INTERNATIONAL STANDARD

ISO 4590

Third edition
2016-07-15

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

Reference number
ISO 4590:2016(E)

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

Page

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 61, *Plastics*, Subcommittee SC 10, *Cellular plastics.*

This third edition cancels and replaces the second edition (ISO 4590:2002), which has been technically revised with the following changes:

— changes on Clause 2;

— introduction of a new test method based on the variation of the volume which is named 2b and is explained under 9.5 to 9.7;

— references to the test methods have been revised consequently and the cross references;

— some editorial updates have been introduced.

Introduction

The method 2b is included in order to update the basics of the method with the modern apparatus. This International Standard kept the same measurement equipment since the first version of 1981 and new test equipment has been included in accordance with the technical advances. The equipment, its performance and calibration, and the calculation of the new method are described in 9.5 to 9.9.

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. Three alternative methods (method 1, method 2a and method 2b), and corresponding apparatus, are specified for the measurement of the impenetrable volume.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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
surface area
S
total surface area of the test specimen determined by measuring its geometrical dimensions

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

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

3.4
impenetrable volume
V_i
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
ratio

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

Note 1 to entry: 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
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 1 to entry: 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
volume percentage remaining after accounting for the corrected volume percentage of open cells

$$\psi_0 = 100 - \omega_0$$

Note 1 to entry: 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), and

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 test specimen.

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) and method 2b

length: (25 ± 1) mm

width: (25 ± 1) mm

thickness: (25 ± 1) mm

— Method 2a: Volume expansion

length: (100 ± 1) mm

width: (30 ± 1) mm

thickness: (30 ± 1) mm

5.4 Sectioning of test specimens

All three 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.

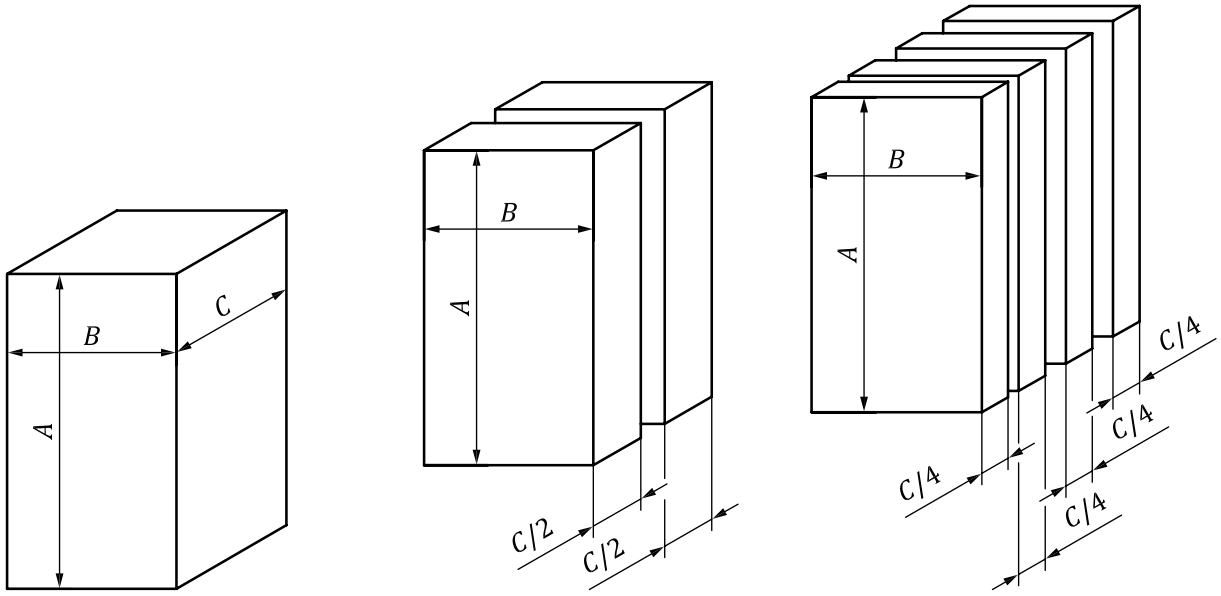
6 Conditioning and test atmospheres

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

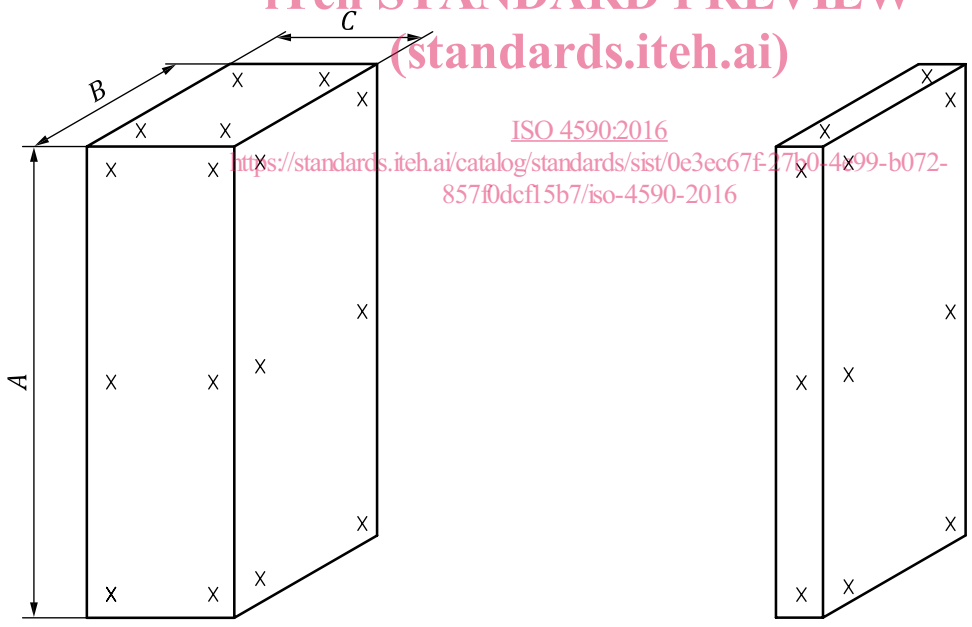
7.1 Determine the linear dimensions of each test specimen in accordance with ISO 1923, except that measurements shall be made to the nearest 0,05 mm. The locations of the measurement points shall be as shown in Figure 2.

