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**Thermal insulating materials for pipes,  
tanks, vessels, ductwork and equipment  
operating within the temperature  
range  $-40\text{ }^{\circ}\text{C}$  to  $+700\text{ }^{\circ}\text{C}$  – Method for  
specifying**



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## Summary of pages

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# Foreword

## Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 30 June 2023. It was prepared by Technical Committee B/540/7, *Thermal insulation for equipment and industrial applications*. A list of organizations represented on this committee can be obtained on request to its committee manager.

## Supersession

This British Standard supersedes BS 5422:2009, which is withdrawn.

## Information about this document

This is a full revision of the standard, and introduces the following principal changes.

- Tables have been revised with simplification in mind where possible. For example, higher thermal conductivity values for materials no longer supplied or very rarely used, have been removed. Thermal conductivity values in this edition are based on the most commonly used insulation materials at time of revision. All pipe sizes are indicated as “less than or equal to” values, which reduces the need for interpolation, and tends to increase the overall thermal efficiency of the targeted systems.
- Reaction to Fire is defined within this publication in terms of Euroclass, which is used in today’s Building Regulations documents and is the default in product marking. Euroclass Reaction to Fire gives a more comprehensive and clear definition of the behaviour of materials exposed to fire than the more limited legacy BS 476 based scope.
- The decision has been made to retain calculation methods on BS EN ISO 12241:2008, which have been superseded by those in BS EN ISO 12241:2022. An updated calculation tool is forecast for Q3 2023; the drafting panel agreed to minimize delays, publish this British Standard and put recalculations on hold for a later update.
- [Table 7](#) and [Table 9](#) are intentionally blank to preserve the existing table numbering. The table numbering is to be updated in a future revision.
- Enhanced insulation thicknesses have been captured from the legacy Energy Technology List/Capital Allowances levels, and can be found in [Table 15B](#), [Table 16B](#), [Table 17B](#), [Table 18B](#), [Table 19B](#), and [Table 20B](#).
- District heating tables for secondary and tertiary systems have been added in [Table 19C](#) and [Table 20C](#).
- Plastic pipes (single wall) are treated as having no insulative value of their own.
- In Wales, Approved Document L2A: New buildings other than dwellings and Approved Document L2B: Existing buildings other than dwellings were recently revised to a single volume - Approved Document L, Conservation of fuel and power; Volume 2: Buildings other than dwellings.

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Where websites and webpages have been cited, they are provided for ease of reference and are correct at the time of publication. The location of a webpage or website, or its contents, cannot be guaranteed.

## **Presentational conventions**

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is “shall”.

*Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.*

Where words have alternative spellings, the preferred spelling of the *Shorter Oxford English Dictionary* is used (e.g. “organization” rather than “organisation”).

## **Contractual and legal considerations**

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## 0 Introduction

In any single application for pipework and equipment, thermal insulation material can perform a variety of functions simultaneously, including:

- a) conserve energy for both cooled and heated systems;
- b) retard freezing of contents;
- c) control condensation on refrigerated, chilled or cold surfaces;
- d) protect personnel from exposure to extremes of surface temperature;
- e) control process or service temperatures; and
- f) limit effects of system on indoor building temperature.

Even within the range listed, consideration should be given to sub-sectors of these functions.

For example, energy conservation can be driven by two distinct considerations. The first, and more traditional, reason for seeking energy saving is to save cost. The second, and more recent, reason for seeking energy saving is to minimize carbon dioxide emissions from the associated power source. Although any insulation measure has desired effects in both of these areas simultaneously, the extent of insulation that can be justified varies with the comparative costs of energy on the one hand, and alternative costs of carbon dioxide emission abatement on the other. Since thermal insulation of pipework and equipment represents one of the most cost-effective ways available of limiting carbon dioxide emissions, this standard highlights a series of thicknesses within its core tables, which have been calculated in accordance with environmental principles as outlined in [Annex A](#).

Although the tables provided in this standard offer a simple method of determining the minimum thickness levels, their use requires the basic information outlined in Clause 4 and, in some cases, additional information may be required. This specific information is outlined in the clauses pertaining to specific applications.

Where information such as the thermal conductivity of the chosen insulation material does not conform to the categories highlighted in the relevant tables, it is possible to interpolate between either columns or rows where the margin of error is not likely to be critical. For greater accuracy, and where the application parameters differ from those covered within the scope of a Table (e.g. different ambient air temperature), the specifier should calculate from first principles by using methods set out in BS EN ISO 12241 and the Annexes to this standard.

The default values for use in relation to this standard are given in [Annex B](#), the criteria used to establish the tables are summarized in [Annex C](#), and the standard diameters of pipes considered are given in [Annex D](#).

## 1 Scope

This British Standard describes a method for specifying requirements for thermal insulating materials on pipes, tanks, vessels, ductwork and equipment for certain defined applications and conditions within the temperature range  $-40\text{ }^{\circ}\text{C}$  to  $+700\text{ }^{\circ}\text{C}$ . It also specifies some physical requirements for the insulating materials. It is intended for use by designers, specifiers, contractors and manufacturers of thermal insulation.

This British Standard does not apply to pipelines that are embedded underground, nor does it refer to the insulation of building construction. However, the standard does apply to any pre-insulated pipework other than buried/underground pipework.

