DRAFT TANZANIA STANDARD

Specification for Bottom-Pouring Refractories Steel Plants

TANZANIA BUREAU OF STANDARDS

1st Edition

0 National Foreword

The Tanzania Bureau of standards is the statutory national standards body for Tanzania, established under the act.No.3 of 1975, amended by act.No.2 of 2009.

This draft Tanzania Standard is being prepared by BCDC 2 Masonry Technical Committee under the supervision of the Building and Construction Divisional Standards committee (BCDC).

In the preparation of this draft Tanzania Standard, reference was made to ***IS 1523:1972 (reaffirmed 2002) Specification for bottom-pouring refractories for steel plants, published by Bureau of Indian Standard.***

1 Scope

This draft Tanzania Standard covers the requirements and test methods for bottom-pouring refractories for steel plants.

2 Supply of materials

General requirements relating to the supply of the refractories shall be laid down in IS 1387:1967+.

The refractories shall be compact, of homogeneous texture and free from cracks, voids and other flaws. They shall be burnt evenly throughout and shall have sufficient mechanical strength and no soft corners

NOTE: +General requirements for the supply of metallurgical materials

3 Tolerance on size

3.1 Variations from specified dimensions, covering both warpage and shrinkage, shall be allowed as follows:

Runner bricks	± 2 percent or ± 2mm whichever is greater
All other bricks	± percent or ± 1mm whichever is greater

3.1.1 In the case of runner bricks, plus and minus tolerances may also be specified if required by the purchaser, but the total tolerance shall not exceed 2 percent or 2 mm whichever is greater.

4 Chemical composition

The alumina content of the refractories, when determined in accordance with IS 1335:1959*, shall be not less than 30 percent.

5 Physical requirements

The refractories shall conform to the requirements given in Table 1.

Table 1-Physical requirements of bottom-pouring refractories for steel plants

Sl No.	Characteristics	Requirement	Test methods.
(i)	Pyrometric cone equivalent, Standard Pyrometric Cone (ASTM) No.28 Min	30	ANNEX A
(ii)	Apparent porosity, percent, Max	25	ANNEX B
(iii)	Permanent linear change after reheating for 5 hours at 350°C, percent, Max	±1	ANNEX C
*Methods of sampling and physical tests for refractory materials *Methods for the director determination of **Alumna in Refractory Materials (Tentave)**			

6 Marking

6.1 The refractory bricks and shapes shall be clearly marked with the manufacturer's name or trade-mark.

6.2 The bricks and shapes may also be marked with the TBS Certification mark.

7 Sampling

7.1 Representative samples shall be drawn according to the scheme of sampling given in IS 1528:1962*

*Methods of sampling and physical tests for refractory materials.

Annex A

(Informative)

DETERMINATION OF PYROMETRIC CONE EQUIVALENT (PCE) OR SOFTENING POINT

A.1 Object of Test
The object of this test is to determine the softening point of refractory materials by comparing the test cones prepared from the refractory material under test with standard pyrometric cones.

A.2 Heating Furnace
A furnace of the type in which a neutral or oxidizing atmosphere may be maintained shall be preferred.

A.3 Preparation of Samples

A.3.1 Raw Materials
Test pieces prepared from raw materials that are subject to considerable modification during reheating shall then be stabilized by heating before their refractoriness is determined. In particular, clays should be calcined at approximately 1000ºC; after calcination, the test pieces shall comply with the requirements of A.4.2.

A.3.2 Fired Shapes
Take 1 kg of the material. In the case of bricks or shapes, obtain a composite sample from bricks or portions of a number of test pieces taken for other tests, and reduce these fragments in size by means of rolls or jaw crusher adjusted to pass lumps no greater than 5 mm in diameter; take precautions to prevent contamination of the sample with steel particles during crushing or grinding. Reduce the quantity through quartering by different stages of grinding to about 50 g as test sample. Grind the full quantity of the material to pass through 212 microns IS Sieve by suitable grinder or agate mortar. Magnet should be used to separate the iron particles introduced during grinding and crushing operations except in the case of materials, which are themselves magnetic. In order to avoid excessive reduction of the fines, remove them frequently during the process of reduction by throwing the sample on the sieve and continue grinding of coarser particles until all the sample passes through the sieve. Subsequently make specimen as specified in A.4.1.

A.3.3 For Dry Monolithic Materials
Samples of unshaped materials, such as, plastic refractories, ramming materials and refractory cement shall be shaped and fired in a manner appropriate to the material and its condition of use; the firing temperature shall be stated in the test report.

