BS EN 6033:2015

BSI Standards Publication

Aerospace series — Carbon fibre reinforced plastics — Test method — Determination of interlaminar fracture toughness energy — Mode I — GIC

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National foreword

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A list of organizations represented on this committee can be obtained on request to its secretary.

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Aerospace series - Carbon fibre reinforced plastics - Test method - Determination of interlaminar fracture toughness energy - Mode I - GIC

Série aérospatiale - Matières plastiques renforcées de fibres de carbone - Méthode d'essai - Détermination de l'énergie de ténacité en rupture interlaminaire - Mode I - GIC

Luft- und Raumfahrt - Kohlenstoffaserverstärkte Kunststoffe - Prüfverfahren - Bestimmung der interlaminaren Energiefreisetzungsrate - Mode I - GIC

This European Standard was approved by CEN on 10 August 2013.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

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European foreword

This document (EN 6033:2015) has been prepared by the Aerospace and Defence Industries Association of Europe - Standardization (ASD-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this Standard has received the approval of the National Associations and the Official Services of the member countries of ASD, prior to its presentation to CEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2016, and conflicting national standards shall be withdrawn at the latest by May 2016.

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1 Scope

This standard specifies the procedure to determine the mode I interlaminar fracture toughness energy G_{IC} of carbon fibre composites manufactured from unidirectional tape or woven fabric.

This standard does not give any directions necessary to meet health and safety requirements. It is the responsibility of the user of this standard to consult and establish appropriate health and safety precautions.

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.

EN 2565, *Aerospace series — Preparation of carbon fibre reinforced resin panels for test purposes* [1)]

EN 2743, *Aerospace series — Fibre reinforced plastics — Standard procedures for conditioning prior to testing unaged materials*

EN 6034, *Aerospace series — Carbon fibre reinforced plastics — Test method — Determination of interlaminar fracture toughness energy — Mode II — G_{IIC}* [1)]

3 Terms and definitions

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

3.1
interlaminar fracture toughness energy
the interlaminar fracture toughness energy is the energy per unit plate width which is necessary to produce an unit crack growth at an interlaminar crack between two plies of a laminate

3.2
Mode I
the mode indicates the method by which the load is applied to produce the crack. A mode I crack extends as a result of peel forces perpendicular to the crack plane

3.3
G_{IC}
G_{IC} is the designation of the interlaminar fracture toughness energy determined by a mode I test procedure

4 Principle of the method

The precracked specimen is loaded continuously by peel-forces until a total propagated crack length of approximately 100 mm has been achieved. During the crack propagation the loads and cross head displacement of the test machine will be recorded continuously. The interlaminar fracture toughness energy is calculated from the propagated crack length and the applied energy determined from the load – cross head displacement diagram.

1) Published as ASD-STAN Prestandard at the date of publication of this standard. http://www.asd-stan.org/

5 Designation of the method

The designation of the method used shall be drawn up according to the following example:

Description block	Identity block
Carbon fibre reinforced plastic materials **Determination of interlaminar fracture toughness energy** **Mode I – G_{IC} - test**	**EN6033**

Number of this standard

NOTE If necessary, the code I9005 may be placed between the description block and the identity block.

6 Apparatus

6.1 Tensile testing machine, accurate to within 1 %, in the load range used.

The misalignment of the grip faces must be less than 0,05 mm at 300 mm separation, increasing by less than 0,1 mm per metre at separations above 300 mm. Parallelism between loading heads should be better than 0,4 mm at any position of the cross head.

6.2 As tabs, bent aluminium strips of about 0,5 mm - 0,7 mm thick or hinged metallic tabs of about 1,0 mm to 1,5 mm thickness shall be used as shown in Figure 1.

6.3 A slide caliper with an accuracy to the nearest 0,05 mm.

6.4 Release film e.g. PTFE (Polytetrafluorethylene) foil of about (0,02 to 0,03) mm thickness.

6.5 Microscope of magnification of 15-25.

7 Test specimen

7.1 Test specimen description

The dimensions of the specimens shall be in accordance with Figure 1. If fabric is used, the thickness shall be of the nearest to Figure 1. The fibre direction for tape material shall be at 0° to the specimen length and at 0°/90° for fabric material.

If the specification invoking the test also asks for G_{IIC} - results according to EN 6034 from the same material, it is recommended to use the remainder of the laminate as a test specimen for G_{IIC} - test (see EN 6034 for specimen dimensions).

