
**Rigid cellular plastics — Determination
of water absorption**

Plastiques alvéolaires rigides — Détermination de l'absorption d'eau

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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 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 2896 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 10, *Cellular plastics*.

This third edition cancels and replaces the second edition (ISO 2896:1987), which has been technically revised.

Annex A forms a normative part of this International Standard.

Rigid cellular plastics — Determination of water absorption

1 Scope

This International Standard specifies a method for the determination of the water absorption of rigid cellular plastics by measuring the buoyant force on a test specimen after immersion under a 50 mm head of water for 4 days. Corrections are specified to take account of any change in volume of the specimen and also to correct for the volume of water in the cut surface cells of the specimen. The water absorption is expressed as the average, for several specimens, of the percentage increase in volume relative to the original volume.

The method described is intended for quality control and for use in product specifications.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 291:1997, *Plastics — Standard atmospheres for conditioning and testing*

ISO 1923:1981, *Cellular plastics and rubbers — Determination of linear dimensions*

3 Principle

The water absorption of a material is determined by measurement of the buoyant force on a specimen immersed in distilled water for a specified time.

4 Materials

4.1 Distilled water, de-aerated (by storage for at least 48 h after distillation), for use as the immersion liquid.

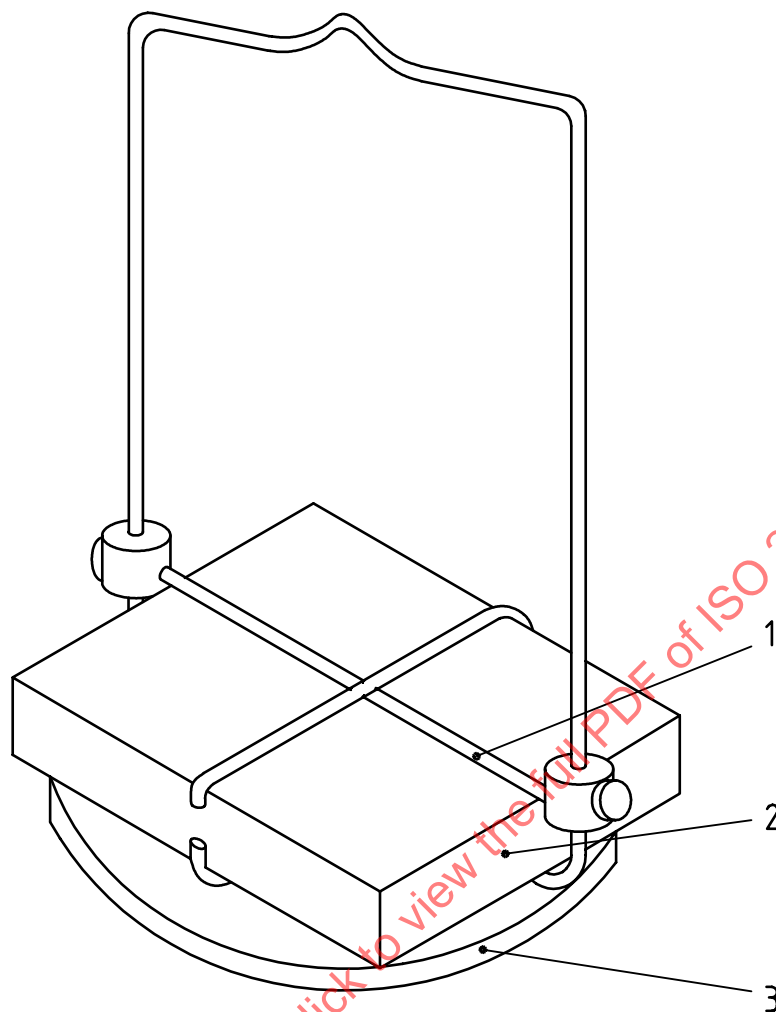
5 Apparatus

5.1 Balance, accurate to 0,1 g and capable of suspending the cage (5.2).

5.2 Underwater-weighing cage, made of a stainless material not attacked by distilled water and large enough to contain a test specimen. A sinker heavy enough to compensate for the upthrust produced by the test specimen shall be attached to the base of the cage. The cage shall be fitted with a means of suspending it from the balance. See Figure 1 for an example.