A.3.4 For Mortar make specimen as per dry monolithic materials and add the liquid component, if any, in appropriate proportion. Subsequently make specimen as specified in A.4.1.

NOTE — At all states, crushing and grinding should be carried out so as to avoid the introduction of extraneous material. At all stages, mixing should be carefully carried out so that the contents of the test pieces are truly representative of the samples.

A.4 Preparation of Test Cone

A.4.1 Moulding
Mix thoroughly the sample prepared under A.3.2 and after adding sufficient alkali free dextrin or glue and water, form into test cones in a metal mould, preferably of brass, in the shape of tetrahedron measuring 8 mm on the sides of the base, and 25 mm high (*see* Figure 1).

A.4.2 Sintering
When dry, subject the test cones, if necessary, to a preliminary burn at a temperature not exceeding 1000°C for the purpose of sintering them into a firm condition to permit handling.

A.5 Procedure

A.5.1 Mount the test cones and the standard pyrometric cones, the feature of typical standard cones used are reported in Table 1, on a plaque with the help of bonding material. Both the plaque and the bonding material should be of such composition, which will not affect the fusibility of the cones.

A.5.2 Mount the cones with the base embedded approximately 3 mm deep in the plaque, and one of the faces inclined towards the centre of plaque and at an angle of 82° with the horizontal. Arrange the test cones around the outer edge of the plaque with standard cones in between them in the anticipated range, as far as practicable (see Figure 2).

A.5.3 Place the test plaque with the test pieces and the pyrometric reference cones attached to it in the uniform temperature zone of the furnace. Avoid reducing conditions in the furnace during heating. Take care that the flame does not strike directly against the cones or the cone plaque. Check the furnace at intervals for uniformity of distribution of heat.

A.5.4 Over a period of 1.5 to 2 h, raise the temperature of the furnace to 200°C below the estimated refractoriness temperature of the test material.

A.5.5 Raise the temperature at the rate of 2.5°C/min or at the rate specified by the manufacturer of the cones. Maintain the heating so that at any moment the deviation from the specified temperature rise curve is less than 10°C.

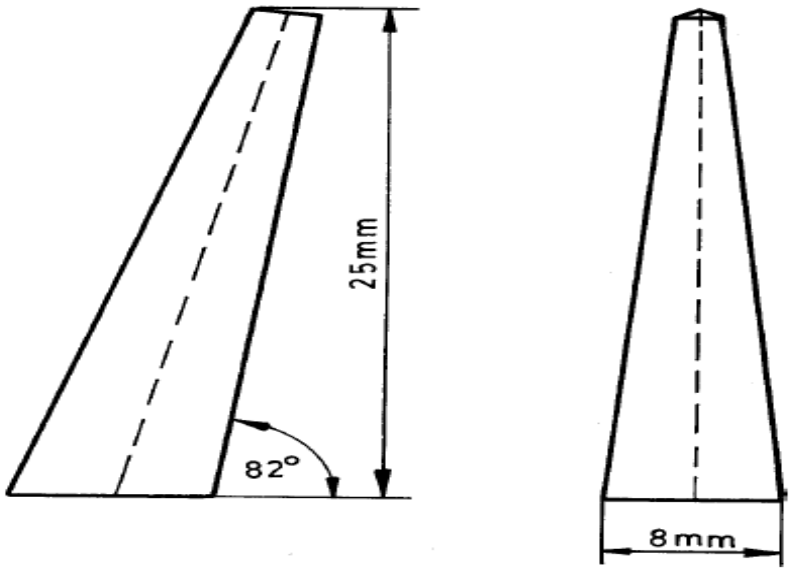


Figure 1-Standard Pyrometric Test Cone

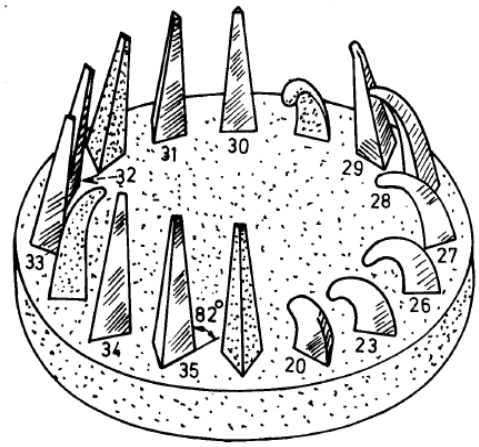


Figure 2-Method of Mounting Test Cone and Appearance After Testing.

