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Indian Standard

METHODS OF SAMPLING AND PHYSICAL TESTS FOR REFRACTORY MATERIALS

PART 4 DETERMINATION OF COLD CRUSHING STRENGTH OF DENSE SHAPED REFRACTORIES PRODUCTS

(Second Revision)

ICS 81.080
FOREWORD

This Indian Standard (Part 4) (Second 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 1962 and subsequently revised in 1974. This standard deals with the method of determination of cold crushing strength of dense shaped refractories products and the other parts in the series are:

- Part 1 Determination of pyrometric cone equivalent (PCE) or softening point
- Part 2 Determination of refactoriness under load
- Part 3 Determination of spalling resistance
- Part 5/ISO 5014 : 1986 Method for determination of modulus of rupture at ambient temperature of dense and insulating shaped refractory products
- Part 6 Determination of permanent change after reheating
- Part 7 Methods of sampling and criteria for conformity
- Part 8 Determination of apparent porosity
- Part 9 Determination of true density
- Part 10 Determination of size of refractory bricks
- Part 11 Determination of wrapage
- Part 12/ISO 5016 : 1997 Method for determination of bulk density and true porosity of shaped insulating refractory products
- Part 13/ISO 12676 : 2000 Determination of resistance to the disintegrating effect of carbon monoxide
- Part 14 Sieve analysis
- Part 15 Method for determination of bulk density, apparent porosity and true porosity of dense shaped refractory materials
- Part 16/ISO 8894-2 : 1990 Determination of thermal conductivity according to the hot wire method (parallel)
- Part 17/ISO 8895 : 1986 Determination of cold crushing strength of shaped insulating refractory products
- Part 18/ISO 3187 : 1989 Determination of creep in compression
- Part 19 Determination of thermal expansion
- Part 20/ISO 5103 : 1985 Determination of modulus of rupture at elevated temperature
- Part 21/ISO 8894-1 : 1987 Determination of thermal conductivity according to hot-wire method (cross-array)
- Part 22/ISO 8841 : 1991 Method for determination of permeability to gases of dense shaped refractory products

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (revised)’. 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

METHODS OF SAMPLING AND PHYSICAL TESTS
FOR REFRACTORY MATERIALS

PART 4 DETERMINATION OF COLD CRUSHING STRENGTH OF DENSE
SHAPED REFRACTORIES PRODUCTS

(Second Revision)

1 SCOPE

This standard (Part 4) prescribes a method for
determination of the cold compressive strength of
dense shaped refractory products.

2 REFERENCES

The following standards contain provisions, which
through reference 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 agreement based on this
standard are encouraged to investigate the possibility
of applying the most recent editions of the standards
indicated below:

<table>
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<th>IS No.</th>
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<tr>
<td>1528 (Part 7)</td>
<td>Methods of sampling and physical tests for refractory materials: Part 7</td>
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<tr>
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<td>Methods of sampling and criteria for conformity (first revision)</td>
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<tr>
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<td>Glossary of terms relating to refractory material (first revision)</td>
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3 TERMINOLOGY

For the purpose of this standard, the definitions given
in IS 4041 shall apply.

4 PRINCIPLE

A test piece of known dimensions is subjected, under
specified conditions, to a steadily increasing
compressive load until it fails, that is when it cannot
support a further increase in load. The cold compressive
strength is calculated from the maximum load indicated
at failure and the mean cross-sectional area over which
the load is applied.

5 APPARATUS

5.1 A mechanical or hydraulic compression testing
machine, fitted with a measuring device capable of
measuring the load exerted on the test piece to within
± 2 percent.

The machine shall be capable of increasing the stress
at a rate of 1.0 N/mm²/s, until the test piece is unable
to support the load.

The platens of machine shall,

a) have a Rockwell hardness value between
   58 HRC and 62 HRC; and
b) be ground plane to flatness tolerance of
   0.03 mm over the area to be in contact with
   the test piece.

The upper platen shall function on a seating that will
compensate for small deviations from parallelism
between the platen and test piece.

NOTE — The platens should be replaceable to allow
re-machining and should not be matted.

