

# International Standard



# 4897

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## Cellular plastics — Determination of the coefficient of linear thermal expansion of rigid materials at sub-ambient temperatures

*Plastiques alvéolaires — Détermination du coefficient de dilatation linéique thermique des plastiques alvéolaires rigides aux températures inférieures à l'ambiante*

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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.

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 4897 was prepared by Technical Committee ISO/TC 61, *Plastics*.

# Cellular plastics — Determination of the coefficient of linear thermal expansion of rigid materials at sub-ambient temperatures

## 1 Scope and field of application

This International Standard specifies two methods for determining the coefficient of linear thermal expansion of rigid cellular plastics at sub-ambient temperatures. Method A is the preferred method since it gives a value on a large sample at a chosen temperature which is more representative because of anisotropy, etc., of the material or product. In practice, difficulties may be encountered in accurately controlling the uniformity of the low temperature inside the test chamber at temperatures below  $-70\text{ }^{\circ}\text{C}$ . Should this be the case, Method B should be employed to obtain an "average" coefficient for the temperature interval between the cryogenic temperature and the ambient temperature.

The values obtained in these tests are valid measurements only for the specific sample tested, at the time tested. They cannot be applied generally to a product and cannot be used to predict performance of the same material at a future date.

Care should also be taken in applying the value obtained in this test to calculate the overall coefficient of expansion of composite products of which the material under test is part.

Many rigid cellular products are not isotropic. This is usually ascribed to the fact that the cells in the material are elongated in a particular direction. This direction is referred to in these methods as the "direction of anisotropy". Tests carried out in this direction normally give results differing from those obtained from other test directions. The direction of anisotropy may vary within a product and thus the number of test specimens required for product specification will generally exceed those given in this International Standard.

## 2 References

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

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

## 3 Definition

**coefficient of linear thermal expansion** : The change in unit length per degree Celsius change in temperature.

## 4 Method A

### 4.1 Apparatus

An apparatus found suitable consists of the following:

#### 4.1.1 Test chamber and cooling system

The test chamber shall consist of a well-insulated box of approximate internal dimensions  $400\text{ mm} \times 1\,000\text{ mm} \times 150\text{ mm}$ , having viewing windows  $900 \pm 10\text{ mm}$  apart. These windows shall be insulated with plugs of insulation between readings to ensure good temperature distribution.

The chamber shall be fitted with a cooling system designed to give a sub-ambient internal temperature distribution complying with the requirements of 4.4. A suitable chamber and cooling system is described in the annex and illustrated in figures 1 and 2.

NOTE — Liquid nitrogen has been found in practice to be the most satisfactory coolant.

#### 4.1.2 Reference length material

Inside the box a reference length material of  $880 \pm 5\text{ mm}$  shall be positioned so that fiducial marks on the end are at the same level and in the same vertical plane as fiducial lines on the test specimens. The coefficient of expansion of the reference length material should be small and accurately known. A suitable material is silica in the form of a rod with ends ground to knife edges (see figure 3). It shall be adequately supported to prevent bowing.

#### 4.1.3 Measuring system

A travelling microscope or equivalent capable of measuring to  $0,01\text{ mm}$  shall be provided. Care shall be taken to ensure that the direction of travel of the instrument is parallel to the edge of the test specimen.

#### 4.1.4 Temperature-measuring device

Any suitable temperature-measuring device may be used; it shall be calibrated over the required range to within  $1\text{ }^{\circ}\text{C}$ .

Temperatures in the box shall be measured by any suitable means in at least five positions equally spaced along the entire length of the test specimen.

## 4.2 Test specimen

The test specimen shall be a rectangular board having the following dimensions:

900  $\pm$  20 mm in length;

100 to 300 mm in width;

25 to 50 mm in thickness.

The test specimen shall be cut without significant deformation of the original cell structure; the surfaces shall be parallel and unbowed and free of surface skins (hot-wire cutting is not permissible).

To each end of the board shall be fixed fiducial lines. These may consist, for example, of razor blades attached rigidly to the corners by drawing pins so that the knife edges project beyond the edge of the specimen and perpendicular to its length (see figure 3).

## 4.3 Conditioning

The test specimens shall be conditioned at  $23 \pm 2$  °C and  $50 \pm 5$  % relative humidity for not less than 16 h. The test shall be carried out immediately after conditioning.

## 4.4 Procedure

**4.4.1** Determine the length of both the test specimen and the reference length in accordance with ISO 1923.

**4.4.2** Support the test specimen in the apparatus so that it does not sag and is free to move, and so that air may circulate freely round it. Position the ends of the specimen carrying the fiducial lines centrally in the windows and symmetrically with respect to the reference length. Then insert the temperature measuring devices and switch on the fan (if used). After the temperature has been steady within  $\pm 2$  °C for 30 min, measure the difference in length between the test specimen and the reference length.

**4.4.3** Adjust the thermostat to reduce the temperature by about 20 °C and insert the plugs in the viewing holes. When the temperature is steady to within  $\pm 2$  °C for 20 min at the new level, again measure the difference between the length of the test specimen and the reference length. Repeat this measurement procedure at approximately 5-minute intervals until three consecutive measurements agree to within 0,03 mm.

**4.4.4** Repeat the above procedure until the lowest temperature required is reached. Also make measurements as the apparatus is brought back to room temperature while observing the same precautions to establish thermal equilibrium. Check the temperature in the box before and after each measurement of length; the average of the total number of readings shall be taken as the temperature to be associated with the length measured. The difference between the average temperature immediately before and after measurement shall not exceed 2 °C and the corresponding difference for any individual temperature measuring device shall not exceed 5 °C.

## 4.5 Expression of results

Use the results obtained to plot a graph of the length of the test specimen against temperature. Make allowance for the (calculated) change in the length of the reference length. The results should all lie on a smooth curve and there should be no significant hysteresis between descending and ascending temperature points. If there is significant hysteresis, repeat the determination allowing more time for the test specimen to attain thermal equilibrium.

Determine the mean coefficient of linear expansion over the selected temperature range as follows:

From the graph, read off the lengths of the specimen at the upper and lower temperatures of the range over which it is required to know the coefficient. Calculate the mean coefficient over the selected temperature range from the following equation:

$$\bar{\alpha} = \frac{\Delta L}{L_0} \times \frac{1}{T_1 - T_2}$$

where

$\bar{\alpha}$  is the mean coefficient of linear expansion, in reciprocal kelvins;

$T_1$  is the higher temperature selected, in kelvins;

$T_2$  is the lower temperature selected, in kelvins;

$\Delta L$  is the change in length, in millimetres, of the test specimen between temperatures  $T_1$  and  $T_2$ ;

$L_0$  is the original length, in millimetres, of the test specimen at  $23 \pm 2$  °C.

## 4.6 Test report

The test report shall include the following:

- a) reference to this International Standard, followed by "Method A";
- b) the description and identity of the sample;
- c) the age of the sample and the date of the test;
- d) the direction of any known anisotropy in relation to the measured length;
- e) the mean coefficient of linear expansion to two significant figures and the temperature range to which the result relates;
- f) copy of the experimental graph;
- g) details of conditioning, if other than those specified in 4.3.