H-33-03

Designation: C 93 – 84

AMERICAN SOCIETY FOR TESTING AND MATERIALS
1916 Race St., Philadelphia, Pa. 19103
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Standard Test Methods for COLD CRUSHING STRENGTH AND MODULUS OF RUPTURE OF INSULATING FIREBRICK[1]

This standard is issued under the fixed designation C 93; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 These test methods cover the determination of the cold crushing strength and modulus of rupture of insulating firebrick.

1.2 The test methods appear in the following order:

	Sections
Cold Crushing Strength	3 to 7
Modulus of Rupture	8 to 12

1.3 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Significance and Use

2.1 Measuring the modulus of rupture and crushing strength of refractories at room temperature has traditionally been a widely accepted means of evaluating insulating firebrick. Many users have specifications based on this type of test. The high porosity of insulating firebrick requires a test that differs from the procedure used for dense refractory brick. This test incorporates sample sizes and loading rates applicable to insulating firebrick.

COLD CRUSHING STRENGTH

3. Apparatus

3.1 *Testing Machine*—A standard mechanical or hydraulic compression testing machine (Note 1) with a sensitivity of at least 20 lbf (89 N) in the range from 0 to 15 000 lbf (67 kN) shall be used.

NOTE 1—The use of a hydraulic testing machine is recommended in preference to the mechanical type.

3.2 *Spherical Bearing Block*—The plane surface of the spherical bearing block (Fig. 1) shall have an area that will cover the 4½ by 4½-in. (114 by 114-mm) surface of the test specimen.

4. Test Specimens

4.1 The test specimens shall consist of ten pieces measuring approximately 4½ by 4½ by 2½ or 3 in. (114 by 114 by 64 or 76 mm) taken from ten different brick. It is permissible to use the half-brick resulting from the modulus of rupture test (Sections 8 to 12). The test surfaces of the specimens shall be approximately parallel planes.

5. Procedure

5.1 Apply the load to the 4½ by 4½-in. (114 by 114-mm) surface of the test specimen.

5.2 Use the bearing block on top of the test specimen and place it so that the center of the sphere is in alignment with the vertical axis of the specimen (Fig. 1). Keep the spherical bearing block thoroughly lubricated to ensure accurate adjustment, which may be made by hand under a small initial load.

5.3 Adjust the testing machine to apply the load at either of the following rates:

Hydraulic machine	7000 lbf (31 kN)/min ± 10 %
Mechanical machine	0.05 in. (1.3 mm)/min ± 10 %

[1] These test methods are under the jurisdiction of ASTM Committee C-8 on Refractories and are the direct responsibility of Subcommittee C08.01 on Strength.

Current edition approved April 27, 1984. Published November 1984. Originally published as C 93 – 33. Last previous edition C 93 – 83.

5.4 During the test, keep the beam of the mechanically actuated testing machine constantly in a floating position.

6. Calculation and Report

6.1 Calculate the cold crushing strength as follows:

$$S = P/A$$

where:

S = cold crushing strength, psi (or MPa),
P = total maximum load at 3 % deformation (Note 2) or at visible failure, whichever is smaller, lbf (or N), and
A = average of the gross areas of the two 4½ by 4½-in. (114 by 114-mm) faces of the specimen, in.^{2} (or mm^2).

NOTE 2—A dial-type micrometer is generally used for obtaining the necessary measurement for calculating the percentage of deformation.

6.2 The report shall state the average cold crushing strength of the ten specimens.

7. Precision and Bias

7.1 *Interlaboratory Test Data*—An interlaboratory test was run in 1980 by six laboratories testing ten specimens from five different classes of insulating firebrick (IFB). Samples were selected from ten boxes of each class manufactured by one source with each laboratory receiving one brick from each box. All 50 samples tested by a given laboratory were tested in a randomized order by a single operator on one testing machine during a single day. The components of variance for cold crushing strength results for each class were calculated as shown in Table 1.

7.2 *Precision (see Table 1)*—The standard test result consisting of 10 samples (n = 10) should be considered significantly different at a confidence level of 95 % if the repeatability or reproducibility, or both, exceed the precision data listed in Table 2.

7.3 *Bias*—No justifiable statement can be made on the bias of the test method for measuring cold crushing strength of insulating firebrick since the true value cannot be established by an accepted referee method.

MODULUS OF RUPTURE

8. Apparatus

8.1 *Testing Machine*—A standard mechanical or hydraulic compression testing machine (see Note 1) with a sensitivity of at least 20 lbf (89 N) in the range from 0 to 2000 lbf (8.90 kN) shall be used.

8.2 *Bearing Cylinders*—The bearing cylinders shall be rounded to a ⅝-in. (16-mm) radius or shall be cylindrical pieces 1¼ in. (32 mm) in diameter. They shall be straight and of a length at least equal to the width of the test specimen. The supporting members for the lower bearing cylinders shall be constructed so as to provide a means for the alignment of the cylinder with the under surface of the test specimen because the test brick may have a longitudinal twist. Apparatus of the design shown in Fig. 2 is recommended, although other types may be used, provided they conform to these requirements. A satisfactory alternative design is shown in Fig. 3.

9. Test Specimens

9.1 At least ten test specimens shall be used, and these shall each be a whole brick measuring 9 by 4½ by 2½ or 3 in. (228 by 114 by 64 or 76 mm), or specimens of equivalent size cut from larger shapes.

10. Procedure

10.1 Place a test specimen flat across the 4½-in. (114-mm) dimension on the bearing cylinders with a span of 7 in. (178 mm), and apply the load at mid-span.

10.2 Adjust the testing machine to apply the load at either of the following rates:

Hydraulic machine	1000 lbf (4.45 kN)/min ± 10 %
Mechanical machine	0.05 in. (1.3 mm)/min ± 10 %

11. Calculation and Report

11.1 Calculate the modulus of rupture as follows:

$$\text{MOR} = 3PL/2bd^2$$

where:

MOR = modulus of rupture, psi (or MPa),
P = concentrated load at rupture, lbf (or N),
L = span between supports, in. (or mm),
b = breadth or width of specimen, in. (or mm), and
d = depth of specimen, in. (or mm).

11.2 The report shall state the average modulus of rupture of the ten specimens.