INTERNATIONAL STANDARD

ISO 11343

Third edition
2019-06

Adhesives — Determination of dynamic resistance to cleavage of high-strength adhesive bonds under impact wedge conditions — Wedge impact method

Adhésifs — Détermination de la résistance dynamique au clivage de joints collés à haute résistance soumis aux conditions d'impact — Méthode d'impact au coin

Reference number
ISO 11343:2019(E)

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Published in Switzerland

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Foreword

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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).

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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.

This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 11, *Products*.

This third edition cancels and replaces the second edition (ISO 11343:2003), which has been technically revised. The main changes compared to the previous edition are as follows:

a) added new terms and definitions;

b) explicitly included usage of different test machines in apparatus;

c) added Note regarding signal filtering;

d) added representative points in force-time figures;

e) minor editorial changes.

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.

Adhesives — Determination of dynamic resistance to cleavage of high-strength adhesive bonds under impact wedge conditions — Wedge impact method

1 Scope

This document specifies a dynamic impact wedge method for the determination of the cleavage resistance under impact loading of high-strength adhesive bonds between two adherends, when tested under specified conditions of preparation and testing. This test procedure does not provide design information.

The method allows a choice of sheet metal or fibre reinforced plastic substrates corresponding to those materials frequently used in industry, such as for automotive applications.

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 291, *Plastics — Standard atmospheres for conditioning and testing*

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

EN 13887, *Structural adhesives — Guidelines for surface preparation of metals and plastics prior to adhesive bonding*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
dynamic resistance to cleavage
force per unit width necessary to bring an adhesive joint to the point of failure by means of a stress applied by a wedge moving between the two substrates of the joint, and thus separating the adherends in a cleaving mode

Note 1 to entry: The dynamic resistance to cleavage is expressed in kilonewtons per metre.

3.2
cracking force
maximum force after which the force falls to a plateau

Note 1 to entry: The cracking force is expressed in newtons.

Note 2 to entry: Typically, it is also the highest force measured. It characterizes the beginning of cracking.

3.3
cleavage force
momentary force during stable crack growth within the adhesive joint

Note 1 to entry: The cleavage force is expressed in newtons.

3.4
average cleavage force
average force of the plateau region, the stable crack growth zone of the adhesive joint

Note 1 to entry: The average cleavage force is expressed in newtons.

Note 2 to entry: The average cleavage force is measured between the first 25 % and the last 10 % of the curve.

3.5
dynamic cleavage energy
energy necessary to bring an adhesive joint to the point of failure by means of a stress applied by a wedge moving between the two substrates of the joint, and thus separating the adherends in a peeling mode

Note 1 to entry: The dynamic cleavage energy is expressed in Joule.

4 Principle

The method allows the determination of the average cleavage resistance, expressed as force or energy, of the adhesive bond between two adherends. The cleavage is caused by a wedge, moving at high speed, separating the adherends.

5 Apparatus

5.1 Instrumented impact-testing machine, capable of applying impact energy of at least 50 J and an impact speed of at least 2 m/s. It shall be provided with a suitable grip to hold the specimen. The jaws of this grip shall firmly engage the outer part of the ends of the adherends and shall have provision for positive location of these adherends by means of a hardened-steel bolt passing through the grips and through an 8 mm hole predrilled in the specimens, to clamp the assembly together.

For testing, falling-weight and servohydraulic-impact machines may be used as well as pendulum machines. The machine shall be equipped with an instrument capable of registering and storing the force data during the impact event, as a function of time or displacement of the wedge. The response time shall be at least an order of magnitude shorter than the impact event. The machine shall be equipped with a microprocessor/computer in order to perform the necessary calculations for expression of the results. Figure 1 represents a pendulum-type impact machine, using a piezoelectric transducer fixed to the specimen clamp.

NOTE Data collection is controlled by the machine type. A servohydraulic machine provides both force-time and force-displacement data, while pendulum-type or falling-weight machines provide only force-time data. Pendulum-type and falling-weight machines do not necessarily allow the calculation of force-displacement data by double integration. Nevertheless, all three machines are usable.

