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ISO RECOMMENDATION
R 178

PLASTICS

DETERMINATION OF FLEXURAL PROPERTIES OF RIGID PLASTICS

1st EDITION

February 1961

For each individual country the only valid standard is the national standard of that country.

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Also issued in French and Russian. Copies to be obtained through the national standards organizations.

BRIEF HISTORY

The ISO Recommendation R 178, *Determination of Flexural Properties of Rigid Plastics*, was drawn up by Technical Committee ISO/TC 61, *Plastics*, the Secretariat of which is held by the American Standards Association (ASA).

Work on this matter which the Technical Committee had begun since 1951, came to an end in 1956, with the adoption of a proposal as a Draft ISO Recommendation.

On 28 November 1958, the Draft ISO Recommendation (No. 193) was distributed to all the ISO Member Bodies and was approved, subject to some editorial amendments, by the following Member Bodies:

Australia	Hungary	Romania
Austria	India	Spain
Belgium	Israel	Sweden
Bulgaria	Italy	Switzerland
Burma	Japan	Turkey
Czechoslovakia	Netherlands	U.S.A.
France	Poland	U.S.S.R.
Germany	Portugal	

No Member Body opposed the approval of the Draft.

The Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in February 1961, to accept it as an ISO RECOMMENDATION.

ISO Recommendation R 178 February 1961

PLASTICS

DETERMINATION OF FLEXURAL PROPERTIES OF RIGID PLASTICS

1. SCOPE

This method covers the determination of the following flexural properties in order to get a measure of the resistance in flexure of test specimens having standard dimensions and of test specimens having other than standard dimensions.

1.1 The flexural stress (in kilogrammes-force per square centimetre) and the deflection at break of materials that break before or at a definite deflection.

1.2 The flexural stress (in kilogrammes-force per square centimetre) at a definite deflection of materials that do not break before or at a definite deflection.

1.3 The flexural stress (in kilogrammes-force per square centimetre) at maximum load.

1.4 Optional: the modulus of elasticity in flexure.*

2. DEFINITIONS

2.1 *Deflection* is the distance over which the loaded surface of the test specimen has deviated during flexure from its position in the original plane of this surface.

2.2 *Flexural stress* (kgf/cm^2) at a given moment of the test is the maximum fibre stress of the material in the section of the test specimen directly under the load. It is calculated according to the relationship given in section 9.

2.3 *Flexural stress* (kgf/cm^2) *at conventional deflection* is the flexural stress at a deflection conventionally fixed at 1.5 times the height of the test specimen.

2.4 *Flexural stress* (kfg/cm^2) *at maximum load* and *flexural stress at rupture* are, respectively, that at the moment when the load reaches a maximum value and that at the moment of rupture.

2.5 *Rigid plastics* are plastics that show a modulus of elasticity in shear which in any direction is larger than 5×10^3 kgf/cm^2.

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

3. TEST SPECIMENS

Bars of rectangular cross-section are prepared according to ISO Recommendation on preparing test specimens.*

3.1 *Standard specimens.* The standard dimensions are in millimetres:

length	l	= 80 or more
breadth	b	= 10 ± 0.5
height	h	= 4 ± 0.2

3.2 *Other specimens.* When for any reason it is not possible or desirable to use the standard specimen, the following rules should be observed:

(a) The length and the height of the test specimen should be in the same ratio as in the standard specimen; that is:

$$l \text{ minimum} = 20\,h$$

(b) The breadth should be chosen either in the same ratio to the height as in the standard specimen:

$$b = 2.5\,h \pm 0.5 \text{ mm}$$

or, in order to simplify the preparation of the specimens, in conformance with Table 1, because the breadth (width) has only a very slight influence on the flexural properties.

TABLE 1

Dimension in millimetres

Height h	Breadth b
from 1 to 3 included	25 ± 0.5
from 3 (excluded) to 10 „	10 ± 0.5
from 10 „ to 20 „	20 ± 0.5
from 20 „ to 35 „	35 ± 0.5
from 35 „ to 50 „	50 ± 0.5

3.3 In the case of anisotropic materials, the specimens should be chosen so that the flexural loading to which they are subjected will be applied in the same direction as that to which the products (articles, sheets, tubes, etc.) from which the specimens will be taken, will be subjected in service. It is this consideration that will determine, in particular, the possibility or impossibility of using standard specimens and, in the latter case, will govern the choice of dimensions of specimens in accordance with clause 3.2.

