

Specification for

Preformed cellular polyethylene (PE) materials for the thermal insulation of pipework

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Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Plastics and Rubber Standards Policy Committee (PRM/-) to Technical Committee PRM/72, upon which the following bodies were represented:

- Association of Building Component Manufacturers
- Brick Development Association
- British Board of Agrement
- British Plastics Federation
- British Rigid Urethane Foam Manufacturers' Association
- Calcium Silicate Brick Association Limited
- Cavity Foam Bureau
- Chief and Assistant Chief Fire Officers' Association
- Department of the Environment (Building Research Establishment)
- Department of the Environment (Construction Directorate)
- Engineering Equipment and Materials Users' Association
- Flat Roofing Contractors' Advisory Board
- Loss Prevention Council
- Ministry of Defence
- National Cavity Insulation Association
- National Federation of Roofing Contractors
- National House-building Council
- Phenolic Foam manufacturers' Association
- Polyethylene Foam Insulation Association
- Royal Institute of British Architects

The following bodies were also represented in the drafting of the standard, through sub-committees and panels:

- Institute of Plumbing
- Thermal Insulation Manufacturers' and Suppliers' Association (TIMSA)
- Thermal Insulations Contractors' Association

This British Standard, having been prepared under the direction of the Plastics and Rubber Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on 31 October 1991

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Foreword

This British Standard has been prepared under the direction of the Plastics and Rubber Standards Policy Committee from a draft provided by the British Plastics Federation.

In this standard, two types of cellular polyethylene pipe insulation are specified; the materials differ principally in their thermal conductivity. Useful information on the use of the products has been included, as well as advice concerning their burning characteristics.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 20, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This British Standard specifies the composition, properties and dimensional tolerances for preformed cellular polyethylene (PE) materials for the thermal insulation of pipework.

The nominal operating temperature range for the materials is $-40\text{ }^{\circ}\text{C}$ to $+80\text{ }^{\circ}\text{C}$ (see note 1).

NOTE 1 Manufacturers have experienced no detrimental effects at service temperatures up to $100\text{ }^{\circ}\text{C}$. Consideration will be given, therefore, to raising the upper service temperature limit at the next revision of this British Standard.

NOTE 2 The titles of the publications referred to in this standard are listed on the inside back cover.

2 Composition

The material shall consist of cellular polyethylene with a closed cell structure.

NOTE Minor additives, e.g. colouring and fire retarding additives, may also be included with some materials.

3 Types

The material shall be divided into two types, A and B, which differ due to their thermal conductivity, type A having the lower thermal conductivity.

4 Dimensions and tolerances

4.1 The bore of a pipe section shall be specified as the nominal outside diameter of the pipe to be insulated.

4.2 The wall thickness of the pipe insulation shall be specified as the thickness of insulation along a line at 90° to any point on the inside bore of the tubular pipe insulation.

4.3 The tolerances on the dimensions of the product shall be as given in Table 1.

5 Physical properties

The physical properties shall comply with the requirements given in Table 2, when tested in accordance with the methods indicated therein.

NOTE For some test methods, a composite structure in a flat sheet form is required. This structure may, however, contain stress cracks and possible cell deformation and may also require lamination using proprietary adhesives, all of which can adversely affect the results achieved.

6 Condition and appearance

The material shall have a uniform fine cell structure.

NOTE The material is normally supplied free from objectionable odour and with a smooth inner and outer surface.

7 Sampling

Test specimens of the same formulation and density as the product shall be used.

NOTE Where it is not possible to cut test specimens from the product, specimens may be moulded to size or cut from larger mouldings.

8 Pipe sections

8.1 Pipe sections shall be supplied as a tube which shall be partially or completely slit through the wall of the insulation.

8.2 The longitudinally mating faces, if slit completely, shall be flat and in the same plane so that when the two faces are put together no gaps exist between the mating surfaces.

8.3 The ends shall be flat and normal to the longitudinal axis of the section.

Table 1 — Dimensional tolerances for pipe insulation

Dimension	Permissible deviation	
	Minimum	Maximum
	mm	mm
Length	-0	$+15$
Bore diameter	-0	$+4$
Wall thickness	-0	$+3$
NOTE Pipe sections are normally supplied in 1 m or 2 m lengths.		

9 Marking

The product shall be marked or labelled with at least the following information:

- the manufacturer's name or trade mark;
- the product type (see clause 3);
- the number and data of this British Standard, i.e. BS 7523:1991¹⁾.

NOTE It is preferred that the marking takes the following form:

"BS 7523:1991:A".

¹⁾ Marking BS 7523:1991 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is therefore solely the responsibility of the person making the claim. Such a declaration is not to be confused with third party certification of conformity, which may also be desirable.

