IS 11239-7 (1985): Methods of Test for Rigid Cellular Thermal Insulation Materials, Part 7: Coefficient of Linear Thermal Expansion at Low Temperatures [CHD 27: Thermal Insulation]

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(Reaffirmed 2001)

Indian Standard

METHODS OF TEST FOR RIGID CELLULAR THERMAL INSULATION MATERIALS

PART 7 COEFFICIENT OF LINEAR THERMAL EXPANSION AT LOW TEMPERATURES

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METHODS OF TEST FOR RIGID CELLULAR THERMAL INSULATION MATERIALS

PART 7 COEFFICIENT OF LINEAR THERMAL EXPANSION AT LOW TEMPERATURES

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 25 March 1985, after the draft finalized by the Thermal Insulation Materials Sectional Committee had been approved by the Chemical Division Council.

0.2 In the preparation of this standard, considerable assistance has been drawn from BS 4370 Part 3: 1974 'Methods for measurement of heat distortion temperature, determination of friability and measurement of coefficient of linear thermal expansion at low temperature', issued by British Standards Institution.

0.3 In reporting the result of a test made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2 - 1960*.

1. SCOPE

1.1 This standard prescribes the method for measurement of coefficient of linear thermal expansion at low temperatures of rigid cellular thermal insulation materials.

1.2 The test is not designed to give information about long-term exposure to low temperature which may alter the measured coefficient of thermal expansion.

NOTE – Care should 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 a part.

*Rules for rounding off numerical values (*revised*).

2. TERMINOLOGY

2.1 For the purpose of this standard the definitions given in IS : 3069-1965* and the following shall apply.

2.1.1 *Coefficient of Linear Thermal Expansion* — The change in unit length per degree celsius change in temperature.

3. PRINCIPLE

3.1 The coefficient of linear thermal expansion is measured by comparing the length of the test specimen with that of a reference length under controlled conditions at several low temperatures.

NOTE — The values obtained in this test should not be used to predict the behaviour of the test materials at temperatures outside the range of those covered in the test.

4. CONDITIONING

4.1 The test specimens shall be conditioned at 27 ± 2°C and 65 ± 5 percent relative humidity for not less than 16 hours. The test shall be carried out immediately after conditioning.

5. APPARATUS

5.1 Test Chamber and Cooling System — The test chamber shall consist of a well insulated box of approximate internal dimensions 400 × 1 000 × 150 mm, having viewing windows 900 ± 10 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 low internal temperature distribution complying with the requirements of **7**.

NOTE — A suitable chamber and cooling system is described in Appendix A and illustrated in Fig. 1 and 2. Liquid nitrogen has been found in practice to be the most satisfactory coolant.

5.2 Reference Length — Inside the box a reference length of 880 ± 5 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 specimen. 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, as shown in Fig. 3. It shall be adequately supported to prevent bowing.

5.3 Measuring System — A travelling microscope or equivalent capable of measuring to 0·01 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; any divergence shall be less than one degree of arc.

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*Glossary of terms, symbols and units relating to thermal insulation materials.