---

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 5970, *Thermal insulation of pipework, ductwork, associated equipment and other industrial installations in the temperature range of –100 °C to +870 °C – Code of practice*

BS EN 12086, *Thermal insulating products for building applications – Determination of water vapour transmission properties*

BS EN 13469, *Thermal insulating products for building equipment and industrial installations – Determination of water vapour transmission properties of preformed pipe insulation*

BS EN 13501-1, *Fire classification of construction products and building elements – Part 1: Classification using data from reaction to fire tests*

BS EN ISO 4590, *Rigid cellular plastics – Determination of the volume percentage of open cells and of closed cells*

BS EN ISO 12241:2008, *Thermal insulation for building equipment and industrial installations – Calculation rules*

BS ISO 1922, *Rigid cellular plastics – Determination of shear properties*

---

## 3 Terms and definitions

For the purposes of this British Standard, the following definitions apply.

### 3.1 chilled water

water that has been processed through cooling plant (typically 0 °C to +10 °C)

### 3.2 economic thickness

thickness of insulation that minimizes the total cost (investment and running costs) over a chosen evaluation period

### 3.3 evaluation period

time over which the heat transfer through insulated surfaces is to be calculated, e.g. to carry out frost protection or economic thickness calculations

### 3.4 finishing materials

materials used to cover the insulation, whether pre-applied or applied on site

### 3.5 heating network system (primary)

distribution pipes that connect the energy centre to the buildings served by the network – mostly buried pre-insulated pipes

### 3.6 heating network system (secondary)

pipes within buildings, and up to the dwelling in residential blocks, even if no hydraulic break is installed

*NOTE The heat meter might also be considered a suitable boundary point.*

### 3.7 heating network system (tertiary)

internal circuits, radiators etc. within dwellings, even if no hydraulic break is installed

[SOURCE: CIBSE CP1]

### 3.8 insulation thickness

thickness of insulating material, excluding any finish or covering

### 3.9 maximum service temperature

highest temperature to which a thermal insulation or other material may be exposed and at which it continues to function within the specified limits of its performance

### 3.10 minimum service temperature

lowest temperature to which a thermal insulation or other material may be exposed and at which it continues to function within the specified limits of its performance

### 3.11 pre-applied

factory applied to the insulation prior to delivery to the point of use

### 3.12 structural elements

load-bearing elements of a building or industrial installation that may physically support, e.g. building services or similar systems, from which intermediate elements such as pipe hangers etc. can be installed

*NOTE* Might also include cladding supports used for ductwork and boiler walls in industrial applications. In the event of poor design, structural elements may also clash with other elements of an installation. Nevertheless, insulation should be installed in a continuous manner wherever possible.

### 3.13 termination point

point at which the thermal insulation applied to a pipe, duct or vessel is terminated, e.g. at a valve or flange, or where traversing a wall or ceiling

### 3.14 vapour resistance (water)

reciprocal of water vapour permeance

### 3.15 water vapour barrier

layer intended to control water vapour diffusion

### 3.16 water vapour permeance

density of water vapour flow rate divided by the water vapour pressure difference between the two surfaces of the specimen during the test

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## 4 Application of this standard

A specification produced in accordance with this British Standard shall specify only those elements of the standard to which conformity is required for a specific application. A specification shall be deemed to conform to this British Standard if it makes reference to the clauses and tables within this standard that pertain to the application being specified. The selection of materials and the insulation thickness to be specified shall be determined according to the intended function of the insulation.

The specification shall state the prime purpose of the insulation and shall specify the performance requirements for the selected insulation system. The specification shall identify the minimum performance requirements for each application or parameter. The application or parameter that requires the greatest thickness of insulation shall take precedence.

The performance requirements shall be specified in accordance with the appropriate clauses and tables of this standard, which shall be determined from the following factors:

- a) system operating temperature;
- b) design ambient air temperature;
- c) relative humidity of the ambient air;
- d) air velocity;
- e) location of the plant (indoors or outdoors);
- f) pipe diameter (or flat surface dimensions);
- g) orientation of pipes (horizontal or vertical);
- h) vertical dimensions of flat surfaces; and
- i) emissivity of outer surface.

For refrigerated, chilled and other cold applications, where applicable, water vapour permeance or resistance of the complete insulation system (including water vapour barrier where applied) shall also be specified in accordance with the appropriate clauses and tables of this standard.

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## 5 General requirements

### 5.1 Physical characteristics

The specifier shall specify the required performance and physical characteristics of the materials, including finishing materials, whether pre-applied or applied on site, in accordance with the appropriate British Standard.

The manufacturer or supplier shall declare the performance and physical characteristics of the materials in accordance with the appropriate British Standard.

To help make certain that the insulation material specified is suitable for the intended application, consideration shall be given as to whether:

- a) the material contains substances that support pests or encourage the growth of fungi;
- b) the material gives off an objectionable odour at the temperatures at which it is to be used;  
*NOTE 1 Transient effects during the initial period of use may generally be ignored.*
- c) the material suffers permanent structural or physical deterioration as a result of contact with moisture;
- d) the material suffers structural or physical deterioration as a result of use at specified operating temperatures;
- e) the material is suitable for specified conditions of use without the physical properties falling outside the tolerances allowed in the appropriate British Standard for the material;
- f) materials in contact are compatible and do not cause corrosion or degradation under normal site conditions; and

- g) the material and its method of application constitutes a known risk to health during application or use.

*NOTE 2 Reference should be made to BS 5970 for health hazards when selecting, storing or removing insulation. Attention is also drawn to the latest edition of COSHH Regulations [1].*

## 5.2 Installation requirements

*NOTE Guidance on the correct application of insulation and associated attachments is given in BS 5970.*

## 5.3 Thermal conductivity

### 5.3.1 General

Manufacturers or suppliers of insulating materials shall supply declared thermal conductivity values based on results of tests carried out in accordance with the appropriate British or European Standards.

