भारतीय मानक **IS 10047 : 2023**

Indian Standard

उच्च सहताप प्लास्टिक और कुटाई संहति के — परीक्षण की पद्धति

(पहला पुनरीक्षण)

Refractory Plastic and Ramming Mass — Method of Test

(First Revision)

ICS 81.080

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August 2023 **Price Group 7**

Refractories Sectional Committee, MTD 15

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Refractories Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard was first published in 1981. While reviewing this standard, in the light of the experience gained during these years, the committee decided to revise it by incorporating the following major modification:

a) Scope has been modified to include refractory plastic in the standard;
b) Addition of an exclusion clause in the scope for excluding dry vibratable masses from the standard which requires different method for sample preparation altogether;
c) The maximum mass of any lot has been limited to 50 tonnes;
d) Size of the specimen has been modified;
e) Test method for evaluation of workability of ramming mass or plastic has been incorporated; and
f) Physical test on determination of porosity measurement of refractory plastic and ramming mass has been incorporated and determination of moisture has been withdrawn.

The test methods prescribed in this standard are intended to be used for assessment of the quality of refractory plastic and ramming mass as well as for checking their conformity to the specification.

This standard contains clauses which call for an agreement between the purchaser and the supplier. Such clauses are **4.2**, **5.1**, **5.2**, **6.1**, **7.3**, **9.1**, **11.2**, **13.2** and **15.1**.

In the preparation of the standard due consideration has been given to manufacturing and trade practices followed in the country in this field and assistance has been derived from ISO 1927-5 : 2012 ‘Monolithic (unshaped) refractory products — Part 5: Preparation and treatment of test pieces’, issued by International Organization for Standardization (ISO).

The composition of the Committee responsible for the in the formulation of this standard is given in Annex B.

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 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

METHOD OF TESTING REFRACTORY PLASTIC AND RAMMING MASS

(*First Revision*)

1 SCOPE

1.1 This standard prescribes the methods of sampling and tests of refractory plastic and ramming mass.

1.2 This standard does not prescribe the methods of sampling and tests for dry vibratable masses.

2 REFERENCES

The standards listed in Annex A contain provisions, which through references in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of these standards.

3 TERMINOLOGY

For the purpose of this standard, the following definition, in addition to those given in IS 4041 shall apply.

3.1 Ramming Mass — Mixtures of graded refractory aggregate with or without air/heat setting binder/additive(s) and with or without liquid(s). It is usually supplied at a consistency which requires mechanical method of application that is ramming. A plasticizing agent may also be incorporated in the ramming masses.

NOTE — According to the type of product, the main bond may be ceramic, chemical, or organic. Ramming mixes are used as-delivered or after the addition of binder/additive(s) additives and/or liquid(s). They harden under the action of heat above ambient temperature.

3.2 Plastic Refractory — Unshaped refractory, supplied ready for use, with a high workability, made up of aggregate, binder/additives(s) and liquid, and which hardens after placing by the action of heat. A plastic refractory is also defined as a refractory material, tempered with water that can be extruded and that has suitable workability to be ponded into place to form monolithic structure.

NOTE — According to the type of product, the main bond may be ceramic, chemical or organic. Plastic refractory materials are normally supplied in soft, pre-formed blocks or slices and placed by ramming (mechanical or manual). They harden under the action of heat above ambient temperature.

3.3 Workability Index — Measure of the ease of moulding or shaping an unshaped refractory.

NOTE — The terms ‘plastic’ and ‘ramming mass’ are generally intended to describe the workability of the material. In this regard, plastics are considered to be materials having high workability index than ramming masses.

3.4 Dry Mix or Dry Vibratable Refractory — Unshaped refractory specially designed to be placed in the dry state by-vibration or ramming.

4 SAMPLING

4.1 Lot

In any consignment, all the containers/bags holding refractory plastic/ramming mass of the same type and grade, manufactured by the same manufacturer under similar conditions of production shall be grouped together to constitute a lot. The maximum mass of any lot, however, shall be limited to 50 tonnes.

4.2 Sample Size

For completing all the tests, a minimum quantity of about 50 kg is required as sample. As these are normally supplied in 50 kg containers/bags, the number of containers/bags shall be selected at random as has been defined in Table 1.

