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Adhesives — Determination of the bond strength of engineering-plastic joints

Adhésifs — Détermination de la résistance de joints collés des plastiques industriels

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 15509 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 11, *Products*.

Introduction

Methods of determining the strength of adhesive joints are well known. Several International Standards describe various methods including the lap-shear test or the butt torsion test. However, these methods are either not suitable for the determination of values which can be used for design purposes, or are restricted to metallic substrates. Because the existing International Standards for the measurement of the strength of bonded plastic materials are derived from test methods for metals and are less suitable for plastic materials due to the bending of substrates and varying modulus of elasticity, a new test method and a new test geometry have been developed and are described in this International Standard.

Adhesives — Determination of the bond strength of engineering-plastic joints

1 Scope

This International Standard describes a test method for measuring the shear and/or tensile strength of an adhesively bonded plastic/plastic specimen of a specific design. This method allows the determination of a combined shear and tensile behaviour of the bond. These shear and tensile values are useful for design purposes.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 291:1997, *Plastics — Standard atmospheres for conditioning and testing*

ISO 10365:1992, *Adhesives — Designation of main failure patterns*

ISO 13895:1996, *Adhesives — Guidelines for the surface preparation of plastics*

3 Principle

A hollow cylindrical test specimen of specific design is used for the determination of the shear and tensile strengths of adhesively bonded plastic/plastic joints. These values can be used in calculation programmes. The rotationally symmetrical specimen allows testing under tensile, torsional or combined tensile/torsional loads if a suitable test machine is used.

NOTE 1 The shear stress is not uniformly distributed as the stress varies by approximately 15 % from the inner radius to the outer radius. Therefore the calculated shear strength represents an “average” value.

NOTE 2 The origin of the stress distribution curve is the deformation of the bond line, as the deformation increases with increasing diameter. The superimposition of shear and tensile stresses is negligible in the bondline of rotationally symmetrical specimen compared to lap-shear specimen as described in ISO 4587, *Adhesives — Determination of tensile lap-shear strength of rigid-to-rigid bonded assemblies*. There are practically no significant peaks in the stress distribution curve compared with the peaks observed in a lap-shear specimen, since the bond is continuous in the direction of the displacement.

4 Specimen

4.1 Preparation

4.1.1 General

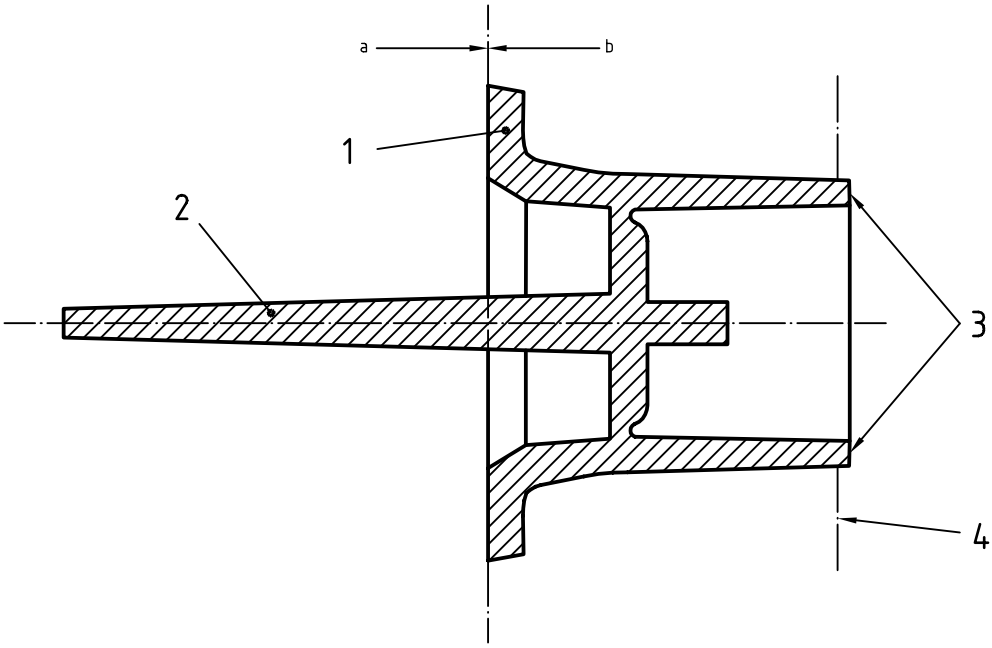
Prepare the adherends by injection moulding as described in 4.1.2 to 4.1.5.

