BS EN 6034:2015

BSI Standards Publication

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

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National foreword

This British Standard is the UK implementation of EN 6034:2015.

Users' attention is drawn to subclause 7.1, which requires that the initial crack in the test specimen be introduced in a defined Mode I procedure (outlined in EN 6033 – *Aerospace series – Carbon fibre reinforced plastics – Test method – Determination of interlaminar fracture toughness energy – Mode I – GIC*), in order to achieve reproducible test results.
A crack produced in Mode I is a result of peel forces perpendicular to the crack plane; a crack produced in Mode II is a result of shear forces at the crack tip introduced by a flexural test (specified in EN 6034). However, the possibility of failure outlined in EN 6033 rarely occurs. The UK committee notes that in practice test results have been achieved by initiating the crack in Mode II, rather than using tested specimens from EN 6033.

The UK participation in its preparation was entrusted to Technical Committee ACE/65, Non-metallic materials for aerospace purposes.

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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English Version

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

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

Luft- und Raumfahrt - Kohlenstofffaserverstärkte Kunststoffe - Prüfverfahren - Bestimmung der interlaminaren Energiefreisetzungsrate - Mode II - GIIC

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

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

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Contents

Page

European foreword

This document (EN 6034:2015) 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

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1 Scope

This standard specifies the procedure to determine the mode II interlaminar fracture toughness energy G_{IIC} 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 2823, *Aerospace series — Fibre reinforced plastics — Test method for the determination of the effect of exposure to humid atmosphere on physical and mechanical characteristics* 1)

EN 6033, *Aerospace series — Carbon fibre reinforced plastics — Test method — Determination of interlaminar fracture toughness energy — Mode I — G_{IC}* 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 II
the mode indicates the method by which the load is applied to produce the crack. Mode Il crack extends as a result of shear forces at the crack tip introduced by a flexural test

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

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

4 Principle of the method

The end notched flexure specimen is used for mode Il testing. A precracked specimen is loaded in a three point bend fixture (see Figure 2) until crack propagation onset. The load applied to the specimen and the cross head displacement of the test machine are recorded continuously during the test. The total fracture toughness energy is calculated from the initial crack length and load-displacement diagram.

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 II – G_{IIC} - test**	**EN6034**

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 Test machine accurate to within 1 % in the load range used.

6.2 Device for recording the deflection as a function of load accurate to within 1 % in the deflection range used.

6.3 Vernier caliper accurate to the nearest 0,1 mm.

6.4 Flat face micrometer accurate to the nearest 0,01 mm.

6.5 Microscope of a magnification of 15-25.

7 Test specimen

7.1 Test specimen description

To achieve reproducible test results the G_{IIC}-test shall only be performed with specimens (see Figure 1) where the initial crack has been introduced in a defined mode I procedure (see EN 6033).

The test specimen shall be cut from the residual part of G_{IC} specimen tested or at least loaded and cracked per EN 6033, and fulfilling the following requirements.

7.2 Test specimen preparation

Prepare the required laminates according to EN 2565 method B for carbon.

The crack front remains approximately a straightline perpendicular to the longitudinal direction of the specimen (as presumed by the marks performed on both already painted longitudinal side faces of the specimen to locate the crack tips after crack stabilization under the mode I loading).

The uncracked portion of the specimen is of sufficient length to comply with the requirements of Figure 1.

The observation during the mode I loading did not show neither fibre bridgings nor moving of the crack to plies adjacent to the mid plies.

The specimen shall be cut in a way that the specified remaining crack length of Figure 1 is guaranteed.

Specimens longer than 112 mm can be used to realize a serie of tests for the determination of G_{IIC} if needed.

Appropriate identification shall be maintained throughout the specimen preparation to ensure traceability to the G_{IC} specimen and to the original laminate.

If not otherwise defined by the specification invoking the test, three specimens shall be tested per test condition.

