

Methods for

Determining thermal insulating properties —

Part 2: Tests for thermal conductivity
and related properties —

Section 2.2 Unguarded hot-plate
method

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- Aggregate Concrete Block Association
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Foreword

This Section of BS 874 was prepared under the direction of the Refrigeration, Heating and Air Conditioning Standards 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 required detailed specifications of the test methods. Accordingly, a complete revision of the standard was 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 they are completed, thus gradually replacing the 1973 edition.

This Section constitutes a revision of **4.2.2** of BS 874:1973 which it supersedes and which was deleted by amendment.

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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

This Section describes an unguarded hot-plate method for determining the steady-state thermal conductivity of homogeneous insulating solids of medium conductivity such as rubbers, dense plastics, glasses and masonry materials in the temperature range $-20\text{ }^{\circ}\text{C}$ to $100\text{ }^{\circ}\text{C}$.

It is not an absolute method since a correction has to be applied for lateral heat flow to, or from the specimen and heater plate edges, based on a calibration of the apparatus using specimens of known conductivity. Nevertheless, as the method is restricted to a limited thermal resistance/conductivity range over which this correction is relatively small, it produces results of comparable accuracy to the guarded hot-plate method described in BS 874-2.1.

To facilitate calibration by direct exchange of specimens with Section 2.1, the present Section specifies the same basic plate dimensions as the guarded hot-plate apparatus, i.e. 305 mm square. Other essential dimensions, tolerances, and design features are detailed in the text and minimum performance requirements are specified for the associated electrical and temperature measuring instruments. The measurement procedures, test conditions and specimen preparation methods, especially for masonry materials, are described and the information required in test reports is specified.

Although the precautions needed to ensure accuracy with different types of test material have been detailed in this Section, experience has shown that heat transfer measurements are far from straightforward and care should be taken to ensure that the execution of its provisions is entrusted to appropriately qualified and trained people.

1 Scope

This Section of BS 874 describes a method for determining the steady-state thermal resistance, conductance, conductivity and resistivity of homogeneous insulating solids in slab form from $-20\text{ }^{\circ}\text{C}$ to $100\text{ }^{\circ}\text{C}$ using the 305 mm unguarded hot-plate apparatus.

NOTE 1 In the context of this Section, thermally homogeneous materials are materials whose measured thermal conductivity or resistivity, at any given temperature, is not affected by a change in the temperature gradient, or the thickness or area of the test specimens. Materials which contain a random distribution of inclusions or cavities whose dimensions are small relative to the specimen thickness are regarded as homogeneous, but layered structures that appreciably distort the heat flux distribution are not.

The method is applicable over the following, mutually inclusive, ranges, i.e. test specimens have to satisfy all four conditions a) to d):

- a) thermal resistance, R , between $0.025\text{ m}^2\text{ K/W}$ and $0.33\text{ m}^2\text{ K/W}$;
- b) thermal conductance, $C = 1/R$, between $3\text{ W/(m}^2\text{ K)}$ and $40\text{ W/(m}^2\text{ K)}$;
- c) thermal conductivity, λ , between 0.15 W/(m K) and 2 W/(m K) ;
- d) thermal resistivity, $r = 1/\lambda$, between 0.5 m K/W and 6.7 m K/W .

NOTE 2 It is recommended that this Section be read in conjunction with BS 874-1.

NOTE 3 The titles of 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 determination of thermal conductivity and related properties by this method involves the measurement of the mean temperature difference between the opposite faces of two identical, parallel-faced specimens at steady-state when a constant heat flux density of known magnitude passes through them. The specimen surface temperatures are measured by means of thermocouples mounted on, or within, the surfaces and the heat flux density passing through them is determined from their effective area and the power supplied to the unguarded heater plate, corrected for a small lateral component of heat flow associated with heat losses or gains from the specimen and heater-plate edges. The magnitude of this correction for any given set of experimental conditions is evaluated from a pre-calibration of the apparatus involving measurements on reference specimens of low thermal conductivity.

