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Plastics — Evaluation of the adhesion interface performance in plastic-metal assemblies —

Part 5:
Fracture energy

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Contents

Page

Foreword

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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*.

A list of all parts in the ISO 19095 series can be found on the ISO website.

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.

Introduction

There is a growing demand for reliability of metal-plastic joints to make lightweight cars and aircraft, which leads to fuel savings and reduced carbon dioxide emissions. Dissimilar joints of plastics and metals is also an important technology for manufacturing high-performance, low-cost electronic components.

Against this background of industrial trends, new bonding technologies are being developed and test methods for assessing the joint performance of metal-plastic assemblies manufactured in various bonding processes need to be standardized.

ISO 19095-1 through ISO 19095-4 were developed for the metal-plastic assemblies to assess the joint strength, sealing properties and environmental durability.

This document provides a test method to evaluate metal-plastic interfacial fracture energy and to characterize the failure behaviour of joints. This test is therefore useful for qualifying a joint's ability to resist fracture in order to ensure joint integrity.

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SAFETY STATEMENT — Persons using this document should be familiar with normal laboratory practice, if applicable. This document does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices. It is recognized that some of the materials permitted in this document might have a negative environmental impact. As technological advances lead to more acceptable alternatives for such materials, they will be eliminated to the greatest extent possible. At the end of the test, care should be taken to dispose of all waste in an appropriate manner.

1 Scope

This document specifies a method of testing the adhesion in plastic-metal joints produced by several techniques: adhesive bonding, direct joining of thermoplastics by injection or compression moulding, or other methods. More specifically this testing method provides a measure of the joint resistance to fracture in the region between plastic and metal adherends.

This method can only be used for comparing adhesives, surface treatments, bonding conditions and effects of environmental conditions. The results cannot be used for engineering design purposes.

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 5893, *Rubber and plastics test equipment — Tensile, flexural and compression types (constant rate of traverse) — Specification*

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

ISO 17212, *Structural adhesives — Guidelines for the 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 https://www.electropedia.org/

3.1
energy to initiate fracture
W_F
total input energy needed to bring the test specimen up to fracture initiation

Note 1 to entry: It is expressed in joules, J.

Note 2 to entry: W_F is determined from the load-displacement curve recorded during the test, by integration, as specified in Clause 6.

3.2
fracture energy
w_F
energy per unit width of the joining area (e_1)

$$w_F = W_F/e_1$$

Note 1 to entry: It is expressed in joules per metre, J/m.

3.3
precrack
non-adhering part of the adjacent faces the two adherends of the joint, acting as a crack initiator

3.4
precrack length
a_1
length of the *precrack* (3.3) in the longitudinal direction of the joint

Note 1 to entry: As specified in Figure 1.

Note 2 to entry: It is expressed in metres, m.

3.5
'nominal crack' length (before fracture)
a
distance from the load line (i.e. the line through the centres of the holes for the insertion of the loading pins) to the tip of the *precrack* (3.3)

Note 1 to entry: As specified in Figure 2.

Note 2 to entry: It is expressed in metres, m.

4 Test specimens

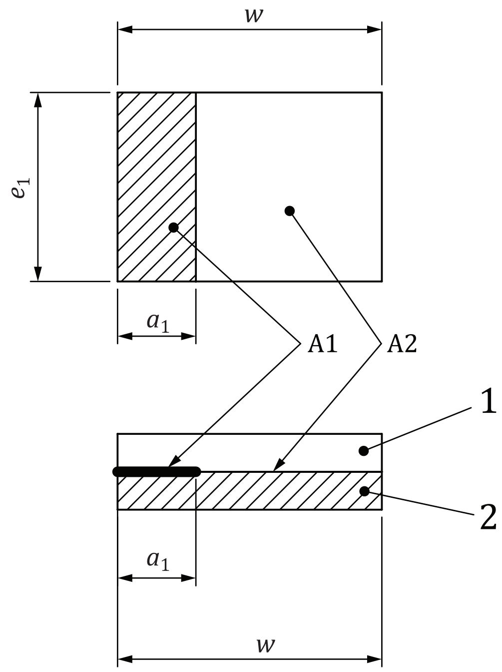
4.1 Shape and size

Test specimens shall be prepared according to Figure 1. Metal and plastic plates having a thickness of 2,0 mm ± 0,1 mm, length w and width e_1, are joined in such a way as to leave a part of the two plates on one side of the laminate (hatched area in Figure 1, top) not bonded. This part will serve as a precrack, with length a_1. Specimen dimensions are as specified in Figure 1.