5.3 Cylindrical vessel, at least 250 mm in diameter and 250 mm in height.

5.4 Low-permeability plastic film, for example polyethylene.



Key

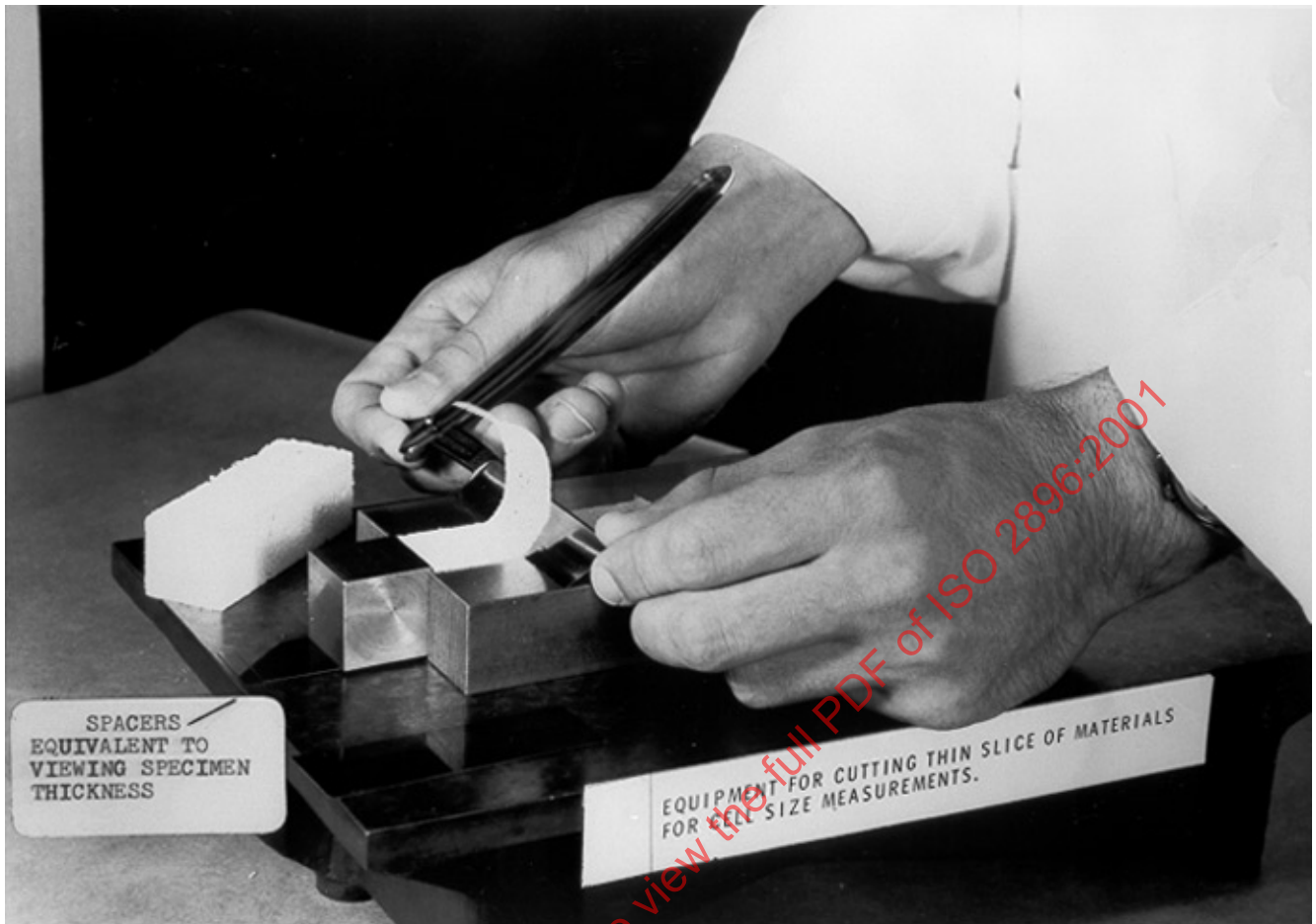
- 1 Mesh cage
- 2 Specimen
- 3 Sinker

Figure 1 — Test specimen in mesh underwater-weighing cage

5.5 Slicer: cutting-blade apparatus capable of preparing thin specimens (0,1 mm to 0,4 mm thick) for cell size viewing. Figure 2 shows an acceptable apparatus.

