INTERNATIONAL STANDARD ISO 178

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Plastics — Determination of flexural properties of rigid plastics

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up 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.

Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 178 (originally Draft International Standard ISO/DIS 1674) was drawn up by Technical Committee ISO/TC 61, *Plastics*.

It was approved in January 1969 by the Member Bodies of the following countries:

Australia	India	Romania
Belgium	Iran	South Africa, Rep. of
Brazil	Israel	Spain
Canada	Italy	Sweden
Czechoslovakia	Japan	Switzerland
Egypt, Arab Rep. of	Korea, Rep. of	Turkey
Germany	Netherlands	United Kingdom
Greece	New Zealand	U.S.A.
Hungary	Poland	

The Member Body of the following country expressed disapproval of the document on technical grounds :

France

This International Standard cancels and replaces ISO Recommendation R 178-1961.

Plastics – Determination of flexural properties of rigid plastics

1 SCOPE AND FIELD OF APPLICATION

This International Standard describes a method for the determination of flexural properties of rigid plastic material in the form of rectangular bars of standard or non-standard dimensions, moulded directly or cut from sheets or other shapes. It applies only to a simple, freely supported beam, loaded at mid-span. The following properties may be determined using the method described.

1.1 The flexural stress and the deflection at rupture of materials that break before, or at, the conventional deflection.

1.2 The flexural stress at the conventional deflection of materials that do not break before, or at, the conventional deflection.

1.3 The flexural stress at maximum load for materials that show maximum load before, or at, the conventional deflection.

1.4 The flexural stress at rupture or at maximum load, when the conventional deflection is exceeded, if so required by the material specification.

1.5 Optional : the apparent modulus of elasticity in flexure (modulus of elasticity determined by flexure test).

NOTE – The modulus of elasticity in flexure is to be considered only as an approximate value of Young's modulus of elasticity.

2 REFERENCE

ISO/R 291, *Plastics – Standard atmospheres for conditioning and testing.*

3 DEFINITIONS

For the purpose of this International Standard the following definitions apply :

3.1 deflection : The distance over which the top or bottom surface of the test piece at mid-span has deviated during flexure from its original position.

3.2 flexural stress at a given time of the test : The maximum outer fibre stress of the material in the section of the test piece at mid-span. It is calculated according to the relationship given in 7.1.

3.3 flexural stress at the conventional deflection : The flexural stress at a deflection equal to 1.5 times the thickness of the test piece.

3.4 flexural stress at maximum load : The flexural stress developed when the load reaches the first maximum.

3.5 flexural stress at rupture : The flexural stress developed at the moment of rupture.

4 APPARATUS

Standard testing machine, properly constructed and calibrated, which can be operated at an approximately constant rate, V, of relative movement of the loading nose and the supports, and in which the error for indicated loads does not exceed ± 1 % and for indicated deflections does not exceed ± 2 %.

NOTE – It is recommended that a machine be used which has less than 2 mm movement of the weighing mechanism for the full scale load.

The radius r_1 of the loading nose and the radius r_2 of the supports shall be as follows :

r_1 : 5 ± 0.1 mm

r_2 : 5 ± 0.2 mm for thicknesses of the test piece up to and including 3 mm, and

2 ± 0.2 mm for thicknesses of the test piece over 3 mm (see Figure 2).

The span shall be adjustable.

5 TEST PIECES

Prepare bars of rectangular cross-section as described in the appropriate International Standard on preparing test pieces or according to the specifications for the material to be tested.

5.1 Standard test pieces

The standard dimensions in millimetres shall be :

length l = 80 or more
width $b = 10 \pm 0.5$
thickness $h = 4 \pm 0.2$

5.2 Other test pieces

When it is not possible or desirable to use the standard test piece, the following rules shall be observed, except as noted below :

a) The length and thickness of the test piece shall be in the same ratio as in the standard test piece, that is :

$$l \text{ min.} = 20\,h$$

b) The width of the test piece may be any value between 10 and 25 mm except for materials with very coarse fillers for which the width shall be 20 to 50 mm.

NOTE — The preparation and dimensions of the test piece may be defined by the specification for the material. Alternatively, the values of width given in the table below may be used :

Dimensions in millimetres

Thickness h	Width b	
$1 < h \leqslant 3$	25	± 0.5
$3 < h \leqslant 5$	10	
$5 < h \leqslant 10$	15	
$10 < h \leqslant 20$	20	
$20 < h \leqslant 35$	35	
$35 < h \leqslant 50$	50	

5.3 Anisotropic materials

In the case of anisotropic materials, the test pieces shall be chosen so that the flexural stress in the test procedure will be applied in the same direction as that to which products (moulded articles, sheets, tubes, etc.) similar to those from which the test pieces are taken, will be subjected in service. The relationship of the test piece chosen to the application will determine the possibility or impossibility of using standard test pieces and, in the latter case, will govern the choice of the dimensions of the test pieces in accordance with 5.2. It should be noted that the position or orientation and the dimensions of the test pieces sometimes have a very significant influence on the test results. This is particularly true of laminates. (See Figure 1.)

