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Rigid cellular plastics — Determination of compression properties

Plastiques alvéolaires rigides — Détermination des caractéristiques de compression

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established 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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 844 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 10, *Cellular plastics*.

This fifth edition cancels and replaces the fourth edition (ISO 844:2004), which has been revised to include a choice of conditioning atmospheres (see 7.4).

Rigid cellular plastics — Determination of compression properties

1 Scope

This International Standard specifies a method of determining

a) the compressive strength and corresponding relative deformation

or

b) the compressive stress at 10 % relative deformation

and

c) when desired, the compressive modulus

of rigid cellular plastics.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1923, *Cellular plastics and rubbers — Determination of linear dimensions*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
relative deformation
ε
ratio of the reduction (in relation to its initial value) in thickness of the test specimen to its initial thickness

NOTE 1 It is expressed as a percentage.

NOTE 2 ε_m is the relative deformation corresponding to σ_m (see 3.2).

3.2
compressive strength
σ_m
maximum compressive force F_m divided by the initial cross-sectional area of the test specimen when the relative deformation ε is < 10 %

3.3
compressive stress at 10 % relative deformation
σ_{10}
ratio of the compressive force F_{10} at 10 % relative deformation ε_{10} to the initial cross-sectional area of the test specimen

3.4
compressive modulus of elasticity
E
compressive stress divided by the corresponding relative deformation below the proportional limit, i.e. when the relation is linear

4 Symbols and abbreviated terms

A_0 initial cross-sectional area, in square metres

E compressive modulus of elasticity, in kilopascals

F_e force corresponding to x_e (conventional proportional limit), in newtons

F_m maximum force, in newtons

F_{10} force at 10 % relative deformation, in newtons

h_0 initial thickness of test specimen, in millimetres

ε_m relative deformation ε corresponding to compressive strength σ_m, in percent

σ_m compressive strength, in kilopascals

σ_{10} compressive stress at 10 % relative deformation, in kilopascals

x_e displacement at F_e in the conventional elastic zone, in millimetres

x_m displacement at maximum force, in millimetres

x_{10} displacement at 10 % relative deformation, in millimetres

kPa kilopascals

Pa pascals

5 Principle

A compressive force is applied in an axial direction to the faces of a rectangular parallelepiped test specimen. The maximum stress supported by the test specimen is calculated.

If the value of the maximum stress corresponds to a relative deformation of less than 10 %, it is noted as the “compressive strength”. Otherwise, the compressive stress at 10 % relative deformation is calculated and its value noted as the “compressive stress at 10 % relative deformation”.

6 Apparatus

6.1 Compression-testing machine

Use a compression-testing machine suited to the range of force and displacement involved and having two square or circular plane, parallel plates which are polished and cannot be deformed and of which the length of one side (or the diameter) is at least 10 cm. One of the plates shall be fixed and the other movable; the latter shall be capable of moving at a constant rate of displacement in accordance with the conditions laid down in Clause 8. Neither plate shall be self-aligning.

6.2 Devices for measuring displacement and force

6.2.1 Measurement of displacement

The compression-testing machine shall be fitted with a system allowing continuous measurement of the displacement x of the movable plate with an accuracy of ± 5 % or ± 0,1 mm if this latter value is a more accurate measurement (see Note to 6.2.2).

6.2.2 Measurement of force

A force sensor shall be fixed to one of the machine plates in order to measure the force F produced by the reaction of the test specimen upon the plates during the test. This sensor shall be such that its own deformation during the course of the measurement operation is negligible compared with that being measured and, in addition, it shall allow the continuous measurement of the force at any point in time with an accuracy of ± 1 %.

NOTE It is recommended that a device be used for the simultaneous recording of the force F and the displacement x that allows, by obtaining a curve of $F = f(x)$, the graphical determination of the pair of values F, x required in Clause 9 with the accuracy laid down in 6.2.1 and this subclause, and provides additional information on the behaviour of the product.

6.2.3 Calibration

Devices for measuring and, if applicable, recording graphically the force and displacement produced by the test machine shall be checked periodically. The devices shall be checked by using a series of standard weights, the masses of which are known to accuracies better than ± 1 % and which correspond to the forces applied during the test. To check the devices, spacers shall be used which have thicknesses known to accuracies better than either ± 0,5 % or ± 0,1 mm, whichever is more restrictive.

6.3 Instruments for measuring the dimensions of the test specimens

These instruments shall be in accordance with ISO 1923.

