

Australian Standard[®]

Methods of testing rigid cellular plastics

Method 7: Determination of volume percentage of open and closed cells

METHOD

1 SCOPE This Standard sets out a method for determining the volume percentage of open and closed cells of rigid cellular plastics by measurement; first of the geometrical volume and then of the impenetrable volume of test specimens. This method also permits taking into consideration (for use as a correction) the volume of cells opened during test specimen preparation by cutting. The results given by this Method can be used for comparative purposes only.

2 REFERENCED DOCUMENTS The following documents are referred to in this Standard:

AS

2498 Methods of testing rigid cellular plastics

2498.1 Method 1: Sampling and conditioning

2498.2 Method 2: Determination of linear dimensions

3 DEFINITIONS For the purposes of this Standard, the following definitions apply.

3.1 Geometrical surface (S)—the total surface 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 Geometrical surface to volume ratio (r)—the ratio 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)—determined by the following ratio:

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

It includes the cells opened during cutting of a test specimen having a geometrical surface (S) and a geometrical volume (V_g), and depends on the nature of the cellular plastic under test and on the geometrical surface to volume ratio (r) of the test specimen.

3.6 Corrected volume percentage of open cells (ω_o)—the apparent volume percentage of open cells (ω_r) corrected to take into account the cells opened during preparation of test specimens by cutting.

It is the limit of the apparent volume percentage (ω_r) as the geometrical surface to volume ratio (r) approaches zero.

3.7 Corrected volume percentage of closed cells (ϕ_o)—the apparent volume percentage of closed cells corrected to take into account the volume of the cell walls.

$$\phi_o = 100 - \omega_o$$

4 PRINCIPLE The geometrical surface (S) and geometrical volume (V_g) of a number of test specimens, each having a different geometrical surface to volume ratio (r), are determined.

The impenetrable volume (V_i) is determined by either of two methods, namely—

- (a) the P method, by pressure variation; or
- (b) the V method, by volume variation.

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.

Calculation of the apparent volume percentage of open cells ω_r of the test specimen, plotting of the curve $\omega_r = f(r)$ and the extrapolation to $r = 0$, followed by the calculation of the corrected volume percentage of open cells (ω_o) and the corrected volume percentage of closed cells (ϕ_o).

5 APPARATUS

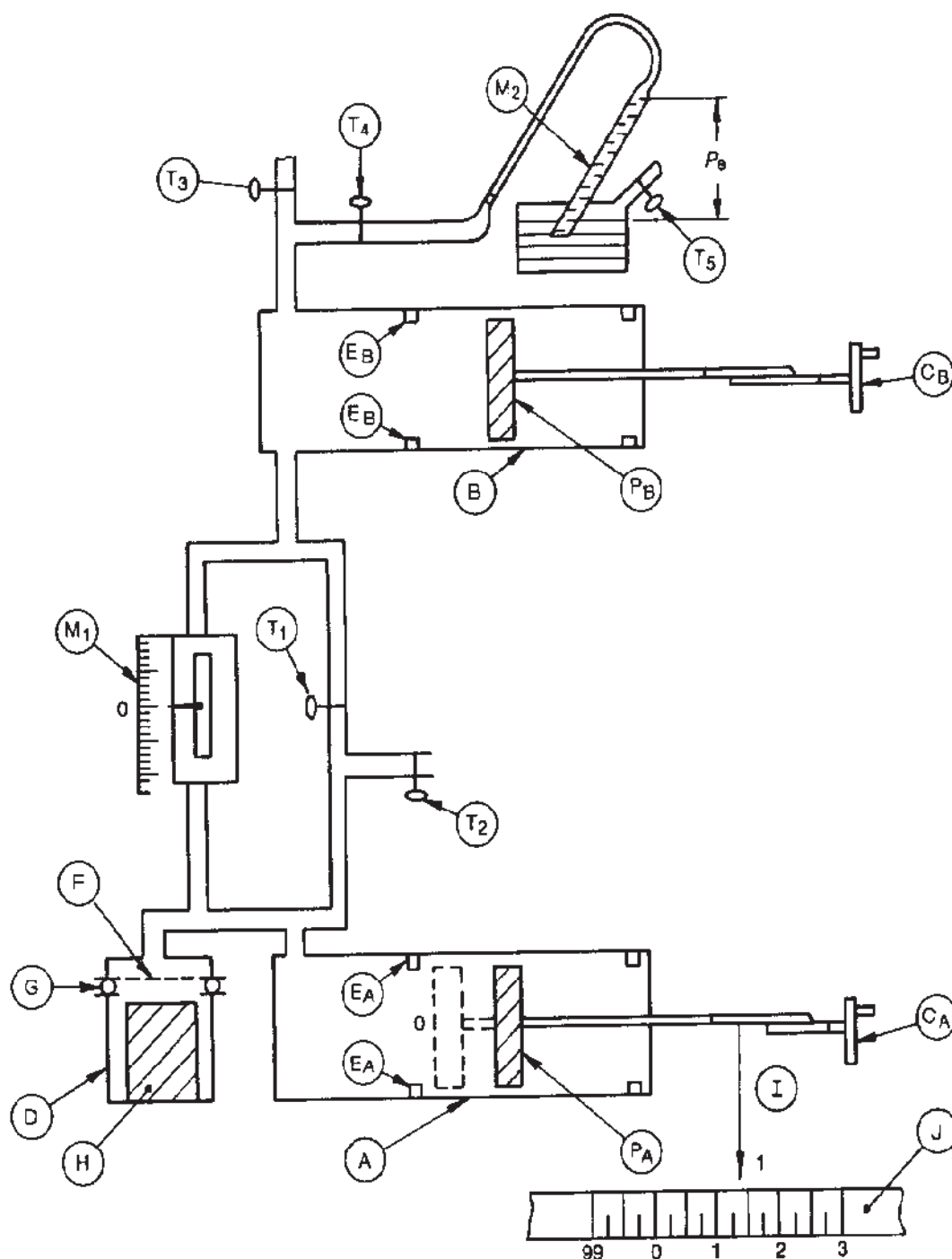
5.1 P Method The apparatus consists of the following items:

- (a) An air pycnometer which permits reading of the difference between internal pressure and atmospheric pressure. A schematic diagram of the apparatus is shown in Figure 1. It consists essentially of the following items:
 - (i) Test chamber (A), including a removable measurement chamber (D) of volume approximately 50 cm³, which fits to the main part of chamber (A) by means of an appropriate mechanical device, a filter (F) and airtight circular joint (G), to ensure impermeability and the reproducibility of the geometrical volume of this part of the test chamber.
 - (ii) Chamber (B) to create the reduced pressure.
- (b) The two chambers (A and B) are linked in parallel by means of tubing fitted with a tap (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 tap (T_2).

When the measurement chamber (D) is connected to the test chamber (A) by means of the airtight joint (G) and the tap (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 tap (T_1), can be modified by moving the piston (P_A) by means of the crank (C_A).

The indicator (I) of the displacement of the piston (P_A) permits reading directly on a scale (J), with a precision of 0.25%, a value l corresponding to twice the change (δV_A) in the volume (V_A), starting from an initial reference value (V_o).

NOTE: This relationship between l and V_A is achieved only if the zero reading on scale (J) is previously adjusted during the setting up of an air pycnometer in accordance with the manufacturer's instructions.



LEGEND:

A Test chamber
 B Reduced pressure chamber
 C_A
 C_B } Cranks
 D Measurement chamber
 E_A
 E_B } End-points for displacement of pistons
 F Filter
 G Airtight joint
 H Test specimen
 I Indicator

J Scale
 M₁
 M₂ } Differential manometers
 P_A
 P_B } Pistons
 P_e Reduced pressure
 T₁
 T₂
 T₃
 T₄
 T₅ } Taps

FIGURE 1 SCHEMATIC DIAGRAM OF APPARATUS FOR DETERMINATION OF IMPENETRABLE VOLUME (V_i) BY P METHOD

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- (c) The measurement chamber (B) can be connected directly to the atmosphere by means of tap (T_3). Moreover, it is connected by means of tubing and tap (T_4) to a differential manometer (M_2) which indicates the reduced pressure which can be imposed at any time to the internal volume of chamber (B) with respect to the ambient atmosphere. The manometer (M_2) shall permit the reading of the reduced pressure with an accuracy of 0.25% (or reduced pressure P_e of -200 mm H_2O shall be read with an accuracy of 0.5 mm H_2O).

The pressure in chamber (B) is adjustable (when the taps (T_1 and T_3) are closed) by moving the piston (P_B) by means of the crank (C_B). The difference (P_e) (negative in the procedure specified in this Standard) between the pressure (P_B) in chamber (B) and the atmospheric pressure (P_{amb}) indicated on the manometer (M_2) when tap (T_4) is open, that is—

$$P_e = P_B - P_{amb}$$

5.2 V Method A schematic diagram of the apparatus is shown in Figure 2. The test specimen chamber (K) is provided with a ground glass cap (L) such that a gas-seal can be obtained by applying vacuum grease to the joint. The chamber (K) is connected via an expansion bulb (N) to a manometer (M_3) filled with water containing a few drops of a surfactant and a colorant. The liquid level in the manometer is adjusted by means of a reservoir (O). (This can be controlled by using a syringe.) The gas in the chamber (K) is brought to atmospheric pressure at the time of test by means of the tap (T_6). A scale (Q), graduated in millimetres, is attached to the open arm of the manometer (M_3).

In order to avoid errors due to fluctuation in ambient temperature, the whole apparatus is enclosed in a draught-proof case (R), fitted with a transparent front panel and a trap door (S) through which test specimens can be introduced into the chamber (K).

NOTE: Several models of such apparatus have been constructed and used successfully, observing the following parameters:

- (a) Volume V_K of the chamber K and glass tubing to mark U_1 : 310 cm³.
- (b) Volume V_N of the expansion bulb between marks U_1 and U_2 : 10.5 cm³.
- (c) Height of mark U_2 above the bottom of the manometer: at least 650 mm.
- (d) Minimum internal diameter of the glass tubing: 10 mm.