4.1.2 Mould

The mould used shall be of the ejector-pin type with a limitation of one moulding per shot. The mould cavity shall be filled through a cone gate.

NOTE The use of this type of mould avoids weld lines which could lead to symmetry problems with the moulding after cooling, or to a weakening of the mechanical properties in this area.

A schematic drawing of an injection-moulded adherend is shown in Figure 1.



Key

1 Base of adherend
2 Sprue
3 Bonding areas
4 Degassing zone

[a] Injection direction
[b] Ejection direction

Figure 1 — Schematic drawing of one of the adherends after moulding

The mould shall be manufactured in accordance with conventional mould-making processes. It shall be of an adequate size so as to allow the preparation of adherends of the dimensions shown in Figure 2[1)].

4.1.3 Injection-moulding parameters

The parameters shall be agreed upon between the user and the plastic material supplier.

NOTE 1 The injection-moulding parameters will depend on the geometry of the mould and the nature of the plastic material.

1) One possible supplier of such a mould is Rusko-Formen GmbH, Friedrich-List-Straße 10, D-73249 Wernau, Germany.

Dimensions in millimetres

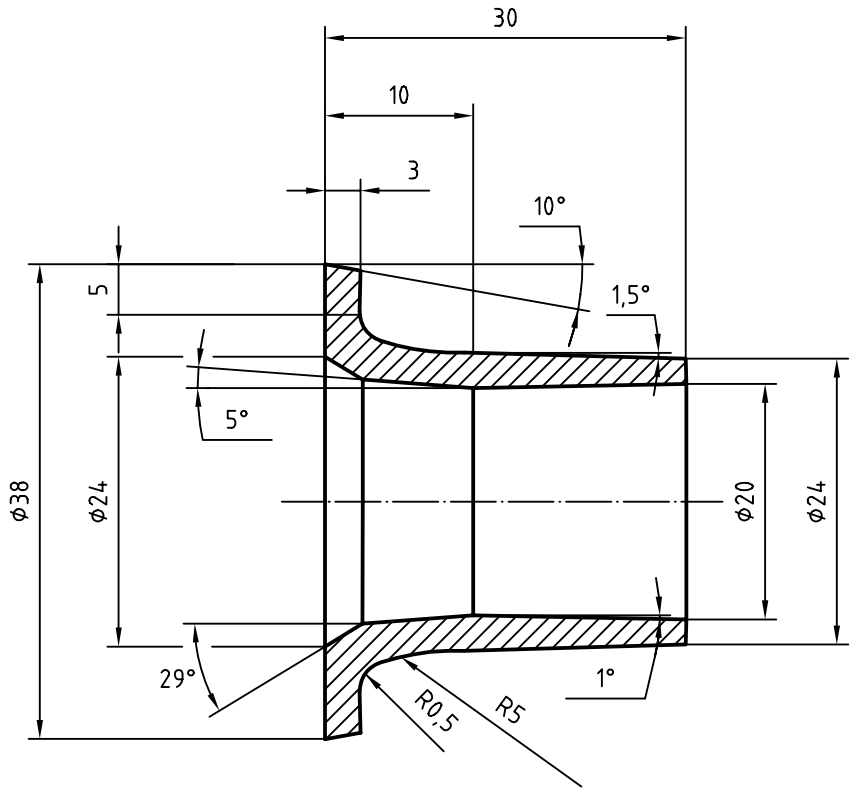


Figure 2 — Dimensions of adherend

The plastic material shall be pre-dried. The temperature and time shall be as agreed upon between the user and the plastic material supplier.

NOTE 2 Temperatures between 100 °C and 150 °C (depending on the type of plastic) over periods of 4 h to 6 h in a vacuum oven are the preferred conditions.

