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Indian Standard

METHODS OF TEST FOR THERMAL INSULATING CEMENTS

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

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Indian Standard

METHODS OF TEST FOR THERMAL INSULATING CEMENTS

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Indian Standard

METHODS OF TEST FOR THERMAL INSULATING CEMENTS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 20 July 1970, after the draft finalized by the Thermal Insulation Materials Sectional Committee had been approved by the Chemical Division Council.

0.2 The purpose of this standard is to provide details of standard methods of test for thermal insulating cements for the assessment of a range of properties.

0.3 In the preparation of this standard, assistance has been drawn from the following publications issued by the American Society for Testing and Materials:

ASTM C 163 - 64	Mixing thermal insulating cement samples.
ASTM C 166 - 61	Covering capacity and volume change upon drying on thermal insulating cement.
ASTM C 353 - 65	Adhesion of dried thermal insulating cement.
ASTM C 354 - 65	Compressive strength of thermal insulating cement.
ASTM C 356 - 60	Linear shrinkage of preformed high-temperature thermal insulation subjected to soaking heat.
ASTM C 405 - 60	Consistency of wet-mixed thermal insulating cement.

0.4 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 methods of test for thermal insulating cements.

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

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 3069 - 1965* in addition to the one given below, shall apply.

2.1.1 *Consistency* — of wet mixed thermal insulating cement is the degree to which it resists deformation due to the application of outside forces like trowel pressure.

3. SAMPLING

3.1 Representative samples of the material shall be drawn as prescribed in the relevant material specification.

4. MIXING THERMAL INSULATING CEMENT SAMPLES

4.0 General — This method covers a procedure for mixing thermal insulating cement samples with water in the preparation of specimens for use in all tests on the sample.

4.1 Apparatus

4.1.1 *Mixing Surface or Pan* — A non-absorbent and corrosion-resistant surface or shallow pan approximately one metre square, for example, enamelled tray.

4.1.2 *Trowels* — A 400-mm, rectangular plasterer's trowel, and a 250-mm, pointed trowel.

4.1.3 *Scales* — Scales accurate to within 20 g with a capacity of about 10 kg.

4.1.4 *Water Container* — A container suitable for holding approximately 10 litres of water.

4.1.5 *Moulds* — The mould may be constructed of either wood or metal.

4.2 Mixing Water — The mixing water shall be equal in quality to that used for drinking purposes. Its temperature shall be between 30°C and 35°C. The quantity used shall be as advised by the supplier for giving the required consistency (*see* **5**).

4.3 Procedure

4.3.1 Weigh the sample (at least 1·5 kg) of dry cement and keep it on the mixing surface or pan.

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

4.3.2 Form a crater in the centre of the dry cement. Pour a weighed amount of mixing water slowly into the crater. Fold the material on the outer edge into the crater by means of the rectangular trowel.

4.3.3 After the water has been in contact with the cement for the period of time recommended by the manufacturer, mix rapidly with the rectangular trowel until the entire batch is of uniform consistency. Mould the cement specimen immediately after mixing or after the lapse of such period of time as may be recommended by the manufacturer.

5. CONSISTENCY OF WET-MIXED THERMAL INSULATING CEMENT

5.0 General — In the methods given here the consistency of thermal insulating cement is determined after mixing with a specified amount of water. The consistency of a wet cement affects such properties as ease of trowelling, wet adhesion, drying shrinkage, dry density and thermal conductivity.

5.0.1 These methods measure consistency of thermal insulating cements in terms of either percentage of deformation as described in Method A (*see* **5.1**) or centimetres of penetration as described in Method B (*see* **5.2**).