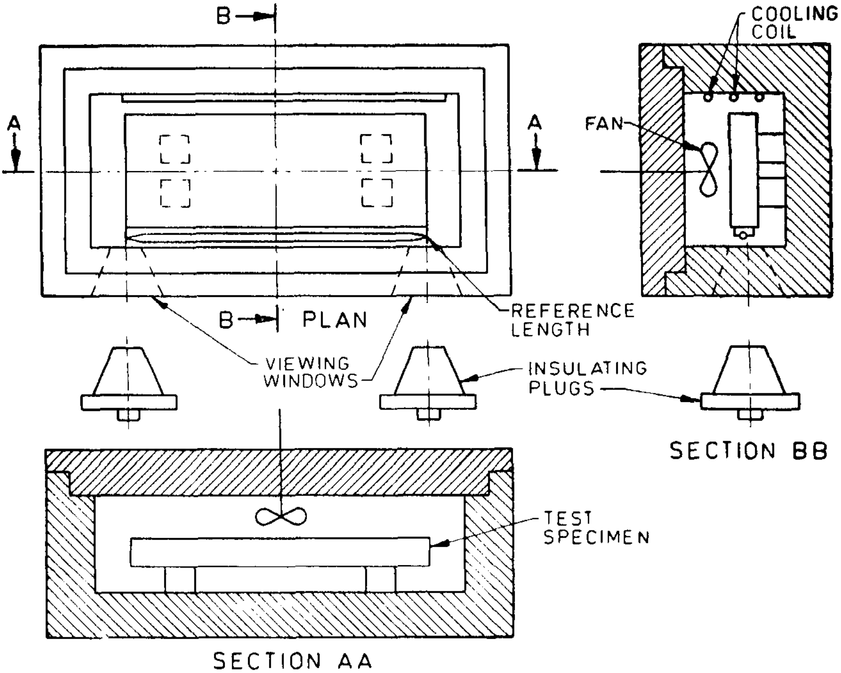


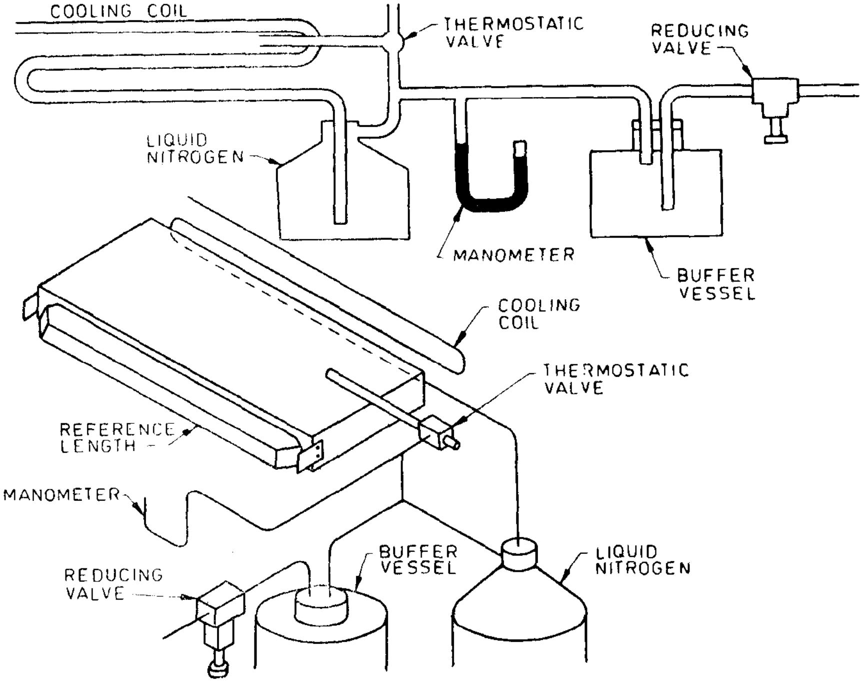
FIG. 1 SUITABLE APPARATUS FOR DETERMINATION OF COEFFICIENT OF THERMAL EXPANSION AT LOW TEMPERATURE

6. TEST SPECIMENS

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

Length	900 ± 20 mm
Width	100 to 300 mm
Thickness	25 to 50 mm

6.2 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 of, for example, 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, as shown in Fig. 3.



NOTE — Attention is drawn to the fact that this particular cooling system is the subject of a patent.

FIG. 2 LAYOUT OF SUITABLE COOLING SYSTEM

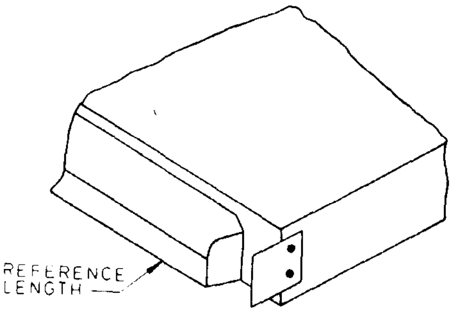


FIG. 3 FIDUCIAL LINES

7. PROCEDURE

7.1 Determine the length of both the test specimen and the reference length in accordance with 11239 (Part 1)-1985*.

7.2 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 end of the specimen carrying the fiducial lines centrally in the windows and symmetrically with respect to the reference length.

7.3 Insert the temperature measuring devices and switch on the fan (if used). After the temperature has been steady within $\pm 2°C$ for 30 minutes, measure the difference in length between the test specimen and the reference length. When the initial difference in length has been noted, adjust the thermostat to reduce the temperature by about 20°C and insert the plugs in the viewing holes. When the temperature is steady within $\pm 2°C$ for 20 minutes at the new level again measure the difference betweeen the length of the test specimen and the reference length. Repeat this measurement procedure at approximately 5 minutes intervals until three consecutive measurements agree to within 0·03 mm.

7.4 Repeat the above procedure until the lowest temperature required is reached. Also make measurements as the apparatus is brought back to room temperature whilst 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.

8. CALCULATION

8.1 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.

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*Methods of test for rigid cellular thermal insulation materials: Part 1 Dimensions.

8.2 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:

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

where

α = mean coefficient of linear expansion per degree Celsius at temperature T, $\frac{1}{°C}$;

T_1 = higher temperature selected, °C;

T_2 = lower temperature selected, °C;

L = change in length of the test specimen between temperatures T_1 and T_2, mm; and

L_0 = original length of the test specimen at 27 ± 2°C mm, and

$$T = \frac{T_1 \pm T_2}{2}, °C$$

9. REPORT

9.1 The report shall include the following:

a) Reference to this standard;

b) Description and identity of the material;

c) Direction of any known anisotropy in relation to the measured length;

d) Mean coefficient of linear expansion to two significant figures, and mean temperature to which the results relate;

e) Copy of experimental graph;

f) Details of conditioning if other than those specified in **4.1**; and

g) Any deviation from the specified procedure.

APPENDIX A

(*Clause* 5.1)

SUITABLE APPARATUS

A-1 SUITABLE APPARATUS

A-1.1 Test Chamber — A box (*see* Fig. 1) made from a good low temperature insulating material. The internal dimensions of the box are approximately 400 × 1 000 × 150 mm with wall thickness of at least 100 mm. In the front of the box two tapered viewing holes of about 50 mm diameter and having centres 900 ± 10 mm apart are cut so that the ends of the test specimen can be viewed under all temperature conditions. These holes are closed on the inside by thin glass sheet; plugs to fill the holes are provided. In the back of the box a cooling coil is fitted consisting of three turns of copper tubing of 5 mm nominal bore running the length of the box; the top limb is pierced with holes of 1·5 mm diameter. The coil is closed at one end and the other end is connected to a liquid nitrogen container by a heavily insulated tube (*see* Fig. 2). A fan is installed in the box to minimize any temperature variation.

A-1.2 Cooling System — Liquid nitrogen is supplied to the cooling coil pressurizing the container with compressed air or nitrogen (Fig. 2). The rate of flow of liquid nitrogen to the coil is regulated by a gas valve controlled by a thermostat which provides venting of the pressurizing air to atmosphere to reduce the pressure in the liquid nitrogen container and also to provide a vent for any boil-off from the liquid nitrogen container. A buffer vessel is provided in the compressed air system to eliminate 'hunting' of the temperature control and a manometer with a range of about 20 kPa to indicate the air pressure to the required accuracy.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	st

Derived Units

Quantity	*Unit*	*Symbol*	*Definition*
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wu/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2