Table 2 — Physical properties

Physical property	Requirement		Method of test
	Type A	Type B	
Maximum thermal conductivity [in W/(m · K)] at a mean temperature of 40 °C (see Appendix A)	0.040	0.045	Appendix B (see note 1)
Maximum water vapour permeability (in ng/m s Pa) (see note 2)	1.4	1.4	Carry out method 8 of BS 4370-2 except that the water vapour pressure gradient shall be created by immersion into an atmosphere of 25 °C and 75 % r.h.
Dimensional stability: maximum shrinkage (in %)	3	3	Carry out method 5B of BS 4370-1 at 80 °C for 96 h with a 1 m long section of pipe insulation. Report only the change in length
Burning characteristics: maximum extent of burning (in mm)	25	25	BS 4735 (see CAUTION below, and Appendix C)
Maximum smoke emission (in %)	10	10	BS 5111-1 (see Appendix C)
Minimum closed cell content (in %)	85	85	Method 10 of BS 4370-2
Maximum apparent water absorption (in %)	2	2	Carry out the test described in Appendix D of BS 4840-1:1985 using test specimens 50 × 50 × 50 mm
CAUTION. The small scale laboratory test described in BS 4735 is solely for assistance in monitoring consistency of production and is not for use as a means of assessing the potential fire hazard of a material in use.			
NOTE 1 Appendix B is technically equivalent to ISO/DIS 8497.			
NOTE 2 To convert values in ng/m s Pa to µg/N h multiply the former by 3.6. Also, this maximum water vapour permeability value equates to a permeance which is within the requirements of 10.4 of BS 6700:1987 (see Appendix D).			

Appendix A Factors affecting the thermal conductivity

The maximum “*K*” values for types A and B given in Table 2 are stated at 40 °C. For comparison purposes only, these values correspond to 0.042 w/m K at 10 °C for type B and 0.037 w/m K for type A when derived by using the method in Appendix C of BS 5422:1977 (see Appendix D).

That method shows that, by plotting a graph of thermal conductivity against the mean temperature at which the test was carried out, a curve can be produced. This enables the thermal conductivity at other temperatures to be derived.

There are several factors which have a noticeable effect on the thermal conductivity of cellular polyethylene materials. These may also be used as a means of quality control by end users and specifiers.

Products with varying densities have been tested and the optimum thermal conductivity values were found to be within the 30 kg/m³ to 40 kg/m³ range.

The closed cell content is also an important factor, as the higher the closed cell content the less convection and radiation across the product.

The cell size should also be taken into account, as large cells increase the convection currents within the cells and very small cells can increase the transmission of heat through the cell walls. So again, there are certain parameters which should be adhered to during production in order to obtain the optimum thermal conductivity value.

Appendix B Method for the determination of thermal conductivity

NOTE This appendix is technically equivalent to ISO/DIS 8497.

B.0 Introduction

The thermal transmission properties of pipe insulation generally have to be determined using pipe test apparatus rather than flat specimen apparatus such as the guarded hot plate or the heat flow meter apparatus, if results are to be representative of end-use performance. Insulation material formed into flat sheets often has different internal geometry from that of the same material formed into cylindrical shapes. Furthermore, properties often depend significantly upon the direction of heat flow in relation to inherent characteristics such as fibre planes or elongated cells: thus flat specimen one-dimensional heat flow measurements will generally not be representative of the two-dimensional radial heat flow encountered in pipe insulation.

Another consideration is that commercial insulations for pipes are often made with the inside diameter slightly larger than the outside diameter of the pipe, thus creating an air gap of variable thickness. In those cases where end-use performance data rather than material properties are to be determined, the insulation is mounted on the test pipe in the same loose manner so that the effect of the air gap will be included in the measurements. This would not be the case if properties were determined in a flat plate apparatus where good plate contact is required.

Still another consideration is that natural convection currents around insulation installed on a pipe will cause non-uniform surface temperatures. Such conditions will not be duplicated in a flat plate apparatus with uniform plate temperatures.

NOTE Comparison tests on apparently similar material using both pipe apparatus and flat plate apparatus have shown varying degrees of agreement of measured thermal transmission properties. It appears that better agreement is often obtained for heavier density products which tend to be more uniform, homogeneous, and sometimes more isotropic. For those materials which have repeatedly shown acceptable agreement in such comparisons, the use of data from flat plate apparatus to characterize pipe insulation may be justified. As a general rule, when such agreement has not been shown, the pipe test apparatus should be used to obtain thermal transmission data for pipe insulations.