To apply the load to the test specimen, load blocks are tightly bonded to both sides of the plastic-metal laminate in accordance with the geometry as specified in Figure 2.

The length, a, of the 'nominal crack' should preferably be in the range $0,45 < a/W < 0,55$, and the specimen width, e_1, is preferably equal to $W/2$.

Dimensions in millimetres



e_1	w	a_1
12,5 ± 0,2	17,5 ± 0,2	5,0 ± 0,1

Key

a_1 precrack length

e_1 width of the joining area

w length of the metal and plastic plates

1 metal plate 2,0 mm ± 0,1 mm thick

2 plastic plate 2,0 mm ± 0,1 mm thick

A1 precracked part

A2 joining part

Figure 1 — Test specimen for interfacial fracture energy measurement

4.2 Procedure for test specimen preparation

Before bonding, the surfaces involved in bonding are degreased and carefully inspected to exclude possible contamination. In the case of anisotropic materials, the reference direction shall be marked on each adherend.

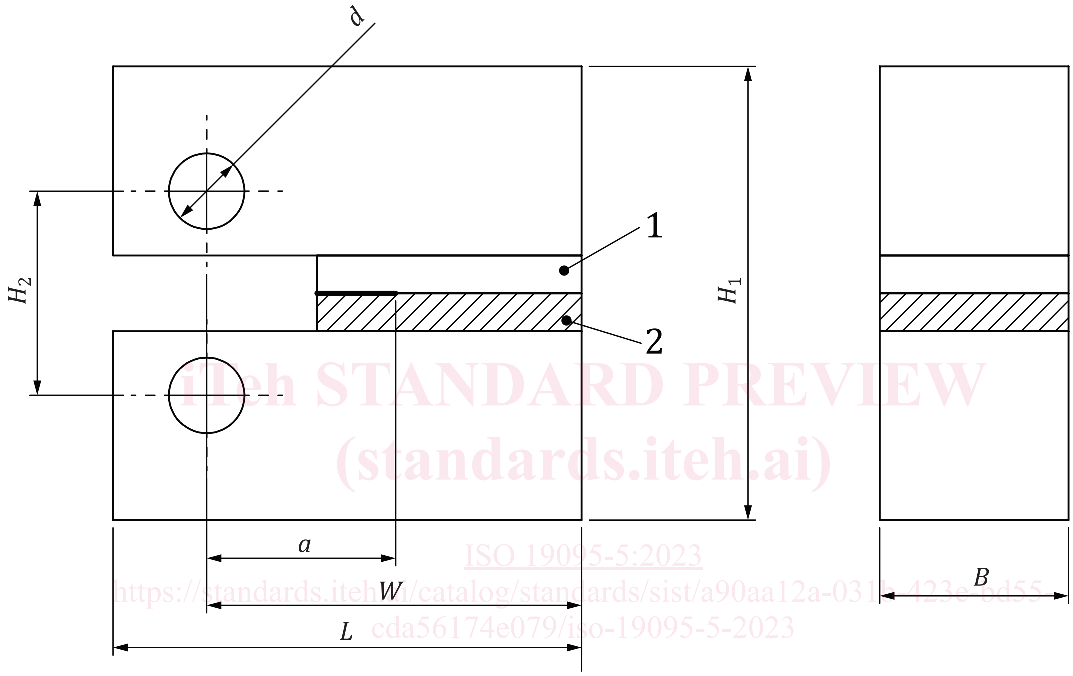
The precrack part (A1 in Figure 1) is prepared either by coating with non-stick ink the defined surface of the metal adherend (see Figure 3), or by inserting a piece of non-stick film, which is recommended to be PTFE with a thickness between 50 µm and 100 µm, between the metal and the plastic plates.

The metal and plastic plates are bonded either by adhesive, or directly by injection moulding-or compression moulding, or by other methods.