A.6 Softening Point
Softening of the cone will be indicated by the top bending over and the tip of the cone touching the plaque surface.

A.7 Standard Cone Data

The standard pyrometric cone equivalents of standard cones are given in Table 1.

A.8 Report of Results

A.8.1 Report the softening point in terms of the standard pyrometric cone, it being that cone which most nearly corresponds in time of softening with the test cone.

A.8.2 If the test cone softens later than one cone but earlier than the next cone and approximately midway between, report the softening point, for example, Cone Number 31-32.

A.8.3 If the test cone starts bending at an early cone but it is not down until a later cone, report the fact.

Table 1 Reference Temperature and Cone Designations

Sl No.	Cone Designation	Temperature ^{O}C
i).	ISO 150	1 500
ii).	ISO 152	1 520
iii).	ISO154	1 540
iv).	ISO 156	1 560
v).	ISO 158	1 580
vi).	ISO 160	1 600
vii).	ISO 162	1 620
viii).	ISO 164	1 640
ix).	ISO 166	1 660
x).	ISO 168	1 680
xi).	ISO 170	1 700
xii).	ISO 172	1 720
xiii).	ISO 174	1 740
xiv).	ISO 176	1 760
xv).	ISO 178	1 780
xvi).	ISO 180	1 800

NOTES
1 The end point temperatures reported in the table have been obtained from the respective manufacturers' catalogue.
2 Any standard cone is acceptable.

ANNEX B

(Informative)

METHOD FOR DETERMINATION OF APPARENT POROSITY

B.1 Principle

B.1.2 The following are determined by weighing:

- The mass of a dry test piece;
- Its apparent mass when immersed in a liquid with which it has been impregnated under vacuum
- Its mass in air while still soaked with the liquid,

B.1.3 the precision of the results does not require any correction to be made for the fact weighing are carried out in air, not in a vacuum.

B.2 Apparatus and materials

B.2.1 Drying oven, capable of being controlled at 110 ^{O}C ± 5 ^{O}C.

NOTE. A fan-assisted oven with ventilation would assist in attaining an even temperature distribution and efficient drying of the test pieces.

B.2.2 Balance, with an accuracy of ±0.01g that can be arranged so that test pieces can be suspended in the immersion liquid (see figure 1)

B.2.3 Beakers, of a suitable size for containing the samples during soaking (see 7.2) and when determining the apparent immersed mass (see 7.3).

B.2.4 Evacuating equipment, capable of reducing the absolute pressure to a value not greater than 2500Pa (0.025 bar) and a means of measuring the pressure used (see Figure 3).

B.2.5 Thermometer, accurate to ±1 ^{O}C

B.2.6 Immersion liquid: For materials that do not react with water, the immersion liquid may be cold distilled water. For materials that are sensitive to contact with water, a suitable organic liquid shall be used. The immersion liquid shall not fractionate at a pressure above the absolute pressure attained in the test.

NOTE. Distilled may be used for hydratable materials.

B.2.7 Desiccator

B.3 Number and shape of test pieces.

B.3.1 The number of items (for example, bricks, shapes, nozzles) to be tested shall be determined by agreement between the interested parties.

B.3.2 The number of test pieces to be tested per item shall be agreed between the parties; it shall be stated in the test report. If the test pieces are cut out of bricks or blocks, the same number shall be cut from each one, in order to facilitate statistical analysis.

B.3.3 Test pieces shall be cutting the form of prisms or cylinders, the bulk volume of a test piece shall be not less than 50cm^3, and shall be not more than 200cm^3. The ratio of the longest to the shortest dimension of a test piece shall not exceed 2:1.

NOTES

1. Where it is not possible to obtain the given size and volume from the item, test piece so for the other dimensions and volume may be used by agreement between parties, and are to be reported.
2. If test pieces are to be cut from an item in which variations in density could occur, the position of the test pieces should be agreed between parties and stated in the report.

B.3.4 Any test piece showing cracks shall be eliminated, since these might falsify the determination of the bulk volume.

B.4 Procedure

B.4.1 Determination of mass of dry test piece (m_1), See figure 2.

Dry the test piece at 11O°C ± 15 ^{O}C to constant mass, i.e., until two successive weighing made before and after at least 2h in the oven (B.4.1) do not differ by more than 0.1%. Before each weighing, place the test piece in a desiccator (B.4.7) until it has cooled to room temperature. Weigh each test piece to the nearest 0.01g. The mass determined is the mass of the dry test piece (m_1).