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.



(r_1) (r_2) (r_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 Formula (1):

$$V_i = \frac{\delta V_{A1} - \delta V_{A2}}{-p_e} p_B \quad (1)$$

where

p_B is equal to $p_{amb} + p_e$.

In practice (see 8.2.2), V_i is calculated from the equivalent Formula (2):

$$V_i = \frac{l_1 - l_2}{-Kp_e} p_B \quad (2)$$

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

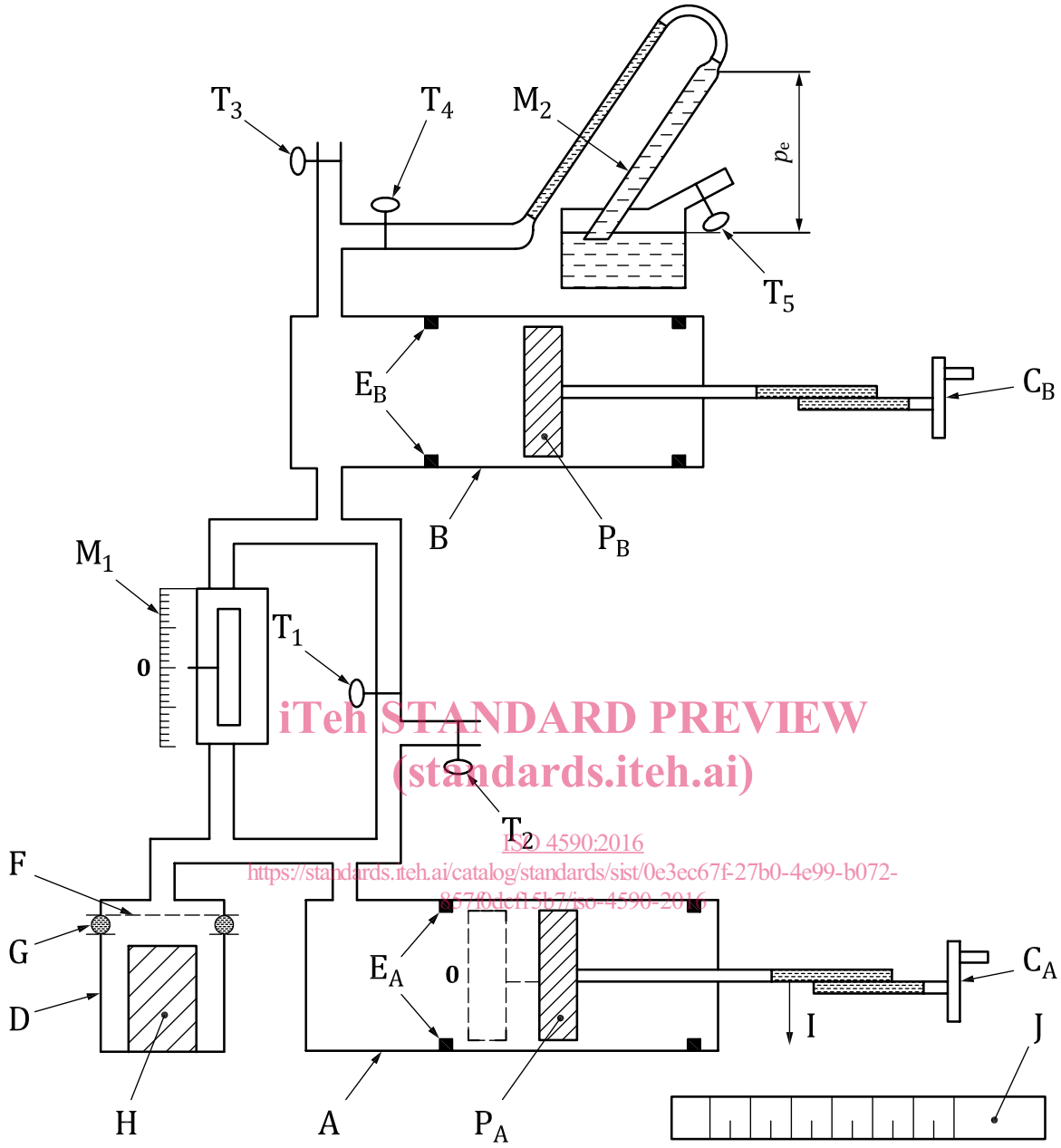
8.2.1 The apparatus consists of an air pyknometer that permits instant reading of the difference between internal pressure and atmospheric pressure. A schematic diagram of the apparatus is shown in Figure 3. It consists essentially of the following items:

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	endpoints 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