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PLASTICS

DETERMINATION OF COMPRESSIVE PROPERTIES OF PLASTICS

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BRIEF HISTORY

The ISO Recommendation R 604, *Plastics—Determination of Compressive Properties of Plastics*, was drawn up by Technical Committee ISO/TC 61, *Plastics*, the Secretariat of which is held by the United States of America Standards Institute (USASI).

Work on this question by the Technical Committee began in 1961 and led, in 1963, to the adoption of a Draft ISO Recommendation.

In March 1964, this Draft ISO Recommendation (No. 747) was circulated to all the ISO Member Bodies for enquiry. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies:

Argentina	Germany	Romania
Australia	Hungary	Spain
Austria	India	Sweden
Belgium	Israel	Switzerland
Bulgaria	Italy	Turkey
Canada	Japan	U.A.R.
Czechoslovakia	Korea, Rep. of	United Kingdom
Denmark	Netherlands	U.S.A.
Finland	New Zealand	U.S.S.R.
France	Poland	Yugoslavia

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 August 1967, to accept it as an ISO RECOMMENDATION.

ISO Recommendation R 604 August 1967

PLASTICS

DETERMINATION OF COMPRESSIVE PROPERTIES OF PLASTICS

1. SCOPE

This ISO Recommendation describes a method intended for use in 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. DEFINITIONS

2.1 **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 kilogrammes-force per square centimetre.

2.2 **Compressive deformation.** The change in length produced in a longitudinal section of the test specimen by a compressive load. It is expressed in centimetres.

2.3 **Compressive strain (unit compressive deformation).** The change in length per unit of original length. It is expressed as a dimensionless ratio.

2.4 **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 kilogrammes-force per square centimetre.

2.5 **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 kilogrammes-force per square centimetre.

2.6 **Compressive strength.** The maximum compressive stress (nominal) carried by a 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 kilogrammes-force per square centimetre.

2.7 **Percentage compressive strain.** The compressive strain times one hundred.

2.8 **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.

2.9 Percentage compressive strain at rupture. A compressive deformation of the test specimen at the moment of rupture, expressed as a percentage of the original length of the measured compressed section.

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

2.11 Slenderness ratio. The ratio of the length of a solid of uniform cross-section (column) to its least radius of gyration.

The slenderness ratio is used as the basis for the calculation of dimensions of the test specimen as follows:

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

where

λ = slenderness ratio,

h = height of the test specimen,

i = least radius of gyration.

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

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

where

I = least *main* moment of gyration of cross-section area,

F = cross-section area.

(*a*) *For a right prism*

Square prisms

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

$$F = a^2$$

$$i = \sqrt{\frac{a^4}{12\, a^2}} = \frac{a}{3.46}$$

Rectangular prisms

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

$$F = ab$$

$$i = \sqrt{\frac{ab^3}{12\, ab}} = \frac{b}{3.46}$$

(*b*) *For right cylinders*

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

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

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

(*c*) *For a right circular crown tube*

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

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

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

where

a = width of the right prism,

b = thickness of the rectangular prism,

d = diameter of right cylinder,

d_1 = inner diameter of tube,

D = outer diameter of tube,

Ip = polar moment of gyration.

3. SIGNIFICANCE OF TEST

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

3.2 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 loadtime scale of the standard test. Such applications require appropriate tests such as impact, creep and fatigue.

4. APPARATUS

The apparatus should consist of:

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

4.1 **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 so that the load is applied through polished surfaces which are flat and parallel to each other. A self-aligning device should be interposed between the compression tool plunger and the testing machine plate.

4.2 **Load indicator,** a load-indicating mechanism capable of showing the total compressive load carried by the test specimen. The mechanism should be essentially free from inertia lag at the specified rate of testing and should indicate the load value with an accuracy of $\pm 1\%$ of the indicated value, or better.

4.3 **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 record 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 should be essentially free from inertia lag at the specified rate of loading and should be accurate to $\pm 1\%$ of the indicated value, or better.

4.4 **Micrometers,** suitable for measuring the dimensions of the test specimens to within 0.001 cm.

5. TEST SPECIMENS

5.1 The test specimen should be in the form of a right prism, cylinder or tube. The ends of the specimens should be parallel to within 0.1% of the height in the direction perpendicular to the application of the load.

5.2 Calculate the dimensions of the test specimen from the formulae defining slenderness ratio and the least radius of gyration (see clause 2.11) as follows:

(*a*) *A right square prism or a rectangular prism*

$$h = i\,\lambda = \frac{\lambda}{3.46} \cdot a$$

or $$h = i = \frac{\lambda}{3.46} \cdot b$$

(*b*) *A right cylinder*

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

(*c*) *A right tube*

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

where

h = height,

λ = slenderness ratio,

a = width of the right prism,

b = thickness of the rectangular prism,

d = diameter of right cylinder,

d_1 = inner diameter of tube,

D = outer diameter of tube.

5.3 The height of test specimens in the form of a square prism, a rectangular prism, or a right cylinder or tube may vary from 10 to 40 mm. The preferred height of test specimens is 30 mm.

5.4 Slenderness ratio for the test specimens should be 10 (unless otherwise required by the specification for the material being tested).

5.5 For the purpose of material specification, the relationship between direction of moulding force and direction of application of load should be closely defined.

5.6 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 five parallel with 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 clause 5.6 (*c*) applies. In case additional tests are made, the exact number is fixed by the desired (statistical) significance level.

5.7 Conditioning. Unless otherwise required by the specification for the material being tested, the test specimens should be conditioned and tested in accordance with ISO Recommendation R 291, *Standard Atmospheres for Conditioning and Testing*.