In the case of adhesive bonding, the thickness of the adhesive layer shall be carefully controlled and shall be less than 1 mm. The thickness of the layer shall not vary by more than 20 % within one joint, and the average thickness of the layer in one joint shall not differ by more than 20 % from that in another joint in the sample. When the adhesive is fully consolidated, remove any excess adhesive by mechanical means carefully enough not to weaken the bond, so as to leave the joint with smooth sides. The average thickness of the consolidated adhesive layer shall be determined for each specimen by measuring the total thickness of the bonded laminate and subtracting the thicknesses of the two adherends. The value of the layer thickness shall be selected by the user, based upon the adhesive manufacturer's recommendations or in consideration of the intended application. It is beyond the scope of this document to specify full manufacturing details of the joints to be tested. Such information should be sought from the adhesive manufacturer and/or the substrate manufacturer.

The test specimen thus prepared shall be tightly bonded to the load blocks made of metal using a suitable adhesive, as specified in Figure 2. The material of the load blocks is recommended to be an aluminium alloy or stainless steel. The adhesive can be of any type as long as it has sufficient stiffness and strength not to fail during the test. The preparation of the test specimens shall be in accordance with ISO 17212.

Dimensions in millimetres



L	H_1	H_2	W	B	a	d
31 ± 0,2	30 ± 0,2	13,5 ± 0,2	25 ± 0,2	12,5 ± 0,2	12,5 ± 0,1	5 ± 0,1

Key

L overall width of the loading blocks

W distance between the loading line (line through the centres of the holes for the loading pins) and the back edge of the laminate

H_1 overall height

H_2 distance between centres of the two pin holes in the loading blocks, symmetrically located with respect to the crack plane

d diameter of the pin hole

B width of the adherends and of the loading blocks

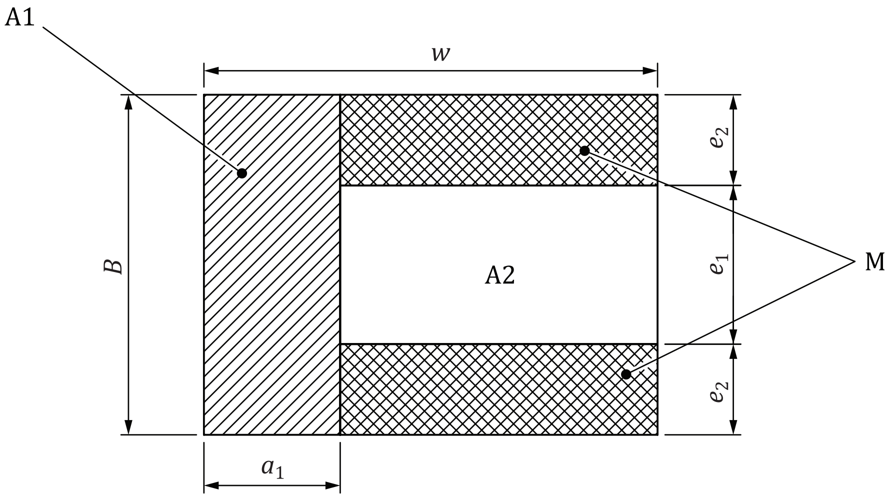
a ‘nominal crack’ length (before fracture)

1 metal plate 2,0 mm ± 0,1 mm thickness

2 plastic plate 2,0 mm ± 0,1 mm thickness

Figure 2 — Arrangement of the test specimen between the loading blocks

If the test specimen detaches from the loading blocks before it fractures in the plastic-metal bonding region, the test is invalid. In an attempt to avoid this, the joining area may be reduced up to 50 % of the original joining area (as specified in Figure 1) by masking the surface of the substrate as indicated in Figure 3. The width of the masked area, e_2, is less than $B/4$.



Key

B	width of the adherends (metal or plastic plate):	$e_1 + 2e_2 = B$
e_1	width of the joining area, with the condition:	$e_1 \geq \frac{B}{4}$
e_2	total width of the mask area, with the condition:	$e_2 \geq \frac{B}{4}$
A1	precrack part	
A2	joining part	
M	masked part	

Figure 3 — Masking of part of the adherends surface to reduce joint strength

5 Test procedure

5.1 Test machine

The test machine shall satisfy the requirements of ISO 5893. The load indicator shall show the total load carried by the test specimen. This device shall be essentially free from inertia lag at the test speeds used. It shall indicate the load with an accuracy of at least 1 % of the actual value.

5.2 Loading rigs

The test specimen is loaded by connecting the jaws of the tensile tester to the load blocks that hold the specimen via two pins inserted into the holes in the load blocks. The displacement of the load points during the test is measured near the pins (see 5.3). An example of a loading clevis designed for this test is shown in Figure 4.