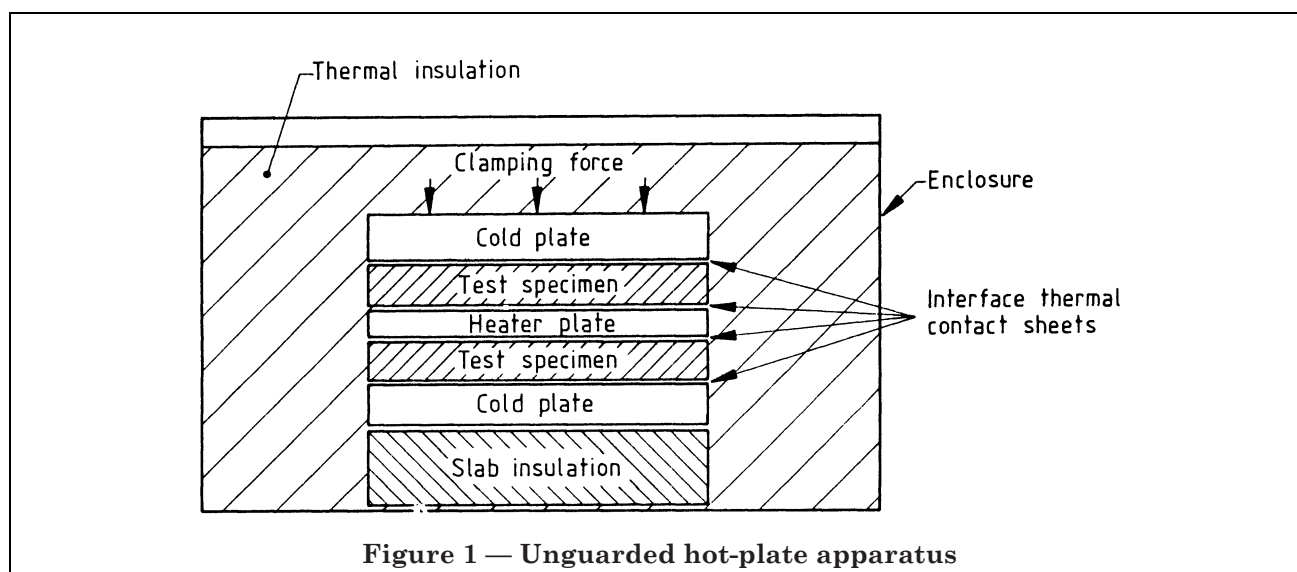


Figure 1 — Unguarded hot-plate apparatus

With reference to Figure 1, two specimens of known thickness and area, having the specified number of thermocouples mounted on their surfaces, are placed on either side of the heater plate and clamped in the horizontal plane between two isothermal cold plates. Good thermal contact between the specimen and plate surfaces is facilitated by placing thin sheets of compressible rubber between them. These also serve to insulate the thermocouples from the metal plates. To minimize heat exchange with the environment, the assembly is surrounded by a thick layer of insulation housed in a container which can be sealed when measurements are required with cold plate temperatures near to, or lower than the dew-point of the ambient air. With the cold plates maintained at an appropriate constant temperature by fluid circulation from a thermostatically controlled bath, stabilized electrical power is supplied to the heater plate to establish, at steady-state, a suitable temperature difference at constant heat flow rate through the specimens. The power supplied to the heater plate is measured potentiometrically using precision instruments of high input impedance. A small correction is applied to compensate for the edge heat losses or gains appropriate to the conditions of test as described in clause 8. The average temperature difference across the specimens at steady-state is determined from the thermocouple e.m.f.s.

The requisite thermal property is evaluated from these measured values using the equations given in clause 9.

4 Laboratory environment

The ambient air temperature of the laboratory shall be maintained constant to within $\pm 2^\circ\text{C}$ and the relative humidity between 25 % and 65 % during the test.

NOTE Closer control of the laboratory relative humidity or the use of an environmental chamber may be required to comply with the conditioning requirements specified for some materials. See also 5.4 and 6.5.1.

5 Apparatus

5.1 Heater plate

The heater plate shall be a double-sided unit consisting of a heating element securely sandwiched between two metal surface plates of high conductivity metal, such as copper or aluminium, some 3 mm to 5 mm thick. The plate shall be nominally 305 mm square and its working surfaces shall be flat within 0.1 mm.

NOTE 1 Guidance on the determination of flatness may be sought from BS 817.

The heater element shall be uniformly wound and be embedded in heat-resisting, electrically insulating material within the surface plates to ensure good thermal contact. The windings shall be symmetrical with respect to the two working surfaces of the heater plate and shall be of sufficiently small pitch to ensure uniform surface temperature on both sides (see Figure 2).

The resistance between the heater elements and plates shall be greater than 1 M Ω .