7.2 Test specimen preparation

The test specimens shall be cut from flat laminates which have been processed in accordance with EN 2565.

Cure processing parameters as temperature, pressure and time, as well as any detailed and/or specific information regarding the process if any, shall be given in accordance with the relevant specification invoking the test.

To introduce the initial crack, a double layer of release film (see 6.4) with dimensions according to Figure 1 shall be incorporated at the mid-plane of the laminate.

CAUTION — When testing fabric material, the results may be influenced by the positioning of the crack between the layers (nested, unnested etc.). It shall be fixed clearly before starting manufacturing the specimens, which interlaminar area shall be tested and how to manufacture specimens.

The metallic end tabs shall be bonded to the specimen according to Figure 1. A high peel strength material shall be used for bonding the tab. The bonding process (surface preparation, curing temperature) may not affect the properties of the material to be tested.

8 Procedure

8.1 Conditioning

Specimens are to be tested dry or in the as cured state at room temperature, should first be conditioned at (23 ± 2) °C, (50 % ± 5 %) RH in accordance with EN 2743 if not otherwised imposed by the relevant specification invoking the test.

8.2 Determination of dimensions

The average of a minimum of three measurements along the length of the specimen is to be recorded.

The width of the specimens shall be measured to the nearest 0,1 mm using the slide caliper (see 6.3).

8.3 Testing

Align the specimen in the test fixture.

To avoid any influence of the incorporated release film the specimen shall be loaded until an initial crack length of 10 mm to 15 mm has been achieved.

Mark the position of the initial crack tip after preloading on both sides of the specimen using microscope of 6.5. A thin layer of white ink applied to the longitudinal side faces of the specimen may be used to facilitate this measurement.

Load the specimen constantly with a cross head speed of 10 mm/min until a total crack length of about 100 mm has been achieved

Record load and cross head displacement during the test.

Mark the final crack length on both sides of the specimen using the microscope of 6.5.

Unload the specimen.

Determine the propagated crack length (see Clause 9).

Analyse the results in accordance with Clause 9.

9 Presentation of the results

To calculate the interlaminar fracture toughness energy, the following formula shall be used:

$$G_{IC} = \frac{A}{a \times w} \times 10^6$$

where

G_{IC} is the fracture toughness energy, in J/m²;

A is the energy to achieve the total propagated crack length, in J
(integration of the area of the load-cross head displacement diagram according to Figure 2);

a is the propagated crack length, in mm
(final crack length minus initial crack length);

w is the width of the specimen, in mm.

10 Test report

The test report shall refer to this standard and include the following:

