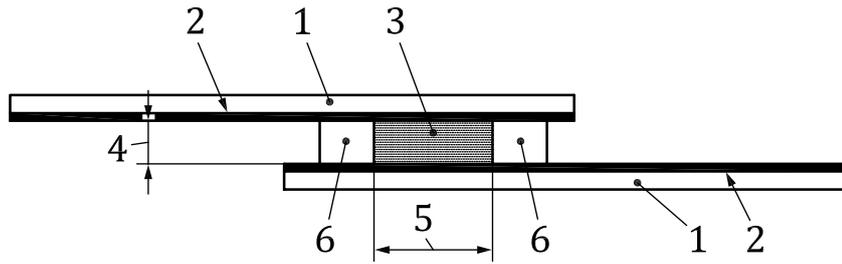
**Key**

- 1 substrate
- 2 coating
- 3 adhesive
- 4 non-adherent film (not required where the bonding frame is made of a non-adherent material (e.g. PTFE))
- 5 fixing element
- 6 spacer
- 7 bonding frame
- 8 test panels/adherends

**Figure 11 — Assembly of specimens in the bonding frame**

Where a bonding frame is not available or specimens have edge properties which are expected to affect the measurement result (e.g. due to the physically induced beading at the edge of lacquered test panels or to coatings damaged during cutting of specimens), the method with two spacers shall be preferred (see [Figure 12](#)). This enables placing the bond in the centre of the substrate.

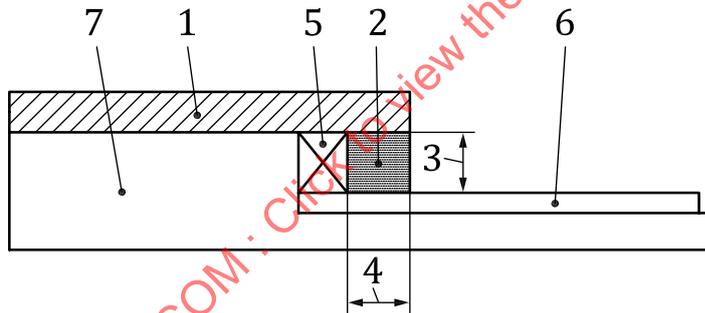
Spacers shall not bond with the adhesive and are usually removed prior to tensile lap-shear strength testing. If the spacers are not removed, their influence on the measurement shall be taken into account.



- Key**
- 1 substrate
  - 2 coating
  - 3 adhesive
  - 4 joint thickness
  - 5 overlap area
  - 6 spacer

**Figure 12 — Assembly of bonded adherends with two spacers (lateral view)**

For specimens where the edge properties of only one adherend are expected to affect the measurement result, a method with one spacer should be used (see [Figure 13](#)). Such influences due to edge properties are not to be expected in case of specimens made from, for example, glass or ceramics. In this case, a bonding frame is required.



- Key**
- 1 substrate and coating without influence on the edge properties
  - 2 adhesive
  - 3 joint thickness
  - 4 overlap area
  - 5 spacer
  - 6 substrate and coating with influence on the edge properties
  - 7 bonding frame made from non-adhesive material (e.g. PTFE)

**Figure 13 — Assembly of bonded adherends with one spacer (lateral view)**

## 8 Curing and exposure of specimens with applied adhesive

### 8.1 Curing

The adhesive shall be cured for the subsequent exposure methods and the test procedure.

In most cases it will be sufficient to cure the adhesive for 7 days at  $(23 \pm 2) ^\circ\text{C}$  and  $(50 \pm 5) \%$  relative humidity according to ISO 3270.

## 8.2 Reference value determination

Immediately after curing is completed and without prior ageing of the specimens, determine the reference values for peel adhesion, peel strength and tensile lap-shear strength in accordance with [9.1](#), [9.2](#) and [9.3](#), as applicable.

## 8.3 Exposure methods

### 8.3.1 Exposure method 1 — Condensation atmosphere with constant humidity

Condensation atmosphere with constant humidity ISO 6270-2 – CH: Expose the specimens to condensation conditions at a temperature of  $(40 \pm 3)$  °C and a relative humidity of about 100 % for 10 days.

Condition the exposed specimens prior to testing at a temperature of  $(23 \pm 2)$  °C and a relative humidity of  $(50 \pm 5)$  % in accordance with ISO 3270 for 24 h. If bond regeneration is not possible, wait at least until cooling to standard temperature  $(23 \pm 2)$  °C has occurred. This duration shall be indicated in the test report.

Subsequently, conduct testing as indicated in [9.1](#), [9.2](#) and [9.3](#), as applicable.

### 8.3.2 Exposure method 2 — Cataplasm storage

Store the specimens in an enclosed moist atmosphere in combination with temperature cycling: Wrap a specimen in a piece of cotton fabric which has been wetted with a volume of deionized water equal to 12 times its mass, wrap with aluminium foil and place the packet in a polyethylene bag. Close the bag to a waterproof seal. Wetting of the specimen shall be ensured throughout the test duration. Store the bag at  $(70 \pm 2)$  °C for 7 days and then at  $(-20 \pm 2)$  °C for 16 h.

