INTERNATIONAL STANDARD 604

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Plastics — Determination of compressive properties

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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 604 (originally Draft International Standard ISO/DIS 2038) was drawn up by Technical Committee ISO/TC 61, *Plastics*, and circulated to the Member Bodies in September 1970.

It has been approved by the Member Bodies of the following countries :

Australia	Hungary	Portugal
Austria	India	Romania
Belgium	Israel	South Africa, Rep. of
Canada	Italy	Spain
Chile	Japan	Sweden
Czechoslovakia	Korea, Rep. of	Switzerland
Egypt, Arab Rep. of	Netherlands	United Kingdom
France	New Zealand	U.S.A.
Germany	Poland	U.S.S.R.

No Member Body expressed disapproval of the document.

This International Standard cancels and replaces ISO Recommendation R 604-1967.

Plastics — Determination of compressive properties

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies a method for determining the compressive properties of plastics in the form of standard test specimens when tested under defined conditions of pre-treatment, temperature, humidity and testing machine speed.

2 REFERENCE

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

3 DEFINITIONS

3.1 compressive stress (nominal) : The compressive load per unit area of original cross-section carried by the test specimen at any time during the compressive test. It is expressed in meganewtons per square metre.

3.2 compressive deformation : The change in length produced in a longitudinal section of the test specimen by a compressive load. It is expressed in millimetres.

3.3 compressive strain; unit compressive deformation : The change in length per unit of original length. It is expressed as a dimensionless ratio.

3.4 compressive yield stress : The compressive stress (nominal) at the first observable point in a compression test where, on the load-deformation curve, an increase in strain or deformation occurs without an increase in load. It is expressed in meganewtons per square metre.

3.5 compressive offset yield stress : The compressive stress (nominal) in a compression test where the load-deformation curve departs from linearity by a specified percentage of deformation (offset). It is expressed in meganewtons per square metre.

3.6 compressive strength : The maximum compressive stress (nominal) carried by the test specimen during a compressive test. It may or may not be the compressive stress (nominal) carried by the specimen at the moment of rupture. It is expressed in meganewtons per square metre.

3.7 percentage compressive strain : The compressive strain multiplied by one hundred.

3.8 percentage compressive strain at compressive yield stress : The compressive strain at the first observable point in a compression test where, on the load-deformation curve, the compressive strain is increasing without increase in load. It is expressed as a percentage of the original length of the measured compressed section.

3.9 percentage compressive strain at rupture : The compressive deformation of the test specimen at the moment of rupture, expressed as a percentage of the original length of the measured compressed section.

3.10 compressive stress at specified strain : The compressive stress (nominal) at the moment of achieving a specified strain. It is expressed in meganewtons per square metre.

3.11 specified compressive strain : The strain considered to be the maximum permitted when the material does not rupture under this strain. Unless otherwise specified in the relevant material specification, the specified compressive strain may be taken as being 0,25.

3.12 compressive load-deformation curve : The curve obtained by plotting compressive loads as ordinates against corresponding deformations as abscissae for the entire course of a compression test.

3.13 slenderness ratio : The ratio of the length of a solid of uniform cross-section (column) to its least radius of gyration. The slenderness ratio λ is used as the basis for the calculation of dimensions of the test specimen as follows :

$$\lambda = \frac{h}{i}$$

where

h is the height of the test specimen;

i is the least radius of gyration.

NOTE — The least radius of gyration i is given by the formula

$$i = \sqrt{\frac{I}{F}}$$

where

I is the least *main* moment of gyration of the cross-sectional area;

F is the cross-sectional area.

a) *For a right prism*

Square prism :

$$I = \frac{a^4}{12}$$

$$F = a^2$$

$$i = \sqrt{\frac{I}{F}} = \sqrt{\frac{a^4}{12a^2}} = \frac{a}{3{,}46}$$

Rectangular prism :

$$I = \frac{ab^3}{12}$$

$$F = ab$$

$$i = \sqrt{\frac{ab^3}{12ab}} = \frac{b}{3{,}46}$$

b) *For a right cylinder*

$$I = \frac{1}{2} I_p = \frac{\pi d^4}{64}$$

$$F = \frac{\pi d^2}{4}$$

$$i = \sqrt{\frac{d^2}{16}} = \frac{d}{4}$$

c) *For a right circular crown tube*

$$I = \frac{1}{2} I_p = \frac{\pi}{64} (D^4 - d_1^4)$$

$$F = \frac{\pi}{4} (D^2 - d_1^2)$$

$$i = \frac{1}{4} \sqrt{D^2 + d_1^2}$$

where

a is the side of the square cross-section (for a square prism) or the longer side of the rectangular cross-section (for a rectangular prism);

b is the shorter side of the rectangular cross-section (for a rectangular prism);

d is the diameter of the right cylinder;

d_1 is the inner diameter of the tube;

D is the outer diameter of the tube;

I_p is the polar moment of gyration.