5.2 Vernier Caliper — Vernier caliper with an
accuracy of 0.1 mm shall be used.

5.3 Set Square

5.4 Drying Oven — Capable of being controlled at
110 ± 5°C. Oven shall be fan assisted and shall have
openings which permit efficient ventilation.

6 TEST SPECIMENS

6.1 A single test piece shall be taken from a standard
brick test item, or a test item equal to or less than
2 000 cm³ or two test pieces from shapes of a
significantly larger volume.

NOTE — The number of test items should be in accordance
with an agreed sampling plan. A minimum of five test piece is
recommended.

6.2 The size of test pieces shall be one of the following:

a) Cubes; depending on the thickness of the
   brick.

b) Cylinders; 50 ± 2 mm in height and
   50 ± 2 mm in diameter.

c) Standard brick (for example 230 mm ×
   114 mm × 76 mm or 230 mm × 114 mm × 64
   mm). In case of non availability of suitable
   machine half bricks can also be used.
d) For checker or similar shaped bricks the size of sample shall be agreed between the purchaser and the supplier.

NOTE — In case test piece size has not been specified, the sample size shall be in the order of (a) to (c) be selected.

6.3 Test pieces shall be cut or drilled from the test items. Test pieces containing cracks or visible defects on any of the surfaces shall be discarded and this shall be reported.

6.4 Both ends of the cylindrical test piece shall be made plane and parallel, grinding the surfaces where required. To ensure that the top and bottom ends of the test pieces are plane over their entire surface, each end shall in turn be pressed, with a load of 3 ± 1 kN, onto a levelling plate which is lined with carbon or blue paper and hard filter paper (0.15 mm in thickness). Test pieces that do not show two complete clearly visible coloured impressions shall be reground. See Fig. 1 to 4 for examples.

NOTE — A steel straight-edge may be used to assist in checking the surfaces. Mortar will not be used to plane the surfaces.

6.5 The parallelism of the test pieces shall be checked by four measurements of the height, at the extremities of two perpendicular diameters. The difference between any two of these measurements shall not exceed 0.2 mm.

6.6 The perpendicularity shall be checked by placing the test piece on a plane surface and using a set square, placed against the side of the test piece, at four positions corresponding to the height measurements. The gap between the side of the test piece and the set square shall not exceed 0.5 mm.

6.7 The prepared test pieces shall be carefully dried to constant mass by placing them in a drying oven at 110 ± 5°C. They are then cooled to room temperature and kept away from moisture until the start of the test.

7 PROCEDURE

7.1 Measurement of Cylinders

Measure two perpendicular diameters of each surface.

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![Fig. 1 Carbon or Blue Paper Replica: Good](image1)

1A Coarse Grained Brick Type  
1B Fine Grained Brick Type

![Fig. 2 Carbon or Blue Paper Replica: Still Admissible](image2)

2A Coarse Grained Brick Type  
2B Fine Grained Brick Type
to within 0.1 mm. From the arithmetic mean of these four measurements, calculate the initial cross-sectional area $A_0$.

### 7.2 Measurement of Cubes

Two measurements of each side to within 0.1 mm. From the arithmetic mean of these measurements, calculate the initial cross-sectional area $A_0$.

Place the test piece centrally between the platens of the machine with or without cellulose fibre board of thickness between 3 mm and 7 mm as per Fig. 5.

Select the load range so that the expected load at failure is greater than 10 percent of the load range.

Apply the load smoothly and continuously, increasing the stress at the rate of $1.0 \pm 0.1$ N/mm. Until the test piece fails, that is until it is unable to support the load. Record the maximum load indicated.

### 8 Calculation and Report

8.1 The cold crushing strength shall be reported as calculated from the following formula:

$$\text{Cold crushing strength} = \frac{W}{A_0}$$

where

- $W$ = total maximum load, in N; and
- $A_0$ = mean area, in mm$^2$.

8.2 The size of the test specimen and the direction of the load applied should be mentioned in the test report.

### 9 Sampling and Criteria for Conformity

The procedure for sampling and the criteria for conformity shall be as laid down in IS 1528 (Part 7).
FIG. 5 COMPRESSION TESTING MACHINE

Key
1 — Platen of testing machine
2 — Spherical seat
3 — Spherical bearing block
4 — Cellulose fibre board (optional)
5 — Centre of spherical surface
6 — Test specimen
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