Thermal conductivity shall be expressed in watts per square metre for 1 m thickness and a temperature difference of 1 K.

*NOTE 1 The values quoted for thermal conductivity relate to the appropriate insulation mean temperature, which is defined as the mean of the operating temperature of the system added to the temperature of the outer surface of the insulation system.*

*NOTE 2 In terms of unit symbols thermal conductivity should be expressed as  $W/(m \cdot K)$ .*

The contractor shall state the manufacturer's declared values of thermal conductivity for each material proposed. These declared values shall be appropriate to the mean temperature of the applied insulation.

### 5.3.2 Composite insulation

When two or more layers of dissimilar insulating material are to be used, the contractor shall provide the declared value of thermal conductivity for each layer under the appropriate temperature conditions. The thickness of each layer shall also be stated.

### 5.3.3 Design value of thermal conductivity and thermal bridges

Additional allowances shall be made to confirm that the specified performance is achieved where system inefficiencies are created through the ageing of the product, or by the presence of valves or other in-line or ancillary fittings.

*NOTE 1 Guidance is given in BS EN ISO 12241.*

*NOTE 2 To limit heat transfer through supports, load-bearing insulating material should be used on the pipe or vessel between the support and the surface to be insulated. If a water vapour barrier is required, the sealing of the load-bearing material should conform to the same requirements as the basic insulation and be fitted so that the integrity of the vapour barrier of the system is maintained. Where the heat transfer through the supports does not need to be limited but a water vapour barrier is required, the edges of the insulation, where interrupted at the support, should be sealed to maintain the effectiveness of the vapour barrier.*

Other structural elements, such as stiffening rings, shall be insulated externally to reduce thermal bridging.

## 5.4 Temperature limitations

The manufacturer or supplier shall state the maximum or minimum service temperatures of the products specified, as appropriate.

If the temperature of the surface to be insulated is above the limiting temperature of the preferred main insulating material, composite or alternative insulation shall be specified. Where composite insulation is specified, the thickness of each layer shall be calculated to confirm that the interface temperature between the two materials does not exceed the limiting temperature for the material of the outer layer.

## 5.5 Thickness

If thicknesses are required other than those given in the tables in the appropriate section, or bases needed other than those from which they were derived, the specification shall state the thickness required or the bases to be used in the calculation.

If the thicknesses derived using this standard do not correspond with commercially available thicknesses, the nearest higher available thickness shall be used.

In multilayer applications, where material thicknesses are rounded up to suit available thicknesses, a further calculation in accordance with BS EN ISO 12241 shall be made to confirm that each interface temperature is below the maximum service temperature of the materials involved.

*NOTE 1 Additional allowances should be made for heat transfer through joints, valves and other fittings when determining insulation thickness in accordance with BS EN ISO 12241. The fittings should be designed to be removable and readily replaceable in a non-destructive fashion.*

*NOTE 2 Thicknesses given in the tables within this standard are specifically calculated against the criteria noted in each Table. Adopting these thicknesses may not necessarily satisfy other design requirements.*

## 5.6 Vapour barrier – Permeance requirements

*NOTE 1 Condensation of water vapour occurs on a surface that is at a temperature below the atmospheric dew point temperature. Moisture can be deposited within the insulating material and on the insulated surface. Where the insulated surface is likely to be at or below the dew point temperature during any part of its operating cycle, an effective vapour barrier should be applied on the warmer face of the insulation to avoid deposition of moisture within the insulating system. The presence of water within an insulation system can reduce thermal effectiveness and lead to corrosion of metal components.*

For the purpose of this standard an effective vapour barrier shall be deemed to be one that meets the water vapour permeance requirements given in this subclause.

Different levels of water vapour permeance shall be specified according to the type of application. Where the insulating material itself does not conform to the water vapour permeance requirement, a “vapour barrier” on the outside (warm side) of the insulation shall be used.

The vapour barrier shall take the form of a coating or sheet material. Any joints in the coating or sheet material or in the insulating material itself, where it is providing the water vapour permeance requirement, shall be fully sealed.

*NOTE 2 This is to make sure that the vapour permeance performance is maintained continuously in the system as installed.*

Particular care shall be taken at termination points. The external vapour barrier, where required, shall be applied before the fluid in the pipe, duct, or vessel is cooled.

When a vapour barrier is used, the system as installed, shall have a fire performance at least equal to that specified in [6.2.2](#), [7.2.2](#), [8.2.2](#), [9.2.2](#) and [10.2.2](#) as appropriate to the type of application.

The water vapour permeance of flexible sheets used as external vapour barriers shall be assessed in accordance with the relevant method. The test conditions, e.g. temperate or tropical, and the thickness of the test specimen shall be stated. Where the apparatus for the method in BS EN 13469 and BS EN 12086 is unsuitable because of the thickness of the test specimen, BS EN ISO 4590 shall

be used. The water vapour permeance of the insulated system shall be selected according to the relationship between the cold surface temperature of the plant and the temperature difference, in degrees centigrade (°C), between the plant temperature and ambient temperature as indicated in [Table 1](#).

*NOTE 3* The permeance values given in [Table 1](#) are applicable at an ambient temperature of 20 °C and a relative humidity of 70%, and other environmental conditions resulting in an equal or lesser partial vapour pressure difference. In order to calculate the partial vapour pressure difference, the internal temperature should be assumed to be equal to the plant temperature and the internal relative humidity to be 100%. In situations where the environmental conditions are normally 25 °C and a relative humidity of 80% the vapour barrier permeance is selected from [Table 1](#) by subtracting 10 °C from the plant operating temperature.