B.1 Field of application

This appendix lays down conditions for the measurement of steady-state thermal transmission properties of thermal insulations for circular pipes generally operating at temperatures above ambient. It standardizes the measurement method, including procedures and apparatus performance, but it does not standardize apparatus design.

The type of specimen, temperatures and test conditions to which this appendix applies are detailed in B.5 and B.6.

B.2 Reference

ISO 7345, *Thermal insulation — Physical quantities and definitions*.

B.3 Definitions

B.3.1 General

The geometry of pipe insulation requires special terms not applicable to flat specimens. The word “lineal” is used to denote properties based upon a unit length (in the pipe axis direction) of a specified insulation size, e.g. the “lineal thermal transference”. These lineal properties, identified by the symbol subscript “l”, are convenient since the total heat loss can then be calculated knowing the pipe length and the applicable temperature.

NOTE The word “lineal” does not denote heat flow in the axial direction. In this appendix, the direction of heat flow is predominantly radial.

The more common “areal” properties, based upon unit area, are often confusing when applied to pipe insulation since the area is chosen arbitrarily and may range from that of the pipe surface to that of the insulation outer surface. If these areal properties are computed it is essential that the area and its location used in the computation be reported.

Except for the transference (see **B.3.2**) the following definitions and symbols are based upon those in ISO 7345.

B.3.2 lineal thermal transference, K_l

Lineal density of heat flow rate divided by the temperature difference between the pipe surface and the ambient air in the steady-state condition. It relates to a specific insulation size.

$$K_l = \frac{\phi/L}{T_0 - T_a} \quad (1)$$

B.3.3 lineal thermal resistance, R_l

Temperature difference between the pipe surface and the insulation outer surface divided by the lineal density of heat flow rate in the steady-state condition. It relates to a specific insulation size and is the reciprocal of the pipe lineal thermal conductance, Λ_l .

$$R_l = \frac{T_0 - T_2}{\phi/L} = \frac{1}{\Lambda_l} \quad (2)$$

B.3.4 lineal thermal conductance, Λ_l

Reciprocal of the lineal thermal resistance, R_l , from the pipe surface to the insulation outer surface. It relates to a specific insulation size.

$$\Lambda_l = \frac{1}{R_l} = \frac{\phi/L}{T_0 - T_2} \quad (3)$$

B.3.5 surface coefficient of heat transfer, h_2

Areal density of heat flow rate at the surface in the steady-state divided by the temperature difference between the surface and the surrounding ambient air. For pipe insulation geometry the following relation applies.

$$h_2 = \frac{\phi}{\pi d_2 L (T_2 - T_a)} \quad (4)$$

B.3.6 thermal conductivity, λ

Defined by the following equation specifically applicable to the pipe insulation geometry. It applies to homogeneous material in the steady-state condition and is the reciprocal of the thermal resistivity.

$$\lambda = \frac{\phi \ln(d_2/d_0)}{2\pi L (T_0 - T_2)} = \frac{1}{r} \quad (5)$$

NOTE 1 In ISO 7345, the thermal conductivity is also defined by the more general relation $q = -\lambda \text{ grad } T$.

NOTE 2 Since the pipe surface temperature, T_0 , is used, the thermal conductivity will include the effect of any gap that exists between the insulation and the pipe, (see **B.6.1**).

B.3.7 thermal resistivity, r

Reciprocal of the thermal conductivity, λ , for a homogeneous material in the steady-state condition.

$$r = \frac{2\pi L (T_0 - T_2)}{\phi \ln(d_2/d_0)} = \frac{1}{\lambda} \quad (6)$$

B.3.8 areal thermal resistance, R

Temperature difference between the pipe surface and the insulation outer surface divided by the areal density of heat flow rate in the steady-state condition. It is the reciprocal of the areal thermal conductance, Λ :

$$R = \frac{T_0 - T_2}{\phi/A} = \frac{1}{\Lambda} \quad (7)$$

where the surface of area A needs to be specified (usually the pipe surface, sometimes the insulation outer surface or other as chosen: see note in **B.3.9**).

B.3.9 areal thermal conductance, Λ

Reciprocal of the areal thermal resistance, R .

$$\Lambda = \frac{1}{R} = \frac{\phi/A}{T_0 - T_2} \quad (8)$$

where the location of the surface of area A needs to be specified (usually the pipe surface, sometimes the insulation outer surface, or other as chosen).

NOTE The value of Λ , the areal thermal conductance, is arbitrary since it depends upon an arbitrary choice of the area, A . For a homogeneous material for which the thermal conductivity is defined as in **B.3.6**, the areal conductance, Λ , is given by

$$\Lambda = \frac{2\pi L \lambda}{A \ln(d_2/d_0)} \quad (9)$$