4 SIGNIFICANCE OF TEST

4.1 Compressive properties determined by this method include compressive yield stress, compressive strength, offset yield stress, percentage compressive strain at compressive yield stress, percentage compressive strain at rupture and compressive stress at specified compressive strain.

4.2 Compressive tests may provide data for research and development, engineering design, quality control, acceptance or rejection under specifications and for special purposes. The tests cannot be considered significant for applications differing widely from the load time scale of the standard test. Such applications require appropriate tests such as impact, creep and fatigue.

5 APPARATUS

5.1 Testing machine of the constant rate-of-crosshead-movement type and comprising essentially the following :

5.1.1 *Compression tool :* a hardened steel compression plate for applying the load to the test specimen, so constructed that the compressive loading is truly axial and that the load is applied through polished surfaces which are flat and parallel to each other. A self-aligning device shall be interposed between the compression tool plunger and the testing machine plate.

5.1.2 *Load indicator :* a load-indicating mechanism capable of showing the total compressive load carried by the test specimen. The mechanism shall be essentially free of inertia lag at the specified rate of testing and shall indicate the load value with an accuracy of ± 1 % of the indicated value or better.

5.1.3 *Deformation indicator* : a suitable instrument for determining the distance between the contact surfaces of the compression tool, or the distance between two fixed points on the test specimen at any time during the test. It is desirable, but not essential, that this instrument automatically records this distance (or any change in it) as a function of the load on the test specimen or of the elapsed time from the start of the test, or both. This instrument shall be essentially free of inertia lag at the specified rate of loading and shall be accurate to ± 1 % of the indicated value, or better.

5.2 Micrometers, suitable for measuring the dimensions of the test specimens to within 0,01 mm.

6 TEST SPECIMENS

6.1 Form

The test specimen shall be in the form of a right prism, cylinder or tube. The ends of the specimen, perpendicular to the direction of the application of the load, shall be parallel to within 0,1 % of the height of the specimen.

6.2 Dimensions

6.2.1 Calculate the dimensions of the test specimen from the formulae defining slenderness ratio and the least radius of gyration (see 3.13) as follows :

a) *For a right square prism or a rectangular prism*

$$h = i\,\lambda = \frac{\lambda}{3,46}\,a$$

or $$h = i\,\lambda = \frac{\lambda}{3,46}\,b$$

b) *For a right cylinder*

$$h = i\,\lambda = \frac{\lambda}{4}\,d$$

c) *For a right circular crown tube*

$$h = i\,\lambda = \frac{\lambda}{4}\sqrt{D^2 + d_1{}^2}$$

where

h is the height;

λ is the slenderness ratio;

a is the side of the square cross-section (for a square prism)
or the longer side of the rectangular cross-section (for a rectangular prism);

b is the shorter side of the rectangular cross-section (for a rectangular prism);

d is the diameter of the right cylinder;

d_1 is the inner diameter of the tube;

D is the outer diameter of the tube.

6.2.2 The height of test specimens may vary from 10 to 40 mm. The preferred height of test specimens is 30 mm.

6.2.3 The slenderness ratio for the test specimens shall be 10 (unless otherwise required by the specification of the material being tested).

When it is found that test specimens buckle during the test, the slenderness ratio shall be reduced to 6.

6.3 Direction of forces

For the purpose of material specifications, the relationship between direction of moulding force and direction of application of load shall be closely defined.

6.4 Number of test specimens

a) Test at least five specimens for each sample in the case of isotropic materials.

b) Test ten specimens, five normal to, and five parallel to the principal axis of anisotropy for each sample, in the case of anisotropic materials.

c) Discard specimens that break at some obvious fortuitous flaw and retest.

d) Retain results (on specimens) that deviate markedly from the mean value of all tests unless 6.4 c) applies. If additional tests are required, determine the number from the desired (statistical) significance level.