7 Test specimens

7.1 Dimensions

The test specimens shall be (50 ± 1) mm in thickness except for products with moulded skins which are intended to remain integral with the product in use. With such products, the specimens shall be the full thickness, provided that the minimum thickness is 10 mm or greater and that the maximum thickness is not greater than the width or diameter of the specimen.

The test specimen base shall be either square or circular, with a minimum area of 25 cm^2 and maximum of 230 cm^2. The preferred geometry and dimensions are a right prism with a base of (100 ± 1) mm × (100 ± 1) mm.

The distance between two faces shall not vary by more than 1 % (tolerance on parallelism).

Under no circumstances may several test specimens be piled up to produce a greater thickness for testing.

Results obtained with specimens of differing thickness shall not be compared.

7.2 Preparation

Test specimens shall be cut so that the specimen base is normal to the direction of compression of the product in its intended use. In some cases with anisotropic materials where a more complete characterization is desired or where the principal direction of anisotropy is unknown, it may be necessary to prepare additional sets of specimens.

Cutting of the test specimens shall be accomplished by methods that do not change the structure of the cellular material. Moulding skins that do not remain with the product in use shall be removed.

In general, any anisotropy is characterized by a plane and the direction perpendicular to this plane; thus, two sets of test specimens need to be considered.

7.3 Number

Regarding the method of selecting the samples for preparation of the test specimens from the blocks or slabs of rigid cellular products and also the number of test specimens to be provided for the test, refer to the specification relating to the type of cellular product under test. In the absence of such specifications, use at least five test specimens.

7.4 Conditioning

Condition the test specimens at

(23 ± 2) °C and (50 ± 10) % relative humidity

or

(23 ± 5) °C and 50^{+20}_{-10} % relative humidity

or

(27 ± 5) °C and 65^{+20}_{-10} % relative humidity

for a minimum of 6 h.

8 Procedure

The test conditions shall be those used for conditioning the test specimens.

Measure the three dimensions of each test specimen in accordance with ISO 1923. Place a test specimen centrally between the two parallel plates of the compression-testing machine and compress it at a rate as close as possible to 10 % of its original thickness h_0 per minute until the test specimen thickness is reduced to 85 % of the original thickness. Record the maximum force reached during the reduction in thickness.

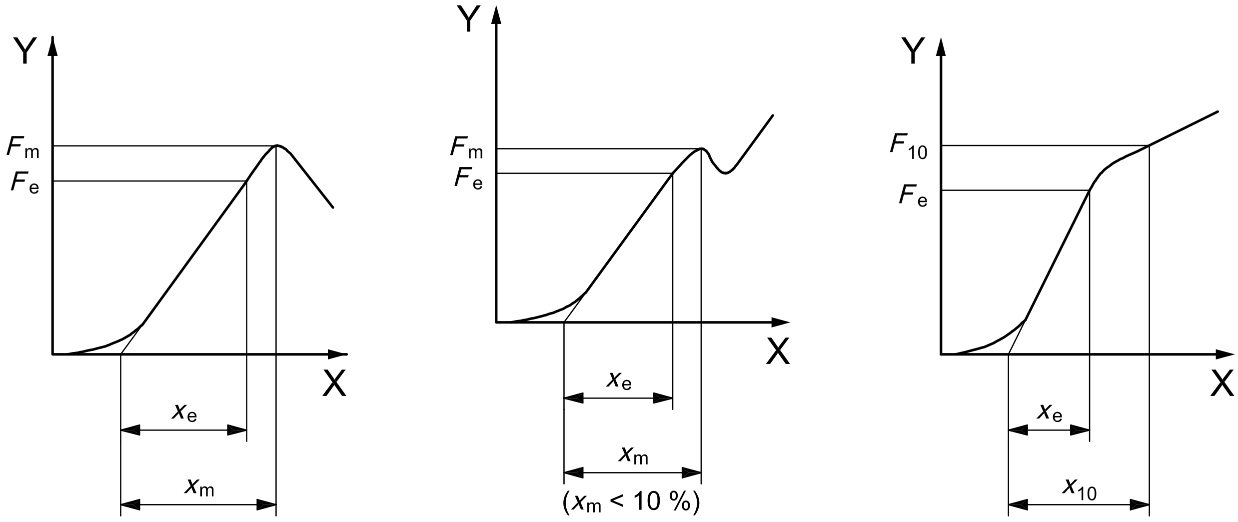
If the compressive modulus of elasticity is to be determined, record a force-displacement graph and draw a tangent to the steepest part of the curve.

Repeat for each of the remaining specimens.