10.1 Complete identification of the tested material, including manufacturers name, designation, batch number etc.

10.2 All details about the preparation of specimens.

10.3 The measured specimen dimensions.

10.4 Ageing and/or exposure conditions prior to the test.

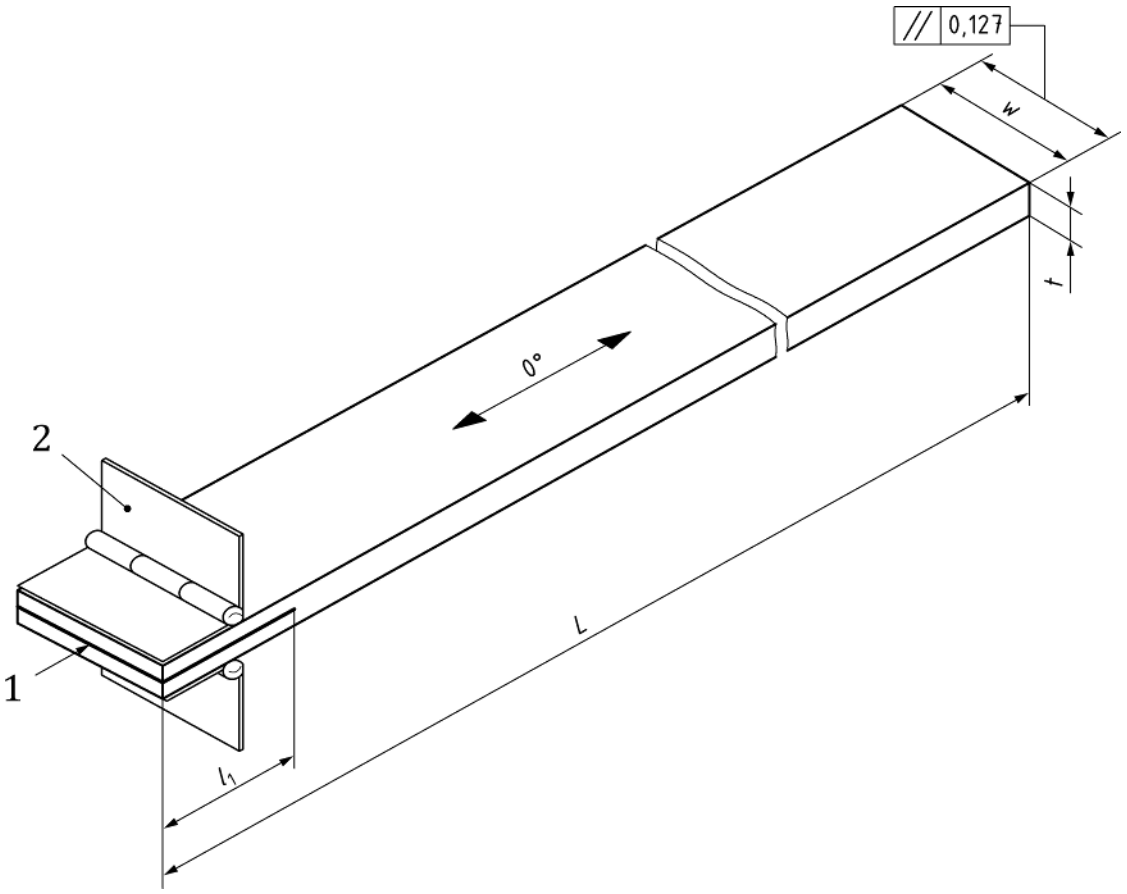
10.5 Date of test, facility and identification of individuals performing the tests.

10.6 Equipment, method and test parameters used.

10.7 Individual test results and calculations plus a set of typical load-cross head displacement curves. Individual curves shall be kept in file by the test laboratory.

10.8 Any incident which may have effected the results and any deviation from this standard. Fibre bridging in the crack or movement of the crack to plies adjacent to the mid plies shall be reported.

Dimensions in millimetres

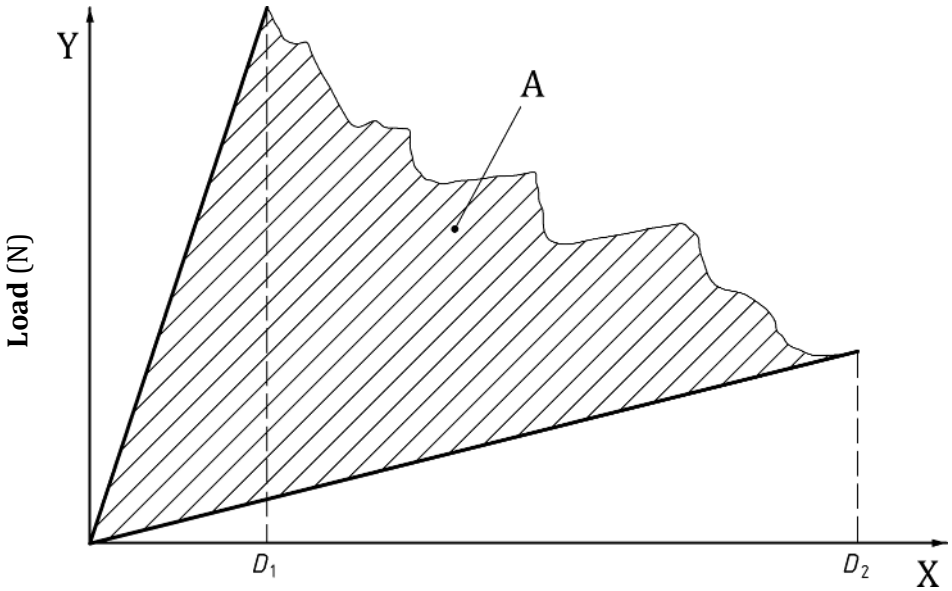


Key

1 Release film (see 6.4)
2 Tabs (see 6.2)

L = (250 ± 5) mm
l_1 = (25 ± 1) mm
w = (25,0 ± 0,2) mm
t = (3,0 ± 0,2) mm

Figure 1 — Test specimen



Key

D_1 Cross head displacement at initial crack length (see Clause 8).

D_2 Cross head displacement at final crack length (see Clause 8).

A Calculated energy (see Clause 8).

Figure 2 — Load – Cross head displacement diagram

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