**Table 1** — Maximum permitted water vapour permeance in relation to plant temperature at an ambient temperature of +20 °C (dry bulb)

| Temperature of plant (cold surface)<br>°C | Water vapour permeance of barrier<br>g/(s · MN) |
|-------------------------------------------|-------------------------------------------------|
| 10                                        | 0.050                                           |
| 5                                         | 0.015                                           |
| 0                                         | 0.010                                           |
| -5                                        | 0.004                                           |
| -10                                       | 0.002                                           |
| -15                                       | 0.001 5                                         |
| -20 to -40                                | 0.001 0                                         |

*NOTE* The most common value for vapour resistance is 0.001 g/(s · MN).

Where it is necessary to add additional claddings to an external vapour barrier, e.g. to provide weather or mechanical protection, the specifier shall state the type of finish to be applied. The installer shall confirm that the application of any additional coverings does not damage the vapour barrier during installation and that it is unlikely to cause damage to, or degrade the performance of, the vapour barrier in service.

*NOTE 4* For further details see BS 5970, Table 7.

## 5.7 Tests on physical properties

Where particular physical properties are required the specifier shall nominate the appropriate British Standard test methods. Only where no suitable British Standard test methods exist shall the specifier authorize the use of an alternative test method to determine whether the required level of performance is met.

## 6 Refrigeration applications

### 6.1 Information to be supplied by the specifier

The specifier shall supply details of the intended function and performance requirements of the application, and the materials to be used, in accordance with [Clause 4](#).

*NOTE* In addition to the parameters outlined in [Clause 4](#), items such as specific heat capacity and mass flow rates of fluids may also be required under certain circumstances, particularly where calculating from first principles using BS EN ISO 12241. However, these additional parameters are not required for the use of the tables contained in this standard.

## 6.2 Physical characteristics

### 6.2.1 General

The physical characteristics of the insulating material including finishing materials and vapour barriers, whether applied during manufacture or on site, shall conform to [5.1](#), [6.2.2](#) and [6.2.3](#).

### 6.2.2 Fire performance

Insulation materials and systems used for refrigeration shall conform to the following requirements.

*NOTE 1 Attention is drawn to the applicable requirements of the Building Regulations [2], the Building (Scotland) Regulations [3] and the Building Regulations (Northern Ireland) [4].*

Insulation systems on pipework or ductwork traversing a fire-resisting division shall maintain the level of fire resistance of the wall, floor or cavity barrier through which they pass.

*NOTE 2 In the event of a fire, some insulation systems can generate appreciable quantities of smoke and toxic fumes. Consideration should be given to the choice of materials, bearing in mind their location, e.g. enclosed areas or adjacent to air ducts through which the smoke or fumes may spread.*

In buildings other than dwellings, the complete assembly of materials as placed on market (whether faced or unfaced) shall be Class B-s3, d2 (European class) or better, in accordance with BS EN 13501-1.

In dwellings, the complete assembly of installed insulation materials (whether faced or unfaced) shall be Class C-s3, d2 (European class) or better.

If there is a potential hazard from contamination by oil or other flammable chemicals, a suitably resistant finish, e.g. a metal sheet or appropriate non-absorbent coating, shall be applied over the vulnerable areas. The lapped joints of sheet finishes shall be arranged to shed contaminating fluids away from the insulating material.

*NOTE 3 See [Annex E](#) for an explanation of Classes A1, A2, B, C, D, E or F (European classes).*

### 6.2.3 Water vapour barrier – Performance requirements

Insulation materials and systems used for refrigeration shall be installed in accordance with and shall conform to the permeance requirements specified in [5.6](#).

When tested in accordance with BS EN 13469, BS EN 12086, BS EN ISO 4590, or BS ISO 1922, as appropriate, the permeance of the material used as a vapour barrier shall not exceed the values given in [Table 1](#) for the appropriate temperature of the plant.

## 6.3 Insulation thickness – Protection against condensation and control of heat gain

**6.3.1** In the absence of specific instructions from the specifier, the insulation thickness shall be not less than that given in [Table 2](#) to [Table 5](#), as appropriate.

**6.3.2** Where the contribution of the heat gain of the distribution pipework does not exceed 5% of the total heat load, the thicknesses given in [Table 2](#) to [Table 5](#) to control condensation shall also be used to limit heat transfer. Where the contribution of the heat gain of the distribution pipework does exceed 5%, the thickness of insulation shall be increased such that the heat gain of the distribution pipe is reduced to less than 5%. Calculating distribution pipework heat gains shall be carried out in accordance with [Annex F](#).

