SLOVENSKI STANDARD
SIST EN 2155-21:2001

01-junij-2001

Aerospace series - Test methods for transparent materials for aircraft glazing - Part 21: Determination of resistance to crack propagation (K factor)

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Luft- und Raumfahrt - Prüfverfahren für transparente Werkstoffe zur Verglasung von Luftfahrzeugen - Teil 21: Bestimmung des Rißfortpflanzungswiderstandes (K-Faktor)

Série aérospatiale - Méthode d'essais pour matériaux transparents pour vitrages aéronautiques - Partie 21: Détermination de la résistance a la propagation des criques (Facteur K)

Ta slovenski standard je istoveten z: **EN 2155-21:1989**

ICS:

49.045	Konstrukcija in konstrukcijski elementi	Structure and structure elements

SIST EN 2155-21:2001 **en**

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 2155

Part 21

March 1989

UDC : 629.73.023.26 : 620.191.33

Key words : aircraft industry, glazing, transparent plastics, glass, tests, strength, crack propagation

English version

Aerospace series
Test methods for transparent materials for aircraft glazing
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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat : Rue Bréderode 2, B—1000 Bruxelles

Brief history

This European Standard has been prepared by the European Association of Aerospace Manufacturers (AECMA).

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

According to the Common CEN/CENELEC Rules, following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxemburg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Contents

1 Scope and field of application

This standard specifies how the resistance to crack propagation of rigid transparent sheet is to be determined.

2 Definitions

Resistance to crack propagation is defined either by fracture toughness K at failure, or by strain energy release rate $\frac{\Delta W}{\Delta A}$ at failure.

The values of failing load and length of crack at fast fracture shall be determined by tensile tests with a specified constant rate loading using a pre-cracked standard specimen.

3 Apparatus

3.1 A tensile testing machine shall be provided such that the specimen can be loaded at a constant rate which will cause fracture in 3 to 5 min.

3.2 Suitable grips shall be provided on this machine of sufficient width to grip the specimen i.e. at least 50 mm in width. Self-tightening wedge grips have been found suitable but great care shall be taken to avoid damaging the specimen.

3.3 A driving yoke and blade for initiating cracks in the specimens shall be provided to the dimensions as illustrated in figure 1.

4 Specimens

Test specimens shall conform to figure 2. The specimen's width shall be measured to the nearest 0,2 mm and their thickness at the centre shall be measured to the nearest 0,02 mm. Five specimens shall be cut from each sample.

5 Conditioning

5.1 For testing at (23 ± 2) °C, (50 ± 5) % relative humidity the specimens shall be conditioned for at least 48 h at this condition prior to testing.

5.2 For testing at (-18 ± 1) °C the specimens shall be conditioned at this temperature for at least 30 min prior to testing.

6 Procedure

6.1 The resistance to crack propagation (toughness) of the material shall be determined as follows :

6.2 Initiation of cracks

Cracks shall be initiated on opposite sides of the centrally located hole in the specimen so as to be oriented in the width direction.

The distance between the heads of the initial cracks shall be between 12,5 mm and 25,0 mm so that the crack length at the point of instability will be between 1/4 and 1/2 of the specimen width. In initiating the cracks, the following procedure is recommended. A fine slot, approximately 0,8 mm deep is made with a jeweller's saw. The driving yoke and blade shown in the figure 1 are employed in initiating the cracks.

With the specimen held firmly in a vertical position with its length horizontal, the blade is inserted through the central hole and seated in the saw cut. The yoke straddles the specimen and engages the blade in the squared notches.

A light hammer tapping on the yoke is used to initiate the crack.

Cracks shall be initiated under conditions of conditioning according to clause 5.1 for testing under these conditions. For low temperature testing, cracks are initiated prior to conditioning at low temperature according to clause 5.2.

6.3 Gripping and loading

The specimen shall be gripped to approximately 25 mm from the ends. Care shall be taken to ensure proper alignment of the specimen.

The specimen shall be loaded at a constant rate that will cause failure in 3 to 5 min; (2,8 $\pm$ 0,5) kN/min will be suitable for most thicknesses.

6.4 Crack length

The failing load, crack length at onset of fast fracture and test temperature shall be recorded. The crack length at onset of fast fracture may be determined by closely following the progress of the crack front during slow fracture and examination of the fracture surface (figure 3 refers).

The average crack length shall be recorded to the nearest 0,2 mm. Figure 3 is a sketch of the cross section of the specimen after failure taken at the centreline of the hole.

7 Expression of results

7.1 Fracture toughness

Fracture toughness K shall be computed from the equation :

$$K = \frac{P}{t}\sqrt{\frac{\pi . Z}{B}} \quad MPa.mm^{1/2}$$

7.2 Strain energy release rate

An alternative method of assessment is to use strain energy release rate $\frac{\Delta W}{\Delta A}$ computed from the equation :

$$\frac{\Delta W}{\Delta A} = \frac{\pi . P^2 . Z}{B . E . t^2} \quad kJ/m^2$$

where :

P = failure load in N

t = thickness of the specimen in mm

B = specimen width in mm

E = modulus of elasticity in MPa, determined in a tensile test under a stress of 10 MPa

π = 3,141

$$Z = \frac{Y\,(2 + Y^4)}{(2 - Y^2 - Y^4)^2}$$ (see table 1)

$$Y = \frac{X}{B}$$

X = crack length at onset of fracture in mm

W = strain energy

A = fracture area

8 Test report

The test report shall include :

8.1 the fracture toughness expressed in $MPa.mm^{1/2}$ at (23 ± 2) °C and at (-18 ± 1) °C,

8.2 and/or the strain energy release rate expressed in kJ/m^2 at (23 ± 2) °C and at (-18 ± 1) °C.

