

Methods for

Determining thermal insulating properties —

Part 3: Tests for thermal transmittance
and conductance —

Section 3.2 Calibrated hot-box method

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Refrigeration Heating and Air Conditioning Standards Policy Committee (RHE/-) to Technical Committee RHE/9, upon which the following bodies were represented:

- Autoclaved Aerated Concrete Products Association
- British Ceramic Research Ltd.
- Chartered Institution of Building Services Engineers
- Combustion Engineering Association
- Cork Industry Federation
- Cranfield Institute of Technology
- Department of Health
- Department of the Environment (Building Research Establishment)
- Department of Trade and Industry (National Engineering Laboratory)
- Department of Trade and Industry (National Physical Laboratory)
- Electricity Supply Industry in England and Wales
- Engineering Equipment and Materials Users Association
- Eurisol (UK Mineral Wool Association)
- Gypsum Products Development Association
- Phenolic Foam Manufacturers Association
- Power Generation Contractors' Association (BEAMA Ltd.)
- Royal Institute of British Architects
- Thermal Insulation Manufacturers and Suppliers Association (TIMSA)
- Thermal Insulations Contractors Association

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

- Aggregate Concrete Block Association
- Association of Lightweight Aggregate Manufacturers
- British Board of Agreement
- British Cement Association
- British Precast Concrete Federation Ltd.
- Flat Glass Manufacturers' Association
- Institute of Refrigeration
- Institution of Chemical Engineers
- Insulation Jacket Manufacturers Federation
- Polyethylene Foam Insulation Association
- University of Salford
- Yarsley Technical Centre Ltd.

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Foreword

This Section of BS 874 was prepared under the direction of the Refrigeration, Heating and Air Conditioning Standards Policy Committee.

Previous editions of BS 874 summarized the methods available for determining thermal insulating properties, and indicated which methods were applicable to various materials intended for use in a variety of temperature ranges, but the methods themselves were not defined in detail.

The growing importance of energy conservation and the need to have reliable information about the insulating properties of materials requires detailed specifications of the test methods. Accordingly, a complete revision of the standard is being undertaken, with each test method being fully specified. The full revision of BS 874 will take several years to complete, and it has therefore been decided to issue each test method as a separate section of BS 874 as and when it is completed, thus gradually replacing the 1973 edition.

The method presented in this Section may be used as an alternative to the guarded hot-box method given in Section 3.1 and was not originally in 4.3 of BS 874:1973.

It should be appreciated that experience in the use of the method is limited and revisions of this Section may become necessary as more experience is gained in the use of the method.

The accuracy levels and the reproducibility which may be expected from the method are not well established. Precision experiments, of the type described in BS 5497-1 are necessary before reliable estimates for these can be given.

It is recommended that this Section of BS 874 be read in conjunction with BS 874-1 and BS 874-3.1.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 12, 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.

0 Introduction

The method described in this Section is intended for tests on large building elements such as parts or sections of walls, roofs, floors, etc., where the thermal properties may not be uniform due to the method of fabrication and the materials used.

The method may be used as an alternative to the guarded hot-box method of BS 874-3.1. A slightly modified procedure, given in Appendix A of BS 874-3.1:1987, enables tests to be made on smaller elements such as window systems.

The design and construction of an apparatus suitable for application of the method is a complex subject and needs to be based on sound scientific principles. While the calibrated hot-box apparatus is simpler in design and operation than the guarded hot-box of BS 874-3.1, detailed calibration procedures are required in order to produce measurements of comparable accuracy. This Section gives guidelines for apparatus design and outlines appropriate calibration procedures.

It is important that users of this method are fully conversant with the principles of heat flow and with precise thermal measurement techniques. All instruments used in this method are required to be traceable to the National Physical Laboratory (NPL) or to a laboratory acceptable to NPL.

1 Scope

This Section of BS 874 describes a method for determining the steady-state thermal transmittance and thermal conductance of construction elements using the calibrated hot-box apparatus.

The method is suitable for construction elements with thermal transmittances and conductances in the range $0.1 \text{ W}/(\text{m}^2 \text{ K})$ to $15 \text{ W}/(\text{m}^2 \text{ K})$ for testing within a temperature range of -50°C to 50°C .

Apparatus designed in accordance with this Section is capable of measurement to an accuracy of $\pm 5\%$ on test elements of uniform thermal conductance (i.e. elements with no thermal bridges between surfaces) in the conductance range $0.5 \text{ W}/(\text{m}^2 \text{ K})$ to $5 \text{ W}/(\text{m}^2 \text{ K})$.

NOTE 1 The potential for achieving these levels of accuracy will depend upon the apparatus, its calibration particulars, and the type of test specimen being measured. The determination of thermal transmittances or conductances below $0.5 \text{ W}/(\text{m}^2 \text{ K})$ requires measurements of high precision, and therefore may be less accurate. Determination of thermal transmittances or conductances in the range above $5 \text{ W}/(\text{m}^2 \text{ K})$ may also be less accurate as there may be higher surface temperature variations and difficulties with measurement of representative surface temperatures. Additionally, greater inaccuracies are to be expected for test elements of nonuniform conductance (i.e. elements with thermal bridges between surfaces).

Some building elements may pose difficult problems of measurement, and careful consideration is required before a test method is chosen. The method is considered particularly appropriate for elements with surface projections or thick metal faces, which could cause difficulties if measured in the conventional guarded hot-box configuration of BS 874-3.1.

