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Fibre-reinforced plastic composites — Determination of mode I interlaminar fracture toughness, G_{IC}, for unidirectionally reinforced materials

Composites plastiques renforcés de fibres — Détermination de la ténacité à la rupture interlaminaire en mode I, G_{IC}, de matériaux composites à matrice polymère renforcés de fibres unidirectionnelles

Reference number
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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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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 13, *Composites and reinforcement fibres*.

This second edition cancels and replaces the first edition (ISO 15024:2001), which has been technically revised.

The main changes are as follows:

— a new double cantilever beam (DCB) has been added [Figure 1 c)].

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.

Fibre-reinforced plastic composites — Determination of mode I interlaminar fracture toughness, G_{IC}, for unidirectionally reinforced materials

1 Scope

This document specifies a method for the determination of mode I interlaminar fracture toughness (critical energy release rate), G_{IC}, of unidirectional fibre-reinforced plastic composites using a double cantilever beam (DCB) specimen.

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 527-1, *Plastics — Determination of tensile properties — Part 1: General principles*

ISO 1268 (all parts), *Fibre-reinforced plastics — Methods of producing test plates*

ISO 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

ISO 9513, *Metallic materials — Calibration of extensometer systems used in uniaxial testing*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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/

3.1
mode I interlaminar fracture toughness
critical energy release rate
G_{IC}
resistance to the initiation and propagation of a delamination crack in unidirectional fibre-reinforced polymer matrix composite laminates under mode I opening load

Note 1 to entry: It is measured in joules per square metre.

3.2
mode I crack opening
crack-opening mode due to a load applied perpendicular to the plane of delamination using the double cantilever beam specimen

Note 1 to entry: The double cantilever beam specimen shown in Figure 1 is shown in Figure 1.

3.3
NL point
point of deviation from linearity on the load versus displacement trace

Note 1 to entry: As shown in Figure 2.

3.4
VIS point
point of the onset of delamination, as determined by visual observation, at the edge of the specimen, marked on the load-displacement trace

Note 1 to entry: As shown in Figure 2.

3.5
5 % / MAX point
point which occurs first on loading the specimen between:

a) the point of 5 % increase in compliance ($C_{5\ \%}$) from its initial value (C_0); and

b) the maximum load point.

Note 1 to entry: See Figure 2.

3.6
PROP points
points of discrete delamination length increments beyond the tip of the insert or starter crack tip marked on the load-displacement trace, points where the crack has been arrested being excluded

Note 1 to entry: See Figure 2.

3.7
delamination-resistance curve
R curve
cross-plot of G_{IC} for initiation and subsequent propagation values for *mode I crack opening* (3.2) as a function of delamination length

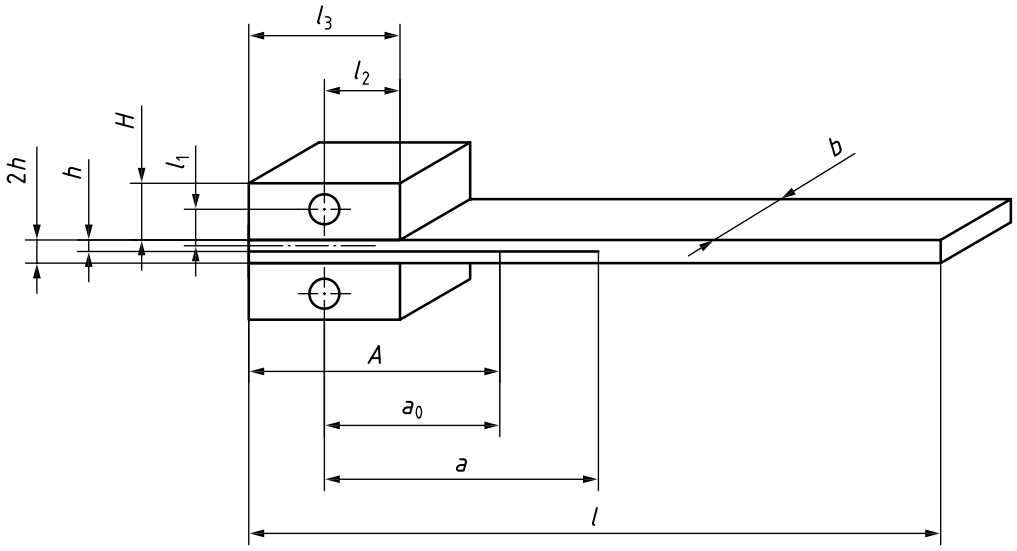
Note 1 to entry: See Clause 10.

