INTERNATIONAL STANDARD

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Rigid cellular plastics — Determination of the volume percentage of open cells and of closed cells

Plastiques alvéolaires rigides — Détermination du pourcentage volumique de cellules ouvertes et de cellules fermées

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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.

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

ISO 4590 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 10, *Cellular plastics*.

This second edition cancels and replaces the first edition (ISO 4590:1981), which has been technically revised.

Annex A forms a normative part of this International Standard.

Rigid cellular plastics — Determination of the volume percentage of open cells and of closed cells

1 Scope

This International Standard specifies a general procedure for the determination of the volume percentage of open and of closed cells of rigid cellular plastics, by measurement first of the geometrical volume and then of the air-impenetrable volume of test specimens. The procedure includes the correction of the apparent open-cell volume by taking into account the surface cells opened by cutting during specimen preparation. Two alternative methods (method 1 and method 2), and corresponding apparatus, are specified for the measurement of the impenetrable volume. The results obtained from method 2 (see clause 9) are intended to be used for comparison purposes only.

2 Normative reference

The following normative document contains 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 edition of the normative document 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 1923:1981, *Cellular plastics and rubbers — Determination of linear dimensions*

3 Terms and definitions

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

3.1
surface area
S
the total surface area of the test specimen determined by measuring its geometrical dimensions

3.2
geometrical volume
V_g
the volume of the test specimen determined by measuring its geometrical dimensions

3.3
surface/volume ratio
r
the ratio $\frac{S}{V_g}$ for the test specimen

3.4
impenetrable volume
V_i
the volume of the test specimen into which air cannot penetrate and from which gas cannot escape, under the test conditions

3.5
apparent volume percentage of open cells
ω_r
the ratio

$$\frac{V_g - V_i}{V_g} \times 100$$

NOTE It includes the volume of the cells opened during cutting of the test specimen, and depends on the nature of the cellular plastic under test and on the surface/volume ratio r of the test specimen.

3.6
corrected volume percentage of open cells
ω_0
the apparent volume percentage of cells ω_r, corrected to take into account the surface cells opened by cutting during preparation of the test specimen

NOTE It is the limit of the apparent volume percentage of open cells ω_r, as the surface/volume ratio r approaches zero.

3.7
corrected volume percentage of closed cells
ψ_0
the volume percentage remaining after accounting for the corrected volume percentage of open cells

$$\psi_0 = 100 - \omega_0$$

NOTE This percentage includes the volume of the cell walls.

4 Principle

The surface area S and geometrical volume V_g of a number of test specimens, each having a different geometrical surface/volume ratio r, is determined.

The impenetrable volume V_i is determined by either of two methods, namely:

a) method 1 — by pressure variation (pyknometer);

b) method 2 — by volume expansion.

The determination of the impenetrable volume V_i is based on the application of the Boyle-Mariotte law to a gas confined in an indeformable chamber, first in the absence and then in the presence of a test specimen.

The apparent volume percentage of open cells ω_r of the test specimen is calculated by plotting the curve $\omega_r = f(r)$ and extrapolating to $r = 0$, followed by calculation of the corrected volume percentage of open cells ω_0 and the corrected volume percentage of closed cells ψ_0.

5 Test specimens

5.1 Number

A minimum of three test specimens shall be prepared for each test. A total of three tests shall be carried out per sample.

5.2 Preparation

Cut test specimens out with a band saw and machine them if necessary, taking care that there is no deformation to the original cell structure other than at the surface. The specimens shall be free of dust, voids and moulding skins.

Hot-wire cutting shall not be used.

5.3 Dimensions

The required test specimen dimensions depend on the specific method used to measure the impenetrable volume V_i. Initial specimen sizes shall be as follows:

Method 1: Pressure variation (pyknometer)

length: (25 ± 1) mm

width: (25 ± 1) mm

thickness: (25 ± 1) mm

Method 2: Volume expansion

length: (100 ± 1) mm

width: (30 ± 1) mm

thickness: (30 ± 1) mm

5.4 Sectioning of test specimens

Both methods require that specimens r_2 and r_3 of each set be further sectioned as shown in Figure 1 to provide a range of surface/volume ratios for testing.