**Table 2** — Minimum insulation thickness for refrigeration applications to control condensation and control heat gain on a high emissivity outer surface (0.90) with an ambient temperature of +20 °C and a relative humidity of 70%

| Outside diameter of steel pipe on which insulation thickness has been based (mm) | Insulation thickness (mm) |                      |                      |                      |                      |                      |                      |                      |                      |                      |                      |                      |
|----------------------------------------------------------------------------------|---------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
|                                                                                  | t = 0                     |                      |                      | t = -10              |                      |                      | t = -20              |                      |                      | t = -30              |                      |                      |
|                                                                                  | $\lambda$<br>= 0.025      | $\lambda$<br>= 0.035 | $\lambda$<br>= 0.045 | $\lambda$<br>= 0.025 | $\lambda$<br>= 0.035 | $\lambda$<br>= 0.045 | $\lambda$<br>= 0.025 | $\lambda$<br>= 0.035 | $\lambda$<br>= 0.045 | $\lambda$<br>= 0.025 | $\lambda$<br>= 0.035 | $\lambda$<br>= 0.045 |
| ≤10                                                                              | 5                         | 7                    | 8                    | 8                    | 10                   | 23                   | 10                   | 13                   | 16                   | 13                   | 16                   | 20                   |
| ≤12                                                                              | 5                         | 7                    | 9                    | 8                    | 11                   | 24                   | 11                   | 14                   | 17                   | 13                   | 17                   | 21                   |
| ≤15                                                                              | 6                         | 7                    | 9                    | 9                    | 11                   | 26                   | 11                   | 15                   | 18                   | 14                   | 18                   | 22                   |
| ≤22                                                                              | 6                         | 8                    | 10                   | 9                    | 12                   | 29                   | 12                   | 16                   | 20                   | 15                   | 20                   | 25                   |
| ≤28                                                                              | 6                         | 8                    | 10                   | 10                   | 13                   | 31                   | 13                   | 17                   | 21                   | 16                   | 21                   | 26                   |
| ≤35                                                                              | 7                         | 9                    | 11                   | 10                   | 14                   | 33                   | 14                   | 18                   | 22                   | 17                   | 23                   | 28                   |
| ≤42                                                                              | 7                         | 9                    | 11                   | 11                   | 14                   | 35                   | 14                   | 19                   | 23                   | 18                   | 23                   | 29                   |
| ≤54                                                                              | 7                         | 9                    | 12                   | 11                   | 15                   | 38                   | 15                   | 20                   | 25                   | 19                   | 25                   | 31                   |
| ≤60                                                                              | 7                         | 10                   | 12                   | 11                   | 15                   | 39                   | 15                   | 21                   | 25                   | 19                   | 25                   | 31                   |
| ≤67                                                                              | 7                         | 10                   | 12                   | 12                   | 16                   | 41                   | 16                   | 21                   | 26                   | 20                   | 26                   | 32                   |
| ≤80                                                                              | 8                         | 10                   | 13                   | 12                   | 16                   | 43                   | 16                   | 22                   | 27                   | 20                   | 27                   | 34                   |

Key

t = temperature of contents (°C)

$\lambda$  = thermal conductivity at mean temperature of insulation [W/(m · K)]

NOTE Thicknesses given are calculated specifically against the criteria noted in the table. These thicknesses may not satisfy other design requirements. In situations where the ambient air temperature is greater than 20 °C and/or the relative humidity exceeds 70%, these thicknesses are not sufficient to control condensation.

**Table 3** — Minimum insulation thickness for refrigeration applications to control condensation and control heat gain on a low emissivity outer surface (0.05) with an ambient temperature of +20 °C and a relative humidity of 70%

| Outside diameter of steel pipe on which insulation thickness has been based (mm) | Insulation thickness (mm) |    |    |                         |    |    |                         |    |    |                         |    |    |
|----------------------------------------------------------------------------------|---------------------------|----|----|-------------------------|----|----|-------------------------|----|----|-------------------------|----|----|
|                                                                                  | t = 0                     |    |    | t = -10                 |    |    | t = -20                 |    |    | t = -30                 |    |    |
|                                                                                  | λ                         | λ  | λ  | λ                       | λ  | λ  | λ                       | λ  | λ  | λ                       | λ  | λ  |
|                                                                                  | = 0.025 = 0.035 = 0.045   |    |    | = 0.025 = 0.035 = 0.045 |    |    | = 0.025 = 0.035 = 0.045 |    |    | = 0.025 = 0.035 = 0.045 |    |    |
| ≤10                                                                              | 9                         | 12 | 14 | 14                      | 18 | 23 | 18                      | 25 | 31 | 23                      | 31 | 37 |
| ≤12                                                                              | 9                         | 12 | 15 | 14                      | 19 | 24 | 19                      | 26 | 33 | 24                      | 33 | 39 |
| ≤15                                                                              | 10                        | 13 | 16 | 15                      | 21 | 26 | 21                      | 28 | 35 | 26                      | 35 | 42 |
| ≤22                                                                              | 11                        | 15 | 18 | 17                      | 23 | 29 | 23                      | 31 | 39 | 29                      | 39 | 47 |
| ≤28                                                                              | 12                        | 16 | 20 | 19                      | 25 | 31 | 25                      | 34 | 42 | 31                      | 42 | 51 |
| ≤35                                                                              | 12                        | 17 | 21 | 20                      | 27 | 33 | 27                      | 36 | 45 | 34                      | 45 | 54 |
| ≤42                                                                              | 13                        | 18 | 22 | 21                      | 28 | 35 | 28                      | 38 | 48 | 36                      | 48 | 57 |
| ≤54                                                                              | 14                        | 19 | 24 | 23                      | 30 | 38 | 31                      | 41 | 52 | 38                      | 52 | 62 |
| ≤60                                                                              | 15                        | 20 | 25 | 23                      | 31 | 39 | 32                      | 43 | 53 | 40                      | 53 | 64 |
| ≤67                                                                              | 15                        | 20 | 25 | 24                      | 32 | 41 | 33                      | 44 | 55 | 41                      | 55 | 66 |
| ≤80                                                                              | 16                        | 21 | 27 | 25                      | 34 | 43 | 34                      | 47 | 58 | 43                      | 58 | 70 |

Key

t = temperature of contents (°C)

λ = thermal conductivity at mean temperature of insulation [W/(m · K)]

NOTE Thicknesses given are calculated specifically against the criteria noted in the table. These thicknesses may not satisfy other design requirements. In situations where the ambient air temperature is greater than 20 °C and/or the relative humidity exceeds 70%, these thicknesses are not sufficient to control condensation.