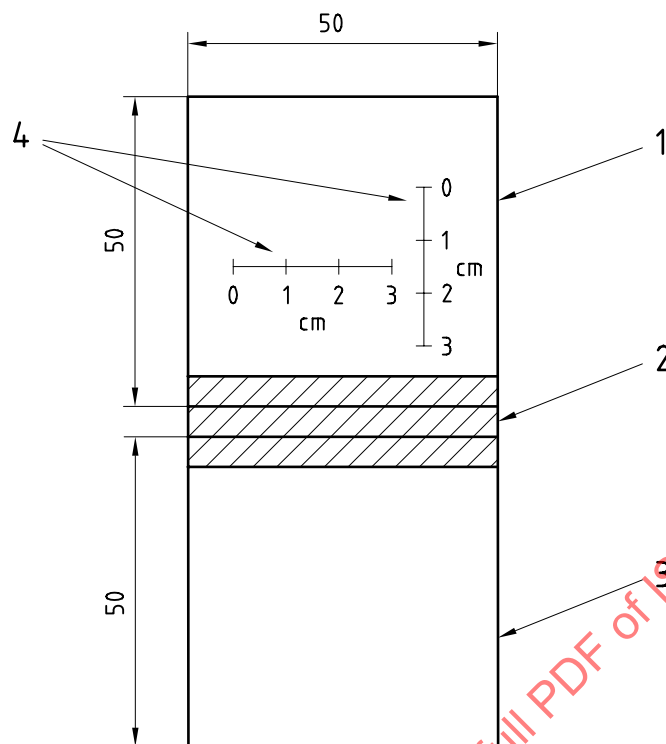
5.6 Slide assembly, consisting of two pieces of slide glass hinged by tape along one edge, between which is placed a calibrated scale (3 cm in length) printed on a thin plastic sheet (see Figure 3).

5.7 Projector: conventional 35 mm slide projector that accepts standard 50 mm × 50 mm slides, or a projection microscope with a calibrated scale.



NOTE The spacer thickness is chosen to give the required viewing-specimen thickness.

Figure 2 — Razor-blade equipment for slicing cellular plastics for determination of average cell diameter

**Key**

- 1 Calibrated glass slide
- 2 Flexible tape hinge
- 3 Blank cover glass
- 4 Cell-count scales

Figure 3 — Slide assembly**6 Specimens****6.1 Number of specimens**

At least three specimens shall be tested.

6.2 Dimensions

Specimens shall be at least 500 cm³ in volume, with a nominal length of 150 mm and a nominal width of 150 mm. For materials produced and sold with natural or laminated skin surfaces, the thickness shall be as produced. For materials produced with a thickness greater than 75 mm and without skin surfaces, the material shall be trimmed to 75 mm in thickness for testing. The distance between two faces shall not vary by more than 1 % (tolerance of parallelism).

6.3 Preparation and conditioning

Surfaces of specimens shall be smooth and free from dust. Dry the specimens in a desiccator at ambient temperature until the results of two successive weighings, at intervals of at least 12 h, do not differ by more than 1 % of their mean.

7 Procedure

- 7.1** Operate in a room where the temperature is maintained in accordance with ISO 291. Unless otherwise specified¹⁾, conditions shall be $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 5) \%$ relative humidity.
- 7.2** Weigh a specimen to the nearest 0,1 g (mass m_1).
- 7.3** Measure the dimensions of the specimen in accordance with ISO 1923 for the calculation of V_0 .
- 7.4** Fill the cylindrical vessel (5.3) with de-aerated distilled water (4.1) at ambient temperature.
- 7.5** Immerse the assembled cage (5.2), remove any bubbles, attach it to the balance and determine the apparent mass (m_2) to the nearest 0,1 g.
- 7.6** Place the specimen in the cage. Re-immerses the cage so that the distance between the surface of the water and the top surface of the specimen is approximately 50 mm. Remove obvious air bubbles from the specimen with a brush or by agitation.
- 7.7** Cover the cylindrical vessel with low-permeability plastic film (5.4).
- 7.8** After (96 ± 1) h, or another agreed immersion period, remove the plastic film and determine the apparent mass (m_3), to the nearest 0,1 g, of the submerged cage containing the specimen.
- 7.9** Visually examine the specimen for evidence of swelling. To determine corrections for swelling and cut surfaces, follow procedure A (8.1) for uniform swelling and procedure B (8.2) for non-uniform swelling.
- 7.10** Carry out the above procedure for each specimen individually.

8 Corrections for swelling and cut surfaces

8.1 Procedure A (uniform swelling)

8.1.1 Applicability

Use procedure A when there is no evidence of non-uniform deformation of the specimen.

8.1.2 Correction for uniform swelling

Remove the specimen from the water and re-measure its dimensions within 4 h of removal. The correction for uniform swelling of the specimen S_0 is

$$S_0 = \frac{V_1 - V_0}{V_0}$$

where

V_0 is the original volume, in cubic centimetres, of the specimen (see 9.1);

1) For tropical countries, test conditions will normally be $(27 \pm 2) ^\circ\text{C}$ and $(65 \pm 5) \%$ relative humidity.

$$V_1 = \frac{d_1 \times l_1 \times b_1}{1000}$$

d_1 being the specimen thickness, in millimetres, after immersion;

l_1 being the specimen length, in millimetres, after immersion;

b_1 being the specimen width, in millimetres, after immersion.