4.1.4 Removal of the sprue

Remove the central part, or sprue, from each of the adherends. A simple method consists of using a chisel while rotating the adherend in a lathe.

Avoid any contact with the bonding area during this operation.

4.1.5 Geometry

The specimen shall consist of two adherends bonded together.

The dimensions of each adherend shall be as given in Figure 2.

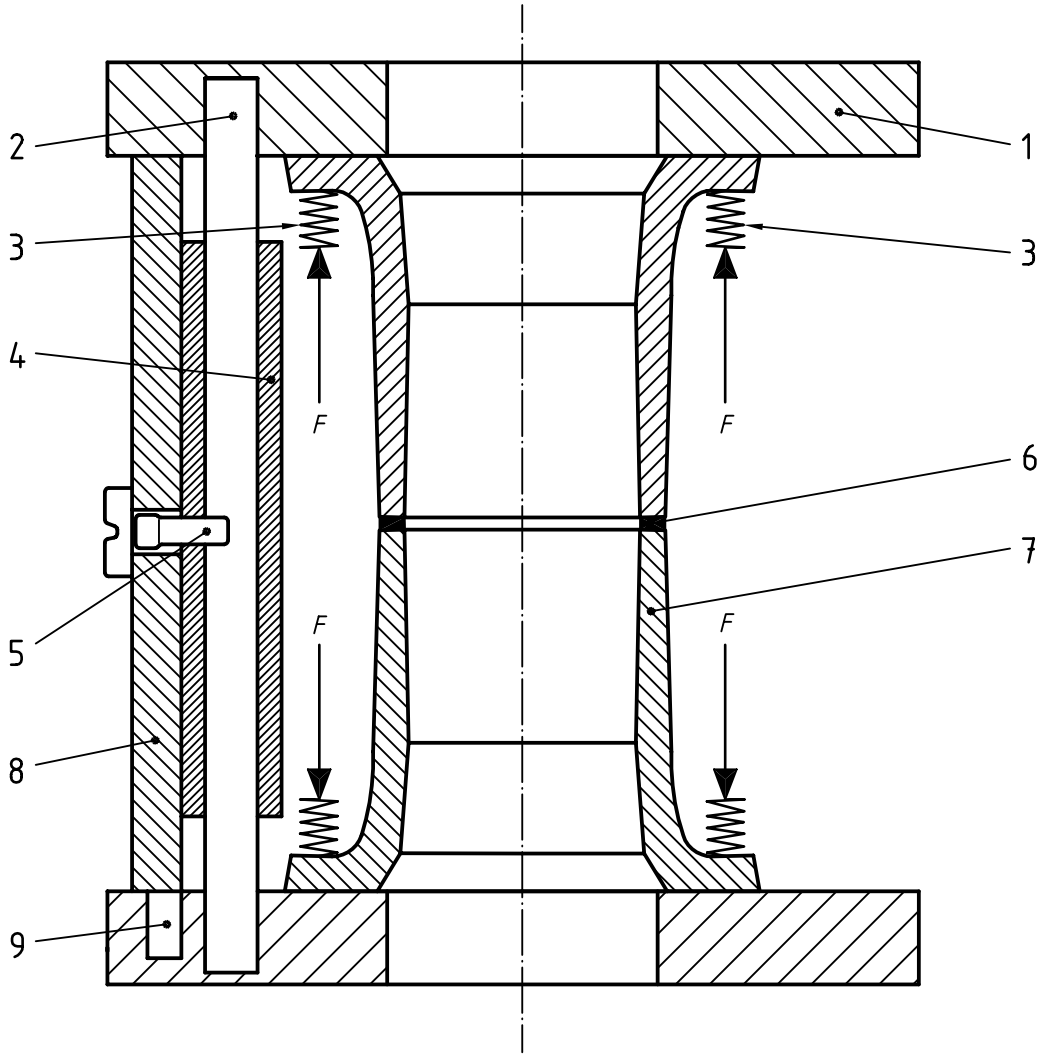
4.2 Surface preparation

Prepare the bonding surfaces of the adherends in accordance with ISO 13895.

NOTE Corona discharge at ambient pressure is the preferred method.

4.3 Assembly of the specimen in the mounting jig

Assemble the specimen using the mounting jig shown in Figure 3.



