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Fibre-reinforced plastic composites — Determination of the mode II fracture resistance for unidirectionally reinforced materials using the calibrated end-loaded split (C-ELS) test and an effective crack length approach

Composites plastiques renforcés de fibres — Détermination de la résistance à la rupture en mode II de matériaux renforcés de fibres unidirectionelles en utilisant l'essai de délaminage (C-ELS) et une approche de la longueur de fissure réelle

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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).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 61, *Plastics*, Subcommittee SC 13, *Composites and reinforcement fibres*.

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Introduction

Previous attempts to determine mode II delamination resistance curves (R-curves) for composites have been hampered by the experimental difficulty of determining crack length in the absence of any applied beam opening displacement and when a complex damage zone develops ahead of the crack front. The effects of friction in the different mode II test specimens have also been widely debated and have typically been determined to introduce errors of between 1 % and 3 % in G_{IIC} determination for ELS specimens (n.b. friction effects would appear to be more significant in 3 point loaded end notch flexure (3ENF) (to be standardized by ASTM) and, particularly, in the 4 point loaded (4ENF) test specimen. Stabilized ENF was not popular in round-robin trials).

The procedure presented here uses the end-loaded split test apparatus and specifies an experimental procedure to calibrate the clamping fixture and simultaneously determine the flexural modulus of the specimen. This serves two purposes. Firstly, the clamp calibration has been found to significantly reduce scatter in the results between different test laboratories and secondly, it provides an accurate means by which crack lengths can be calculated and thus their measurement can be avoided. Although this procedure still includes an experimental determination of crack length, the use of calculated (or effective crack lengths) means that values of G_{IIC} can be determined without experimentally measured crack length values. The procedure is a development of that published by ESIS (the European Structural Integrity Society), Technical Committee 4, Polymers and Composites[1], who carried out the preliminary enabling research through a series of round-robin exercises conducted in 2004 and 2007.

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1 Scope

This International Standard specifies a method for the determination of mode II shear load delamination resistance. G_{IIC}, (critical energy release rate), of unidirectional fibre-reinforced plastic composites using the calibrated end-loaded split (C-ELS) test.

It is applicable to carbon-fibre and glass-fibre reinforced thermosets and thermoplastics.

The scope is not necessarily limited to these fibres and lay-ups, but for laminates with other types of fibres or lay-ups, no recommendations for specimen dimensions and fibre volume content are currently available.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 15024, *Fibre-reinforced plastic composites — Determination of mode I interlaminar fracture toughness, GIC, for unidirectionally reinforced materials*

3 Symbols and abbreviated terms

For the purposes of this document, the following terms and definitions apply.

a	measured delamination length, distance between the load-line (intersection of the plane through the pin-hole centre of the load-block normal to the specimen width and the plane of delamination) and the tip of the delamination on the edge of the specimen (see Figure 1)
a_o	insert film length, measured from the load-line to the tip of the insert film (seeFigure 1)
a_p	precrack length, the length between the load-line and the tip of the precrack formed in during the precracking step
b	width of the specimen
C	compliance δ/P of the specimen
C_{max}	compliance of the specimen at maximum load
C_0	initial compliance of the specimen neglecting start-up effects, e.g. due to play in the specimen fixture

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