8.1.3 Correction for the volume of water in the cut surface cells

8.1.3.1 Using the method described in annex A, determine the average cell diameter D of a specimen obtained from the same sample of material as that from which the water absorption specimens were taken. Use this average cell diameter D , expressed in millimetres, to calculate the volume V_c of the surface cells cut during specimen preparation as follows:

8.1.3.1.1 For samples with natural or laminated skin surfaces:

$$V_c = \frac{0,54D (l \times d + b \times d)}{500}$$

8.1.3.1.2 For samples having cut cells on all surfaces:

$$V_c = \frac{0,54D (l \times d + l \times d + b \times d)}{500}$$

8.1.3.2 For samples with an average cell diameter of less than 0,50 mm and a specimen volume of at least 500 cm³, the correction for cut surface cells is relatively small (less than 3,0 %) and may be omitted.

8.2 Procedure B (non-uniform swelling)

8.2.1 Applicability

Use procedure B when there is evidence of non-uniform deformation of the specimen.

8.2.2 Combined correction for swelling and the volume of water in the cut surface cells

Obtain a cylindrical vessel similar to the one described in 5.3 but fitted with an overflow. Fill this vessel with water until it runs from the overflow. When the water level has stabilized, place a graduated receptacle of capacity at least 600 cm³ under the overflow. This receptacle shall be capable of allowing the volume of water deposited in it to be measured to $\pm 0,5$ cm³ (this may be done by weighing). Remove the specimen and cage from the original vessel. Allow them to drain until the surface water has run off (approximately 2 min). Carefully immerse the specimen and cage in the water-filled vessel and determine the volume of water displaced V_2 . Repeat this procedure with the empty cage to determine its volume V_3 .

The combined swelling and cut surface correction factor S_1 is given by

$$S_1 = \frac{V_2 - V_3 - V_0}{V_0}$$

where V_0 is the original volume of the specimen (see 9.1).

9 Expression of results

9.1 Calculate the original volume of the specimen using the equation

$$V = \frac{d \times l \times b}{1000}$$

where

V_0 is the original volume, in cubic centimetres, of the specimen;

d is the original thickness, in millimetres, of the specimen;

l is the original length, in millimetres, of the specimen;

b is the original width, in millimetres, of the specimen.

9.2 Calculate the water absorption WA_V , expressed as a percentage by volume, as follows:

9.2.1 If procedure A (8.1) was used:

$$WA_V = \frac{m_3 + V_1 \times \rho - (m_1 + m_2 + V_c \times \rho)}{V_0 \times \rho} \times 100$$

where ρ is the density of water ($= 1 \text{ g/cm}^3$).

9.2.2 If procedure B (8.2) was used:

$$WA_V = \frac{m_3 + (V_2 - V_3)\rho - (m_1 + m_2)}{V_0 \times \rho} \times 100$$

where ρ is the density of water ($= 1 \text{ g/cm}^3$).

9.3 Calculate the average water absorption for all specimens tested.

10 Precision and accuracy

10.1 Precision

Table 1 — Precision data

All values in volume % except where otherwise stated

Material	Thickness mm	Average water absorption	s_r	s_R	r	R
Polyisocyanurate	75	2,06	0,138	0,049	0,039	1,36
Extruded polystyrene	75	0,17	0,042	0,08	0,12	0,23

where

s_r is the within-laboratory standard deviation for the indicated material (obtained by pooling the within-laboratory standard deviations of the test results from all the participating laboratories):

$$s_r = [(s_1)^2 + (s_2)^2 + \dots (s_n)^2]/n^{1/2}$$

s_R is the between-laboratory reproducibility, expressed as a standard deviation;

r is the within-laboratory critical interval between two test results ($= 2,8 \times s_r$);

R is the between-laboratory critical interval between two test results ($= 2,8 \times s_R$).

NOTE This table is based on a round robin conducted in 1996 in accordance with ASTM E 691, *Standard Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method*, and involving two materials tested by seven laboratories. For each material, all the samples were prepared at one source, but the individual specimens were prepared at the laboratories which tested them. Each test result was the average of three individual determinations. Each laboratory obtained one test result for each material.

10.2 Concept of r and R in Table 1

If s_r and s_R have been calculated from a large enough body of data, and for test results that are averages from testing three specimens, then the following statements apply:

Repeatability: Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the r -value for that material, r being the interval representing the critical difference between two test results for the same material, obtained by the same operator using the same equipment on the same day in the same laboratory.

Reproducibility: Two test results obtained by different laboratories shall be judged not equivalent if they differ by more than the R -value for that material, R being the interval representing the critical difference between two test results for the same material, obtained by different operators using different equipment in different laboratories.

10.3 Accuracy

The accuracy of this method cannot be determined because standard reference materials are not available.