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Rigid cellular plastics — Determination of compression properties

Plastiques alvéolaires rigides — Détermination des caractéristiques de compression

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Foreword

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This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 10, *Cellular plastics*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 249, *Plastics*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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This seventh edition cancels and replaces the sixth edition (ISO 844:2014), which has been technically revised. The main changes compared to the previous edition are as follows:

— different extensometer gage lengths have been given for use with different specimen thicknesses;

— repeatability and reproducibility results from the interlaboratory test on Procedure B have been added for compressive strength and compressive modulus of elasticity measurements;

— Annex A has been added to provide information on the determination of the compressive modulus by means Procedure B.

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Rigid cellular plastics — Determination of compression properties

1 Scope

This document specifies methods for determining the compressive strength and corresponding relative deformation, the compressive stress at 10 % relative deformation, and the compressive modulus of rigid cellular plastics.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 291, *Plastics — Standard atmospheres for conditioning and testing*

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

ISO 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

ISO 9513, *Metallic materials — Calibration of extensometer systems used in uniaxial testing*

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3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
nominal relative deformation (procedure A)
ε_C
ratio of the reduction (in relation to its initial value) in thickness of the test specimen

Note 1 to entry: It is expressed as a percentage.

Note 2 to entry: $\varepsilon_{C\mathrm{m}}$ is the nominal relative deformation corresponding to σ_m (see 3.3).

3.2
relative deformation (procedure B)
ε
ratio of the reduction (in relation to its initial value) of extensometer gauge length

Note 1 to entry: It is expressed as a percentage.

Note 2 to entry: ε_m is the relative deformation corresponding to σ_m (see 3.3).

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3.3
compressive strength
σ_m
maximum compressive force F_m divided by the initial cross-sectional area A_0 of the test specimen when the relative deformation ε and the nominal relative deformation ε_C respectively is < 10 %

Note 1 to entry: It is expressed in megapascals (MPa).

3.4
compressive stress at 10 % nominal relative deformation (procedure A)
σ_{C10}
ratio of the compressive force F_{10} at 10 % nominal relative deformation ε_{C10} to the initial cross-sectional area of the test specimen

Note 1 to entry: It is expressed in megapascals (MPa).

3.5
nominal compressive modulus of elasticity (procedure A)
E_C
difference in compressive stress divided by the difference in corresponding nominal relative deformation below the proportional limit, i.e. when the relation is linear

Note 1 to entry: It is expressed in megapascals (MPa).

3.6
compressive modulus of elasticity (procedure B)
E
difference in compressive stress divided by the corresponding difference in relative deformation below the proportional limit, i.e. when the relation is linear

Note 1 to entry: It is expressed in megapascals (MPa).

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3.7
conventional proportional limit
X_e
upper limit of the linear part of the force - deformation curve

Note 1 to entry: It is expressed in millimetres (mm).

4 Symbols

Symbol	Definition	Unit
A_0	initial cross-sectional area	in square millimetres
E	compressive modulus of elasticity	in megapascals
E_C	nominal compressive modulus of elasticity	in megapascals
F_e	force corresponding to x_e (conventional proportional limit)	in newtons
F_{Ce}	force corresponding to x_{Ce} (nominal proportional limit)	in newtons
F_m	maximum force	in newtons
F_{10}	force at 10 % nominal relative deformation	in newtons
h_0	initial thickness of test specimen (Procedure A)	in millimetres
l_o	initial gauge length of the extensometer (Procedure B)	in millimetres
Ra	surface roughness	
t	thickness	
X_e	displacement at F_e in the conventional elastic zone, (Procedure B)	in millimetres
X_{Ce}	nominal displacement at F_{Ce} in the conventional elastic zone, (Procedure A)	in millimetres

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Symbol	Definition	Unit
X_{m}	displacement at maximum force	in millimetres
$X_{C\mathrm{m}}$	nominal displacement at maximum force	in millimetres
X_{C10}	displacement at 10 % nominal relative deformation	in millimetres
ε_{m}	relative deformation corresponding to compressive strength σ_{m}	in percent
$\varepsilon_{C\mathrm{m}}$	nominal relative deformation corresponding to compressive strength σ_{m}	in percent
ε_{C10}	10 % nominal relative deformation	in percent
σ_{m}	compressive strength	in megapascals
σ_{10}	compressive stress at 10 % nominal relative deformation	in megapascals

5 Principle

A compressive force is applied in an axial direction and perpendicular to the faces of test specimen.

There are two procedures:

— Procedure A employs crosshead motion for determination of compressive properties. Procedure A shall be used to determine:

  — compressive strength and the corresponding nominal relative deformation;

  — compressive stress at 10 % nominal relative deformation;

  — nominal compressive modulus.

— Procedure B employs strain measuring devices connected to the specimen (contact or optical extensometer) or similar device which directly measures the specimen deformation. Procedure B shall be used to determine:

  — compressive strength and the corresponding relative deformation;

  — compressive modulus.

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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. The compression plates shall be of any convenient size which ensures that test specimens are compressed over their whole areas. The following conditions have been found acceptable:

a) surface roughness of $Ra \leq 0{,}4$ µm;

b) steel plate thickness of $t \geq 8$ mm in the loading direction;

c) in case of thin samples, platens dimensions shall be so that clip on short travel extensometers with stop stud, can be appropriately clamped to the specimen when it is put in the centre of the platens.