Key

1 Baseplate
2 Guide pin
3 Fixation holding the adherend on the baseplate
(three fixation points round the circumference, using springs exceeding a force higher than the weight of the adherend)
4 Metal sleeve
5 Screw for fixing spacers on the metal sleeve
6 Gap for adhesive bond
7 Adherend
8 Spacer used to define the bond gap thickness
(three pairs of spacers round the circumference, manufactured from the same material as the adherends)
9 Adjustment screw (for adjusting bond gap)

Figure 3 — Schematic drawing of the specimen during the assembly process

NOTE 1 The mounting jig allows a small amount of movement of the adherends. This compensates for deformations which are caused by the shrinkage or thermal expansion of the adhesive and the adherends during curing.

The spacers shall be made of the same material as the adherends in order to eliminate differences in thermal expansion between the spacers and the adherends.

The spacers shall be linked to the metal sleeves which shall be freely movable along the guide pins.

The alignment of the adherends in the two halves of the mounting jig shall be ensured by a metal centering cone on each baseplate. Each cone shall be freely rotating and have a spring (strong enough to prevent the adherend sliding) which presses the adherend against the centering cone. When contact is established between the adherends and the centering cones, fix the adherends in place at the fixation points.

Assemble both baseplates (with the adherends but without adhesive) by introducing the guide pins into the sleeves and verify the gap between them (for the adhesive bond). The gap can be adjusted ba means of the adjustement screws.

NOTE 2 The adjustment is usually made in order to achieve a bond thickness of 0,1 mm.

4.4 Application of the adhesive

Apply the adhesive using the application device as shown in Figure 4, as follows.

Place a baseplate carrying one of the adherends under the dispenser.

Adjust the dispenser so that the nozzle is located exactly above the application area. Apply the adhesive.

NOTE An automated rotating device coupled with the dispenser has been shown to give good results.

Assemble the two halves of the mounting jig and cure the adhesive in accordance with the manufacturer's instructions.

4.5 Conditioning and testing atmosphere

The specimens shall be conditioned and tested in one of the standard laboratory atmospheres specified in ISO 291.

5 Apparatus

5.1 Test machine, equipped with a temperature-controlled enclosure for tests carried out at temperatures other than ambient.

5.2 Clamping jig (see Figure 5), consisting of an adapter, and two jaws with hinge, screw and locknut.

NOTE This special clamping jig allows easy and quick fixing of the specimen in the test machine.

