

इंटरनेट

मानक

Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

“जानने का अधिकार, जीने का अधिकार”

Mazdoor Kisan Shakti Sangathan

“The Right to Information, The Right to Live”

“पुराने को छोड़ नये के तरफ”

Jawaharlal Nehru

“Step Out From the Old to the New”

IS 9490 (1980): Method for determination of thermal conductivity of insulation materials (water colorimeter method) [CHD 27: Thermal Insulation]



“ज्ञान से एक नये भारत का निर्माण”

Satyanarayan Gangaram Pitroda

“Invent a New India Using Knowledge”



“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”

Bhartrhari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”

BLANK PAGE



IS : 9490 - 1980

Indian Standard

**METHOD FOR DETERMINATION OF
THERMAL CONDUCTIVITY OF
THERMAL INSULATION MATERIALS
(WATER CALORIMETER METHOD)**

(Second Reprint AUGUST 1993)

UDC 662.998 : 536.21.083 : 536.62

© *Copyright* 1981

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

AMENDMENT NO. 1 MAY 2002
TO
IS 9490 : 1980 METHOD FOR DETERMINATION OF
THERMAL CONDUCTIVITY OF THERMAL INSULATION
MATERIALS (WATER CALORIMETER METHOD)

(Page 6, clause 4.4, line 3) — Substitute 'not less than 5 mm thick' *for* 'about 3 mm thick'.

(CHD 27)

Reprography Unit, BIS, New Delhi, India

Indian Standard

METHOD FOR DETERMINATION OF THERMAL CONDUCTIVITY OF THERMAL INSULATION MATERIALS (WATER CALORIMETER METHOD)

Thermal Insulation Materials Sectional Committee, CDC 37

Chairman

DR B. C. RAYCHAUDHURI

Representing

Central Mechanical Engineering Research Institute
(CSIR), Durgapur

Members

SHRI R. N. BANERJEE (<i>Alternate to</i> Dr B. C. Raychaudhuri)	
DR K. N. AGARWAL	Central Building Research Institute (CSIR), Roorkee
SHRI S. P. JAIN (<i>Alternate</i>)	
CHEMIST & METALLURGIST ICF, MADRAS	Research, Designs and Standards Organization (Ministry of Railways), Lucknow
ASSISTANT CHEMIST & METALLURGIST (<i>Alternate</i>)	
SHRI J. J. D'COSTA	Llyod Insulations (India) Pvt Ltd, New Delhi
SHRI C. P. KHANNA (<i>Alternate</i>)	
SHRI N. N. GOYAL	Fibreglass Pilkington Limited, Bombay
SHRI A. SHARIF (<i>Alternate</i>)	
SHRI K. V. GURUSWAMY	Indian Oil Corporation Ltd (Refineries & Pipelines Division), New Delhi
SHRI P. K. LAKHANPAL (<i>Alternate</i>)	
SHRI S. R. KHANNA	Directorate General of Technical Development, New Delhi
SHRI K. V. SAMPATH (<i>Alternate</i>)	
SHRI R. P. PUNJ	Punj Sons Pvt Ltd, New Delhi
SHRI Y. P. PUNJ (<i>Alternate</i>)	
SHRI D. RAMAMURTHY	Bharat Heavy Electricals Ltd, Hyderabad
SHRI R. SANKARAN (<i>Alternate</i> I)	
SHRI A. K. DUBEY (<i>Alternate</i> II)	
SHRI B. V. APPA RAO	Steel Authority of India Ltd, Ranchi
SHRI S. K. CHATTERJI (<i>Alternate</i>)	

(Continued on page 2)

© Copyright 1981

BUREAU OF INDIAN STANDARDS

This publication is protected under the *Indian Copyright Act* (XIV of 1957) and reproduction in whole or in part by any means except with written permission of the publisher shall be deemed to be an infringement of copyright under the said Act.

IS : 9490 - 1980

(Continued from page 1)

Members

DR H. C. ROY

SHRIS. P. S. KHALSA (*Alternate*)
SHRI S. B. SARKAR

SHRI N. SRINIVAS

SMT U. ROY (*Alternate*)

SHRI M. BALA SUBRAMANIAM

SHRI R. N. GANJOO (*Alternate*)

DR S. P. SUKHATME

SHRI V. A. SURA

SHRI V. P. WASAN

SHRI K. N. BHATNAGAR (*Alternate*)

DR HARI BHAGWAN,
Director (Chem)

Representing

The Fertilizer (Planning & Development India)
Ltd, Sindri

Ministry of Energy (Fuel Conservation Committee),
New Delhi

PIBCO Ltd, New Delhi

BASF India Limited, Bombay

Indian Institute of Technology, Bombay

Newkem Products Corporation, Bombay

National Physical Laboratory (CSIR), New Delhi

Director General, ISI (*Ex-officio Member*)

