

Australian Standard®

Methods of testing rigid cellular plastics

Method 8: Determination of water absorption

PREFACE

This Method was prepared by the Standards Australia Committee on Rigid Cellular Plastics for Thermal Insulation under the direction of the Plastics Standards Board.

FOREWORD

The buoyant force of an object less dense than water is equal to the weight of the volume of water it displaces when submerged, less the dry weight of the object. Water absorbed into the object lowers the buoyant force by reducing the volume of water actually displaced. With a known volume and initial dry weight of the object, the initial buoyant force at the end of the immersion period is measured with an underwater weighing assembly. The difference between the initial and final buoyant force is the weight of water absorbed, which can be expressed in terms of water absorbed per unit of specimen volume. An error may be encountered if there is a rapid absorption of water before an accurate initial wet weight or initial zero volume can be obtained. This variable is eliminated when the only submerged measurement required is a final weighing taken after 96 h immersion period.

METHOD

1 SCOPE This Method sets out a method for determining the water absorption of rigid cellular plastics by measuring the change in buoyant force resulting from immersion in distilled water.

NOTES:

- 1 Some materials may absorb significant additional amounts of water when immersed for longer than 96 h, or under a greater hydrostatic head.
- 2 If a full assessment of the water absorption characteristics of a rigid cellular plastics is required, it is essential to make measurements over a range of immersion periods and plot a graph of water absorption against time.

2 APPLICATION This method is intended for use in quality control and for product specifications. It is not applicable for end-use design requirements unless end-use conditions are similar to those for the test method in both duration and head.

Results by this method can not be used to compare the resistance of rigid cellular plastics to water vapour transmission with subsequent condensation within the cells.

3 REFERENCED DOCUMENT The following document is referred to in this Standard:

AS

2498 Methods of testing rigid cellular plastics

2498.2 Method 2: Determination of linear dimensions

4 PRINCIPLE The change in buoyant force is measured when a test specimen is immersed under a 50 mm head of distilled water for a period of 96 h. Water absorption is expressed as a percentage increase in volume of the original volume of the test specimen. Corrections are made for volume changes caused by immersion in water and for the volume of water contained in cut surface cells of the test specimen.

5 APPARATUS

5.1 Balance—capable of weighing up to 2500 g with an accuracy of 0.1 g. The balance must have provision for attaching a sling below the balance platform for making submerged weighings.

5.2 Underwater weighing jig—constructed of stainless steel or other material not attacked by distilled water. The jig should be large enough to hold a 150 mm × 150 mm test specimen. The jig should have a dry weight of approximately 2500 g and be fitted with a means of suspending it from the balance. The jig and test specimen should not trap any air when submerged in water (see Figure 1).

5.3 Immersion tank—of sufficient size to accommodate three test specimens with the top faces (150 mm × 150 mm) horizontal, with additional space for the weighing jig.

5.4 Test specimen rack—constructed of material not attacked by distilled water, weighted to prevent the upthrust of the test specimens, that will fit into the immersion tank and is capable of holding three test specimens under a 50 mm head of water.

5.5 Balance platform—which enables the balance to be placed above the immersion tank and which allows positioning of the sling suspending the weighing jig from the balance.

5.6 Forced-air circulating oven—capable of maintaining a temperature of 50 ± 3 °C.

5.7 Dessicator

5.8 Low-permeability plastic film—such as polythene film.

5.9 Measuring instruments—capable of measuring linear dimensions in accordance with AS 2458.2.

6 TEST SPECIMENS

6.1 Dimensions Test specimens shall be at least 5×10^5 mm³ (0.5 L) in volume with a nominal length of 150 mm and nominal width of 150 mm.

For cellular plastics produced and sold in thicknesses greater than 75 mm with natural or laminated skin surfaces, the actual thickness must be used, in which case the width and length of the test specimen must be increased to no less than twice the thickness. To accommodate these larger test specimens it may be necessary to increase the size of the test equipment.

For cellular plastics produced and sold in thicknesses greater than 75 mm but with no natural skins, the material shall be cut to 75 mm thickness for testing. The distance between opposite faces shall not vary by more than one percent.

6.2 Preparation Test specimens shall be cut by saw or knife. A hot wire cutter shall not be used.

6.3 Number At least three test specimens shall be tested from each sample.

6.4 Conditioning The conditioning procedure shall be as follows:

- After cutting the test specimens, condition them in a forced-air circulating oven maintained at 50 ± 3 °C for not less than 24 h.
- At the completion of the conditioning period, allow the test specimens to cool to room temperature in a desiccator for a minimum period of 1 h, then weigh to the nearest 0.1 g.
- Return the test specimens to the oven maintained at 50 ± 3 °C for a further 4 h, cool for at least 1 h in the desiccator and weigh to the nearest 0.1 g.
- Repeat Step (c) above as necessary until two successive weighings agree within 0.2 g.
- Record the final dry mass of each test specimen to the nearest 0.1 g (m_1).

7 PROCEDURE The testing procedure shall be as follows:

- Measure the dimensions of each test specimen to the nearest 0.02 mm in accordance with AS 2498.2.
- Place the test specimens underneath the weighing jig in the immersion tank.
- Immerse the test specimens in the immersion tank filled with de-aerated distilled water maintained at 23 ± 2 °C. Locate the test specimens underwater in the weighted test specimen rack.
- Adjust the water level to maintain a $50 - 0, + 2$ mm head of water above the test specimens, with the 150 mm × 150 mm faces in a horizontal position.
- Remove any air bubbles clinging to the test specimens with a soft bristle brush.