Table 1 Numbers of Bags/Containers to be Selected for Different Lots

(*Clauses* 4.2 *and* 7.3)

Sl No.	Lot Weight	No. of 50 Kg Containers/Bags to be Selected as Samples
(1)	(2)	(3)
i)	Up to 10 tonnes	1
ii)	10 tonnes to 25 tonnes	2
iii)	Over 25 tonnes up to 50 tonnes	4

4.3 The collected samples shall be used for various physical tests given below and chemical analysis:

a) Pyrometric cone equivalent (PCE);
b) Apparent porosity;
c) Bulk density (BD);
d) Permanent linear change (PLC);
e) Cold crushing strength (CCS);
f) Thermal conductivity; and
g) Hot modulus of rupture (HMOR).

NOTE — The same test sample may be used for more than one test, if permitted by respective test methods. For example, bulk density, permanent linear change, cold crushing strength and chemical analysis can be measured using the same test specimen. A part from the aforementioned tests, additional tests can be carried out using the same test specimens if mutually agreed between the purchaser and the supplier.

5 CHEMICAL ANALYSIS

5.1 Chemical analysis of the ramming specimen should be conducted on loss free basis by grinding 50 mm × 50 mm cylindrical test specimen to 104 µm for gravimetric analysis or 45 µm for instrumental analysis. The procedure for preparation of 50 mm × 50 mm cylindrical test specimen has been detailed in **7**. It should be ensured that the Bulk density (BD) of the selected specimen is within the specified ranges mutually agreed between the purchaser and the supplier. Specimen having bulk density in the specified range ensures that ramming mass/plastic formulation constituents are present in correct proportion. Such sample would be more representative in nature than random sample collection from various locations.

5.2 For alumino-silicate ramming mass/plastics, the chemical analysis shall be carried out in accordance with the procedure specified in IS 1527 and IS 12107 (Part 1). For basic material the procedure should be as per IS 1760 (Part 2) or IS 12667 (Part 1) depending on the constituents present in the product. For chrome containing products IS 12667 (Part 1), should be used as agreed between the purchaser and the supplier, instrumental analysis can also be carried out alternatively. However, in case of any dispute gravimetric analysis will be the referee method.

6 DETERMINATION OF PYROMETRIC CONE EQUIVALENT (PCE)

6.1 Preparation of Test Cones

A 50 mm diameter and 50 mm height cylinder should be prepared as per **7**. It should be ensured that the bulk density of the selected specimen is within the specified ranges mutually agreed between the purchaser and the supplier. Such cylinder would be treated as test sample. The test specimen (cone) preparation should be done as per IS 1528 (Part 1) using the aforementioned cylinder as test specimen.

6.2 Test Method

Pyrometric cone equivalent (PCE) test should be conducted in accordance with IS 1528 (Part 1) using the cones prepared as given in **6.1**.

7 PREPARATION OF TEST SPECIMENS FOR BULK DENSITY, MODULUS OF RUPTURE, COLD CRUSHING STRENGTH AND PERMANENT LINEAR CHANGE

Where the ramming mix is supplied in ready for use condition, the test specimens are prepared from as received material. In case, addition of binder prior to installation is recommended by the manufacturer, then the proposed binder in the recommended proportion should be added for the test sample preparation.

7.1 Apparatus

The apparatus required for making of test specimens are as under:

a) Sand rammer;
b) Moulds;
c) Balance — Laboratory balance, 10 kg capacity with ± 0.1 g accuracy;
d) Callipers;
e) Trowel — Pointing type or stiff-bladed spatula with a typical size of 150 mm length and 40 mm width;
f) Drying oven; and
g) Furnace.

7.2 Procedure for Dry Ramming Mass

7.2.1 The selected containers/bags shall be emptied on a suitable dry surface and the material should be thoroughly mixed. The mixed mass should subsequently be reduced to 50 kg by coning and quartering. This final sample shall be divided equally into five test samples by successive coning and quartering.

7.2.2 Where the ramming mix is supplied dry, mix the dry material for 30 s, and add the liquid for mixing evenly in the next 20 s. Continue for mixing between 2 min and 6 min till the time ramming consistency is attained. The amount of liquid to be added to dry ramming mixes should be specified by the manufacturer, who also may recommend a mixing time. If necessary, switch the mixer off after 1 min mixing time in order to scrape off the adhering material at the edges of the mixer. Report the liquid addition and mixing time.