5.2 Test wedge, made of hardened steel, for cleaving the specimen (see Figure 2 and Figure 3, symmetric and asymmetric wedges).

The wedge, attached to its support frame which has a vertical degree of freedom, is pulled through the adhesive joint by the force of the impact on the frame. Because of the degree of freedom, the wedge aligns itself with the adhesive joint during the test. The included angle of the wedge, its leading-edge radius and its maximum depth will determine the progression of opening of the bonded joint ahead of the wedge tip. The wedge surface condition and state of cleanliness shall be maintained and inspected before each test, since friction unduly increases the energy consumed. A deformed, bend, scraped, roughened or otherwise compromised wedge shall be replaced and the respective test shall be discarded.

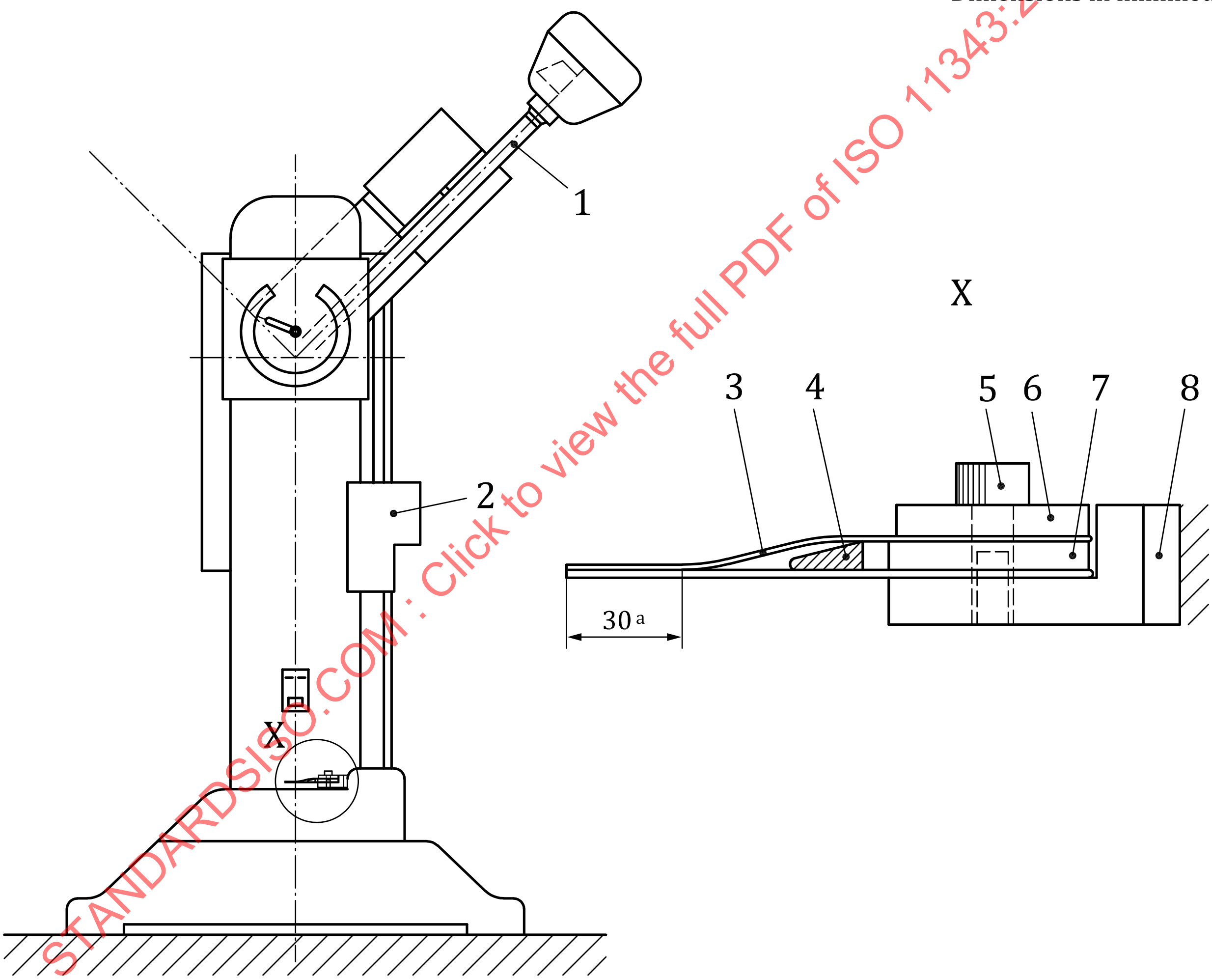
The three-dimensional diagram in Figure 4 shows the interrelation of the path of the impact head and the positions of the wedge and the test specimen.