- (f) Cover the entire water surface with a low-permeance plastics film.
- (g) Maintain the head of water over the test specimens at $50 \pm 0, + 2$ mm, and the temperature at $23 \pm 2^\circ\text{C}$ for $96 \pm 0, +0.5$ h.
- (h) At the completion of the immersion period, remove the plastics film from the water, place the balance platform and balance above the tank and zero the balance.
- (i) Attach the underwater weighing jig to the balance. Ensure that the jig is free of trapped air bubbles and the top of the jig is $50 \pm 0, + 2$ mm from the water surface.
- (j) Weigh the empty submerged jig to the nearest 0.1 g (m_2).
- (k) Without removing the test specimens from the water, place them in the submerged underwater weighing jig. Weigh to the nearest 0.1 g (m_3). No test specimens should be removed from the water until all have been weighed, to avoid reducing the $50 \pm 0, + 2$ mm head.
- (l) Remove the test specimens from the water, rapidly remove the surface water from the test specimens with a towel, and measure the dimensions (length, width, thickness) of each test specimen to the nearest 0.02 mm.

8 CORRECTION FOR SWELLING AND CUT SURFACE CELLS

8.1 Procedure A (uniform swelling)

8.1.1 Applicability Use this procedure when there is no evidence of non-uniform deformation of the specimen.

8.1.2 Determination of correction for volume of the cut surface cells Use the method described in Appendix A to determine the average cell diameter (D) of a test specimen obtained from the same sample of material from which the test specimens were taken. Use this average cell diameter to calculate the volume (V_c) of cut surface cells as follows:

For specimens having natural or laminated skins on two faces:

$$V_c = 0.54D \frac{(l.d + b.d)}{500} \quad \dots 8.1.2(1)$$

For specimens having cut cells on all surfaces:

$$V_c = 0.54D \frac{(l.b + l.d + b.d)}{500} \quad \dots 8.1.2(2)$$

where

V_c = the volume of cut surface cells, in cubic centimetres

D = the average cell diameter, in millimetres, as determined by the method in Appendix A.

NOTE: If the average cell diameter is less than 0.5 mm and the test specimen volume is greater than $5 \times 10^5 \text{ mm}^3$ (0.5 L) this correction is comparatively small and can be neglected

l = the original test specimen length, in millimetres

d = the original test specimen width, in millimetres

b = the original test specimen thickness, in millimetres.

8.1.3 Correction for uniform swelling Calculate the correction for uniform swelling of the specimen (S_o) using the equation:

$$S_o = \frac{V_1 - V_o}{V_o} \quad \dots 8.1.3(1)$$

where

$$V_o = \frac{d.l.b}{1000}$$

$$V = \frac{d_1.l_1.b_1}{1000} \quad \dots 8.1.3(2)$$

and where

d_1 = the test specimen thickness after immersion, in millimetres

l_1 = the test specimen length after immersion, in millimetres

b_1 = the test specimen width after immersion, in millimetres.

8.2 Procedure B (non-uniform swelling)

8.2.1 Applicability Use this procedure when there is evidence of non-uniform deformation of the specimen.

8.2.2 Determination of correction for swelling and for cut surface cells The following procedure shall be used to obtain both a correction for swelling and for cut surface cells:

- Select a cylindrical vessel which is of sufficient diameter to hold the underwater weighing jig containing the test specimen.
- Fit the empty vessel with an overflow and fill with water until it runs out of the overflow.
- When the water level has stabilized, place a graduated cylinder of at least 600 mL capacity under the overflow.
- Remove the test specimens and the weighing jig from the test tank, allow them to drain until all surface water has drained (approximately 2 min.)
- Carefully immerse the test specimen and weighing jig in the filled vessel and collect the water overflowing in the graduated cylinder.
- Determine the volume of water displaced to the nearest 0.5 mL (V_2). (Do this by weighing if necessary.)
- Repeat this procedure with the empty jig to determine its volume (V_3).

The combined swelling and surface correction factor (S_1) for non-uniform swelling is obtained from the following equation:

$$S_1 = \frac{V_2 - V_3 - V_o}{V_o} \quad \dots 8.2.2(1)$$

where

V_2 = the volume of water displaced by specimen and jig, in cubic centimetres

V_3 = the volume of water displaced by jig only, in cubic centimetres

V_o = the original volume of the test specimen, in cubic centimetres.

9 CALCULATION OF RESULTS

9.1 Original volume Calculate the original volume of the test specimen from the following equation:

$$V_o = \frac{d.l.b}{1000}$$

where

V_o = the original volume of the test specimen, in cubic centimetres

d = the original test specimen width, in millimetres

l = the original test specimen length, in millimetres

b = the original test specimen thickness, in millimetres.

9.2 Surface area Calculate the surface area of the test specimen from the following formula:

$$A = \frac{(l.b + l.d + b.d)}{50} \quad \dots 9.2(1)$$

where

A = the original surface area, in square centimetres.

9.3 Percentage water absorbed

9.3.1 No deformation If no deformation or swelling of the test specimen was observed, and the correction procedure of Clause 9.1 was followed, use the following equation to calculate the amount of water absorbed, as a percentage by volume, (V_A):

$$V_A = \frac{[m_3 + \rho V_o - (m_1 + m_2 + \rho V_o)]}{\rho V_o} \times 100 \quad \dots 9.3(1)$$

where

ρ = density of water

= 1 g/cm³

m_1 = dry weight of the test specimen, in grams

m_2 = weight of empty submerged weighing jig, in grams

m_3 = weight of submerged specimen and weighing jig, in grams

V_o = the original volume of the test specimen, in cubic centimetres.