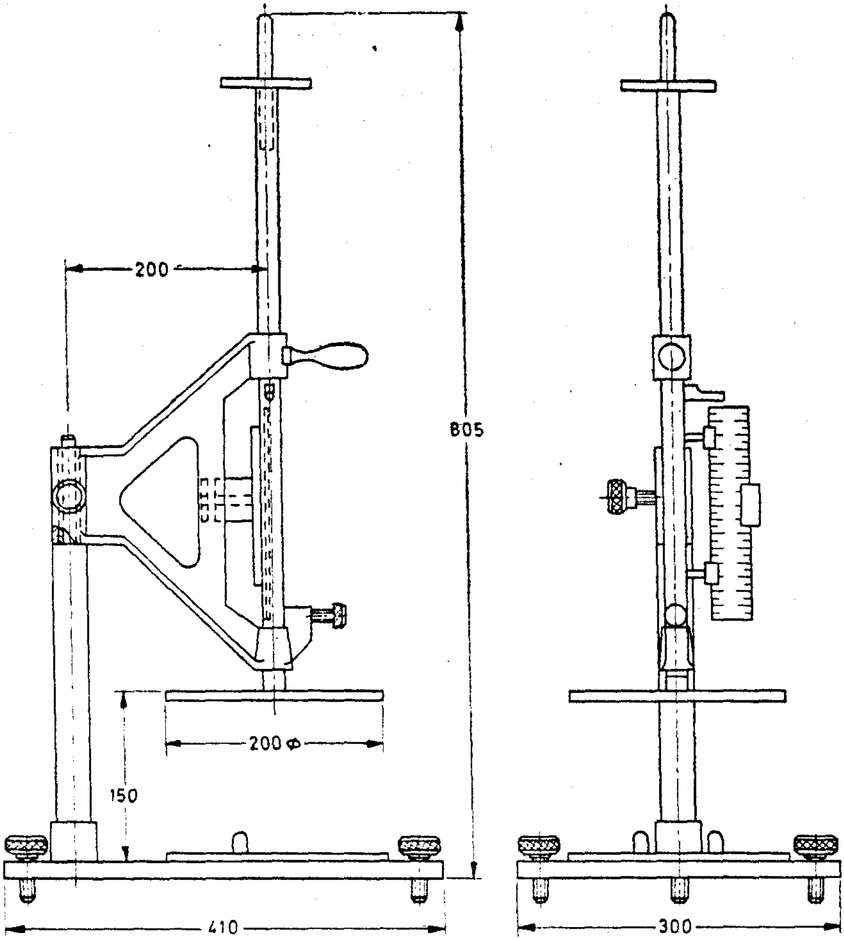
5.1 Method A — Deformation Method

5.1.1 *Apparatus*

5.1.1.1 *Dead load tester* — As shown in Fig. 1, equipped with two clamps, one of which permits the loading member arm to swivel out of the way while the sample is put in position, while the other keeps the loading member from sliding until it is released. The total weight of the loading member (sliding vertical bar plus 200-mm diameter disk) is adjusted to exactly 2·5 kg by adding weights as necessary at the top of the bar. A cylindrical brass mould, 75 mm inside diameter by 150 mm in height, is used to prepare the sample.

5.1.2 *Sample Preparation* — At least 1·5 kg of dry cement shall be sampled and mixed with a weighed amount of water at a temperature of 30 to 35°C as prescribed in **4**. When thoroughly mixed, the cement shall be smoothed into a circular mound about 75 to 100 mm high and allowed to set for one hour. Then, it shall be mixed once again before testing (hydraulic setting cements shall be tested at least 15 minutes after mixing).

NOTE — All the water to be mixed with the dry cement shall be added at one time; tests at other water-cement ratios shall be performed using entirely new batches of cement mixed as described above.



All dimensions in millimetres.

FIG. 1 APPARATUS FOR MEASURING CONSISTENCY BY DEFORMATION OF WET-MIXED THERMAL INSULATING CEMENTS

5.1.3 *Procedure*

5.1.3.1 Oil the inside of the cylindrical mould lightly. Fill the mould by throwing 25 to 30 small pieces of wet cement into it with just enough force to eliminate voids. When the mould is slightly over full, strike off the excess cement level from the top of the mould, with a trowel or spatula; take care not to compress the cement when this is done.

5.1.3.2 Centre the filled mould under the load member of the apparatus, remove the mould, and place the load member flush on the sample. If the sample deforms (sags) when it is freely standing, place the load member flush on the sample, and include the amount of sag as part of the measured deformation. Release the load member and measure the deformation 30 sec later.

5.1.3.3 Obtain at least three tests from each batch of wet-mixed cement prepared in accordance with **5.1.2**.

5.1.4 *Calculation*

$$\text{Deformation, percent} = \frac{150 - A}{150} \times 100$$

where

A = height after deformation in mm.

5.1.5 *Report* — Average the percentage deformation for all tests and report the average, along with the water-cement ratio used. If any single test value differs from the average by more than $\pm$ 5 percent deformation, discard it and repeat the determination.