5.3 Device for measuring thickness, with an accuracy of ±0,01 mm.

5.4 Wedge support frame, consisting of two parallel steel bars with the wedge fixed between them (at one of their ends) and a steel crosshead, for receiving the impact, positioned parallel to the wedge and connected perpendicular to the two bars at their other ends. The bar cross-section shall be 6,0 mm to 6,5 mm wide by 4,5 mm to 5,0 mm high. The total mass of the wedge support frame assembly shall be 820 g ± 5 g.

NOTE The mass of the wedge support frame assembly does not affect the impactor mass.

Dimensions in millimetres



Key

1 pendulum
2 sliding unit for setting initial pendulum height
3 specimen
4 wedge
5 specimen-retaining bolt
6 clamping plate
7 spacer
8 transducer
a Adhesive region.

Figure 1 — Example of pendulum-type impact machine

6 Specimens

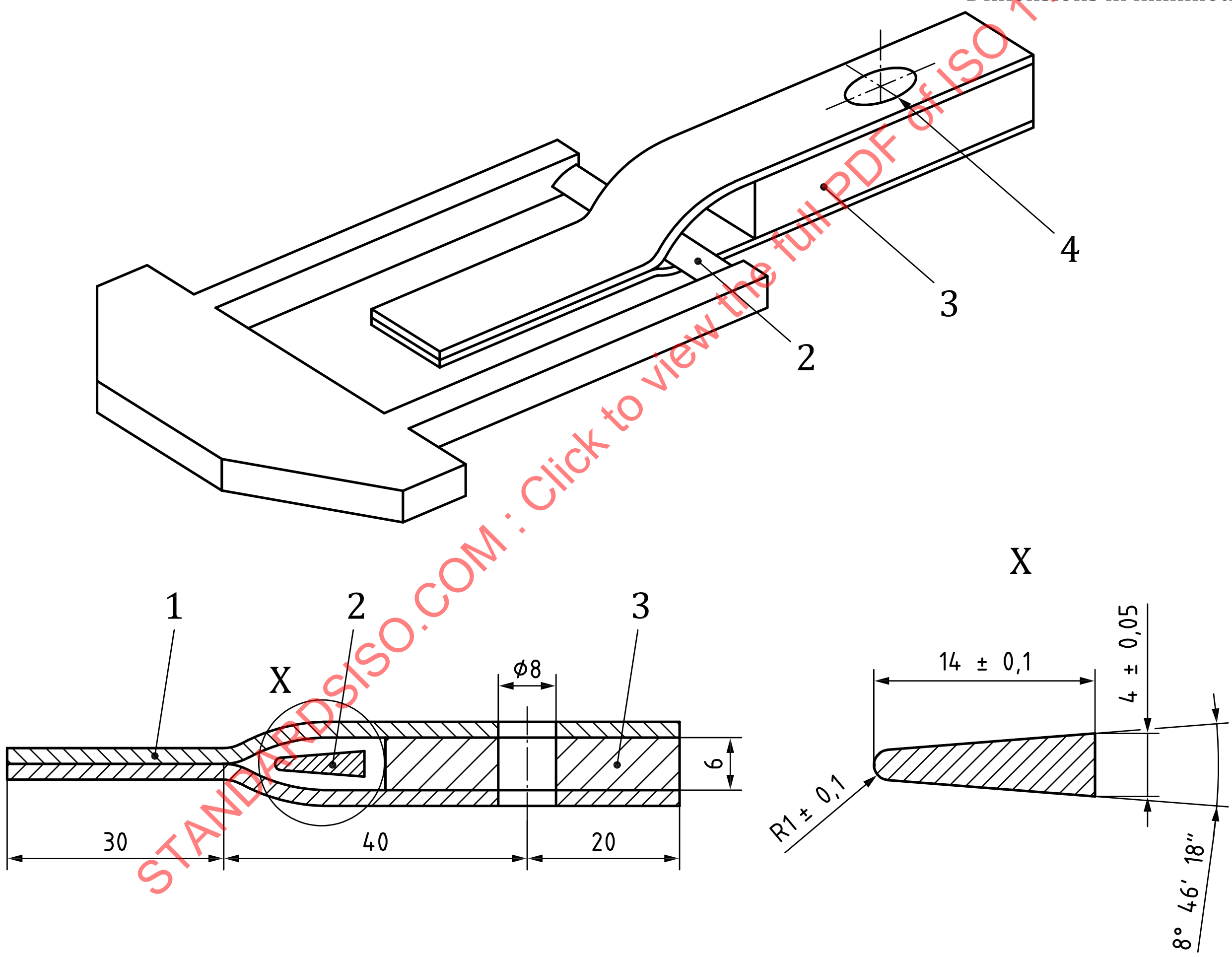
6.1 Specimens of the dimensions shown in Figures 2 and 3 shall be prepared individually, and shall consist of two adherends properly prepared and bonded together.

