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Cellular plastics, rigid — Determination of water absorption

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

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Foreword

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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. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 2896 was prepared by Technical Committee ISO/TC 61, *Plastics.*

This second edition cancels and replaces the first edition (ISO 2896 : 1974), of which it constitutes a technical revision.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Cellular plastics, rigid — Determination of water absorption

1 Scope and field of application

1.1 This International Standard specifies a method for the determination of the water absorption of rigid cellular plastics by measuring the change in the buoyant force resulting from immersion of a specimen 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. Water absorption is expressed as an average percentage increase over the original volume of the specimens.

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

2 References

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

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

3 Principle

Determination of the water absorption by measurement of the buoyant force of a specimen immersed in distilled water for a specified time.

4 Immersion liquid

Distilled water, de-aerated (by storage for at least 48 h after distillation).

5 Apparatus

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

5.2 Mesh cage, made of a stainless material not attacked by distilled water and large enough to contain a test specimen. A sinker large enough in mass to compensate for the upthrust of 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.

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

6 Specimens

6.1 Number of specimens

At least three specimens shall be tested.

6.2 Dimensions

Specimens shall be at least 500 cm^3 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 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 vary 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 specified[1], conditions shall be 23 ± 2 °C and (50 ± 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.

7.4 Fill the cylindrical vessel (5.3) with the de-aerated distilled water (clause 4) at ambient temperature.

7.5 Immerse the assembled cage (5.2), remove any bubbles, attach it to the balance (5.1) and determine the apparent mass (m_2) to the nearest 0,1 g.

7.6 Place the specimen in the cage. Re-immerse 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 other agreed immersion period (see 1.2), 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 remeasure its dimensions within 4 h of its removal from the water. 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);

$$V_1 = \frac{d_1 \cdot l_1 \cdot b_1}{1\,000}$$

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 the annex, 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 of the surface cells V_c cut during specimen preparation as follows.

8.1.3.1.1 For samples with natural or laminated skin surfaces :

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

8.1.3.1.2 For samples having cut cells on all surfaces :

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

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.

1) For tropical countries, test conditions will normally be 27 ± 2 °C and (65 ± 5) % relative humidity.

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 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 cm^3 under the overflow. This receptacle shall be capable of allowing the volume of water deposited in it to be measured to $\pm$ 0,5 cm^3 (this may be done by weighing). Remove the specimen and cage from the original vessel. Allow 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

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

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

$$V_0 = \frac{d.l.b}{1\,000}$$

where

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

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

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

b is the width, in millimetres, of the original 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 :

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

where ϱ is the density of water (= 1 g/cm^3).

9.2.2 If procedure B (8.2) was used :

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

where ϱ is the density of water (= 1 g/cm^3).

9.3 Calculate the average water absorption for all specimens tested.

10 Precision and accuracy

10.1 According to interlaboratory tests carried out in the USA, the reproducibility of this method was found to be $\pm$ 1,0 % (V/V).

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

11 Test report

The test report shall include the following particulars :

a) reference to this International Standard;

b) description, type of material and lot number;

c) method of preparing the test specimen, including whether the material is with or without skin;

d) number of specimens tested and their dimensions;

e) time of immersion;

f) correction procedure (A or B) used and the corrections expressed as a percentage by volume, i.e. :

$S_0 \times 100$

$S_1 \times 100$

$\frac{V_c}{V_0} \times 100$

g) individual corrected results for water absorption and their average, expressed as a percentage by volume.

h) average cell diameter for each specimen and average for all specimens tested, expressed in millimetres;

i) any observed anisotropic characteristics of the sample;

j) any observations relevant to the behaviour of the material.

Annex

Determination of average cell diameter (see 8.1.3.1)

(This annex forms an integral part of the Standard.)

A.1 Principle

Cutting of a cellular plastic specimen to less than monocellular thickness on a slicer and projection of its shadowgraph on a screen by means of a scale slide assembly and projector. Determination of the average chord length by counting the cells or cell-wall intersections in a specified distance and conversion of this value to average cell diameter by a mathematical formula.

A.2 Specimens

A.2.1 Number of specimens

For cellular plastics having symmetrical cells of relatively uniform size, one specimen will normally provide a representative average cell diameter. For cellular plastics known to be significantly anisotropic, a specimen cut in each of the three principal directions will normally permit a representative average cell diameter to be determined.

A.2.2 Dimensions

A specimen 50 mm × 50 mm and of the thickness of the sample shall be cut from the sample in the area to be tested.

A.3 Procedure

A.3.1 Prepare the cell viewing specimen by cutting a thin slice (less than monocellular) from one of the cut surfaces of the specimen. The slice shall be as thin as practicable so that a shadowgraph will not be occluded by overlapping cell walls. Optimum slice thickness will vary with the average cell size of the material, with smaller cell diameters requiring thinner slices.

A.3.2 Insert the sliced specimen into the slide assembly (5.6). Position the scale zero on the grid line at the top of the area to be measured. Reassemble the slide.

A.3.3 Insert the slide assembly into the projector (5.7). Focus the projector on the wall or screen so that a sharp image shadowgraph results.

A.3.4 Determine the average cell chord length t from the projected shadowgraph. First count the number of cells (or cell walls) that intersect the 3 cm straight line projected with the specimen. Then divide the length of the line by the number of cells counted to obtain the average chord length t. If the specimen is less than 3 cm, count the cells on the maximum grid length usable.

A.3.5 When the cell structure is anisotropic, determine the average cell diameter in each of the three principal directions and use the average of the three results.

A.4 Calculation

Calculate the average cell diameter, using the equation

$$D = \frac{t}{0{,}616}$$

where

D is the average diameter, in centimetres, of the cells;

t is the average length, in centimetres, of the cell chord.

Multiply by 10 to convert to millimetres and report to two significant figures.

NOTE — Assumptions made in the derivation of the equation for average cell diameter are that the cell shape is spherical and that the cells are relatively uniform with respect to size. Clause A.3.4 describes the procedure for determining t, the average measured chord length of the randomly truncated cells. The relationship between t and the average cell diameter $\overline{d}$ appearing at the plane of the cut surface may be calculated as follows.

The mean value of the ordinates in the first quadrant for any circle, $x^2 + y^2 = r^2$, is

$$\overline{y} = \frac{1}{r}\int_0^r \sqrt{r^2 - x^2}\,\mathrm{d}x = \frac{\pi r}{4} \qquad \ldots (1)$$

where

r is the radius of the cell in the surface plane;

$$\overline{y} = \frac{t}{2}$$

Therefore :

$$\frac{t}{2} = \frac{\pi r}{4} \qquad \ldots (2)$$

Since $r = \frac{\overline{d}}{2}$

$$t = \frac{\pi \overline{d}}{4} \qquad \ldots (3)$$

Rearrangement of equation (3) yields

$$\overline{d} = \frac{t}{0{,}785} \qquad \ldots (4)$$