5.2 Method B — Penetration Method

5.2.1 *Apparatus*

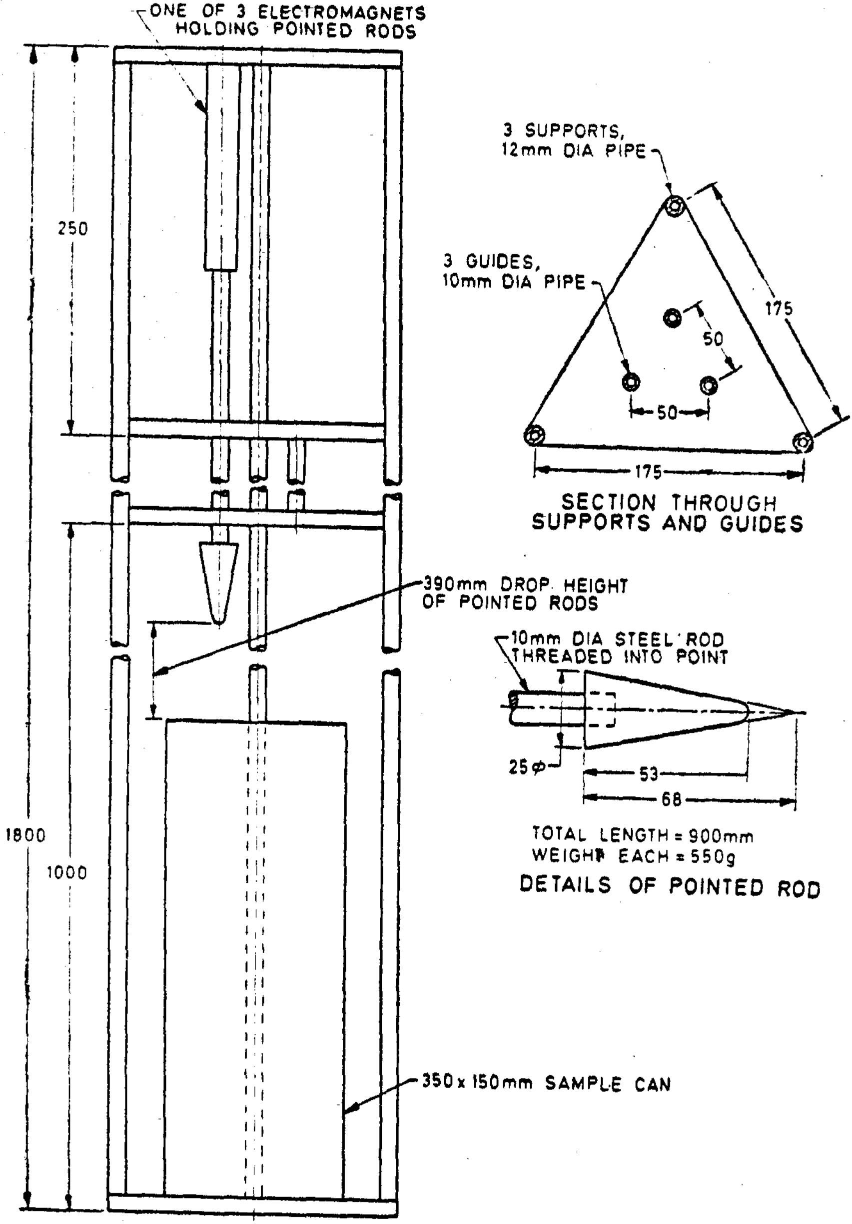
5.2.1.1 *Penetration tester* — as shown in Fig. 2. The three pointed steel rods or spears have a loose sliding fit in their guides, which are 600 mm long. The rods are held up by three electromagnets connected to a switch; when the switch is thrown, the three spears are released and dropped simultaneously. A scale is attached to each of the supporters and a pointer to each rod so that the penetration of the spears can be read directly correct to a millimetre.

5.2.2 *Sample Preparation* — same as in **5.1.2**.

5.2.3 *Procedure*

5.2.3.1 Drop handfuls of wet cement into the sample can from a height of approximately 1 000 mm. When the can is slightly over full, strike off the excess cement with a trowel or spatula, flush with the top of the can but without exerting any pressure on the cement. Then place the filled sample can in position below the raised spears of the apparatus.

5.2.3.2 Release the spears by means of the electrical switch. Measure the depth of penetration of each of the spears 30 sec later, and take the average depth of penetration of the three spears as the measure of consistency for that test.



All dimensions in millimetres.

FIG. 2 APPARATUS FOR MEASURING CONSISTENCY BY PENETRATION OF WET-MIXED THERMAL INSULATING CEMENTS

5.2.3.3 Perform at least two tests at each water-cement ratio to be tested.

5.2.4 *Report* — Report the average of test results along with the water-cement ratio used. Discard the value and repeat the determinations if the penetration of any spear differs by more than ±25 mm.

6. COVERING CAPACITY AND VOLUME CHANGE UPON DRYING OF THERMAL INSULATING CEMENT

6.0 General — Wet covering capacity and volume change upon drying are often of major importance in the application of thermal insulating cement and can be determined at the same time when the determination of dry covering capacity are made.

6.1 Apparatus

6.1.1 *Mould* — A rigid mould having inside dimensions of 725 × 200 × 25 mm with one end and one face open, and a piece of wood or other suitable material 200 × 40 × 25 mm in dimensions for squaring up the end of the test specimen towards the open end of the mould.

6.1.2 *Wax Paper* — sheets of wax paper 750 × 200 mm in dimensions.

6.1.3 *Engine Oil*

6.1.4 *Trowel* — a 400-mm rectangular plasterer's trowel.

6.1.5 *Steel Rules* — ½ and 1 metre in length graduated in millimetres.