6 Conditioning and test atmospheres

The test specimens shall be conditioned for not less than 16 h at (23 ± 2) °C and (50 ± 5) % relative humidity prior to testing. It is important that the test be conducted at (23 ± 2) °C and preferably at controlled and moderate humidity, i.e. (50 ± 5) %.

7 Measurement of surface area S and geometrical volume V_g

7.1 Determine the linear dimensions of each test specimen in accordance with ISO 1923, except that measurements shall be made to the nearest 0,05 mm. The locations of the measurement points shall be as shown in Figure 2.

7.2 Calculate the average linear dimensions, the surface area S and the geometrical volume V_g, retaining all significant figures for test specimens r_1 (one parallelepiped), r_2 (two parallelepipeds) and r_3 (four parallelepipeds).

Round off the final values for surface area S to the nearest 0,01 cm^2 and for the geometrical volume V_g to the nearest 0,01 cm^3.

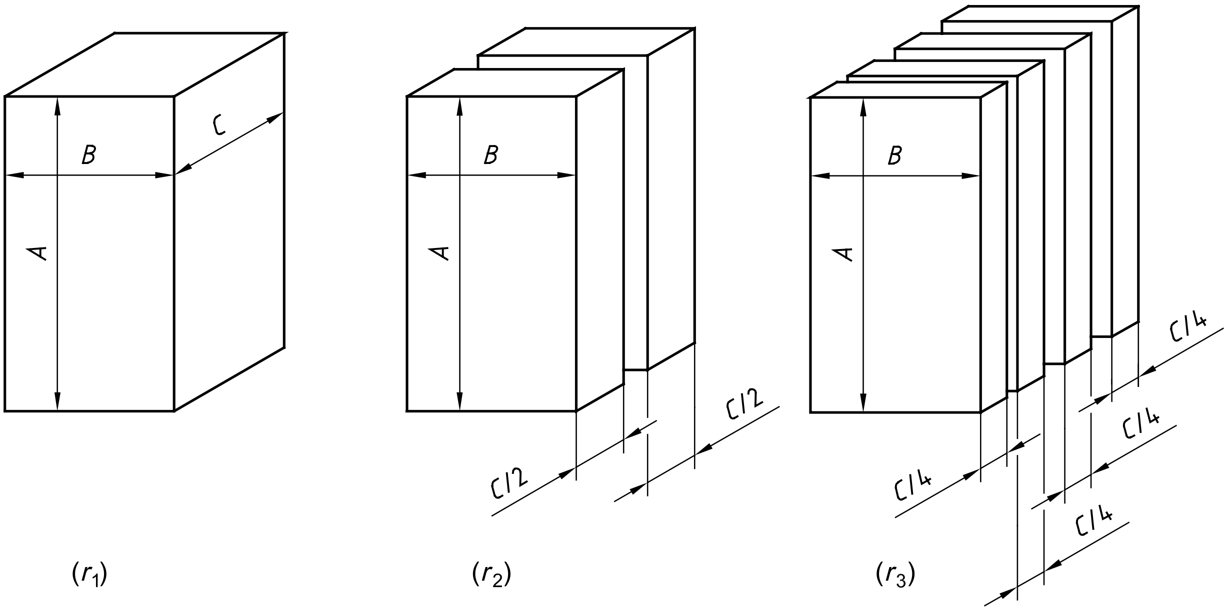
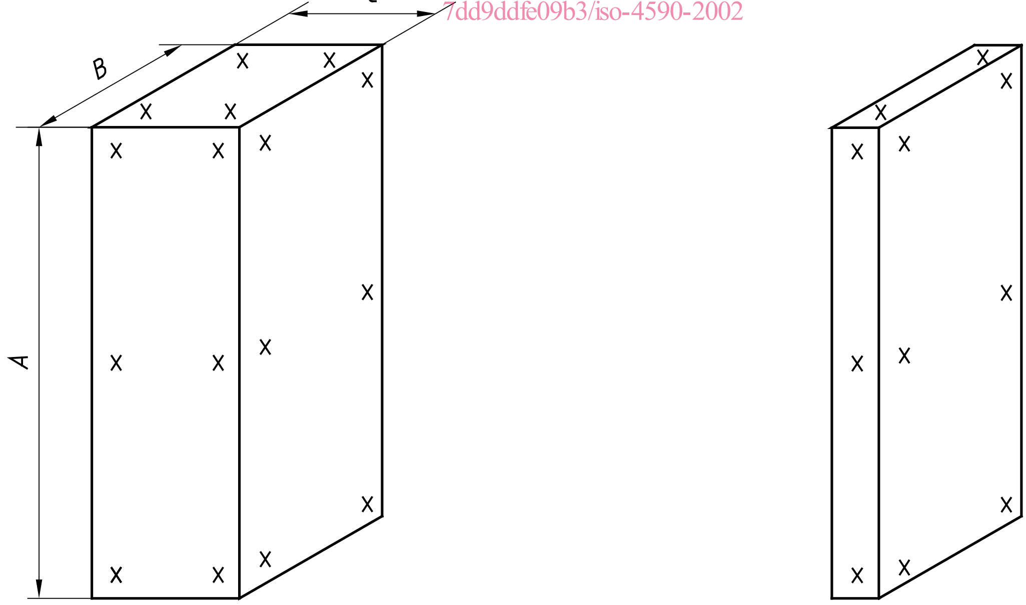