9 Expression of results

9.1 General

Depending upon the case, it will be necessary to calculate σ_m and ε_m (see 9.2 and Figure 1a), or σ_{10} (see 9.3 and Figure 1b), or all three properties (see Figure 1c) if the material yields before completion of the test but still resists an increasing force.



a) b) c)

Key

X displacement

Y force

Figure 1 — Examples of force-displacement curves

9.2 Compressive strength and corresponding relative deformation

9.2.1 Compressive strength

The compressive strength σ_m is given, in kilopascals, by the equation

$$\sigma_m = 10^3 \times \frac{F_m}{A_0}$$

where

F_m is the maximum force reached, in newtons;

A_0 is the initial cross-sectional area, in square metres, of the test specimen.

9.2.2 Relative deformation

Using a straight edge, carefully extrapolate to zero force the steepest straight-line portion of the force-deformation curve (see 6.2.2). Measure all displacements for deformation calculations from this "zero-deformation point". Three examples of this procedure are shown in Figure 1.

If there is no well-defined straight portion of the force-deformation curve or if the “zero-deformation point” obtained in this manner results in a negative value, this procedure shall not be used. In such cases, the “zero-deformation point” shall be taken as the deformation corresponding to a stress of (250 ± 10) Pa.

The relative deformation ε_m is given, as a percentage, by the equation

$$\varepsilon_m = \frac{x_m}{h_0} \times 100$$

where

x_m is the displacement, in millimetres, corresponding to the maximum force reached;

h_0 is the initial thickness, in millimetres, of the test specimen.

9.3 Compressive stress at 10 % relative deformation

The compressive stress at 10 % relative deformation σ_{10} is given, in kilopascals, by the equation

$$\sigma_{10} = 10^3 \times \frac{F_{10}}{A_0}$$

where

F_{10} is the force, in newtons, corresponding to a relative deformation of 10 %;

A_0 is as defined in 9.2.1.

9.4 Compressive modulus of elasticity

If required, calculate the compressive modulus of elasticity E, in kilopascals, from the equations

$$E = \sigma_e \times \frac{h_0}{x_e}$$

and

$$\sigma_e = 10^3 \times \frac{F_e}{A_0}$$

where

F_e is the force at the end of the conventional elastic zone (well-defined straight portion of the force-displacement curve), in newtons;

x_e is the displacement at F_e, in millimetres.

If there is no well-defined straight portion of the force-displacement curve or if the “zero-deformation point” obtained in accordance with 9.2.2 results in a negative value, this procedure shall not be used. In such cases, the “zero-deformation point” shall be taken as the deformation corresponding to a stress of (250 ± 10) Pa.

NOTE For some cellular plastic materials, the apparent compressive modulus changes significantly with test specimen thickness. Compressive moduli for different materials can only be compared if the test specimen thickness is the same.

10 Precision

An inter-laboratory test was performed with 10 laboratories in 1993. Four products with different compression behaviour characteristics were tested, three of which were used for statistical evaluation of the reproducibility (two test results for each product), and one for statistical evaluation of the repeatability (five test results).

The results, analysed in accordance with ISO 5725:1986, *Precision of test methods — Determination of repeatability and reproducibility for a standard test method by inter-laboratory tests* (now withdrawn), are given in Tables 1 and 2.

Table 1 — Compressive strength σ_m or stress at 10 % relative deformation

Range	95 kPa to 230 kPa
Estimate of repeatability variance s_r	0,5 %
95 % repeatability limit	2 %
Estimate of reproducibility variance s_R	3 %
95 % reproducibility limit	9 %

Table 2 — Compressive modulus of elasticity

Range	2 500 kPa to 8 500 kPa
Estimate of repeatability variance s_r	3 %
95 % repeatability limit	8 %
Estimate of reproducibility variance s_R	10 %
95 % reproducibility limit	25 %

11 Test report

The test report shall include the following information:

a) a reference to this International Standard;

b) all details necessary for complete identification of the product tested, including date of production, if known;

c) the dimensions of the test specimens, if other than a right prism with a base of (100 ± 1) mm × (100 ± 1) mm and thickness of (50 ± 1) mm;

d) the direction in which the force was applied in relation to anisotropy or product geometry;

e) the average of the test results, to three significant figures, expressed as:

— compressive strength σ_e and corresponding relative deformation ε_m,

or

— compressive stress at 10 % relative deformation σ_{10},

or

— all three properties for results similar to Figure 1c,

— plus compressive modulus of elasticity E, when requested;

f) the individual test results if individual specimen values vary by more than 10 %;

g) the date of testing;

h) any deviation from the procedure specified in this International Standard.

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