**Table 4** — Minimum insulation thickness for refrigeration applications to control condensation and control heat gain on a high emissivity outer surface (0.90) with an ambient temperature of +25 °C and a relative humidity of 80%

| Outside diameter of steel pipe on which insulation thickness has been based (mm) | Insulation thickness (mm) |                      |                      |                      |                      |                      |                      |                      |                      |                      |                      |                      |
|----------------------------------------------------------------------------------|---------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
|                                                                                  | t = 0                     |                      |                      | t = -10              |                      |                      | t = -20              |                      |                      | t = -30              |                      |                      |
|                                                                                  | $\lambda$<br>= 0.025      | $\lambda$<br>= 0.035 | $\lambda$<br>= 0.045 | $\lambda$<br>= 0.025 | $\lambda$<br>= 0.035 | $\lambda$<br>= 0.045 | $\lambda$<br>= 0.025 | $\lambda$<br>= 0.035 | $\lambda$<br>= 0.045 | $\lambda$<br>= 0.025 | $\lambda$<br>= 0.035 | $\lambda$<br>= 0.045 |
| ≤10                                                                              | 10                        | 13                   | 16                   | 13                   | 17                   | 21                   | 17                   | 22                   | 27                   | 20                   | 26                   | 32                   |
| ≤12                                                                              | 10                        | 13                   | 16                   | 14                   | 18                   | 22                   | 17                   | 23                   | 28                   | 21                   | 27                   | 33                   |
| ≤15                                                                              | 11                        | 14                   | 17                   | 15                   | 19                   | 24                   | 18                   | 24                   | 30                   | 22                   | 29                   | 35                   |
| ≤22                                                                              | 12                        | 16                   | 19                   | 16                   | 21                   | 26                   | 20                   | 27                   | 33                   | 24                   | 32                   | 39                   |
| ≤28                                                                              | 13                        | 16                   | 20                   | 17                   | 23                   | 28                   | 22                   | 28                   | 35                   | 26                   | 34                   | 41                   |
| ≤35                                                                              | 13                        | 17                   | 21                   | 18                   | 24                   | 29                   | 23                   | 30                   | 37                   | 27                   | 36                   | 44                   |
| ≤42                                                                              | 14                        | 18                   | 22                   | 19                   | 25                   | 31                   | 24                   | 31                   | 38                   | 28                   | 37                   | 46                   |
| ≤54                                                                              | 14                        | 19                   | 24                   | 20                   | 26                   | 32                   | 25                   | 33                   | 41                   | 30                   | 40                   | 49                   |
| ≤60                                                                              | 15                        | 19                   | 24                   | 20                   | 27                   | 33                   | 26                   | 34                   | 42                   | 31                   | 41                   | 50                   |
| ≤67                                                                              | 15                        | 20                   | 25                   | 21                   | 28                   | 34                   | 26                   | 35                   | 43                   | 31                   | 42                   | 51                   |
| ≤80                                                                              | 15                        | 21                   | 26                   | 21                   | 29                   | 35                   | 27                   | 36                   | 45                   | 33                   | 43                   | 53                   |

Key

t = temperature of contents (°C)

λ = thermal conductivity at mean temperature of insulation [W/(m · K)]

NOTE Thicknesses given are calculated specifically against the criteria noted in the table. These thicknesses may not satisfy other design requirements. In situations where the ambient air temperature is greater than 25 °C and/or the relative humidity exceeds 80%, these thicknesses are not sufficient to control condensation.