Figure 1 — Pattern for cutting test specimens



a) Thick specimen

b) Thin specimen

Figure 2 — Locations of measurement points

8 Determination of impenetrable volume V_i by method 1: Pressure variation (pyknometer)

NOTE The impenetrable volume V_i is determined by either method 1 or method 2. The principle, description of apparatus, calibration, procedure and calculation for these two methods are specified in this clause and clause 9, respectively.

8.1 Principle of method 1

The following characteristics are determined for an atmospheric pressure p_{amb} and a pressure reduction p_e in the test chamber in relation to p_{amb}:

a) the corresponding change in volume δV_{A1} of the test chamber in the absence of a test specimen; this determination constitutes the calibration of the apparatus;

b) the corresponding change in volume δV_{A2} of the test chamber in the presence of a test specimen.

The impenetrable volume V_i of the test specimen is given by the equation

$$V_i = \frac{\delta V_{A1} - \delta V_{A2}}{-p_e} p_B$$

where $p_B = p_{amb} + p_e$.

In practice (see 8.2.2), V_i is calculated from the equivalent equation

$$V_i = \frac{l_1 - l_2}{-K p_e} p_B$$

where

l_1 is the pyknometer scale reading corresponding to $K\delta V_{A1}$;

l_2 is the pyknometer scale reading corresponding to $K\delta V_{A2}$;

K is a constant relating the pyknometer scale readings to volume change in the chamber.