4 Principle

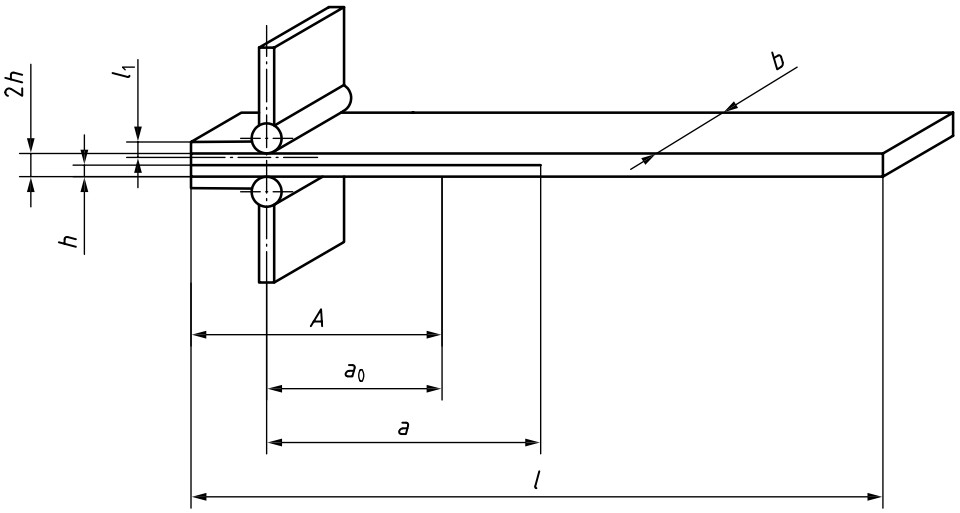
A mode I double cantilever beam (DCB) specimen, as shown in Figure 1, is used to determine G_{IC}, the critical energy release rate, or interlaminar fracture toughness, of fibre-reinforced plastic composites. Figure 1 represents three different loading arrangement for the specimen as following, a) Specimen loading using load blocks, b) Specimen loading using piano hinges, c) Specimen loading using insert hinges (see Annex D). The test method is limited to zero-degree unidirectional lay-ups only (see B.1). Data reduction yields initiation and subsequent propagation values of G_{IC} for mode I opening fracture toughness. A delamination-resistance curve, or R curve, is generated by plotting G_{IC} on the ordinate as a function of delamination length plotted on the abscissa.

The aim of the test method is to determine initiation values for the composite material tested. Fibre bridging is observed in a DCB test and it might not be representative of the composite material tested. Fibre bridging is considered to be the main cause for the observed shape of the R curve, which typically rises before reaching a roughly constant value of G_{IC} for long delamination lengths. A crack-opening load is applied to the DCB specimen, perpendicular to the plane of delamination, through load blocks or piano hinges under displacement control at a constant rate. The DCB specimen contains a thin, non-adhesive starter film embedded at the midplane as shown in Figure 3, which is used to simulate an initial delamination. The specimen is precracked by unloading the DCB specimen immediately after the first increment of delamination growth from the insert, followed by re-loading. The onset of stable delamination growth is monitored, and the delamination initiation and propagation readings are recorded. The R curve is plotted with the initiation values from both the insert and the mode I precrack,

and with the propagation from the precrack. Under certain prescribed circumstances (see 9.2.7), an alternative wedge precracking procedure can be used but is not recommended.



a) Specimen loading using load blocks



b) Specimen loading using piano hinges