6 TEST SPECIMENS

6.1 Dimensions Test specimens shall be rectangular parallelepipeds having the following dimensions:

- (a) P Method:

Length: 40 mm
Width: 30 mm
Thickness: 20 mm

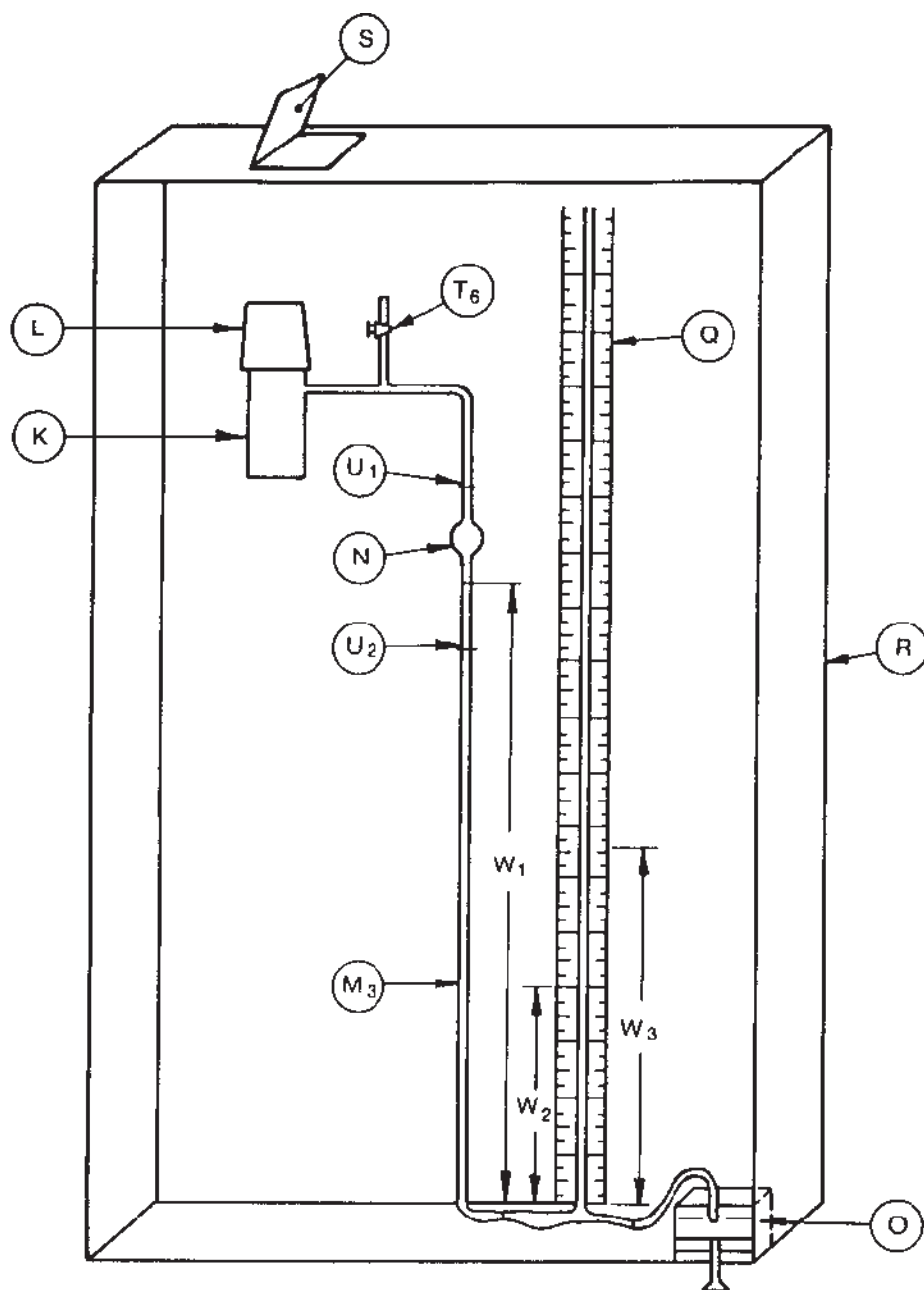
- (b) V Method:

Length: 100 mm
Width: 30 mm
Thickness: 30 mm

6.2 Preparation Test specimens shall be free from dust, voids and moulding skins; they shall be cut with a bandsaw and machined, if necessary, with minimum deformation of the original cellular structure.

Hot-wire cutting is not permissible.

6.3 Number A minimum of three specimens shall be tested.



LEGEND:

K Test specimen chamber
 L Ground glass cap
 M₃ Manometer
 N Expansion bulb
 O Reservoir
 Q Scale
 R Draughtproof case

S Trap door
 T₆ Tap
 U₁ } Marks
 U₂ }
 W₁ } Liquid levels
 W₂ }
 W₃ }

FIGURE 2 SCHEMATIC DIAGRAM OF APPARATUS FOR DETERMINATION OF IMPENETRABLE VOLUME (V_i) BY V METHOD