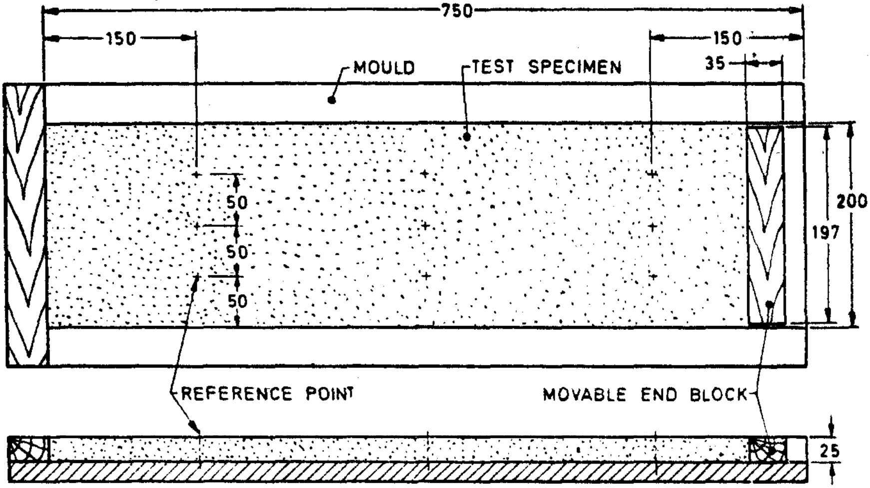
6.1.6 *Depth Gauge* — A depth gauge consisting of a rigid, pointed rod approximately 3 mm in diameter, fitted with a flat disc about 15 mm in diameter which may be moved along the rod either by sliding action or by means of threads.

6.2 Procedure

6.2.1 Oil the inside surfaces of the mould well, or line them with wax paper in order to prevent the cement from sticking to the sides and to permit convenient removal of the specimen. Then place the mixed cement in the mould.

6.2.2 Trowel the cement in one layer and in two direction lengthwise of the mould without tamping, until the surface is smooth and flush with the top edges of the mould. Sufficient wet cement shall be used to fill the mould when the piece of wood or other suitable material is in place in the open end of the mould and in contact with the cement, in order to make a square end and to prevent movement after trowelling is completed.

6.2.3 Measure the thickness at nine points on the top surface of the sample as indicated in Fig. 3.



All dimensions in millimetres.

FIG. 3 MOULD FOR TEST SPECIMENS AND LOCATION OF POINTS FOR THICKNESS MEASUREMENT

6.2.4 Make the thickness measurements within an accuracy of ± 2 percent by means of a depth gauge (*see* **6.1.6**). Carefully push the pointed rod of the depth gauge through the cement until it comes in contact with the bottom of the mould. Hold the rod constantly in a vertical position and adjust the disk until its flat surface just comes into contact with the top surface of the cement. Determine the thickness of the cement by measuring the distance from the flat surface of the disk to the pointed end of the rod with a steel rule or by some other suitable scale. Do not fill the indentations in the cement showing the points of measurement, but allow them to dry in place.

6.2.5 Make the width and length measurements with the steel rules within an accuracy of ± 1 mm. Make the width measurements at locations approximately 100 mm from each end of the specimen. Make the length measurements at locations approximately 50 mm from each side of the specimen. While making these measurements, allow the edge of the steel rule to make an indentation in the wet cement in order to assure measurements at the same locations after the cement has been dried.

6.2.6 Immediately after the measurements have been made, or as soon thereafter as recommended by the manufacturer, place the cement specimen and mould in an oven at 110 ± 5°C until dried to constant weight. The oven chamber shall be adequately vented in such a manner so as to ensure complete circulation of the atmosphere of the entire oven chamber, preferably by fan or other forced circulation method.

6.2.7 After the dried specimens have been weighed, measure it for thickness, width and length at the same locations at which corresponding measurements were made before the specimen was dried. These locations are indicated by the indentation marks made in the wet cement. Measure the thickness as described in **6.2.4**. In order to prevent false thickness measurements on the dry specimen, due to the bottom surface of the specimen having become warped in drying, remove the specimen from the mould and place a flexible steel rule so as to conform to the bottom surface of the specimen at points where the thickness is to be measured. Insert the point of the depth gauge from the original top face until it touches the steel rule.

6.3 Calculations — Calculate the wet and dry covering capacities and the volume change on drying as follows:

$$C_w = \frac{d\,b\,l}{100\,000\,W},$$

$$C_d = \frac{d_1 b_1 l_1}{100\,000\,W}, \text{ and}$$

$$V = \frac{d\,b\,l - d_1 b_1 l_1}{d\,b\,l}\,100$$

where

C_w = wet covering capacity in m^2, 1 cm in thickness per 100 kg of dry cement;

C_d = dry covering capacity in m^2, 1 cm in thickness per 100 kg of dry cement;

V = percentage volume change upon drying;

d = average thickness in mm of wet specimen;

b = average width in mm of wet specimen;

l = average length in mm of wet specimen;

W = mass in kg of the dry material;

d_1 = average thickness in mm of dry specimen;

b_1 = average width in mm of dry specimen; and

l_1 = average length in mm of dry specimen.

7. COMPRESSIVE STRENGTH OF THERMAL INSULATING CEMENT

7.0 General

7.0.1 The compressive strength of a dried layer of thermal insulating cement is a measure of its resistance to deformation (compaction, crushing or displacement) under a compressive load applied by a flat loading member.