7.3 Procedure for Plastic and Wet Ramming Mass

Selected containers/bags/batches should be discharged on dry floor. In case of plastic refractories, numbers of bags to be collected, at random, should be as per the guideline provided in Table 1. For example, for a lot in the range of 10 metric tonnes to 50 metric tonnes, 2 bags should be collected. For wet ramming mass, the selected containers/bags should be emptied on a suitable dry surface so that it does not get contaminated and subsequently the material should be mixed with shovel or any other suitable implement. The requisite quantity of the material should be collected from different locations of the heap, as agreed between the purchaser and the supplier.

7.4 All the test specimens tested for various physical and chemical characteristics shall meet the corresponding requirements for acceptance of the lot.

7.5 Shaping of Test Specimens Using the Sand Rammer and Mould

Reduce the amount of the material for shaping with the riffle (quartering – coning) sampler. The batch size depends on the number of test pieces which are required to be prepared.

7.5.1 *Description of Sand Rammer and Mould*

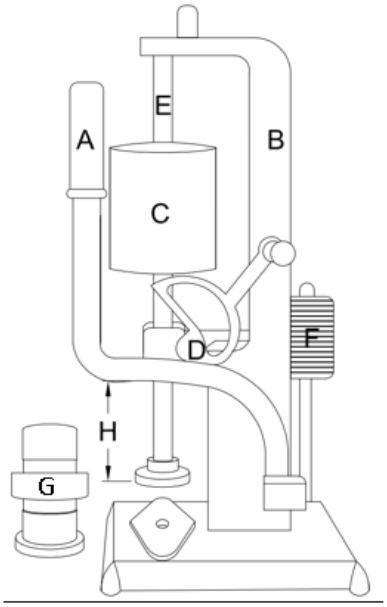
7.5.1.1 *Sand rammer*

The sand rammer has to be fitted with a 50 mm diameter stamp head, a 6.4 kg mobile weight and a 50 mm weight drop height (*see* Fig. 1). Before preparation, maintain the blocks at a temperature between 18 °C and 22 °C for 24 h, taking care that no loss in moisture occurs during that period.

In case of plastics delivered ready for use, the amount of the material for shaping shall be taken from blocks divided manually into pieces having maximum dimension of 25 mm. The material should be taken out from the interior section of the blocks. Compaction for test specimen preparation should be carried out immediately after dividing the blocks.

7.5.1.2 *Moulds*

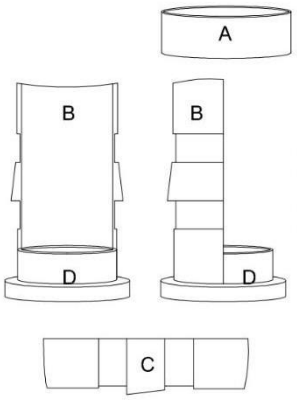
Mould design should be user friendly for the preparation of test specimen. Mould should be water tight and may be dismountable. A typical design of dismountable mould has been illustrated in Fig. 2. The illustrated mould design is for guidance only. The construction material for the mould should be such that it does not react with the material to be tested. If the aforementioned criteria are met by any other mould, the same should be acceptable. Typical dismountable mould components and its assembled form are illustrated in Fig. 2A and Fig. 2B, respectively. Where the ramming mix is supplied in ready for use condition, it is normally formed into test pieces as received. But some liquid may be added, if necessary. Plastic in any event is in ready to use form and thus, the specimens should be prepared from as received material.



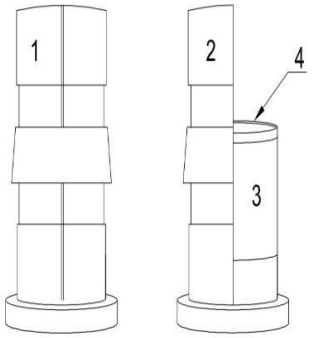
Key

A Weight lifting lever
B Sand rammer framework
C Sliding weight (6.4 kg)
D Cam handle
E Steel shaft
F Lubricated mould conditioner
G Mould

FIG. 1 ILLUSTRATION OF SAND RAMMER



2A MOULD PARTS



2B ASSEMBLED MOULD PARTS

Key

A Ring of assembly for the two half-shells B and C
B and C Half-shells
D Pedestal base
1 Mould (core box) assembeled
2 Mould partially open
3 Test piece
4 Disc of support

FIG. 2 DISMOUNTABLE MOULD

7.5.2 *Procedure for Test Piece Preparation*

7.5.2.1 The mould should be lubricated with grease or silicone spray.

7.5.2.2 The mould should be slowly filled with a spoon in order to avoid any segregation of the product.

7.5.2.3 Take a portion of the laboratory sample and measure its temperature. Clean and coat the inside of the mould with a light oil or similar lubricant for ease of de-moulding. Fill the specimen tube with sufficient quantity of sample to obtain an initial height of 50 mm ± 2 mm. Use the quantity given in the Table 2 as guideline. The exact material requirement may differ based on the other aspects/characteristics of the material under evaluation. Table 2 reports the material requirement for the preparation of test specimen of 50 mm × 50 mm cylinder.