8.2 Description of apparatus for method 1

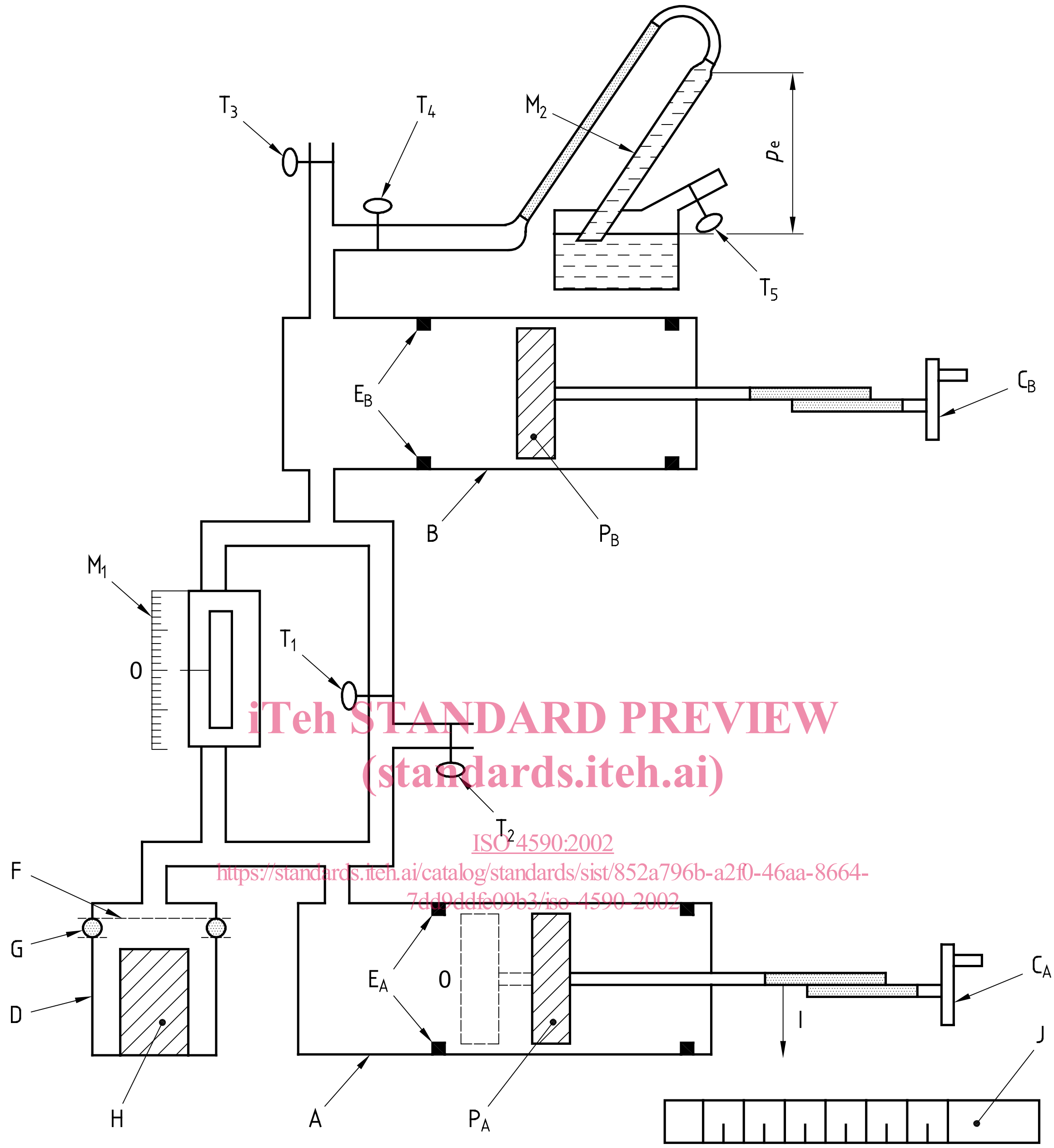
8.2.1 The apparatus consists of an air pyknometer that permits instant reading of the difference between internal pressure and atmospheric pressure. A schematic diagram of the apparatus is shown in Figure 3. It consists essentially of the following items:

a) test chamber A, including a removable measurement chamber D of volume approximately 50 cm^3, which fits to the main part of chamber A by means of an appropriate mechanical device, a filter F and an airtight circular joint G, to ensure impermeability and reproducibility of the geometrical volume of this part of the test chamber;

b) chamber B to create the reduced pressure.

8.2.2 The two chambers A and B are linked in parallel by means of tubing fitted with a valve T_1, which can connect or disconnect them, and a differential manometer M_1. The tubing can be connected directly to atmosphere by means of valve T_2.

When chamber D is connected to chamber A by means of the airtight joint G and the valve T_1 is closed, the volume V_A of the combined chambers (including the free volume of the chambers and of the tubing connected to the manometer M_1 and to the valve T_1) can be modified by moving piston P_A by means of crank C_A.



Key

A	Test chamber	H	Test specimen
B	Reduced-pressure chamber	I	Indicator
C_A, C_B	Cranks	J	Scale
D	Measurement chamber	M_1, M_2	Differential manometers
E_A, E_B	End points for displacement of pistons	P_A, P_B	Pistons
F	Filter	T_1 to T_5	Valves
G	Airtight joint		

Figure 3 — Schematic diagram of apparatus for determination of impenetrable volume V_i by method 1

The indicator I of the displacement of piston P_A permits reading directly on a scale J, with a precision of 0,25 %, a value l which has been precalibrated by the manufacturer to some corresponding change δV_A, starting from an initial reference value V_0.

NOTE The relationship between l and δV_A is defined by a proportionality constant K ($l = K\delta V_A$) as provided by the equipment manufacturer or by calibration from standard volumes. The proper value for K is obtained only if the zero reading on scale J is previously adjusted during the setting up of the air pyknometer in accordance with the manufacturer's instructions. The value of K for one commercially available air pyknometer is 2,0.