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

8 Procedure

8.1 Conditioning

If not otherwise defined by the specification invoking the test, specimens to be tested dry or in the as cured state, should first be conditioned at (23 ± 2) °C, (50 ± 5) % RH in accordance with EN 2743, same requirements to be applied to perform room temperature testing.

Aged specimens shall be tested directly after ageing procedure (a maximum storage of 8 h at (23 ± 2) °C is allowed before testing).

8.2 Determination of dimensions

The width and length of the specimens shall be measured using a vernier caliper (see 6.3).

A minimum of three thickness measurements distributed over the specimen shall be made using a flat face micrometer (see 6.4), the average shall be recorded.

8.3 Testing

The crack length has to be measured by vernier caliper (see 6.3), using the microscope (see 6.5). A thin layer of white ink applied to the longitudinal side faces of the specimen may be used to facilitate this measurement.

For the entire duration of the test, a continuous load-displacement record shall be made, measuring the displacement of the loading nose.

Place the specimen in the test fixture in accordance with Figure 2, assuring the position of the initial crack:

$a = (35 \pm 1)$ mm

The following procedure shall then apply:

— Adjust the load cell reading at zero.

— Remove any slack between the loading nose and the specimen by making the needed displacement.

— Adjust the displacement reading at zero if necessary.

— Load the specimen under displacement control at a displacement rate of 1 mm/min.

— Optically observe the crack tip in order to detect the crack propagation onset (microscope of 6.5).

— Record the critical load at delamination crack onset and stop the loading as soon as evidence of crack propagation has been confirmed by a small load drop.

8.4 Elevated and sub-zero temperature tests

If not otherwise defined by the specification invoking the test, apply a thermocouple on the specimen as close as possible to cracked area of the specimen and seal the thermocouple from the surrounding air by using vacuum bag sealant.

The soak time at test temperature, defined by the specification invoking the test, shall be $(5 \pm 0{,}5)$ min for dry specimens and in accordance with EN 2823 for conditioned specimen.

If more then one determination is provided for, wait for crack stabilization under load and mark the current tip location on the painted sides of the specimen.

Unload the specimen to zero.

The complete procedure shall be repeated for the subsequent determinations when needed.

Unless otherwise specified, the remaining uncracked portion of the specimen shall be delaminated after removal from the test fixture (cooling the specimen down to liquid nitrogen temperature will facilitate this operation).

Verification measurements of the crack lengths shall then be made from the crack front (thumbnail marks) on the fractured specimen. Care shall be taken to protect the delamination surfaces for later inspection of failure mode if requested.

The results shall be analysed in accordance with Clause 9.

9 Presentation of the results

9.1 Calculation

To calculate G_{IIC} the following formula shall be used:

$$G_{IIC} = \frac{9 \times P \times a^2 \times d \times 1000}{2 \times w(1/4\, L^3 + 3a^3)}$$

where

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

d is the crosshead displacement at crack delamination onset, in mm;

P is the critical load to start the crack, in N;

a is the initial crack length (see Figure 2), in mm;

w is the width of the specimen, in mm;

L is the span length (see Figure 2), in mm.

9.2 Test results validation

The test results and calculation shall be valid if the crack front is approximately perpendicular to the specimen longitudinal direction and does not extensively change from a straightline across the width of the fractured test specimen.

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 Measured dimensions of the specimens.