7.0.2 Compressive strength is related to density and, for the results of this test to be representative, the density of the test specimens should approximate that obtained by means of the procedures for determining volume changes upon drying.

7.1 Apparatus

7.1.1 *Testing Machine* — A suitable hydraulic or mechanical testing machine or mechanical compression testing machine.

7.1.2 *Spherical Bearing Block* — A spherical bearing block having a plane bearing surface at least 150 mm square.

7.2 Test Specimen

7.2.1 *Dimensions* — The test specimen shall be 150 mm square and 40 mm thick.

7.2.2 *Mixing* — Mix the dry cement with the requisite amount of water (*see* **4.3**).

7.2.3 A wet moulded block approximately 330 × 180 × 50 mm thick (dimensions depend on shrinkage characteristics) will provide two test specimens of the required size. Mould the block on a flat, heavy-gauge metal drying plate covered with wax paper to prevent adhesion, and prepare the block with adequate packing and trowelling to ensure a solid uniform structure throughout.

7.2.4 Dry the wet moulded blocks to constant weight in a vented oven at 110 ± 5°C (*see* **4.4**).

7.2.5 Weigh the test specimens to the nearest 1 g. Measure the average hickness and dimensions of both square faces to the nearest 0·25 mm, then return the specimens to the oven for 2 hours.

7.3 Procedure

7.3.1 At least four specimens shall be tested. The sized specimens shall be tested within one hour after removal from the drying oven.

7.3.2 The load shall be applied perpendicularly to the square face of the test specimen. The bearing block shall be used on top of the test specimen in vertical testing machines where only one bearing block is provided. The plane bearing surface of the block assembly shall be in contact with the entire area of the top square face of the test specimen, the specimen being carefully centred under the bearing block, and the bearing surface shall be parallel to the weighing table of the testing machine (*see* Fig. 4). The spherical seat of the bearing block shall be kept thoroughly lubricated to ensure accurate adjustment, which shall be made by hand under an initial load of 0·14 kgf/cm².

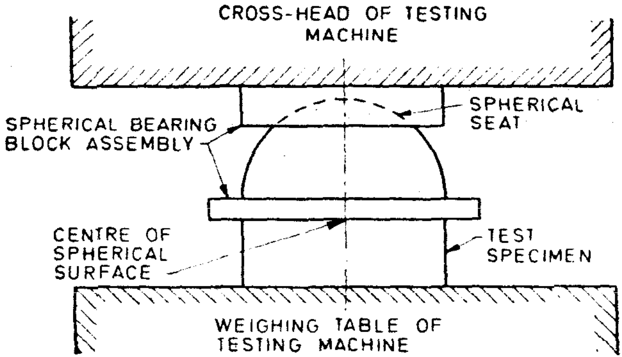


FIG. 4 SPHERICAL BEARING BLOCK FOR COMPRESSIVE STRENGTH TEST

7.3.3 The initial thickness of the test specimen for deformation calculations shall be considered as the distance between the plane bearing surface of the block assembly and the weighing table of the testing machine after the initial 0·14 kgf/cm² load. The speed of the moving head of the testing machine shall be not more than 1 mm/min.

7.3.4 The specimen shall be compressed to a deformation of 5 percent of its initial thickness unless definite failure occurs before this deformation is reached.

7.4 Calculation — Calculate the compressive strength as follows:

$$S = \frac{W}{A}$$

where

S = compressive strength in kgf/cm²,

W = load in kg (including weight of spherical test block assembly) at 5 percent deformation, and

A = average of the gross areas of the top and bottom faces of the specimens in square cm.

8. DETERMINATION OF THERMAL CONDUCTIVITY

8.1 Thermal conductivity determinations on thermal insulating cements may be carried out in accordance with IS : 3346-1966*.

9. LINEAR SHRINKAGE OF PREFORMED HIGH-TEMPERATURE THERMAL INSULATION SUBJECTED TO SOAKING HEAT

9.0 General — Linear shrinkage refers to the change in linear dimensions that has occurred in test specimens after they have been subjected to soaking heat for a period of 24 hours and then cooled to room temperature.

9.1 Apparatus

9.1.1 *Furnace* — A gas-fired or electrically heated muffle furnace, having a size sufficient to accommodate at least four test specimens and two dummy specimens, each 150 × 65 × 40 mm spaced so as to allow a clearance of at least 15 mm on all surfaces of every test specimen. The temperature of the furnace shall be controlled throughout the volume occupied by the specimens to within ±1 percent of the desired temperature expressed in deg C. A furnace temperature indicator or recorder is required.

NOTE — If the structure is not homogeneous throughout its thickness or if thinner materials are under test, the specimen should be tested without altering the original thickness. For smaller ovens, unable to accommodate the required number of specimens, it will be necessary to make several test batches in order to secure the minimum number of specimens required.