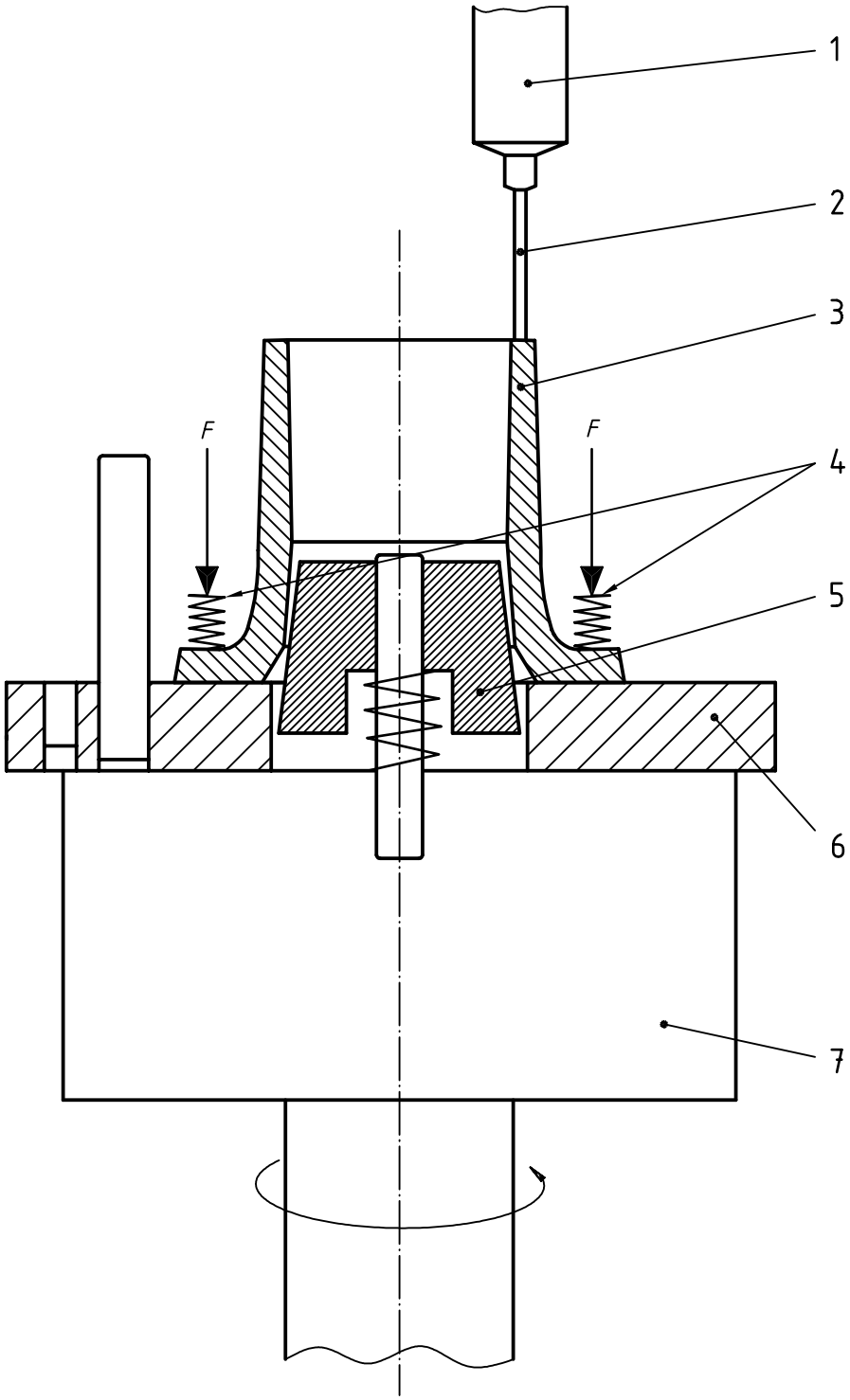
6 Procedure

Place the adapter and the specimen in the jaws. Secure them with the screws. Draw in the locknut to hold the specimen by its flange

Insert the clamping jigs in the test machine, ensuring that no load is applied to the bonded joint.

Apply a tensile force at a crosshead speed of 1 mm/min and/or a torsional force at a speed of 5°/min until the joint fails. Record the ultimate force reached during the test.