Thermal conductance measurements are not appropriate on elements of particularly non-uniform construction (see clause 7).

The method does not provide for measurements where there is transport of air through the test element during the test.

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

2 Definitions

For the purpose of this Section of BS 874, the definitions given in BS 874-1 apply.

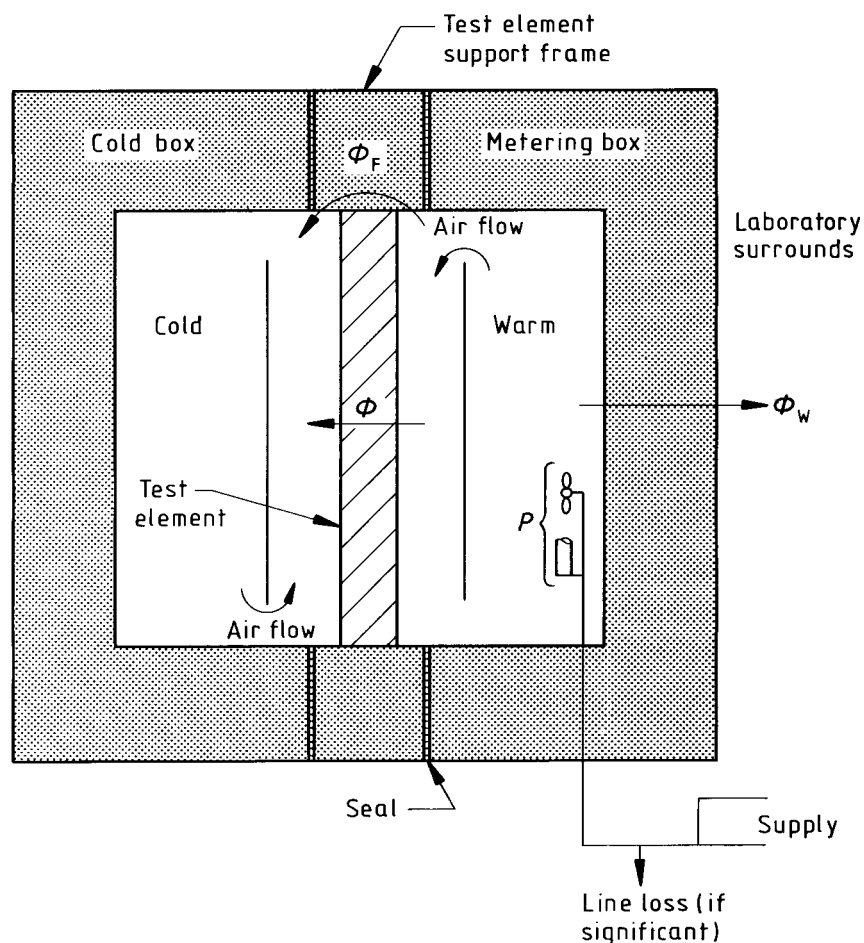
3 Principle

The basis for the method is the measurement, at equilibrium, of the heat flux through the test element and the corresponding temperature difference(s) across it. The apparatus is shown schematically in Figure 1 and consists of two principal items, a metering box and a cold box, between which the test element, usually assembled in a support frame, is placed.

Heat supplied to the metering box passes through the test element to the cold box, which is maintained at a constant low temperature. The heat flux through the test element is determined from the total power supplied to the metering box, correcting for losses or gains through the metering box walls and the flanking loss (see 4.4) to the cold box occurring around the perimeter of the specimen (see Figure 1). These corrections are determined from prior calibration measurements using specimens of known thermal properties.

It is important that both of these corrections be kept small. Heat flow through the metering box walls is restricted by making them of high thermal resistance, and, where appropriate, controlling external ambient temperature fluctuations (see 4.2.2). To reduce flanking losses, the test element is usually well insulated around its perimeter (see 4.4.2).

NOTE More complicated versions of this type of apparatus have been built, in which the metering box is enclosed in a temperature screen or guard (to control metering box wall heat exchanges) and in which the test panel edges are also guarded (to minimize flanking losses). Although not dealt with specifically in this Section of BS 874, such an apparatus, when properly designed and constructed, may be taken to meet all the requirements of the present method.



NOTE The energy flux through test element, ϕ is given by the following equation.

$$\phi = P - \phi_W - \phi_F$$

where

- P is the power supplied to metering box (in W)
- ϕ_W is the heat flux to laboratory surrounds (in W)
- ϕ_F is the flanking loss (in W)

Figure 1 — Calibrated hot-box apparatus

Heat may be supplied to the metering box at a constant rate, in which case the apparatus slowly reaches the desired equilibrium condition. Alternatively, the temperature in the metering box may be kept constant by suitable control of the heat input. When thermal equilibrium is achieved, i.e. when the temperatures on each side of the test element and the heat flux through it are essentially constant, then the final measurements are taken.

Heat exchange at the hot and cold surfaces of the test element involves both convective and radiative components. The former depends upon air temperature and air speed, while the latter depends upon the temperatures and emissivities of surfaces seen by the element surface. The effects of heat transfer to or from a surface by convection and radiation are conveniently combined in the concept of an environmental temperature and a surface heat transfer coefficient. Thermal transmittance is defined between two environmental temperatures and therefore suitable temperature measurements are required to enable these to be determined (see Appendix B of BS 874-3.1:1987). This is particularly important with test elements of low thermal resistance for which the surface resistances form a significant fraction of the total resistance.