B.4.2 Soaking of test piece

Carry out a check test to ensure that the apparatus will hold a vacuum. Place the cooled and dried test piece in an air-tight vessel. After sealing the vessel, evacuate it until a pressure of not more than 2500Pa is attained; maintain this vacuum for at least 15min. In order to ensure that all the air has been removed from the open pores, isolate or disconnect the vessel from the vacuum pump and check that pressure does not rise through any de-gassing of the test piece. Re-connect the vessel to the vacuum pump and progressively introduce the immersion liquid (B.2.6) so that, after 3 min, the test piece is covered by about 20 mm of liquid. Maintain this reduced pressure for 30 min, then switch off the pump and open the vessel. Wait a further 30 min to ensure that the liquid penetrates into all the open pores. The test piece or test pieces shall remain covered by the immersion liquid throughout the impregnation and until removed for subsequent weighing (see B.2.3 and B.2.4).

NOTE. Certain fine porosity materials such as refractories containing carbon and some clay products may require longer periods of evacuation and soaking. If a different soaking time is used this time should be stated in the report.

B.4.3 Determination of apparent mass of immersed test piece (m_2), See Figure 4.

Suspend the test piece by a thin thread from the load-pan suspension point of a balance (5.2) and weight while completely immersed in a quantity of the immersion liquid, contained in a beaker (5.3) standing on the bridge, if used. In this way, the apparent mass of the immersed test piece is obtained (m_2). The weighing shall be made to the nearest 0.01g Determine the temperature of the immersion liquid to an accuracy of ±1 ^{O}C.

B.4.4 Determination of mass of soaked test piece (m_3).

Remove the test piece from the liquid and immediately sponge it quickly and carefully with a damp sponge or cloth to remove droplets and the surface film of liquid. Be sure not to draw liquid out of any of the pores.

NOTE. Consistent results have been obtained by keeping- for this purpose alone-linen cloth which, having been washed two or three times when new to remove the dressing, is immersed in the immersion liquid and lightly wrung out by hand before each use.

Immediately weigh the test piece in air to the nearest 0.01g. Take care to ensure that evaporation of the immersion liquid does not lead to any appreciable loss in mass during the weighing operation. In this way, the mass of the soaked test piece is obtained (m_3).

B.5 Expression of results.

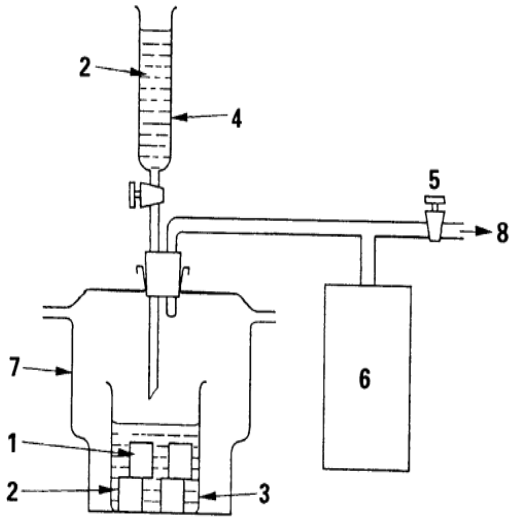
B.5.1 The apparent porosity π_a expressed as a percentage by volume, is given by equation.

$$\pi_a = \frac{M3-M1}{M3-M2} X\ 100$$

B.5.2 Test report

The test report shall include the following information:

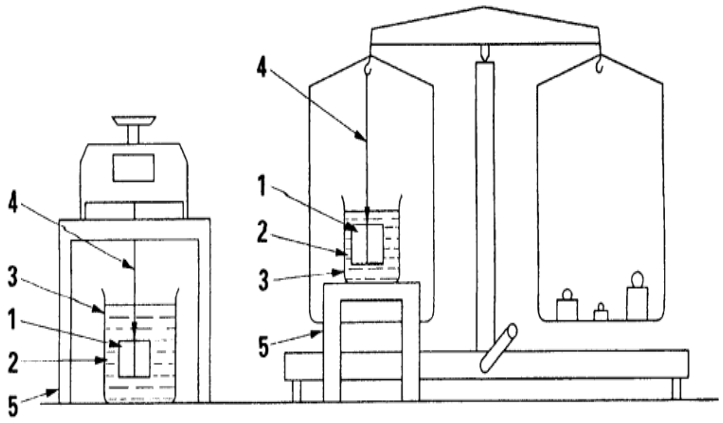
a) The name of testing establishment;
b) The date of the test;
c) The reference to this Tanzania Standard;
d) The description of the test material (manufacturer, type, batch number);
e) The number of items tested;
f) The number of test pieces per item and if relevant their position;
g) The pressure to which the vacuum chamber was reduced;
h) The immersion liquid used;
i) The individual value and the mean value of the apparent porosity for each item