5.4 Number of test pieces

5.4.1 At least five test pieces shall be tested.

5.4.2 The results from test pieces that break outside the central one-third of the span length shall be discarded and new test pieces shall be tested in their place.

5.4.3 When the material shows a significant difference in flexural properties in two principal directions, it is to be tested in these two directions. If, because of the application, this material is subjected to stress at some specific orientation to the principal direction, it is desirable to test the material in that orientation.

5.5 Conditioning of test pieces

The test pieces shall be conditioned as required by the specification for the material.

6 PROCEDURE

6.1 Carry out the test in one of the standard atmospheres specified in ISO/R 291.

6.2 Measure the width, b, of the test piece to the nearest 0.1 mm and the thickness, h, to the nearest 0.02 mm. Adjust the length of the span, L, to :

$$L = 15\,h \text{ to } 17\,h$$

Measure the length of the span to within 0.5 %.

6.3 For testing to a specification, V (relative rate of movement of the loading nose and supports) shall be as required in the specification for the material.

NOTE — If desired, V may be calculated as follows :

$$V = \frac{S_r L^2}{6\,h}$$

where

V is the relative rate of movement of the loading nose and supports in millimetres per minute;

S_r is the strain rate, per minute, 0.01 or as required by the material specification;

L is the span length in millimetres;

h is the thickness of the test piece in millimetres.

6.4 Load the test piece as a simple beam at mid-span without impact (see Figure 2).

6.5 If it is desired to measure the modulus of elasticity, read the load and the deflection values simultaneously sufficiently frequently so that a smooth load-deflection curve may be plotted.

6.6 For test pieces that rupture before, or at, the moment of reaching the conventional deflection (see 3.3), record the load and deflection at rupture.

6.7 For test pieces that do not rupture before, or at, the conventional deflection (see 3.3), record the load at the conventional deflection. Alternatively, if required by the material specification, continue the test without interruption beyond the conventional deflection, until rupture occurs or a maximum load is reached; record the load and deflection at whichever of these points is specified.

6.8 For test pieces that show maximum load before the conventional deflection is reached, record the maximum load and the corresponding deflection.

7 CALCULATION AND EXPRESSION OF RESULTS

7.1 The flexural stress σ_f at a load F is calculated, in meganewtons per square metre[1], from the formula :

$$\sigma_f = \frac{M}{W}$$

where

M is the flexural moment at load F, given by the formula :

$$M = \frac{FL}{4}$$

in which

F is the load, in meganewtons;

L is the span length, in metres;

W is the section modulus, in cubic metres.

For a rectangular section :

$$W = \frac{bh^2}{6}$$

and

$$\sigma_f = \frac{3FL}{2bh^2}$$

NOTES

1 If M is expressed in newton millimetres and W in cubic millimetres, σ_f is obtained in N/mm^2, numerically equal to MN/m^2. If M is expressed in kilogram-force millimetres, and W is in cubic millimetres, σ_f is obtained in kgf/mm^2.

2 For a more accurate calculation of the flexural stress which takes into account the horizontal component of the flexural moment at deflection d, the following equation may be used :

$$\sigma_f = \frac{3\,FL}{2\,bh^2}\left(1 + \frac{4d^2}{L^2}\right)$$

where d is the deflection at mid-span in millimetres.

The other terms are as previously defined.

7.2 To calculate the apparent modulus of elasticity, E_b, in meganewtons per square metre[1], a load-deflection curve is plotted using the data collected. The modulus of elasticity is determined from the initial linear portion of the load-deflection curve by using at least five values of the deflection and the load for the test piece. E_b is given by the following formula :

$$E_b = \frac{L^3}{4\,bh^3} \times \frac{F}{Y}$$

where

E_b is the modulus of elasticity;

L is the span length;

b is the width of the test piece;

h is the thickness of the test piece;

F is the load at a chosen point on the initial linear portion of the load-deflection curve;

Y is the deflection corresponding to load F.

If L, b, h and Y are in millimetres, and F is in newtons, then E_b is in N/mm^2 which is numerically equal to MN/m^2.