It should be noted that the bearing for position and the dimensions of the test specimens have sometimes a very significant importance with respect to the final result. This is particularly applicable to laminates (see Fig. 1).

* To be drafted.

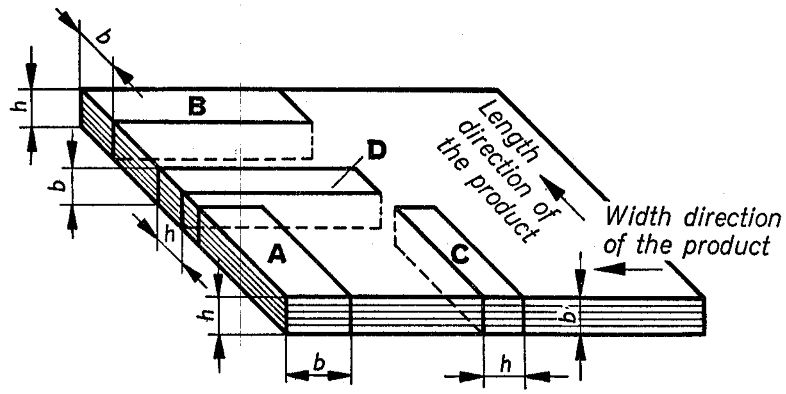

FIGURE 1. **Bearing of test specimens**

4. NUMBER OF TEST SPECIMENS

4.1 The number of test specimens should be a minimum of five and such that the results of 5 of them do not show a larger deviation from the arithmetical mean than twice the standard deviation.

4.2 Test specimens that are broken outside the middle third part are discarded.

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.

5. APPARATUS

A standard testing machine, properly constructed and calibrated, which can be operated at an approximately constant rate of crosshead movement and in which the error for indicated loads which are recorded should not exceed $\pm$ 1 per cent * and the error for indicated deflections should not exceed $\pm$ 2 per cent.

The radii of the loading nose and the supports are:

$$r_1 = 5 \pm 0.1 \text{ mm}$$
$$r_2 = 2 \pm 0.1 \text{ mm (see Fig. 2)}$$

The span should be adjustable.

6. CONDITIONING

The test specimens should be conditioned according to the relevant ISO Recommendation.**

7. PROCEDURE

Measure the dimensions of b and h to the nearest 0.1 mm and 0.02 mm, respectively, and adjust the distance of the support (span) L_v to:

$$L_v = 16\ h \pm 0.5 \text{ mm}$$

Load the specimen as a simple beam at midspan (see Fig. 2).

Carry out the test at one of the standard laboratory atmospheres, according to the relevant ISO Recommendation.**

* It is recommended to use a machine that shows a motion of the weighing mechanism less than 2 mm for a load corresponding to the full scale.

** The ISO Recommendation relating to standard atmospheres for conditioning and testing plastics materials is being prepared.

Load the test specimen without bumping. Load and deflection should be read off.

Note 1. The deflection is most accurately measured by means of a dial micrometer placed at the center of the lower surface of the specimen.

In the case of substances exhibiting little retarded elasticity, the velocity v of the loading nose shall be:

$$v = \frac{h}{2}\ \text{mm/min} \pm 0.2\ \text{mm/min}$$

where v = velocity, in millimetres per minute,

h = height of test specimen, in millimetres.

Note 2. If greater accuracy in measuring the loading nose velocity is desired, the following formula may be used:

$$v = \frac{S_r L^2_v}{6h}$$

where
v = loading nose velocity, in millimetres per minute;
S_r = straining rate, in millimetres per millimetre per minute;
L_v = span, in millimetres;
h = height of specimen, in millimetres.

Note 3. In the case of substances characterized by pronounced retarded elasticity, it may be advantageous to run three series of tests, with three velocities showing mutual differences of at least one decade.

It is recommended to plot a load-deflection curve (see Appendix) from which the load and the deflection may be measured.

The modulus E is determined in the elastic linear initial range of the load-deflection curve by reading off at least five values for the deflection of the test specimen and the forces required.