Key

1 Test pieces
2 Immersion liquid
3 Beaker
4 Tap funnels
5 Pump isolation
6 Pump isolation valves
7 Pressure measuring device (e.g. manometer)
8 Desiccator Air outlet (to vacuum pump)

Figure 3 — Example of a vacuum system for soaking test pieces



Key
1 Test piece
2 Immersion liquid
3 Beaker
4 Suspension thread
5 Bridge

Figure 4 — Arrangement for the determination of apparent mass of immersed test piece using single- and double-pan balances

ANNEX C
(Informative)

Determination of Permanent Linear Change After Reheating

C.1 Principle

Test pieces prepared out of the bricks are dried. Initial dimension with respect to length in case of Insulating product and initial volume in case of dense shaped product are determined. The test pieces are heated in a furnace at a prescribed rate to a specified temperature, which is maintained for a specified time. After cooling to ambient temperature, test pieces are measured again for final length or final volume and permanent linear change is calculated. For dense shaped products, volume change before and after firing is divided by 3 to arrive at linear change.

C.2 Apparatus

C.2.1 Furnace — Either electric or gas fired, capable of firing the test pieces at the specified rate and of maintaining the test temperature for the required time. The furnace should be equipped with temperature controlling system which shall be able to comply the heating schedule mentioned in **C.8**.

NOTE — Use of electric furnace is recommended.

C.2.2 Thermocouple — Thermocouple(s) to measure the temperature.

C.2.3 Length Measuring Device — Vernier callipers or a dial gauge comparator with an accuracy of 0.1mm.

C.2.4 Drying Oven — Oven shall be fan assisted and shall have openings, which permit efficient ventilation

C.2.5 Drying Oven — Oven shall be fan assisted and shall have openings, which permit efficient ventilation.

C.3 Test Pieces

C.3.1 Size of Test Pieces

C.3.1 For Insulation Bricks 114 mm × 114 mm × 64 mm or 76 mm, that is, half of standard brick.

C.4 PROCEDURE

C.4.1 Dry the test specimen in a drying oven at 110 ± 5°C to constant mass.

C.4.2 Measurement of Test Pieces

C.4.3 For Insulating Refractory Shaped Product

Calibrated length measuring device shall be used for measurement of dimensions. Make measurements on each test piece to the nearest 0.2 mm of the distance *L*o between the opposite faces nominally 114 mm apart. Make two of these measurements parallel to the centrelines (EF and *GH* in Figure 5) of the top and bottom faces of the test pieces, 15 mm from the edges of those faces, and two parallel to the centrelines (*AB* and *CD*) of the front and rear faces of the test pieces 15 mm from the edges of those faces. Mark the position of the measurements with refractory paint.

C.5 Mounting of test pieces in the furnace.

C.5.1 Furnace

Place the test pieces in the furnace as given as follows:

For Insulation Bricks — Place each sample on a 114 mm × 76 mm or 114 mm × 64 mm face.
The samples shall be protected from direct radiation in an electrically heated furnace or from the flame of the gas burner in a gas fired furnace. Do not superimpose test pieces one on another. To allow free circulation of the hot gases, the test pieces shall be separated from each other by a distance of not less than 20 mm and shall be not nearer than 50 mm to the wall of the furnace to avoid direct heat impingement. The test pieces shall be placed in the furnace on bricks of 30 to 65 mm thick preferably of same quality.

C.6 Test Temperature

Unless otherwise agreed, the test temperature shall be 800°C or a higher temperature in multiples of 50°C.

C.7 Temperature Measurement

Thermocouple shall be placed away from the walls of the furnace, away from the heaters so as not to be in contact with any flames or direct heating from elements.

C.8 Heating

Raise the temperature in the furnace at one of the following rates:

a) For test temperatures up to 1 250°C:
   - From ambient temperature up to 50°C below the test temperature: between 5 to 10°C/min
   - For the last 50°C: between 1 to 5°C/min.

b) For test temperatures above 1 250°C:
   - From ambient temperature up to 1 200°C: between 5 to 10°C/min.
   - From 1 200°C up to 50°C below the test temperature: between 2 to 5°C/min.
   - For the last 50°C: between 1 to 5°C /min.