And if L, b, h and Y are in millimetres but F is in kilograms-force, then E_b is in kgf/mm^2.

8 TEST REPORT

The test report may include some or all of the following particulars :

a) brand, identification mark, origin, date of receipt and other pertinent data concerning the tested material;

b) method of preparation of the test pieces;

c) measured dimensions of the test pieces and the length of span used;

d) when test pieces have ruptured,

1) flexural stress at rupture, the arithmetic mean and the standard deviation (see Appendix),

2) deflection at rupture, giving the arithmetic mean and the standard deviation;

e) when test pieces have not ruptured,

1) flexural stress at the conventional deflection, (see 3.3), and/or

2) flexural stress and deflection at the maximum load (see 3.4), giving the arithmetic mean and the standard deviation in each case;

f) optional : the load-deflection curve and the arithmetic mean value of apparent modulus of elasticity, E_b, together with the standard deviation of E_b;

g) conditioning procedures and laboratory conditions.

1) $1\ MN/m^2 \approx 0.102\ kgf/mm^2$

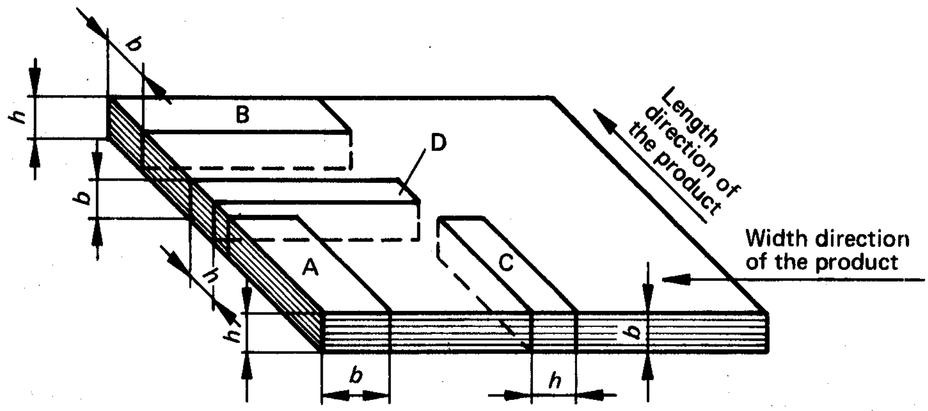

FIGURE 1 – Position of test piece in relation to length and width of sheet

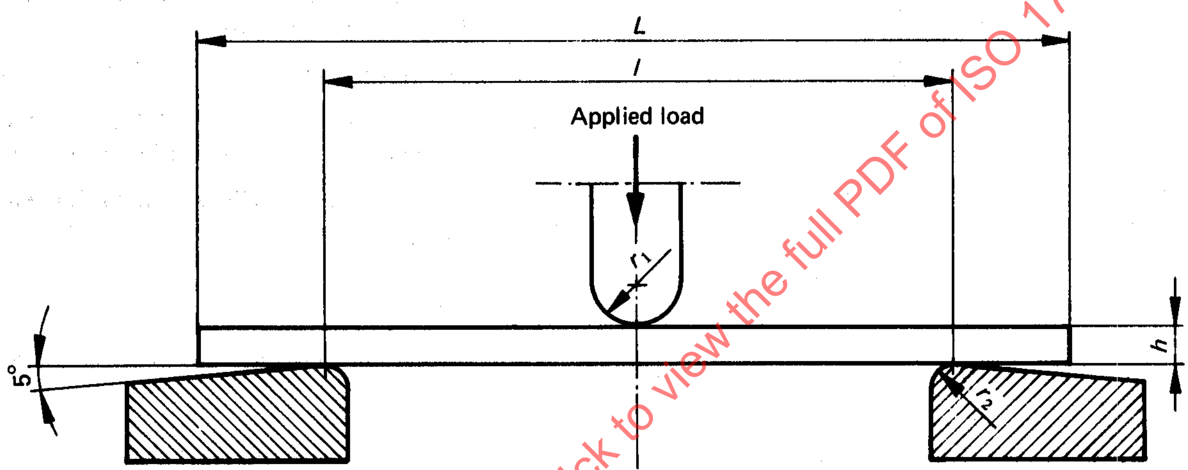

FIGURE 2 – Position of test piece during test

APPENDIX

ESTIMATED VALUE OF STANDARD DEVIATION

The value of the standard deviation, S, is estimated from the formula :

$$S = \sqrt{\frac{\Sigma (x - \bar{x})^2}{n - 1}}$$

where

x is the value of a single observation;

$\bar{x}$ is the arithmetical mean of all n values of x;

n is the number of observations.