6.2 Devices for measuring displacement and force

6.2.1 Measurement of displacement

6.2.1.1 Procedure A — 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 6.2.2.2).

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6.2.1.2 Procedure B — The compression-testing machine shall be equipped with an extensometer which directly measures the specimen deformation. If used, however, the extensometer shall comply with class 1 of ISO 9513. The extensometer gage length as a function of specimen thickness is shown in Table 1.

Table 1 — Specimen thickness versus extensometer gage length

Specimen thickness h_0, (mm)	**Gage length** l_0, (mm)
20 to 32	15 ± 1,0 or 12,5 ± 1,0
>32 to 42	20 ± 1,0
>42 to 52	25 ± 1,0
>52 to 72	35 ± 1,0
>72	50 ± 1,0

The exact gage length used for calculation shall be measured to an accuracy of ±0,1 mm

6.2.2 Measurement of force

6.2.2.1 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. The force measurement shall comply with class 1 of ISO 7500-1 within the relevant part of the curve.

6.2.2.2 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 8 with the accuracy laid down in 6.2.1 and this subclause, and provides additional information on the behaviour of the product.

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6.2.3 Calibration

The machine shall be calibrated periodically according to ISO 7500-1 (force measurement) and ISO 9513 (displacement measurement).

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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 preferred geometry and dimensions are a right prism with a base of (100 ± 1) mm × (100 ± 1) mm × (50 ± 1) mm.

Also acceptable, but not preferred, are test specimens which the base shall be either square or circular, with a minimum area of 25 cm^2 and maximum of 230 cm^2.

The thickness of the specimens shall be minimum (20 ± 1) mm 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 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.

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Since sample geometry and dimensions may have an influence on results, it is recommended to compare results only if obtained by testing samples having the same geometry and dimensions.

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 (see Annex A).

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

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Condition the test specimens at:

— (23 ± 2) °C and (50 ± 10) % relative humidity, according ISO 291, class 2;

or

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

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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.

— When using Method B, connect the extensometer to the test specimen.

— Start the machine at a rate as close as possible to 10 % of the original thickness of the test specimen per minute (see NOTE 1).

— Compress the specimen until σ_m or/and σ_{10} are determined.

NOTE 1 Using specimens of 50 mm thickness, this condition corresponds to a test speed of 5 mm/min.

NOTE 2 Using Procedure B, strain is calculated on extensometer gauge length.

If the compressive modulus of elasticity is to be determined, record a force-displacement curve and find the most linear steepest part of the curve (see NOTEs in 9.4, 9.5 and Annex A).

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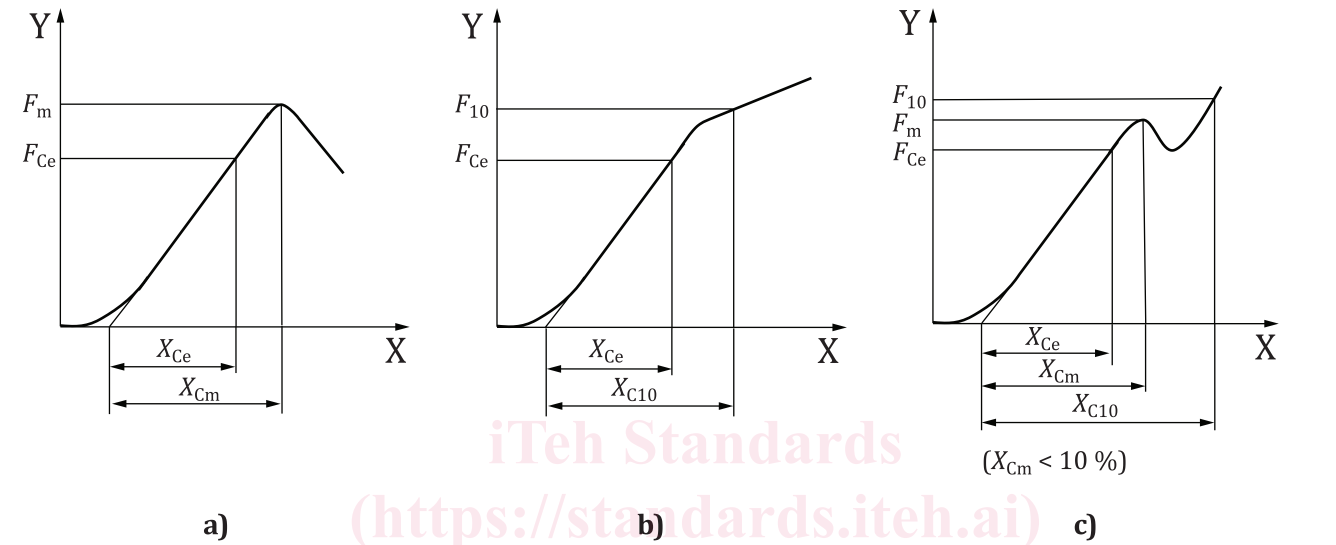
Repeat for each of the remaining specimens.

9 Expression of results

9.1 General

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



Key

X displacement

Y force

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Figure 1 — Examples of force-displacement curves — Procedure A

Using Procedure B, the behaviour of the force-displacement curves are as per Figure 2 and differently from Figure 1, X_e and X_m start from the origin of the X and Y-axis, where also the linear part of the curve starts.

Stress-strain curves are preferred to load-displacement curves.

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