Secretary

SHRI A. K. BAHL

Assistant Director (Chem), ISI

Panel for Terminology and Methods of Test for Thermal Insulation, CDC 37 : P1

Convener

DR B. C. RAYCHAUDHURI

Central Mechanical Engineering Research Institute
(CSIR), Durgapur

Members

DR K. N. AGARWAL

Central Building Research Institute (CSIR),
Roorkee

SHRI P. R. DAS

National Test House, Calcutta

SHRI A. K. GUPTA

Hyderabad Asbestos Cement Products Ltd,
Hyderabad

SHRIM. SAMBASIVARAO (*Alternate*)

SHRI R. P. PUNJ

Punj Sons Pvt Ltd, New Delhi

SMT U. Roy (*Alternate*)

DR S. P. SUKHATME

Indian Institute of Technology, Bombay

SHRI V. P. WASAN

National Physical Laboratory (CSIR), New Delhi

SHRI K. N. BHATNAGAR (*Alternate*)

Indian Standard

METHOD FOR DETERMINATION OF THERMAL CONDUCTIVITY OF THERMAL INSULATION MATERIALS (WATER CALORIMETER METHOD)

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 29 April 1980, after the draft finalized by the Thermal Insulation Materials Sectional Committee had been approved by the Chemical Division Council.

0.2 The determination of thermal conductivity of a material is not simple since it may involve the measurement of a very small heat flow and the maintenance of steady temperatures and electrical energy inputs over considerably long periods. In addition, temperatures or temperature differences have to be measured accurately with suitable devices and care has to be taken to minimize heat losses.

0.3 Thermal conductivity determinations are usually made on slabs or sheets of the material, the apparatus being such that the heat flow is normal to the faces, and lateral heat losses from the test area are generally prevented by a guard ring or the like. The need for normal flow militates against the use of thick specimens unless they are also of considerable area. On the other hand, many insulating materials have a granular structure, and the sample cannot be representative unless it is thick enough to include several diameters of the average grain. A compromise, therefore, has to be made in such situations for appropriate dimensions of the test specimen.

0.4 This is a secondary routine method for measuring the thermal conductivity of homogeneous insulating materials, and its reproducibility is 5 percent. Wherever applicable, the method given in IS : 3346-1980* shall be used as a referee method for determination of thermal conductivity.

*Method for the determination of thermal conductivity of thermal insulation materials (two slab, guarded hot-plate method) (*first revision*).

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

1. SCOPE

1.1 This standard prescribes the general procedures and design of equipment for determining the thermal conductivity of dry samples of thermal insulating materials, provided that:

- a) the materials are sufficiently uniform with regard to their aggregates and pores; and
- b) the thermal conductivity of the material does not exceed 1.5 W/mK.

1.2 The equipment described in this standard is suitable for hot face temperature between 675 K and 1 275 K.

1.3 The thermal conductivity coefficients obtained apply only to the particular sample tested.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions of terms, symbols and units given in IS : 3069-1965† shall apply.

3. PRINCIPLE OF MEASUREMENT

3.1 A specimen of the material to be tested is placed on a horizontal heater assembly. On the specimen a water flow calorimeter is placed along with a guard ring. The assembly is suitably insulated to minimize heat losses. The amount of heat flowing through the specimen is determined by the flow rate of water through the calorimeter and its temperature rise. Thermal conductivity is measured using temperature drop and heat flow through the specimen, and its area and thickness.

4. EQUIPMENT

4.1 Heater Assembly—The heater assembly shall consist of a heater resistance wire coil laid in a suitable refractory material with grooves,

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

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

meant for the purpose, deep enough so that the coil does not touch the sample (or plate) placed on it, and produces uniform heating. The material shall be strong enough to withstand the load of specimen, calorimeter, etc, placed on it. Its dimensions shall be about 450×450 mm.

4.1.1 The heater shall be fed from stabilized lead acid batteries of sufficient ampere-hour capacity or through a stabilized and regulated power supply from the mains, so that its temperature does not fluctuate in one hour of a test period by more than 0.5 percent of the temperature difference between the hot and cold plates.