9.1.2 *Oven* — A conditioning oven whose temperature can be controlled within the range 110±5°C.

9.1.3 *Specimen Measuring Apparatus* — Any instrument suitable for measuring a gauge length up to 150 mm with an accuracy of 0·05 mm. Care must be taken, by the use of proper measuring techniques, to assure reproduction of any measurement to within 0·2 mm. It is particularly important to avoid crushing the ends of specimens during measurement, especially in the case of soft materials.

9.1.4 *Balance* — A balance which can weigh up to 0·01 g, for weighing the specimen before and after heating.

9.2 Sampling and Preparation of Test Specimen

9.2.1 All samples that will be required to complete the tests shall be selected at one time and in such a manner as to the representative of the material.

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

9.2.2 Specimens for any one test condition shall be selected from the original sample lot so as to be as representative as possible. The specimens shall be cut or sawed from full-size pieces in such a manner that they will be fully representative of the entire, full-size piece as well as of the material. These specimens shall be cut to size $150 \times 65 \times 40$ mm, in such a manner that the length and width are cut parallel to the length and width, respectively, of the original full-size piece. If it is impossible to faithfully represent the material by cutting to 40 mm thick specimen or for thinner pieces, then the original thickness of the material shall be tested. Rectangular specimens cut from pipe covering may be used if the material is homogeneous and if the sections are large enough. If the material is not homogeneous or the sections are not sufficiently large, then curved or partly curved segments of a cylinder may be used. In this case, the specimens shall preferably be cut to an overall width of 65 mm, with the sides cut parallel to the length of cylinder rather than on a radius.

9.3 Procedure

9.3.1 Prepare or select a minimum of four test specimens as prescribed in **9.2**. Weigh the specimens in the as received condition and then dry them at 110 ± 5°C until the excess moisture is driven off, as indicated when a constant weight is reached.

9.3.2 Upon removal from the conditioning oven, place the specimens in a desiccator and allow them to cool to within 5°C of room temperature. After cooling, remove the specimens from the desiccator and weigh before any changes in weight occur due to moisture absorption. This is followed by drying and weighing at intervals until constant weight is established. Then, before any changes in dimensions occur, determine the linear dimensions. Make at least one measurement of length and two each of width and thickness at marked points so that re-measurements can be made again at the same points after soaking heat.

9.3.3 Place the measured and weighed specimens in the furnace, the temperature of which shall not initially exceed 115°C. The specimens shall rest on their 120×40 mm edges, supported by at least three supports (namely, small ceramic triangular bars, or cylindrical rods), which in turn shall be supported on a protective plate. The supporting bars or rods shall be large enough so that the specimens have a clearance of at least 15 mm above the protective plate. Arrange the specimens face to face in a group, but separated at least 15 mm from each other. Place dummy block or other protective means along the sides of the two specimens at each end of the group so as to protect the faces of these two specimens from radiation losses or gains from the inner surfaces of the furnace. This arrangement of the specimens will allow free access of heat to all of their surfaces.

9.3.4 Apply the source of heat after the specimens have been arranged in the furnace. The rate of heat supply should be held constant, or reasonably so during the heating-up period. This rate should be gauged so that the average rise of the temperature of furnace shall not exceed 170°C per hour. During the heating-up period, especially in the initial stages, make frequent observations to note any signs of combustibility, by opening the furnace door momentarily or, if possible through observation parts. After the furnace has reached the desired test temperature, maintain soaking-heat conditions for a period of 24 hours, and then cut off the supply of heat. When the furnace has cooled to 110° ± 5°C remove the specimens and place them directly into a desiccator.

9.3.5 When the specimens have cooled to within 5°C of room temperature, remove them from the desiccator and measure again before any changes can occur. Weigh the specimens and measure their dimensions at the exact points which were used for determining the original lengths (*see* **9.3.2**). If any warpage occurred during the soaking heat, determine the amount of warpage to the nearest 0·2 mm. If the warpage exceeds 1·0 mm the actual length of the specimen as such shall not be determined. Instead determine the apparent length of the specimen by measuring the chord connecting the two edges of the concave surface of the warped specimen, or by measuring the chord connecting the two-points of original measurement, as the case may be.

9.3.6 Examine the specimens, and note any visible changes that may have occurred during the heating.

9.4 Calculation

9.4.1 *Linear Shrinkage* — Calculate the percentage linear dimensional change after soaking heat as follows:

$$S = \frac{L_1 - L_2}{L_1} \times 100$$

where

S = percentage linear dimensional change upon soaking heat;

L_1 = average length, width, or thickness of specimen, in mm, before soaking heat; and

L_2 = average length, width, or thickness of specimen, in mm, after soaking test.

9.4.2 *Apparent Linear Shrinkage* — Calculate the percentage apparent dimensional change after soaking heat when a specimen has warped excessively (more than 1·0 mm) by the same formula as for linear shrinkage, except that L_2 shall represent the apparent length of the specimen after soaking heat.