C.9 Cooling

Switch off the furnace after reaching and holding at the test temperature. Allow it to cool at its natural rate, the test pieces being allowed to cool in the furnace.

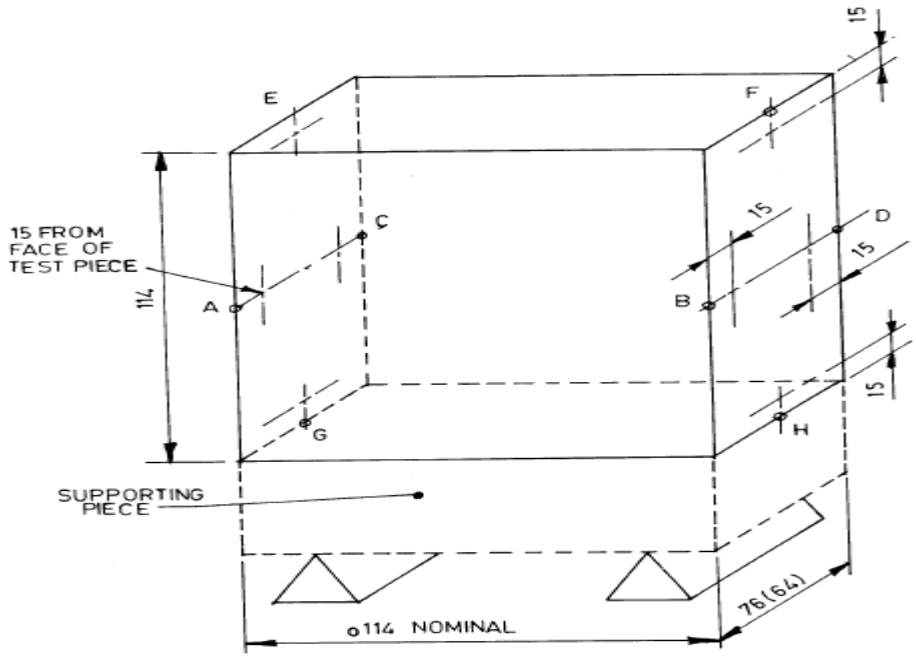


Figure 5- Position of Measurements and Mounting of the Test Pieces in The Furnace

C.10 Measurement of Test Pieces After Firing

First examine the test pieces, noting particularly any blisters or accretions produced during firing.

C.10.1 Linear Measurement for Insulating Brick Samples

Measure the distance between the two opposite faces of each test piece as described in **C.4.2.** If any of the measuring points might be affected by such a defect, measure at the nearest point unaffected. If necessary, rotate the test piece to avoid contact between defects.

C.10.2 Volume Measurement

The bulk volume V_b of the test piece is given, in cubic centimetres, by the equation.

$V_b = lbd$

where l, b and d are the length, breadth and thickness, respectively, in centimetres, of the test piece.

C.11 Expression of Results

For Insulation refractory quality, calculate the change in the relevant length, Δ*L* as a percentage of original value *L*o, that is, 100 × *L* / *L*o. Calculate the change in length for each measuring point. For dense shaped refractory sample, calculate the change in relevant volume, *V* as a percentage of original volume *V*o, that is, 100 × *V*/*V*o. Divide the percentage change in volume by 3 to arrive at the linear change. Report increases in length as positive (+) and decrease as negative (–).

C.12 Test Report

The test report shall include the following:

a). Description of the material tested,
b). Number of items tested,
c). Number of test pieces per item or brick,
d). Type of length measuring device used,

e). Type of furnace used,
f). The heating schedule used,
g). Test temperature,
h). Period of the actual holding time at test temperature, and
i). Appearance of test pieces after firing.

Bibliography

1 **IS 1528-1: 2010** Methods of sampling and physical tests for refractory materials-Part 1: Determination of pyrometric cone equivalent (PCE) or softening point (Third revision).

2 **IS 1528-15:2007/ISO 5017:1998** Methods of Sampling and Physical Tests for Refractory Materials-Part 15: Method for Determination of Bulk Density, Apparent Porosity and True Porosity of Dense Shaped Refractory Products (First revision).

3 **IS 1528-6:1974** Methods of sampling and physical tests for refractory materials-Part 6: Determination of permanent change after reheating (Second revision).