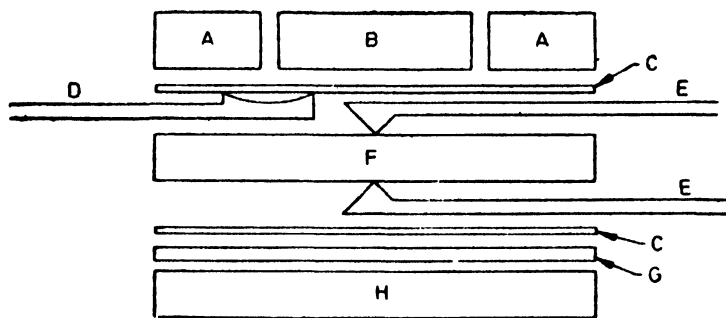
4.2 Calorimeter and Guard Ring — The water flow calorimeter plate shall be about 230×230 mm. The guard ring shall be co-planar, about 110 mm wide, fitted around the calorimeter plate, with a gap not more than 3 mm wide maintained between the guard plate and the calorimeter plate in order to minimize thermal contact between the two. In order to ensure that lower surfaces of the calorimeter and guard ring are co-planar and that the calorimeter remains centered in the guard ring, the two shall be placed on a levelling plate and the gap between them filled with strips of blotting paper or any other suitable material. The two shall then be linked suitably so as to lock them together. The calorimeter and the guard ring shall consist of a manifold of high conducting metallic tube of not less than 7 mm bore packed as tightly as possible and brazed or clamped continuously to a thick high conducting metallic plate on one side and a strong iron plate on the other. The high conducting metallic surface plate shall be flat to within 0.25 mm/m and shall be not less than 5 mm in thickness. A twin-tube manifold is preferable in so far as every portion of the plate will then have the same temperature. The calorimeter and guard ring may also be made of high conducting metallic plates, with suitably designed cut-in counter flow channels, which on assembly would form continuous tube space inside the plate assembly so that uniform temperature could be maintained in the entire plate surface by circulation of water.

4.2.1 The calorimeter and the guard ring shall be supplied with water at a steady flow rate from a constant-head tank. The accuracy of measurement of flow rate of water shall be within ± 0.2 percent. The rate of flow shall not vary by more than 1 percent during the test period.

4.3 Thermocouples — Calibrated, similar thermocouples shall be used to measure temperatures to 0.02 K or better in conjunction with a calibrated potentiometer having an accuracy of ± 0.1 percent or better. Cold junctions of the thermocouples shall be maintained at 273 K, for example, in an ice cell containing mixture of ice and water. At least 4 thermocouples shall be placed on the heating side, and 2 under the

calorimeter. Preferably, for precise detection of temperature imbalance between the guard surface and the calorimeter surface, additional thermocouples may be fitted across the gap at each face along the periphery of the gap. These thermocouples across the gap may be fitted at a distance of about 10 mm from the edge of the calorimeter and guard surface. Thermocouples shall be made of wire not larger than 0.46 mm in diameter (No. 26 SWG).

4.4 Assembly — General arrangement of the equipment is shown in Fig. 1. A flat plate of a heat resistance alloy measuring 450×450 mm and about 3 mm thick and flat to within 0.25 mm/m shall be placed on the heater assembly. This plate shall have one cut, about 100 mm long, in each corner and edge to reduce warping. The sample shall be placed on this plate, sandwiched between two sheets of asbestos paper about 0.3 mm thick. The thermocouples shall be placed between the sample and the asbestos sheets. Calorimeter and guard ring shall be placed on the top asbestos sheet. The edges of the test specimen shall be covered with thermal insulating material at least 70 mm thick to minimize heat losses. The exposed surfaces of the calorimeter and guard ring shall also be covered with at least 70 mm of insulating material.



A — Guard ring
B — Water calorimeter
C — Asbestos paper
D — Thermocouples for detecting temperature imbalance

E — Thermocouples
F — Specimen
G — Plate
H — Heater assembly

FIG. 1 ARRANGEMENT OF WATER CALORIMETER APPARATUS

5. PROCEDURE FOR THERMAL CONDUCTIVITY MEASUREMENT

5.1 Samples — A test specimen, 450 × 450 mm and of uniform thickness 50 mm to 80 mm shall be used. The materials to be tested in the apparatus may be of various types and shall be suitably supported horizontally in the apparatus as given in 5.1.1 to 5.1.3.

5.1.1 Rigid Slabs — Rigid slabs such as those of cellular concrete or calcium silicate insulation or slabs built up of bricks bonded with cement may be held in a frame of angle iron about 600 mm square, if necessary, which is fitted with screws which support the edges of the slab. Shallow grooves shall be made on the surface to place the thermocouples. Care shall be taken to ensure that the faces of the slab are flat to within 0.25 mm/m.

5.1.2 Semi-rigid Slabs — Semi-rigid slabs and similar materials such as fibrous mats or plastic compositions shall be placed in the apparatus on the flat plate. Where the compressibility of the material makes it necessary the thickness of the test specimen shall be maintained by supporting the calorimeter and guard ring on small distance pieces inserted in holes in the test specimen. A correction shall be applied for the heat flow through the distance pieces.

5.1.3 Loose Fill Materials — Loose fill materials, such as powders or granules, shall be packed as uniformly as practicable into a frame about 450 × 450 mm resting on the plate. Where necessary, the thickness of test specimen shall be maintained as in 5.1.2 or by means of a grid of thin mica sheets. A correction shall be applied for the heat flow through the distance pieces.