9.4.3 *Change in Weight* — Calculate the percentage change in weight after soaking heat as follows:

$$C = \frac{W_1 - W_2}{W_1} \times 100$$

where

C = percentage change in weight after soaking heat;
W_1 = weight of the specimen, in g, before soaking heat; and
W_2 = weight of specimen, in g, after soaking heat.

9.5 Report — The report shall include the following:

i) Temperature of test, the time to reach the temperature, the time for which the specimen is kept at that temperature and the time for the temperature to drop to 50°C after the heat is turned off;
ii) Linear shrinkage;
iii) Warpage, if any;
iv) Apparent linear shrinkage, if the warpage is in excess of 1·0 mm;
v) Change in weight;
vi) Any visible changes in the material after soaking heat, particularly when the changes are not uniform on all faces; and
vii) Any evidence of combustibility which may have occurred during the heating period or during soaking heat, for example, flaming, glowing, smoking, smouldering, etc.

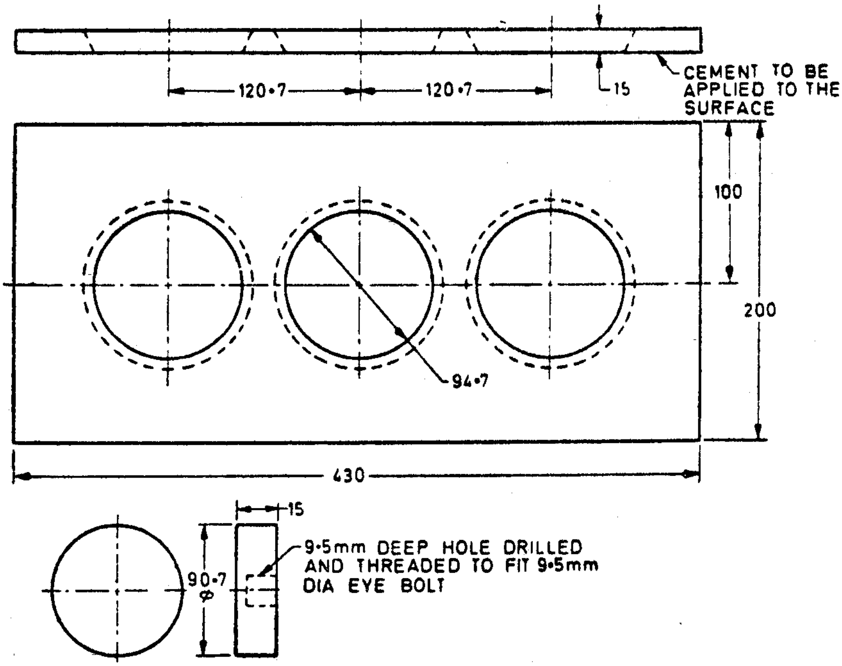
10. ADHESION OF DRIED THERMAL INSULATING CEMENT

10.0 General — This method deals with the measurement of the relative adhesion of dried thermal insulating cement to a particular test surface. While this test is valuable in rating these products generally, it should be pointed out that adhesion of cement to one type of surface cannot be construed as being fully indicative of its adhesion to another type of surface.

10.1 Apparatus

10.1.1 *Test Plate* — A rectangular stainless steel plate (*see* Fig. 5) 430 × 200 × 15 mm, provided with these 45-mm top diameter circular openings bevelled at 20° angle to a larger bottom diameter.

10.1.2 *Test Disks* — Three 15-mm thick stainless steel disks (Fig. 5), each having a surface area of 645 cm² (90·7 mm in diameter). One surface shall be smoothly finished, and 9·5-mm deep hole threaded to fit a 9·5-mm eye bolt, shall be centered in the other surface.



Total weight = 4·1 kg
Nub size = 9·5 mm diameter × 3 mm high
Material = Brass
Cylinder drilled through to proper length.
Roll turns freely on axis.
Twelve rows of nubs—alternate rows staggered.

All dimensions in millimetres.