6.2 Surface treatment shall be such as to obtain consistent results in the bonded assembly. Thus, the preparation of the surfaces shall be in accordance with either the adhesive manufacturer’s instructions or EN 13887. When a surface contaminant, such as oil, is required for the purpose of the test, then it shall be applied in a manner that ensures uniformity between specimens.

The adhesive shall be applied in accordance with the manufacturer's instructions to obtain an optimum bond with minimum variation.

NOTE Direct comparison of different adhesives is made only when specimen construction, adherend materials and dimensions, and test conditions are identical.

Dimensions in millimetres



Key

1 specimen
2 wedge
3 spacer
4 bolt hole

Figure 2 — Symmetric wedge

6.3 The thickness of the adherends shall be chosen from sheet materials representative of industrial manufacturing and shall fall into the range 0,6 mm to 1,7 mm.

Where two adherends of different thicknesses, materials or yield point are to be tested or if the adherends are of different modulus, the asymmetric wedge shall be employed with the adherent with lower influence on the measurement on the bottom (flat side of the wedge). Usually, this is the adherent with either higher modulus or higher yield point or higher thickness. If the adherends are identical, the symmetric wedge shall be employed. The symmetric wedge is not always suitable for high strength steel or fibre reinforced plastic substrates. Use of the asymmetric wedge with a suitable steel substrate on the upper side is recommended (mixed material approach).