6.5 Conditioning

Unless otherwise required by the specification for the material being tested, the test specimens shall be conditioned and tested in accordance with ISO/R 291.

7 RATE OF DEFORMATION

For the determination of compressive properties, the rate of deformation is dependent on the height of the test specimen.

The rate of deformation S is given, in millimetres per minute, by the following formula

$$S = 0,3\,h$$

where h is the height of the test specimen, in millimetres.

8 PROCEDURE

8.1 Measure the width and thickness or diameter of the test specimen to the nearest 0,01 mm and calculate the minimum value of the cross-sectional area.

Measure the height of the test specimen to the nearest 0,01 mm.

8.2 Place the test specimen between the surfaces of the compression plate and align the centre line of the test specimen through the centre line of the compression plate surfaces. Ensure that the ends of the specimen are parallel to the surfaces of the compression plate and adjust the machine so that the surfaces of the ends of the test specimen and compression plate are just touching.

8.3 Attach the deformation indicator.

8.4 Set the machine speed to give the required speed of testing.

8.5 Start the machine and record the following :

a) loads and corresponding compressive strains at appropriate intervals of strain;

b) the total load, in newtons, carried by the test specimen at the moment of rupture;

c) if the test specimen does not rupture, the total load, in newtons, carried by the test specimen at the yield point or at the offset yield point and, if applicable, at the point of specified strain;

d) the results obtained in 8.5 a) plotted on a graph. Obtain from this graph the compressive deformation at the moment of rupture and, if applicable, the compressive deformation at the yield point to the nearest 0,05 mm or better.

NOTE – If an automatic load-deformation recorder is used, the compressive deformation can be obtained from the automatic recorder to within 0,05 mm, or better.

9 CALCULATION AND EXPRESSION OF RESULTS

9.1 Compressive strength

Calculate the compressive strength by dividing the maximum load, in meganewtons, carried by the test specimens (which may or may not be at the moment of rupture) by the original minimum cross-sectional area in square metres. Report the result to three significant figures.

9.2 Compressive yield stress

Calculate the compressive yield stress by dividing the total load, in meganewtons, carried by the test specimen at the yield point by the original minimum cross-sectional area in square metres. Report the result to three significant figures.

9.3 Percentage compressive strain at rupture

Calculate the percentage compressive strain at rupture by dividing the compressive deformation at rupture by the original height of the test specimen and multiplying the result by one hundred. Report the result to two significant figures.

9.4 Percentage compressive strain at compressive yield stress

Calculate the percentage compressive strain at compressive yield stress by dividing the compressive deformation at the yield point by the original height of the test specimen and multiplying the result by one hundred. Report the result to two significant figures.

9.5 Offset yield stress

Determine the offset yield stress as follows : On the load-deformation diagram prepared in accordance with 8.5 d) draw a line parallel to the initial straight line portion of the curve corresponding to a specified value of deformation (for example 0,2 %). Where this line intersects the load-deformation curve read off the value of load. This value, divided by the original minimum cross-sectional area of the test specimen, in square metres, gives the offset yield stress. Express the result in meganewtons per square metre and report it to three significant figures.

9.6 Compressive stress at specified strain

Calculate the compressive stress at specified strain by dividing the total load, in meganewtons, carried by the test specimen at the moment of specified compressive strain by the original minimum cross-sectional area in square metres. Report the result to three significant figures.

9.7 Standard deviation

Calculate the (estimated) standard deviation s using the following formula

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

where

x_i is the value of a single observation;

n is the number of observations;

$\bar{x}$ is the arithmetic mean of the set of observations.

10 TEST REPORT

The test report shall include the following particulars :

a) complete identification of the material tested, including type, source, manufacturer's code number, form, principal dimensions, previous history, etc.;

b) the method of preparing the test specimens;

c) the type of test specimens and their dimensions;

d) if any test specimen has been cut from intermediate products;

e) the position of the test specimen relative to the product;

f) the direction of application of the moulding force on the test specimen;

g) the direction of application of the compressive stress;

h) the number of specimens tested;

i) the conditioning procedure used;

j) the atmospheric conditions in the test room;

k) the rate of deformation;

l) the average value and standard deviation of the compressive strength or of the compressive yield stress, or of both;

m) the average value and standard deviation of the compressive stress at specified compressive strain;

n) the average value and standard deviation of the percentage compressive strain at rupture or of the percentage compressive strain at compressive yield stress, or of both;

o) the specified compressive strain;

p) the date of the test.