7.5.2.4 Subject the material in the tube to 10 impacts with the rammer by turning the hand crank and allowing the weight to rise and fall freely on the sample thus compacting it. Turn the tube over, hand push the material to the other end and subject it to another 10 impacts with the rammer. Remove the specimen from the tube with the plunger. Measure the specimen height with callipers to ensure it is within 50 mm ± 2 mm. In case, the specimen dimension deviates from the requisite value, increase or decrease the material quantity, as the situation would demand, and repeat the procedure till the specimen dimension is within the specified range. Take the test specimen out after de-moulding. Fig. 3 illustrates the typical appearance of the test specimen and its dimensions.

7.5.2.5 Table 2 reports the material requirement for the preparation of test specimen of 50 mm × 50 mm cylinder. The Table 2 is for guidance purpose only.

8 MEASUREMENT OF WORKABILITY INDEX

8.1 Procedure

Suspend the weight on hangers. Place the specimen, prepared as per **4**, with spacer on the base of the sand rammer and centre it under the rammer shaft. Lower the shaft till the plunger is in contact with the specimen. Read the initial height of the specimen from the attached scale of the sand rammer. Remove the weight from hangers and gently lower it till at rest. Do not drop the weight. Subject the specimen to 3 impacts with the rammer by turning the hand crank. Suspend the weight on hangers again. Read the final height of the specimen from the attached scale.

8.2 Calculation

Calculate the workability index using the below formula:

$$Workablity\ Index = \frac{(Initial\ height\ in\ mm) - (Final\ height\ in\ mm)}{(Initial\ height\ in\ mm)} \times 100$$

9 FIRING OF TEST SPECIMENS

The test specimens should be fired in electrically heated furnace at the requisite test temperatures, which is as per the agreement between the refractory the purchaser and the supplier. The test specimens should be placed in the furnace on their circular surface. For carbon containing products the specimens should be heat treated in such a way that carbonaceous constituents of the product does not get oxidised. Usually, such heat treatment is carried out in a silicon carbide or mullite box containing metallurgical coke approximately 0.2 mm to 1.6 mm by leaving a space of 20 mm between the test pieces, the lid and the bottom of the box then shut off with a lid sealed with a jointing material. Typical heating schedule for the heat treatment of the test specimens are as under:

a) Heat the furnace at the rate of 100 °C/h till to reach the required test temperature;

b) Maintain the temperature for a soak period of 6 h. Maintain the temperature inside the box within ± 10 °C around the test temperature for the specified period and then switch off the furnace and cool naturally inside the furnace. From 500 °C, the door can be progressively opened in order to cool quickly; and

c) After natural cooling inside the furnace, remove the test pieces then clean them of the coke fixed on the surface and keep them in a desiccator till the characterization.

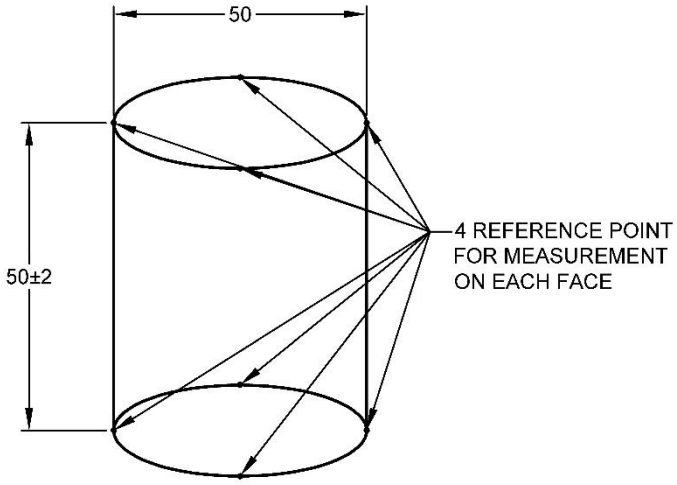
10 DETERMINATION OF BULK DENSITY

10.1 Test Specimen

Test specimens are cylinders of 50 mm diameter and 50 mm height, prepared as per the procedure described in **7**. The test specimen should be dried at 110 °C for 24 h to ensure that all physically held water of the specimen has been driven out.