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

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

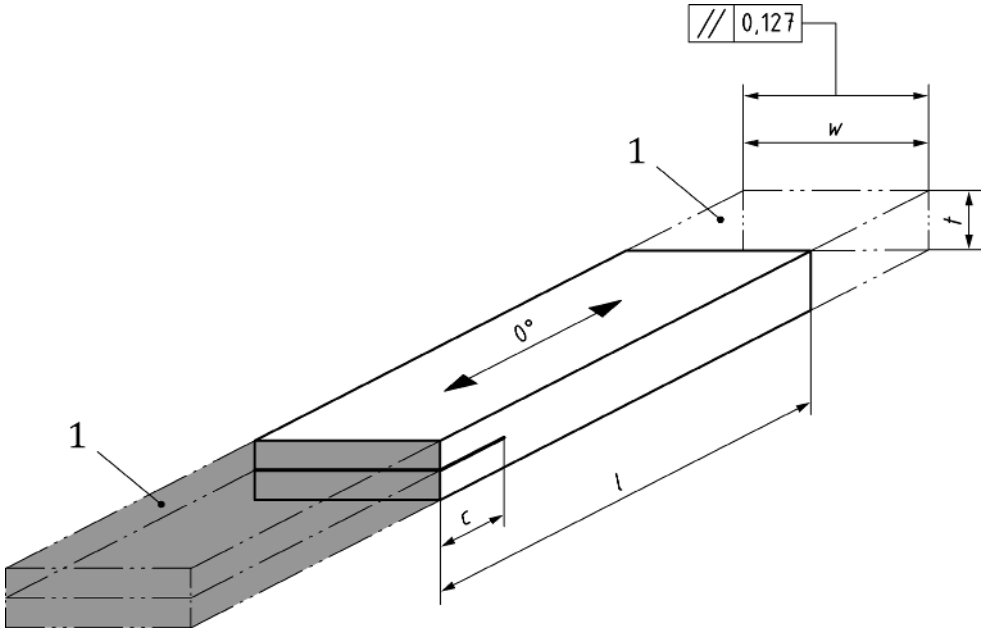
10.6 Equipment, method and test parameters used.

10.7 Individual test results and calculations plus a typical set of load-displacement curves.

The 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. Movement of the crack to plies adjacent to the mid plies shall be reported.

Dimensions in millimetres

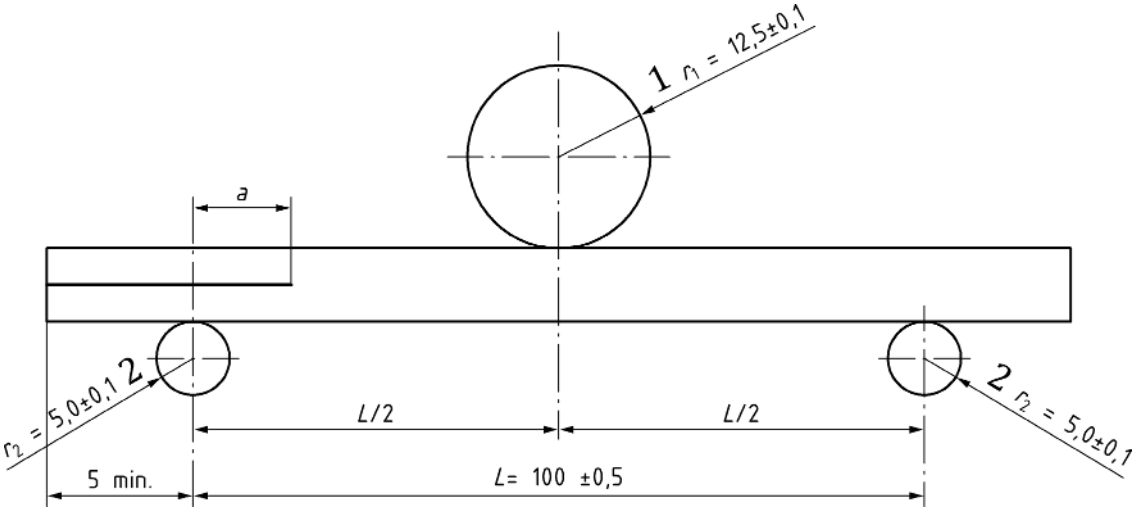


Key

1 Cuts from G_{IC} specimen

l	=	> 110	mm
w	=	(25,0 ± 0,2)	mm
t	=	(3,0 ± 0,2)	mm
c	=	(40 ± 1)	mm

Figure 1 — Test specimen



Key

1 Loading nose (steel)
2 Support steel

Figure 2 — Test fixture

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