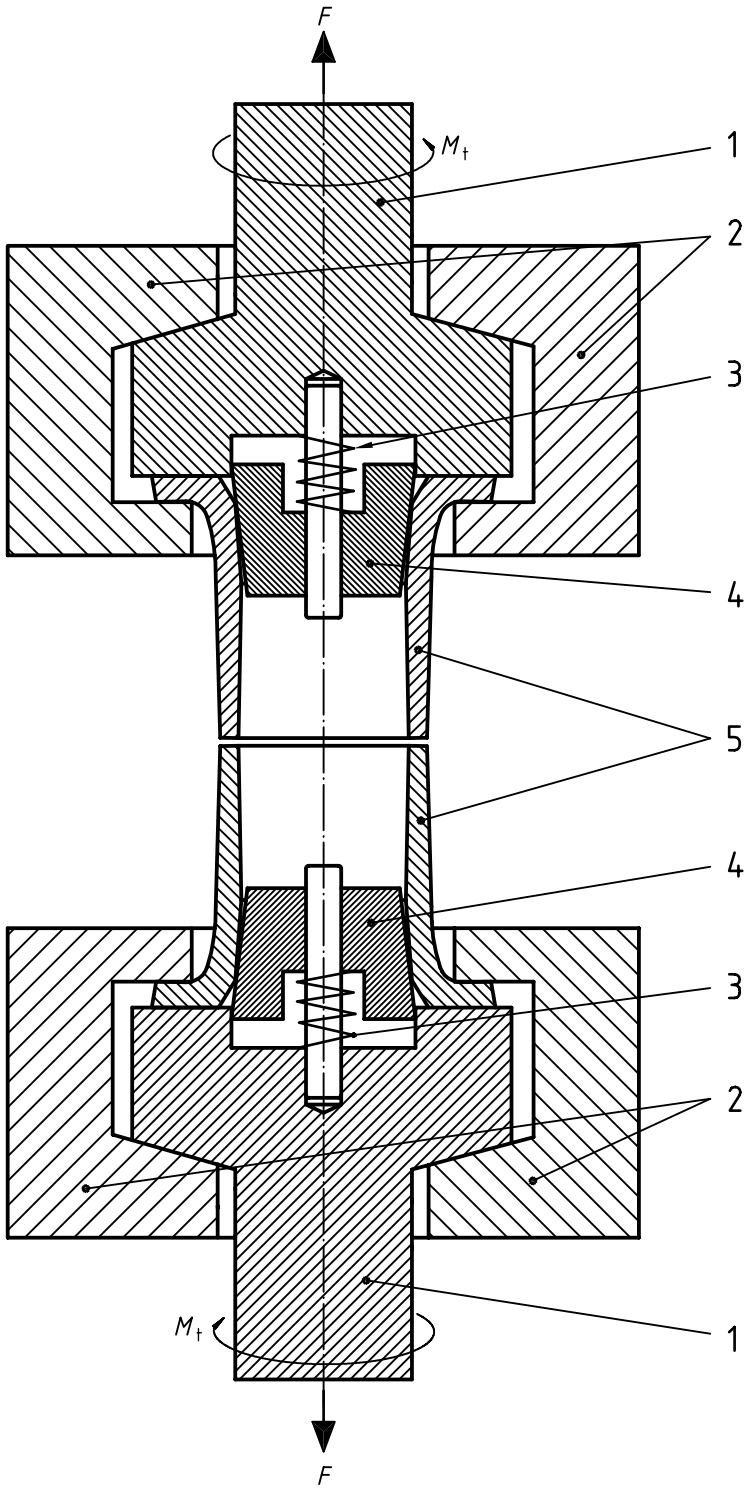
Examine the surface of the bonded parts after failure, and record the failure pattern in accordance with ISO 10365.



Key

1 Dispenser
2 Dispenser nozzle
3 Adherend
4 Fixation holding the adherend on the baseplate
5 Centering cone
6 Baseplate
7 Rotating support

Figure 4 — Application of the adhesive



Key

1 Adapter
2 Jaws (hinge, screw and locknut not shown)
3 Spring
4 Metal centering cone
5 Test specimen

Figure 5 — Schematic drawing of clamping jig

7 Expression of results

The bonded area corresponds to

$$\frac{\pi}{4}\left(d_1^2 - d_2^2\right)$$

where

d_1 is the outer diameter of the bonded area, expressed in millimetres (mm);

d_2 is the inner diameter of the bonded area, expressed in millimetres (mm).

Since $d_1 = 24$ mm and $d_2 = 20$ mm, the area is 138 m^2.

The tensile strength, in pascals is given by the force at failure in newtons, divided by the bonded area, in square millimetres.

The shear strength τ_{max} is given in megapascals by

$$\tau_{max} = \frac{M_t \times 16 \times d_1}{\pi\left(d_1^4 - d_2^4\right)}$$

where M_t is the moment at failure, expressed in megapascals (MPa).

8 Precision

The precision of this test method is not known because inter-laboratory data are not available. Inter-laboratory data are being obtained and a precision statement will be added at a subsequent revision.

9 Test report

The test report shall include the following information:

a) a reference to this International Standard;

b) all details necessary for complete identification of the adhesive tested, including type, source and manufacturer's code number, batch or lot number, etc.;

c) all details necessary for complete identification of the adherends used, including details of preparation and moulding, the method of preparation of the surface prior to bonding, the conditions used to cure the adhesive and the atmosphere used to condition the specimens;

d) the test conditions and test mode (tensile or torsional);

e) the number of specimens tested;

f) the shear and/or tensile strength of each specimen;

g) the failure pattern of each specimen, in accordance with ISO 10365;

h) the date of the testing.

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