10.2 Geometric Measurement

Determine the mean height of each test piece from three measurements with different angles. An example of the angles at which the specimen height could be measured is illustrated in Fig. 4.



All dimension in millimetres.

FIG. 3 50 mm × 50 mm CYLINDRICAL TEST SPECIMEN

Table 2 Material Requirement for Different Densities

(*Clauses* 7.5.2.3 *and* 7.5.2.5)

Sl No.	Shape	Dimensions	Volume cm^3	Weight in Grams of the Test Piece According to the Bulk Density g/cm^3					
				2.20	2.30	2.40	2.50	2.60	2.70
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
i)	Cylinder	50 mm × 50 mm	98.175	216	226	236	246	256	265

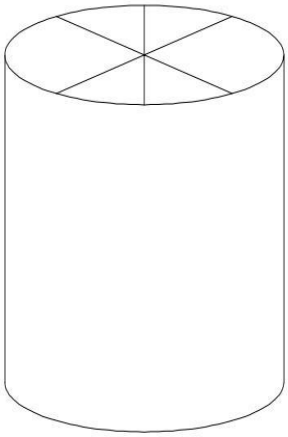


FIG. 4 TEST SPECIMEN HEIGHTS MEASURED AT THREE DIFFERENT ANGLES

10.3 Test Method

Plastics and ramming masses do not develop adequate strength till they are fired to high temperature. Hence, it is recommended that the bulk density is measured as per IS 1528 (Part 12), that is measurement of test specimen dimensions.

Bulk density of the test specimens, with adequate strength, can be measured as per IS 1528 (Part 15) provided the specimens do not disintegrate when in contact with water. The volume of the test specimen should be calculated based on the measurement of the exact dimensions of the test cylinder. The weight of the test specimen should be measured with an accuracy of 0.1 g.

10.4 Calculation

Calculate the bulk density (BD) using the following formula:

$$BD = \frac{W}{V}$$

where

BD = bulk density, in g/cm^3;

W = weight of the cylinder; and

V = calculated volume of the cylinder, in cm^3.

11 DETERMINATION OF APPARENT POROSITY

11.1 Test Specimen

Test specimens for the porosity measurement are cylinders of 50 mm diameter and 50 mm height prepared as per the procedure described in **7**.

11.2 Test Method

Since the ramming masses, in general, are quite friable till they are heated up to form permanent chemical or ceramic bond, apparent porosities are measurable only for specimens which have developed adequate strength and do not disintegrate while in contact with water or kerosene. Based on the aforementioned facts, the preheat temperatures for porosity measurement should be as per the agreement between the purchaser and the supplier. Apparent porosity shall be determined according to IS 1528 (Part 15).

12 DETERMINATION OF COLD CRUSHING STRENGTH

12.1 Test Specimen

50 mm × 50 mm test cylindrical specimen, prepared as per the procedure described in **7** shall be used for determining the CCS. Two tungsten carbide or a steel plates should be placed on each of the circular surface of the test specimen. These plates shall be at least 10 mm thick and 52 mm ± 2 mm in diameter. Their surfaces shall be plane to within 0.02 mm. During the test the two test plates are placed in such a way that the upper plate is maintained vertically above the lower plate with the sample sandwiched between the two.

12.2 Test Method

Cold crushing strength test shall be determined according to IS 1528 (Part 4). The load shall be applied uniformly. The individual results of minimum four test specimens and their average should be reported. The average result should be the one used for quality conformity of the product.

13 DETERMINATION OF PERMANENT LINEAR CHANGE (PLC)

13.1 Test Specimen

Cylindrical test specimen of 50 mm diameter and

50 mm height, prepared as per the procedure described in **7** is used for PLC measurement.

13.2 Test Method

The test specimens are cured and dried at 110 °C. Dried test specimen is marked at 4 locations on each circular surface. An example of the makings where the distances could be measured is illustrated in Fig. 4. The minimum distances between the markings along the specimen height are measured. The specimens are heat treated as per the process defined in **9**. The specimens are held at the final test temperature for the duration agreed between the purchaser and the supplier or as per the parameters defined in the product data sheet. After cooling the fired prisms to room temperature, the distance between at least 3 markings made prior to the firing of specimens, shall be measured. The shrinkage or expansion shall be calculated and reported in percentage with respect to the original dimensions. The individual values of linear change of two test specimens for each temperature should be reported as per IS 1528 (Part 6). The average of the measured values shall be used for conformity to specification.