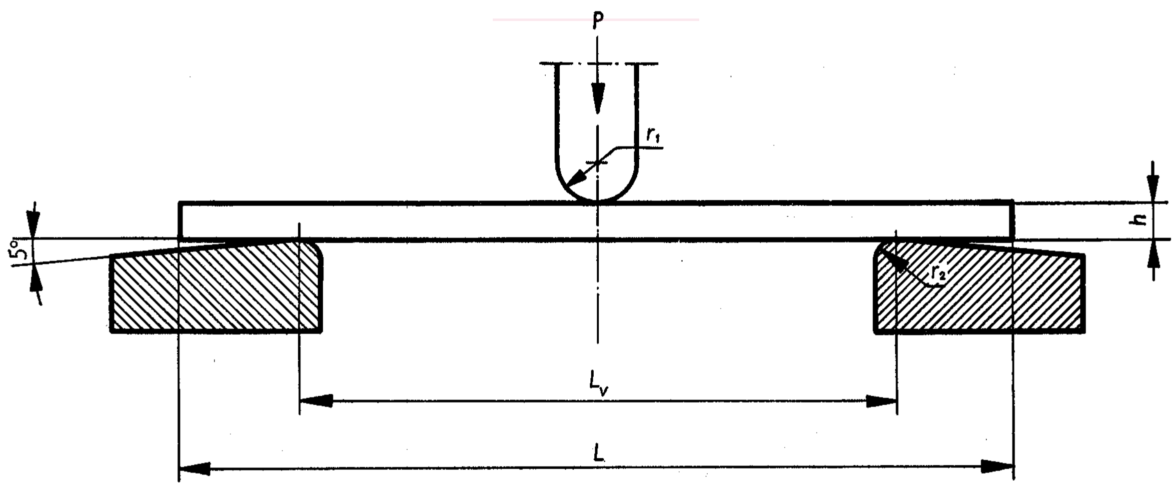

FIGURE 2. Testing device

8. RESULTS OF THE TEST

8.1 For test specimens that break before or at the moment of reaching the deflection prescribed in clause 2.3, the load and the deflection at break are recorded.

8.2 For test specimens that do not break at the deflection prescribed in clause 2.3, the load causing this deflection is recorded; eventually the maximum load prescribed in clause 2.4 is also recorded (see Appendix).

9. CALCULATION AND EXPRESSION OF RESULTS

9.1 The flexural stress at rupture σ_{fB} (in case of not breaking denoted as flexural stress σ_f) is calculated as follows:

$$\sigma_{fB} = \frac{M}{W} \text{ in kilogrammes-force per square centimetre,}$$

where M = flexural moment, in kilogrammes-force·centimetre,
W = section modulus, in cubic centimetres.

According to the method of loading mentioned above:

$$M = \frac{F L_v}{4} \text{ in kilogrammes-force·centimetre,}$$

where F = load, in kilogrammes-force,
L_v = distance of supports, in centimetres.

For rectangular section:

$$W = \frac{b h^2}{6} \text{ in cubic centimetres } (b \text{ and } h \text{ in centimetres})$$

so

$$\sigma_{fB} \text{ (or } \sigma_f) = \frac{3 F L_v}{2 b h^2} \text{ in kilogrammes-force per square centimetre.}$$

9.2 The modulus of elasticity E_B is calculated from the load-deflection curve as

$$E_B = \frac{L_v^3}{4 b h^3} \cdot \frac{F}{Y} \text{ in kilogrammes-force per square centimetre,}$$

where L_v = distance of supports, in centimetres,
b = breadth (width) of test specimen, in centimetres,
h = height of test specimen, in centimetres,
F = load for a chosen point of straight part of load-deflection curve, in kilogrammes-force,
Y = deflection caused by load F, in centimetres.

10. REPORT

The report should include the following:

10.1 Brand, identification mark, origin, date of receipt and further data of the tested material.

10.2 Data about the preparation of the test specimens.

10.3 Measured dimensions of the test specimens and of the applied span.

10.4 When test specimens have been broken:
Flexural stress at rupture σ_{fB} in kilogrammes-force per square centimetre,*
Deflection d_B, in millimetres.*

10.5 When test specimens have not been broken:

Flexural stress σ_f at the conventional deflection according to clause 2.3, and/or
Flexural stress at the maximum load according to clause 2.4.

10.6 Optional: the load-deflection curve and the modulus of elasticity calculated from the linear part of this curve.

* To be recorded: (1) the arithmetical mean,
(2) the standard deviation.