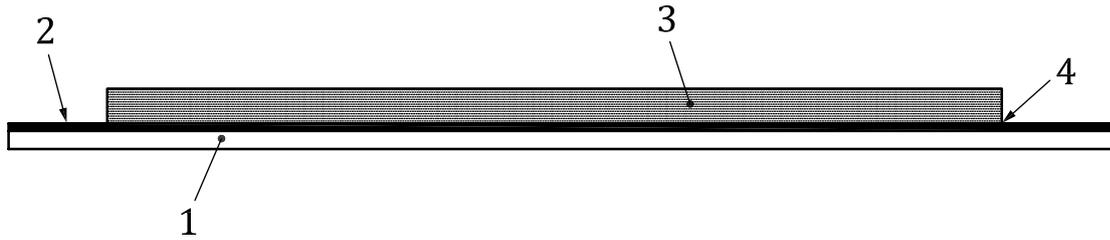
Condition the exposed specimens prior to testing at a temperature of  $(23 \pm 2)$  °C and a relative humidity of  $(50 \pm 5)$  % in accordance with ISO 3270 for 24 h. If bond regeneration is not possible, wait at least until cooling to standard temperature  $(23 \pm 2)$  °C has occurred. This duration shall be indicated in the test report.

Subsequently, conduct testing as indicated in [9.1](#), [9.2](#) and [9.3](#), as applicable.

## 9 Test procedure

### 9.1 Adhesive strength test method A — Peel adhesion

Lift the adhesive bead off the adhesive tape, if required, by using pliers. Where the adhesive has been applied without the use of adhesive tape, cut into the adhesive bead directly at the coating surface first (see [Figure 14](#)).



**Key**

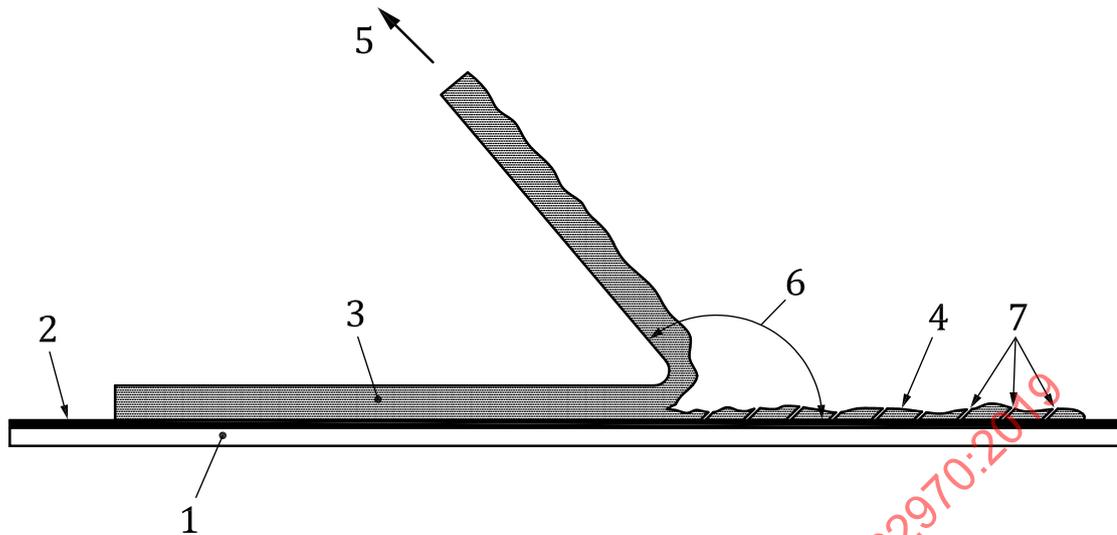
- 1 substrate
- 2 coating
- 3 adhesive
- 4 cut, adhesive tape

**Figure 14 — Preparation of peel test specimen**

Due to the elasticity of the adhesive, the peeling angle shall be between 75° and 160° as agreed between the interested parties. When selecting the peeling angle, care shall be taken that sufficient force is applied to the bead to effect clearly visible tearing of the adhesive. The free end of the bead shall be kept under tension, if necessary, by using pliers (5.1.9) and peeled off the substrate while maintaining the agreed angle (see Figure 15) or, in case of highly elastic adhesives, peeling shall be conducted by coiling up the adhesive (see Figure 16). If tearing of the adhesive occurs during the peeling process, cut the bead with a cutter (5.1.7) in regular intervals depending on the elasticity of the respective adhesive at an angle of about 45° in the peeling direction. When testing the adhesion of the adhesive on the coating, cut through the adhesive beads down to the coating surface. When doing this, damage of the surface shall be avoided. When testing the entire adhesive bond, the cuts shall run through the coating and down to the substrate. This process shall be repeated until a test segment of at least 50 mm length is released by peeling.