| Outside diameter of<br>steel pipe on which<br>insulation thickness<br>has been based (mm) | Insulation thickness (mm) |                      |                      |                      |                      |                      |                      |                      |                      |                      |                      |                      |                      |                      |                      |
|-------------------------------------------------------------------------------------------|---------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
|                                                                                           | t = 0                     |                      |                      | t = -10              |                      |                      | t = -20              |                      |                      | t = -30              |                      |                      | t = -40              |                      |                      |
|                                                                                           | $\lambda$<br>= 0.025      | $\lambda$<br>= 0.035 | $\lambda$<br>= 0.045 | $\lambda$<br>= 0.025 | $\lambda$<br>= 0.035 | $\lambda$<br>= 0.045 | $\lambda$<br>= 0.025 | $\lambda$<br>= 0.035 | $\lambda$<br>= 0.045 | $\lambda$<br>= 0.025 | $\lambda$<br>= 0.035 | $\lambda$<br>= 0.045 | $\lambda$<br>= 0.025 | $\lambda$<br>= 0.035 | $\lambda$<br>= 0.045 |
| ≤10                                                                                       | 19                        | 25                   | 32                   | 26                   | 36                   | 45                   | 34                   | 46                   | 58                   | 41                   | 56                   | 70                   | 48                   | 66                   | 83                   |
| ≤12                                                                                       | 20                        | 27                   | 33                   | 28                   | 38                   | 47                   | 36                   | 48                   | 61                   | 43                   | 59                   | 74                   | 51                   | 69                   | 87                   |
| ≤15                                                                                       | 21                        | 28                   | 36                   | 30                   | 40                   | 50                   | 38                   | 51                   | 65                   | 46                   | 63                   | 79                   | 54                   | 74                   | 93                   |
| ≤22                                                                                       | 24                        | 32                   | 40                   | 33                   | 45                   | 56                   | 43                   | 58                   | 72                   | 52                   | 70                   | 88                   | 61                   | 82                   | 103                  |
| ≤28                                                                                       | 26                        | 34                   | 43                   | 36                   | 48                   | 61                   | 46                   | 62                   | 78                   | 56                   | 75                   | 94                   | 65                   | 88                   | 111                  |
| ≤35                                                                                       | 27                        | 37                   | 46                   | 39                   | 52                   | 65                   | 49                   | 66                   | 83                   | 60                   | 80                   | 101                  | 70                   | 94                   | 118                  |
| ≤42                                                                                       | 29                        | 39                   | 49                   | 41                   | 55                   | 68                   | 52                   | 70                   | 88                   | 63                   | 85                   | 106                  | 74                   | 100                  | 125                  |
| ≤54                                                                                       | 31                        | 42                   | 53                   | 44                   | 59                   | 74                   | 56                   | 76                   | 95                   | 68                   | 92                   | 115                  | 80                   | 107                  | 134                  |
| ≤60                                                                                       | 32                        | 44                   | 54                   | 45                   | 61                   | 76                   | 58                   | 78                   | 98                   | 70                   | 95                   | 118                  | 82                   | 111                  | 139                  |
| ≤67                                                                                       | 33                        | 45                   | 56                   | 47                   | 63                   | 79                   | 60                   | 81                   | 101                  | 73                   | 98                   | 122                  | 85                   | 115                  | 143                  |
| ≤80                                                                                       | 35                        | 48                   | 59                   | 50                   | 67                   | 83                   | 63                   | 85                   | 107                  | 77                   | 103                  | 129                  | 90                   | 121                  | 151                  |

*NOTE* Thicknesses given are calculated specifically against the criteria noted in the table. These thicknesses may not satisfy other design requirements. In situations where the ambient air temperature is greater than 25 °C and/or the relative humidity exceeds 80%, these thicknesses are not sufficient to control condensation.

## 7 Chilled and cold water applications

### 7.1 Information to be supplied by the specifier

The specifier shall supply details of the intended function and performance requirements of the application, and the materials to be used, in accordance with Clause 4.

*NOTE* In addition to the parameters outlined in Clause 4, items such as specific heat capacity and mass flow rates of fluids may also be required under certain circumstances, particularly where calculating from first principles using BS EN ISO 12241. However, these additional parameters are not required for the use of the tables contained in this standard.

### 7.2 Physical characteristics

#### 7.2.1 General

The physical characteristics of the insulating material, including fixing and finishing materials whether pre-applied or applied on site, shall conform to 5.1, 7.2.2 and 7.2.3.

#### 7.2.2 Fire performance

Insulation materials and systems used for chilled and cold water applications shall conform to the following requirements.

*NOTE 1* Attention is drawn to the applicable requirements of the Building Regulations [5], the Building (Scotland) Regulations [3] and the Building Regulations (Northern Ireland) [6].

Insulation systems on pipework or ductwork traversing a fire-resisting division shall maintain the level of fire resistance of the wall, floor or cavity barrier through which they pass.

*NOTE 2* In the event of a fire some insulation systems can generate appreciable quantities of smoke and toxic fumes. Consideration should be given to the choice of materials bearing in mind their location, e.g. enclosed areas or adjacent to air ducts through which the smoke or fumes may spread.

In buildings other than dwellings, the complete assembly of materials as placed on market (whether faced or unfaced) shall be Class B-s3, d2 (European class) or better, in accordance with BS EN 13501-1.

In dwellings, the complete assembly of installed insulation materials (whether faced or unfaced) shall be Class C-s3, d2 (European class) or better.

If there is a potential hazard from contamination by oil or other flammable chemicals, a suitably resistant finish, e.g. a metal sheet or appropriate non-absorbent coating, shall be applied over the vulnerable areas. The lapped joints of sheet finishes shall be arranged to shed contaminating fluids away from the insulating material.

*NOTE 3* See Annex E for an explanation of Classes A1, A2, B, C, D, E or F (European classes).

#### 7.2.3 Water vapour barrier – Permeance requirements

Insulation materials and systems used for chilled and cold water applications shall be installed in accordance with and shall conform to the permeance requirements specified in 5.6.

When tested in accordance with BS EN 13469, BS EN 12086, BS EN ISO 4590, or BS ISO 1922, as appropriate, the permeance of the material used as a vapour barrier shall not exceed the values given in Table 1 for the relevant temperature of the plant.

## 7.3 Insulation thickness

### 7.3.1 Protection against condensation

In the absence of specific instructions from the specifier, the insulation thickness shall be not less than that given in [Table 6](#) to [Table 9](#) as appropriate.

### 7.3.2 Control of heat gain to cooled and chilled water pipes

In the absence of specific instructions from the specifier, and where the cooling load is not proven to be less than 5%, the insulation thickness shall be not less than that given in [Table 10](#) or [Table 11](#), as appropriate.

The cooling load shall be calculated in accordance with [Annex F](#).

For pipes or vessels of diameter greater than 273 mm, the items in [Table 10](#) and [Table 11](#) shall be assumed to be 273 mm for calculation purposes.

To show compliance with the requirements of [Table 10](#) and [Table 11](#), insulation thicknesses shall be calculated using standardized assumptions: horizontal pipe at  $t$  °C in still air at 25 °C, emissivity of outer surface of insulated system as specified.