Dimensions in millimetres

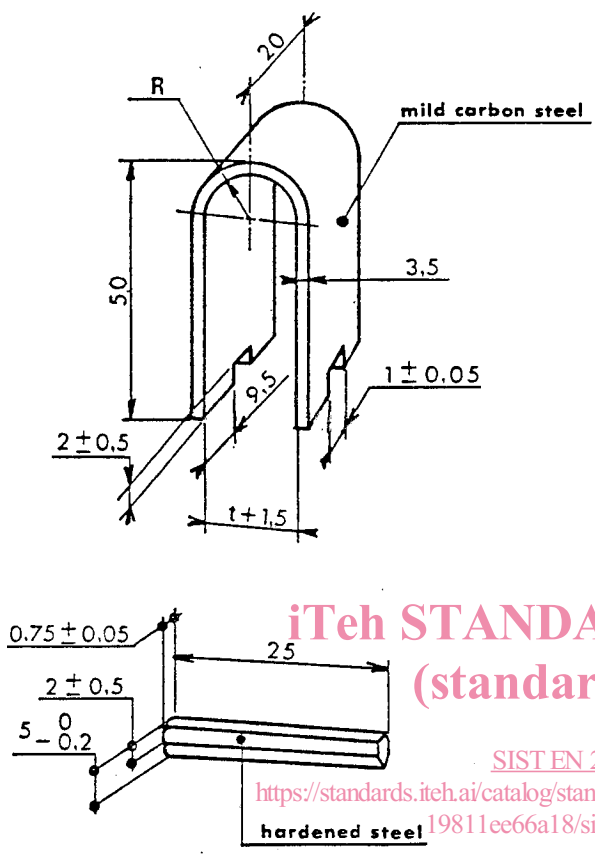

FIGURE 1 - Driving yoke and blade for initiating cracks in toughness specimens

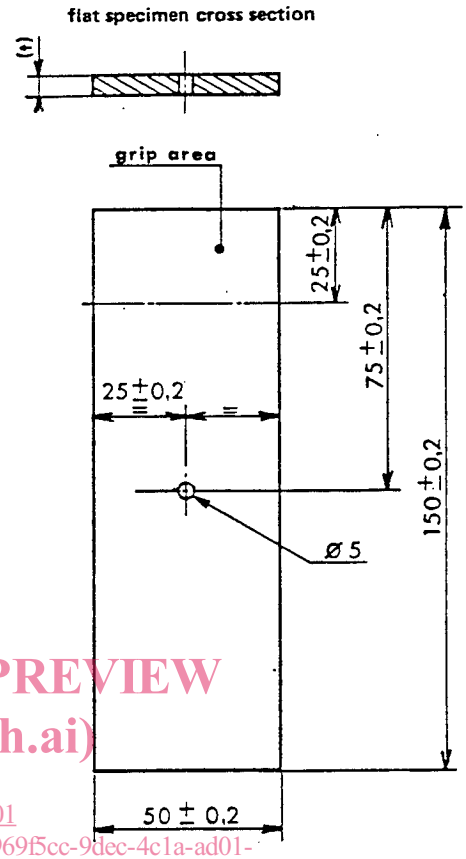

FIGURE 2 - Toughness specimen

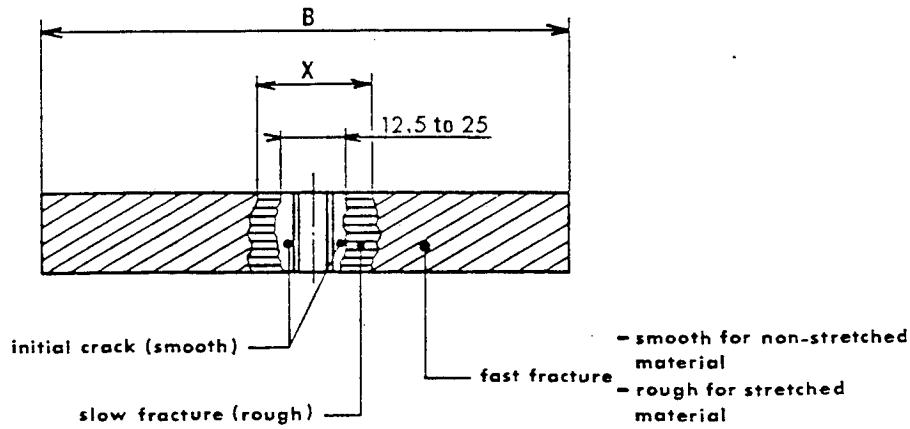

FIGURE 3 - The fracture zones on a failed specimen