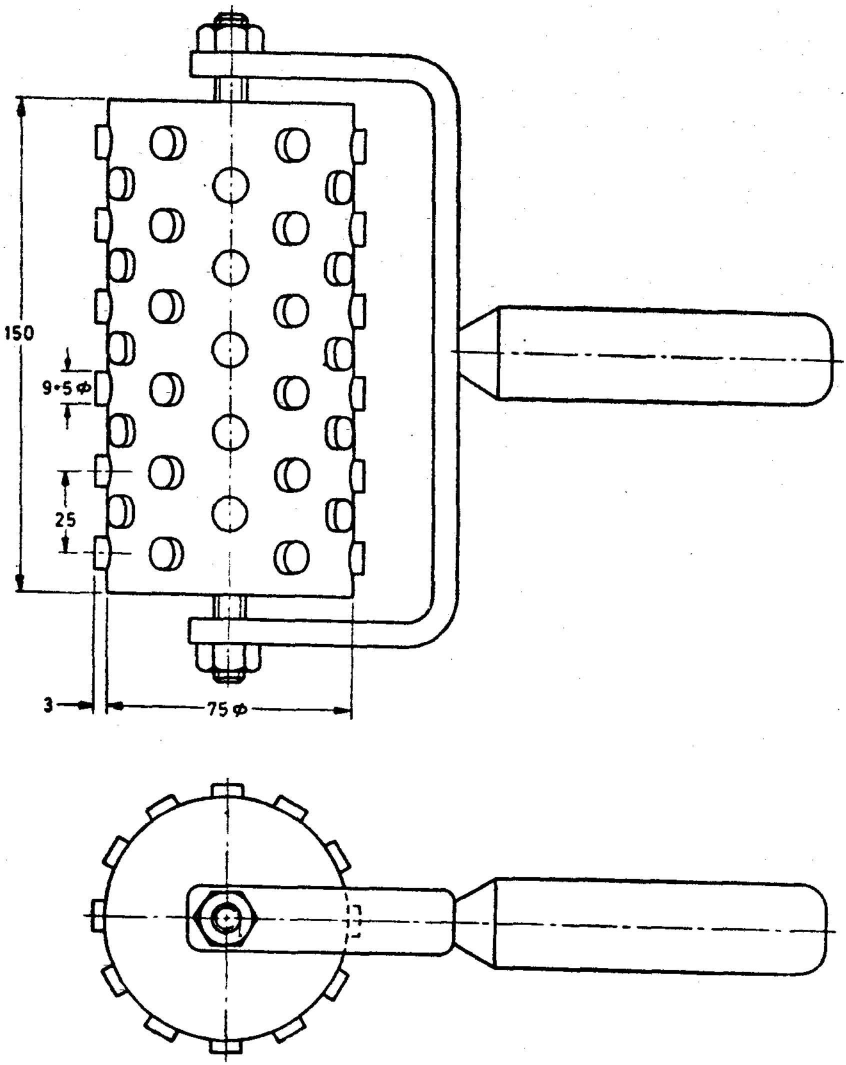
FIG. 5 ADHESION TEST PLATE AND DISKS

10.1.3 *Mould Frame* — A demountable mould frame to control the wet cement to a 20-mm thickness during application to the disk surfaces.

10.1.4 *Small Pointing Trowel*

10.1.5 *Special Sheep's Foot Roller* — as shown in Fig. 6, 75 mm in diameter, 150 mm in width, weighing 4 kg, and having twelve rows of nubs. The nubs shall be about 9·5 mm in diameter, shall extend 3 mm from the face of the roller and shall be 25 mm apart. Alternate rows shall be staggered.

10.2 Sampling and Mixing — The cement shall be sampled and mixed in accordance with **4.3**.



All dimensions in millimetres.

FIG. 6 SHEEP'S FOOT ROLLER

10.3 Procedure

10.3.1 Carefully clean the test disks with soap and water, rinse in boiling water, air-dry and assemble with the threaded portion of the test disk and down with the rectangular plate and mould frame on a supporting plate of flat, heavy-gauge steel. Take care not to touch the cleaned test surfaces of the disks with the fingers during assembly. Centre the test disks in the holes of the rectangular test plate. A jig may be used for this purpose, in which case it may also be used as the support for the assembly.

10.3.2 Loosely pack the properly mixed cement in the mould frame, then press and trowel it lightly in place until the frame is well filled to a depth of approximately 20 mm.

10.3.3 Place a strip of wet, medium-heavy canvas 0·55 kg/m^2 over the filled mould and pass the sheep's foot roller 30 times over the length of the mould. A pass shall consist of pulling the roller through the length of the mould in one direction. Do not lift the roller until the compression and working of the cement has been completed, and always pull the roller in the direction of travel rather than pushing it in one direction and pulling it in the other.

10.3.4 Lift the roller and remove the canvas and mould frame. Place the plate, disk and cement assembly, still mounted on the heavy gauge plate (or jig), in a drier at 110 ± 5°C until it reaches constant weight.

10.3.5 When thoroughly dry, carefully invert the assembly and, with a sharp-pointed instrument, clean out dried material in the opening around each test disk to prevent wedging or edge adhesion. Allow the assembly to stand at room conditions for 1 hour.

10.3.6 Align the assembly in a hold down jig on a testing machine capable of measuring the load to an accuracy of 0·5 kg, and pull each disk to failure at rate not to exceed 25 kg/min.

10.4 Report

10.4.1 Report the adhesive strength in kilograms per square centimetre (load in kilograms at rupture divided by 64·5) for each disk, and report the average for three disks.

10.4.2 If the adhesion of any single disk varies more than 20 percent from the average of the three disks, the test shall be repeated except where strengths are below 0·35 kg/cm^2, when a maximum variation from the average of 0·07 kg/cm^2 shall be considered an acceptable test.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	Unit	Symbol
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	Unit	Symbol	Definition
Force	newton	N	1 N = 1 $kg.m/s^2$
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

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