*NOTE 1* Guidance on cooled ducts is given in [Table 12](#) and [Table 14](#).

*NOTE 2* Attention is drawn to the energy performance requirements of Approved Document L Volume 2 [5], Technical Booklet F2 [6] and Non-domestic Technical Handbook [7], Section 6.

*NOTE 3* The thicknesses of insulation specified in [Table 10](#) and [Table 11](#) to limit heat transfer meet or improve upon the minimum requirements of Approved Documents L Volume 2 [5] and Technical Booklet F2 [6]. However, these thicknesses of insulation might not comply with future revisions of the Building Regulations [2] and the Building Regulations (Northern Ireland) [4], and the current versions of these documents should be consulted to confirm compliance.

*NOTE 4* It should be noted that Building Regulations [2], [3], [4] provide minimum requirements for heat transfer to reduce energy use. The use of greater thicknesses of insulation can provide substantial financial and environmental benefits. Additional considerations might include acoustic performance, aesthetic qualities, fire properties, durability and thermal performance for reasons other than energy reduction; such as process control, control of condensation, internal building environment, surface temperature and freezing. This standard provides guidance on fire properties and thermal performance only and it is recommended that additional requirements are considered early in the design/specification stage to avoid any conflicts in design.

**Table 6** — Minimum insulation thickness for chilled and cold water pipes to control condensation on a high emissivity outer surface (0.9) with an ambient temperature of +25 °C and a relative humidity of 80%

| $\epsilon = 0.9$                                                                 |                           |                   |                   |                           |                   |                   |                           |                   |                   |
|----------------------------------------------------------------------------------|---------------------------|-------------------|-------------------|---------------------------|-------------------|-------------------|---------------------------|-------------------|-------------------|
| Outside diameter of steel pipe on which insulation thickness has been based (mm) | $t = 10$                  |                   |                   | $t = 5$                   |                   |                   | $t = 0$                   |                   |                   |
|                                                                                  | Insulation thickness (mm) |                   |                   | Insulation thickness (mm) |                   |                   | Insulation thickness (mm) |                   |                   |
|                                                                                  | $\lambda = 0.025$         | $\lambda = 0.035$ | $\lambda = 0.045$ | $\lambda = 0.025$         | $\lambda = 0.035$ | $\lambda = 0.045$ | $\lambda = 0.025$         | $\lambda = 0.035$ | $\lambda = 0.045$ |
| ≤17.2                                                                            | 7                         | 9                 | 11                | 9                         | 12                | 15                | 11                        | 15                | 18                |
| ≤21.3                                                                            | 7                         | 9                 | 11                | 9                         | 12                | 15                | 12                        | 15                | 19                |
| ≤26.9                                                                            | 7                         | 10                | 12                | 10                        | 13                | 16                | 12                        | 16                | 20                |
| ≤33.7                                                                            | 8                         | 10                | 13                | 10                        | 14                | 17                | 13                        | 17                | 21                |
| ≤42.4                                                                            | 8                         | 11                | 13                | 11                        | 14                | 18                | 14                        | 18                | 22                |
| ≤48.3                                                                            | 8                         | 11                | 13                | 11                        | 15                | 18                | 14                        | 19                | 23                |
| ≤60.3                                                                            | 8                         | 11                | 14                | 12                        | 15                | 19                | 15                        | 19                | 24                |
| ≤76.1                                                                            | 9                         | 12                | 15                | 12                        | 16                | 20                | 15                        | 20                | 25                |
| ≤88.9                                                                            | 9                         | 12                | 15                | 12                        | 17                | 21                | 16                        | 21                | 26                |
| ≤114.3                                                                           | 9                         | 12                | 16                | 13                        | 17                | 22                | 16                        | 22                | 27                |
| ≤139.7                                                                           | 9                         | 13                | 16                | 13                        | 18                | 22                | 17                        | 23                | 28                |
| ≤168.3                                                                           | 10                        | 13                | 16                | 13                        | 18                | 23                | 17                        | 23                | 29                |
| ≤219.1                                                                           | 10                        | 14                | 17                | 14                        | 19                | 24                | 18                        | 24                | 30                |
| ≤273                                                                             | 10                        | 14                | 17                | 14                        | 19                | 25                | 18                        | 25                | 31                |
| ≤323.9                                                                           | 10                        | 14                | 18                | 14                        | 20                | 25                | 19                        | 25                | 32                |
| ≤355.6                                                                           | 10                        | 14                | 18                | 15                        | 20                | 25                | 19                        | 26                | 32                |
| ≤406.4                                                                           | 10                        | 14                | 18                | 15                        | 20                | 26                | 19                        | 26                | 33                |
| ≤457                                                                             | 11                        | 15                | 18                | 15                        | 21                | 26                | 19                        | 26                | 33                |
| ≤508                                                                             | 11                        | 15                | 19                | 15                        | 21                | 26                | 19                        | 27                | 34                |
| ≤610                                                                             | 11                        | 15                | 19                | 15                        | 21                | 27                | 20                        | 27                | 35                |

**Key** $t$  = temperature of contents (°C) $\lambda$  = thermal conductivity at mean temperature of insulation [ $W/(m \cdot K)$ ]

NOTE Thicknesses given are calculated specifically against the criteria noted in the table. These thicknesses may not satisfy other design requirements. In situations where the ambient air temperature is greater than 25 °C and/or the relative humidity exceeds 80%, these thicknesses might not be sufficient to control condensation.

Table 7 — TABLE NOT USED AND INTENTIONALLY BLANK

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