6.4 Specimens shall be prepared individually.

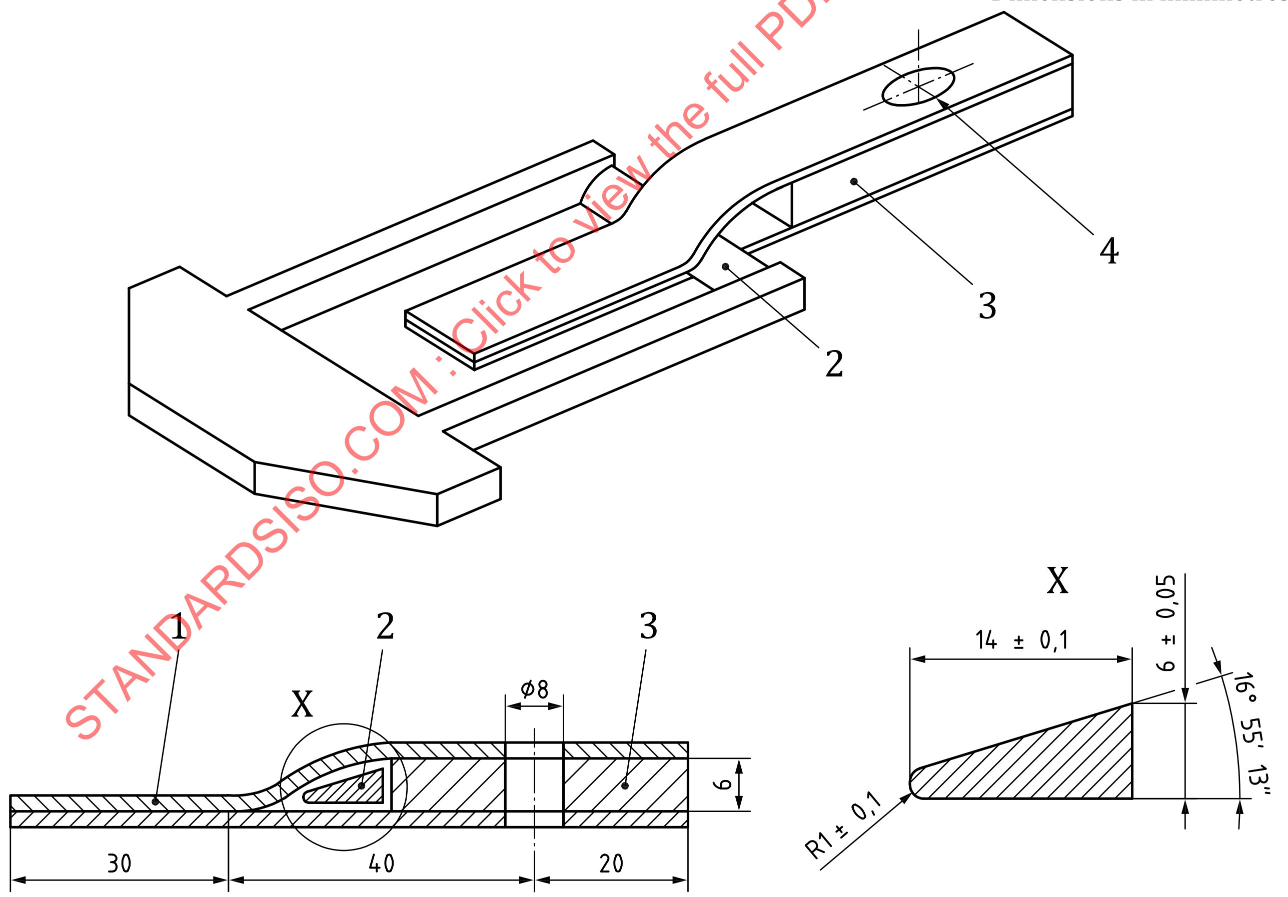
The width shall be either

a) 20 mm (preferred)

or

b) any other convenient width, provided that the test equipment is suitably adapted and the width is given in the test report.