14 DETERMINATION OF THERMAL CONDUCTIVITY

14.1 Test Specimens

The specimens prepared for the measurement should be pre-fired at 1 000 ºC to ensure that the specimen is devoid of any chemically bonded or physically held water or any other volatile constituents. Test specimen should be prepared so that it meets the requirement of the thermal conductivity method selected for the measurement. The test specimen should be prepared by tamping and it should be ensured that the bulk density of the specimen prepared is within ± 2 percent of that obtained as per **10**.

14.2 Test Method

The thermal conductivity test shall be determined as per IS 17107.

15 DETERMINATION OF HOT MODULUS OF RUPTURE (HMOR)

15.1 Test Specimens

HMOR measurement should be done with a specimen (25 ± 1) mm × (25 ± 1) mm and a length of approximately 150 mm. The length of the test specimen should be such that it fits in the furnace without any hindrance and is appropriately supported for 3 point bending measurement. The test specimen should be prepared by using the mould illustrated in Fig. 5. The test specimen should be prepared by tamping of the ramming mass in the mould by a suitably designed piece of wood or steel. While tamping it should be ensured that the test specimen is without any lamination. Lamination can be avoided by filling the mould in stages, filled mass be tamped and the tamped surface should be scratched with a knife. Subsequently further material should be added in the mould and the process of compaction should be repeated. The density of the test specimen should be as per the specification provided by the manufacturer and thus, the tamping should be done accordingly.

The test specimen, thus, prepared be cured as per the guidelines provided by the ramming mass supplier and fired to the 1 400 ºC or at a temperature agreed between the purchaser and the refractory supplier.

15.2 Test Method

The measurement of HMOR should be done, using the test specimen prepared as described in **15.1**, as per the procedure defined in IS 1528 (Part 20).

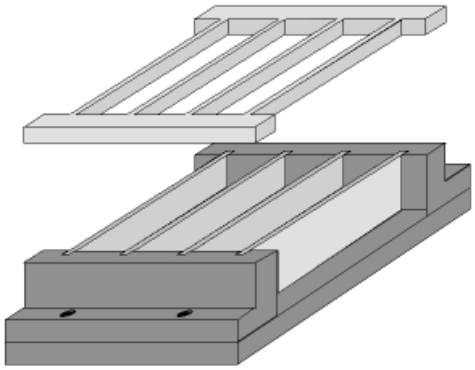


FIG. 5 MOULD WITH OVERFILL RING FOR HMOR TEST SPECIMEN PREPARATION

ANNEX A

(*Clause* 2)

LIST OF REFFERED STANDARDS

IS No.	*Title*
IS 1527 : 1972	Methods for chemical analysis of high silica refractory materials (*first revision*)
IS 1528	Methods of sampling and physical tests for refractory materials:
(Part 1) : 2010	Determination of pyrometric cone equivalent (PCE) or softening point (*third revision*)
(Part 4) : 2012	Determination of cold crushing strength of dense shaped refractories products (*second revision*)
(Part 6) : 2010	Determination of permanent linear change after reheating for shaped insulating and dense refractories (*second revision*)
(Part 12) : 2007/ ISO 5016 : 1997	Method for determination of bulk density and true porosity of shaped insulating refractory product (*second revision*)
(Part 15) : 2020/ ISO 5017 : 2013	Method for determination of bulk density, apparent porosity and true porosity of dense shaped refractory products (*second revision*)
(Part 20) : 1993/ ISO 5013 : 1985	Determination of modulus of rupture at elevated temperature
IS 1760 (Part 2) : 1991	Chemical analysis of limestone, dolomite and allied materials: Part 2 Determination of silica (*first revision*)
IS 4041 : 2006/ ISO 836 : 2001	Terminology of refractories (*first revision*)
IS 12107 (Part 1) : 1987	Methods of chemical analysis of alumino silicate refractory materials: Part 1 Determination of loss on ignition
IS 12667 (Part 1) : 1989	Chromite sand for foundries — Methods of chemical analysis: Part 1 Determination of silica
IS 17107 : 2019	Method for determination of thermal conductivity of dense as well as insulating fired refractories, refractory monolithics and precast prefired (PCPF) shapes