5.2 Observations — After assembling the apparatus, operate it, and when conditions are steady, make a series of observations of temperatures, the water-flow rate and water temperature rise through the calorimeter. The heat flow shall be calculated from these observations. For each hot face temperature condition, make observations using at least two different water flow rates. The thermal conductivity of the central section of the specimen shall be calculated from the heat flow through the central section, regarded as flowing through a square of area half way between that of the calorimeter and that of the central hole in the guard plate, together with the observed hot and cold face temperatures and thickness of the central section. The test observations shall be made at intervals of not less than 30 minutes until four successive sets of observations give thermal conductivity values differing by not more than 1 percent.

IS : 9490 - 1980

Thermal conductivities at high cold face temperatures shall be determined by measuring the temperature by means of thermocouples fixed parallel to the faces at known positions inside the test specimen.

6. CALCULATION

6.1 Thermal conductivity shall be calculated as follows:

$$\lambda = \frac{f l s (t_o - t_i)}{A (t_h - t_c)} \text{ W/mK}$$

where

λ = thermal conductivity of the material, W/mK;

f = flow rate of water, g/s;

l = thickness of sample (or distance between hot face and cold face), m;

s = specific heat capacity of water in J/gK;

t_o = outlet temperature of water, K;

t_i = inlet temperature of water, K;

A = Area of heat flow (central section), m²;

t_h = hot face temperature, K; and

t_c = cold face temperature, K.

7. REPORT

7.1 The report of the results of each test shall include the following:

- a) Name and other identifications of the materials;
- b) Thickness of the specimen tested (or distance between hot face and cold face);
- c) Mass of the specimen, after drying, used for the test;
- d) Density before test just after placing the specimen in the apparatus of the specimen used for the test;
- e) Moisture, as received, in the specimen used for the test;
- f) Moisture regain, during test, of the specimen;

- g) Hot face temperature;
- h) Cold face temperature;
- j) Mean temperature of the test;
- k) Heat input per unit area;
- m) Thermal conductivity;
- n) Flow rate of water; and
- p) Special remarks, if any. Here mention should also be made of the following:
 - i) Whether some metallic portions, or coatings of insulation, were removed during test;
 - ii) Whether thermocouples were fixed inside the specimen for determining thermal conductivity at higher cold face temperature; and
 - iii) Any other special point that may be relevant from the scientific or application point of view.

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002

Telephone: 331 01 31, 331 13 75

Telegrams : Manaksanatha
(Common to all offices)

Regional Offices:

Telephones

Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI-110002	[331 01 31 331 13 75
*Eastern : 1/14 C.I.T. Scheme VII M, V. I. P. Road; Maniktola, CALCUTTA 700054	36 24 99
Northern : SCO 445-446, Sector 35-C, CHANDIGARH 160036	[2 18 43 3 16 41
Southern : C. I. T. Campus, MADRAS 600113	{ 41 24 42 41 25 19 41 29 16
†Western : Manakalaya, E9 MIDC, Marol, Andheri (East), BOMBAY 400093	6 32 92 95

Branch Offices:

'Pushpak' Nurmohamed Shaikh Marg, Khanpur, AHMEDABAD 380001	[2 63 48 2 63 49
‡Peenya Industrial Area, 1st Stage, Bangalore Tumkur Road BANGALORE 560058	[38 49 55 38 49 56
Gangotri Complex, 5th Floor, Bhadbhada Road, T. T. Nagar, BHOPAL 462003	6 67 16
Plot No. 82/83, Lewis Road, BHUBANESHWAR 751002	5 36 27
53/5, Ward No. 29, R. G. Barua Road, 5th Byalane, GUWAHATI 781003	3 31 77
5-8-56C L. N. Gupta Marg (Nampally Station Road), HYDERABAD 500001	23 10 83
R14 Yudhister Marg, C Scheme, JAIPUR 302005	[6 34 71 6 98 32
117/418 B Sarvodaya Nagar, KANPUR 208005	[21 68 76 21 82 92
Patliputra Industrial Estate, PATNA 800013	6 23 05
T.C. No. 14/1421, University P.O., Palayam TRIVANDRUM 695035	[6 21 04 6 21 17
<i>Inspection Office (With Sale Point) :</i>	
Pushpanjali, 1st Floor, 205-A West High Court Road, Shankar Nagar Square, NAGPUR 440010	2 51 71
Institution of Engineers (India) Building, 1332 Shlvaji Nagar, PUNE 411005	5 24 35

*Sales Office in Calcutta is at 5 Chowringhee Approach, P.O. Princep Street, Calcutta 700072 27 65 00

†Sales Office in Bombay is at Novelty Chambers, Grant Road, Bombay 400007 39 65 28

‡Sales Office in Bangalore is at Unity Building, Narasimharaja Square Bangalore 22 36 71
560002