Dimensions in millimetres



Key

1 specimen
2 wedge
3 spacer
4 bolt hole

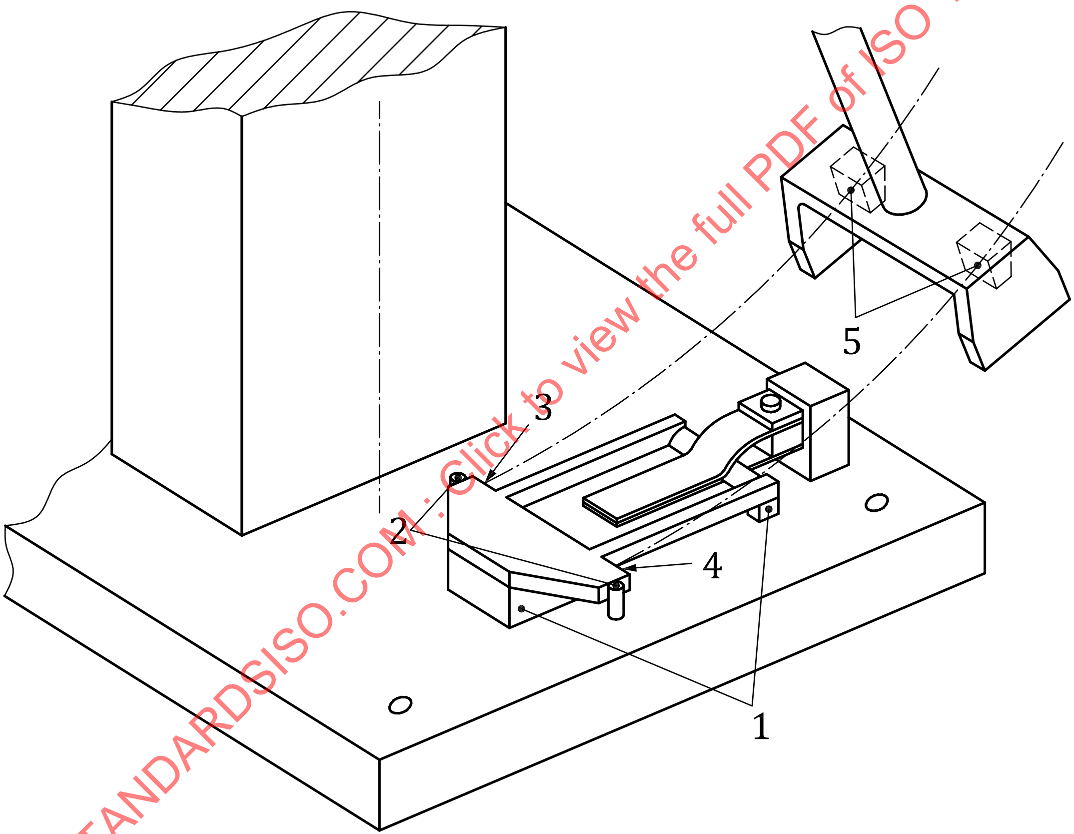
Figure 3 — Asymmetric wedge

6.5 The unbonded ends of the adherends shall be bent to allow clamping in the grip of the test machine. Adherends preformed to the shape of the wedge may also be used. When using the asymmetric wedge, only the top, thinner or lower-modulus adherend shall be bent. Since the radius of the bending influences the results, the type of bending of the substrates has to be documented. Influence on measurement is bigger with higher rigidity of the substrates.

6.6 The number of specimens to be tested shall be five or more.

6.7 The thickness of the adhesive layer after formation of the bond shall be determined on at least five specimens, to an accuracy of 0,01 mm (5.3). The variation in each dimension within a set of specimens shall not exceed 5 %. The maximum bond thickness shall be 2 mm. Specimens with a bond thickness greater than this shall be discarded. It is important, that excess adhesive is removed from the area where the wedge first hits the adhesive. Otherwise, the results, especially the cracking force, are impaired.

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



Key

1 stand for the wedge fixture
2 pins to prevent lateral slip
3 face A
4 face B
5 point of impact

NOTE Faces A and B of the crosshead are aligned parallel with the axis of the pendulum support.

Figure 4 — Three-dimensional diagram of the pendulum impact wedge test

7 Test procedure

7.1 Insert the specimen into the wedge test fixture (5.2) as shown in Figure 2 and Figure 3, with the unbonded ends protruding enough to interleave the spacer. Assemble the test fixture, tighten the specimen-retaining bolt by hand, and tighten the bolt an additional quarter turn using an appropriate tool. The wedge should be placed as close as possible to the bondline.