8.2.3 Chamber B can be connected directly to the atmosphere by means of valve T_3. Moreover, it is connected by means of tubing and valve T_4 to a differential manometer M_2 which indicates the pressure reduction that can be imposed at any time on the internal volume of chamber B with respect to the ambient atmosphere. The manometer M_2 shall permit the reading of the pressure reduction to 0,25 % (i.e. a pressure reduction p_e of − 200 mmH_2O shall be read to within ± 0,5 mmH_2O).

The pressure in chamber B is adjustable (when valves T_1 and T_3 are closed) by moving piston P_B by means of crank C_B. The difference p_e (negative in the procedure for method 1) between the pressure p_B in chamber B and the atmospheric pressure p_{amb} is indicated on the manometer M_2 when valve T_4 is open:

$$p_e = p_B - p_{amb}$$

8.3 Calibration of pyknometer apparatus

Determine, in accordance with the test procedure specified in 8.4 and for the atmospheric pressure p_{amb} prevailing at the moment of test, the reading l_1 corresponding to a pressure change $p_e = -200$ mmH_2O in relation to p_{amb}.

NOTE 1 In order to eliminate the need to determine l_1 each time the barometric pressure p_{amb} changes, it may be desirable to establish a calibration curve of $l_1 = f(p_{amb})$ for a given value of p_e. This can be accomplished as shown in Figure 4 by repeating the calibration procedure over a period of several days over which p_{amb} varies.

NOTE 2 If it is desired, for some cellular materials, to determine the impenetrable volume of the test specimens at another pressure reduction p_e', for example − 300 mmH2O, it will be necessary to plot a calibration curve for p_e'.

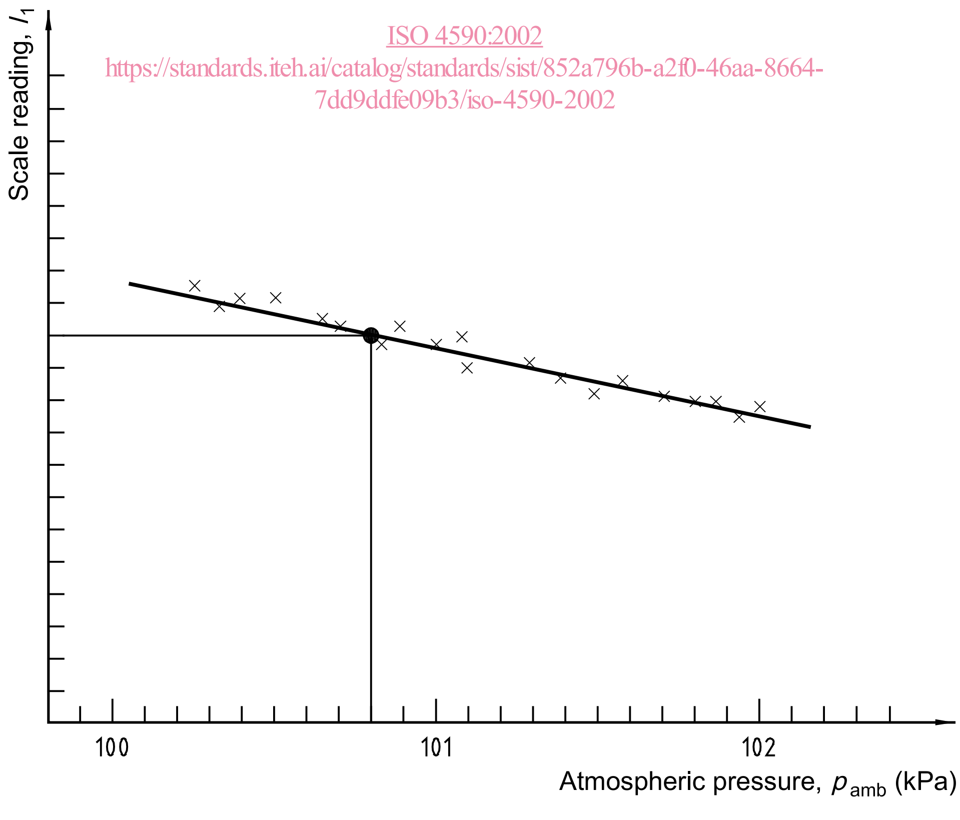


Figure 4 — Calibration graph for method 1 ($p_e = -200$ mmH_2O)