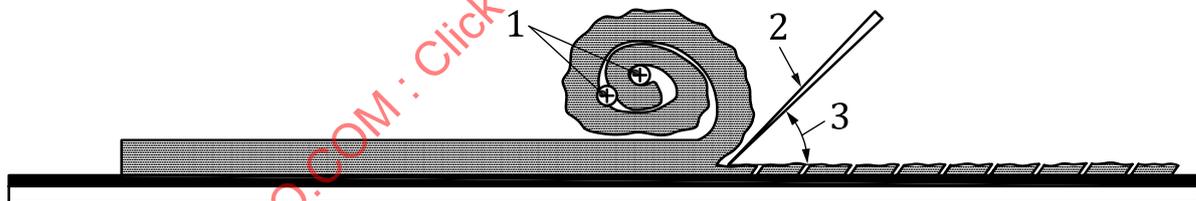
When using steel plates as substrates, a magnetized clamping device should be used.

The peeling angle shall be indicated in the test report.

**Key**

- 1 substrate
- 2 coating
- 3 adhesive bead
- 4 adhesive residues
- 5 peeling force
- 6 peeling angle, 75° to 160°
- 7 cuts

**Figure 15 — Peel adhesion testing by manual pulling**

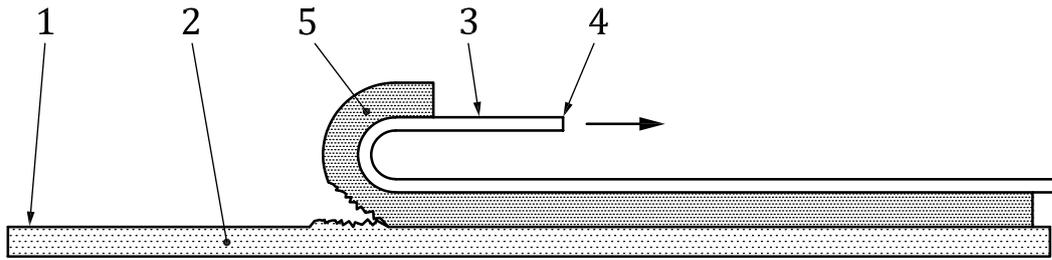
**Key**

- 1 plier tips
- 2 cutter
- 3 cutting angle, about 45°

**Figure 16 — Peel adhesion testing by coiling with pliers**

## 9.2 Adhesive strength test method B — Peel strength

Mount the adherend in the tensile test machine such as to prevent deformation under tension. Then lift the pressed bead carefully off the PE film or the siliconized paper, as applicable, bend the adhesive bond backwards using a peeling plate and fix it. Now pull the bond with uniform tension thereby peeling it off in an angle of 180°, if not agreed otherwise (see [Figure 17](#)). (Recommended pulling speed: 30 mm/min)



**Key**

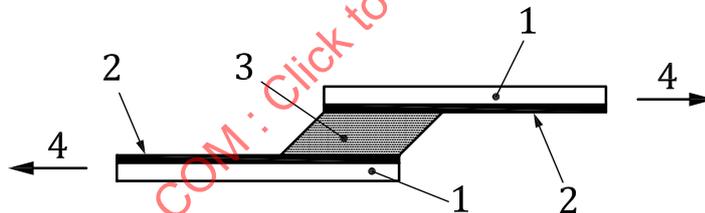
- 1 fixing by means of clamping device
- 2 adherend
- 3 peeling plate
- 4 positioning of pulling device
- 5 adhesive

**Figure 17 — Peel strength specimen assembly (top view)**

**9.3 Adhesive strength test method C — Tensile lap-shear strength**

Place the adherend symmetrically in the grips. Ensure that each grip is located  $(50 \pm 1)$  mm from the nearest edge of the overlap. If necessary, a shim may be used in the grips to ensure that the force is applied in the plane of the adhesive bond (see [Figure 18](#)).

During tensile lap-shear strength testing, ensure that the load applied to the specimen is increased at a constant rate. This rate shall be selected such as to break the specimen within  $(65 \pm 20)$  s. The rate shall be agreed and indicated in the test report.



**Key**

- 1 substrate
- 2 coating
- 3 adhesive
- 4 tensile force

**Figure 18 — Deformation within the adhesive layer of a unilaterally overlapping adhesive bond**

**10 Expression of results**

**10.1 Adhesive strength test method A — Peel adhesion**

Evaluate the ratio between those areas with cohesion failure in the adhesive and those with adhesion failure after peeling off the bead. Cohesion failure in the adhesive alone indicates a very good adhesive strength. The peel adhesion is evaluated by visually assessing the ratio between the adhesive and the cohesive fractions of the bonded area's failure pattern. Figures to facilitate designation of failure behaviour can be found in ISO 10365. Occurrence of a failure with a previously defined surface area within the coating system renders the test run invalid. This result shall be indicated in the test report together with the main plane of separation.