ANNEX B

(*Foreword*)

COMMITTEE COMPOSITION

Refractories Sectional Committee, MTD 15

Organization	*Representative(s)*
SKG Refractories Ltd, Kolkata	SHRI ARUP KUMAR CHATTOPADHYAY **(*Chairperson*)**
Calderys India Refractories Limited, Nagpur	DR I. N. CHAKRABORTY SHRI SANTANU BASAK (*Alternate* I) DR SAUMEN SINHA (*Alternate* II)
CSIR - Central Glass and Ceramic Research Institute, Kolkata	DR H. S. TRIPATHI
Dalmia Institute of Science & Industrial Research, Sundargarh	DR PREMA RANJAN RAUTA SHRI SUDHIR KUMAR PANDA (*Alternate*)
Engineers India Limited, New Delhi	SHRI PRASENJIT SAHA SHRI BISWARUP SARKAR (*Alternate* I) SHRI PRASENJIT PAL (*Alternate* II)
Hindalco Industries Limited, New Delhi	DR NAGESWAR KAPURI SHRI P. SARAVANAN (*Alternate*)
IFGL Refractories Limited, Kalunga	SHRI S. D. MAJUMDAR SHRI SAJAHAN MANDAL (*Alternate*)
Indian Refractory Makers Association, Kolkata	DR ARUP GHOSH SHRI ANIRBANDIP DASGUPTA (*Alternate*)
Mahakoshal Refractories Private Limited, Katni	DR SUKUMAR ADAK SHRI SHYAMALENDU KABIRAJ (*Alternate*)
Maithan Ceramic Limited, Chirkunda	SHRI S. N. SU SHRI J. N. CHAKRABORTY (*Alternate*)
MECON Limited, Ranchi	SHRI S. BANERJEE SHRI B. BERA (*Alternate*)
M N Dastur and Company Private Limited, Kolkata	SHRI SAURAV GHOSAL SHRI ARINDAM CHAKRABORTY (*Alternate*)
National Aluminium Company Limited, Bhubaneswar	SHRI PRANAB KUMAR DAS SHRI SATYAKAM NAYAK (*Alternate*)
National Council for Cement and Building Materials, Faridabad	DR S. K. CHATURVEDI SHRI GIASUDDIN AHAMED (*Alternate*)
OCL India Limited, Rajgangpur	DR J. K. SAHU DR A. K. PATNAIK (*Alternate*)

Organization	*Representative(s)*
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SKG Refractories Ltd, Kolkata	SHRI GAUTAM CHOWDHURY SHRI ABHISHEK SARKAR (*Alternate*)
Steel Authority of India Limited (SAIL), Bhilai Steel Plant, Bhilai	SHRI SANDEEP SRIVASTAVA MS D. SATYA DEVI (*Alternate*)
Steel Authority of India (SAIL), Centre for Engineering and Technology (CET), Ranchi	SHRI SURENDRA PRASAD SHRI AISHWARYA DEWANGAN (*Alternate*)
Steel Authority of India Limited (SAIL), Research & Development Centre for Iron & Steel (RDCIS), Ranchi	SHRI M. K. KUJUR SHRIMATI A. BHATTACHARYA (*Alternate*)
Tata Steel Limited, Jamshedpur	SHRI BAJENDRA SHRI GOUTHAM GHOSH (*Alternate* I) SHRI PRASANTA PANIGRAHI (*Alternate* II)
TRL Krosaki Refractories Limited, Jharsuguda	SHRI ARUP KUMAR SAMANTA SHRI S. K. SUBUDHI (*Alternate*)
In Personal Capacity (*Flat 1 A, Himkunj Cooperative Society, Block 1st Number – 167 B. P. Township, Kolkata*)	DR BARUN DEB MUKHERJEE
In Personal Capacity (*Plot No BC 224, Sector-1, Salt Lake, Kolkata*)	SHRI K. K. PAUL
BIS Directorate General	SHRI SANJIV MAINI, SCIENTIST 'F'/SENIOR DIRECTOR AND HEAD (METALLURGICAL ENGINEERING) [REPRESENTING DIRECTOR GENERAL (*Ex-officio*)]

Member Secretary
SHRI SAAQIB RAAHI
SCIENTIST 'B'/ASSISTANT DIRECTOR
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