A typical impact velocity is 2 m/s, deviation from this is possible. The impact velocity shall be mentioned in the test report.

Select the temperature specified and allow the specimen to stabilize at that temperature for a specified period before applying the impact.

7.2 During the impact event, the transducer signal will be automatically and unselectively detected by the microprocessor and recorded; the force-time (or force-displacement) data can subsequently be manipulated separately.

7.3 Discard the result if the clamping bolt hole in the adherend becomes elongated or if the adherend fails on either side of the bolt hole. This indicates that the clamping pressure employed is insufficient and an adjustment is necessary.

8 Expression of results

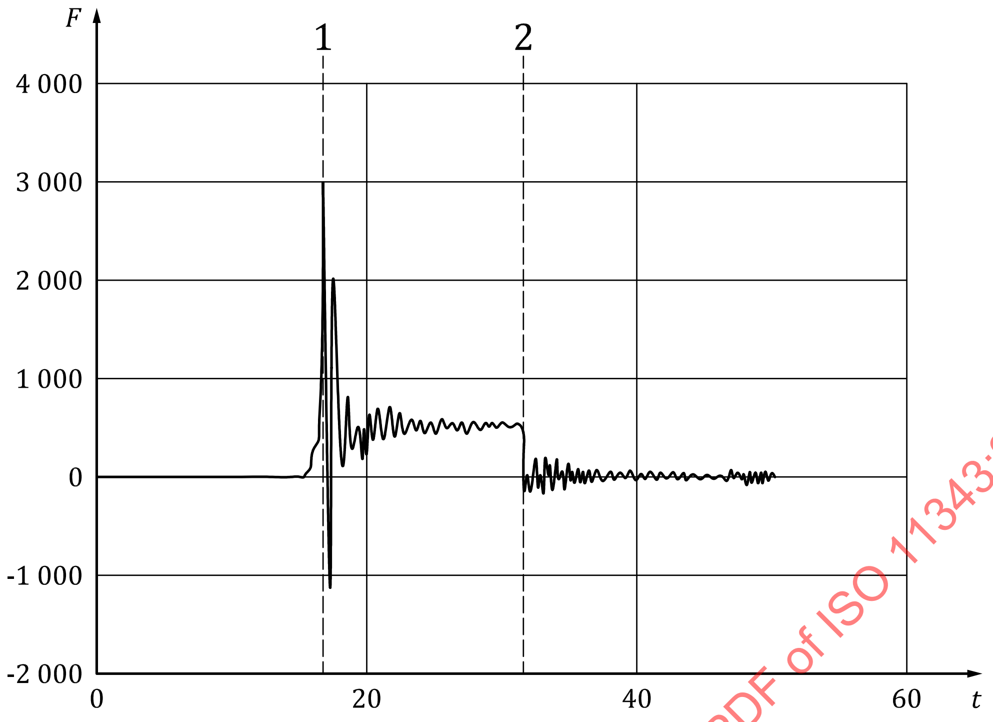
If the tested material provides force curves which are highly irregular, then discard the test result.

For a reliable evaluation characteristic points of the force-displacement (or force-time), data shall be identified.

This is first the point of cracking and second is the point where the two adherents are separated. It might happen that the data is biased with elastically stored energy in the test setup which can usually be seen as a strongly alternating force signal with declining amplitude.

Figure 5, Figure 6 and Figure 7 illustrate the identification of the relevant points in exemplary result diagrams.

NOTE 1 Due to the elastic component of the impact event, resonant oscillations can affect the results, thus making it difficult to interpret the force-deflection curve. In this case, it can be useful to carry out low-pass filtering on the recorded force-time diagram or parts of it, although the accuracy of the measurements can thereby be reduced. If post-test filtering is used, the type of filter and its essential characteristics are documented in the test report.



Key

1 cracking force

2 failure

F force

t time

Figure 5 — Example of a diagram with force transmitting zero after first point of cracking

