Designation: C773 – 88 (Reapproved 2020)

Standard Test Method for Compressive (Crushing) Strength of Fired Whiteware Materials[1]

This standard is issued under the fixed designation C773; 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 This test method covers two test procedures (A and B) for the determination of the compressive strength of fired whiteware materials.

1.2 Procedure A is generally applicable to whiteware products of low- to moderately high-strength levels (up to 150 000 psi or 1030 MPa).

1.3 Procedure B is specifically devised for testing of high-strength ceramics (over 100 000 psi or 690 MPa).

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E4 Practices for Force Verification of Testing Machines

E6 Terminology Relating to Methods of Mechanical Testing

E165/E165M Practice for Liquid Penetrant Testing for General Industry

3. Significance and Use

3.1 Resistance to compression is the measure of the greatest strength of a ceramic material. Ideally, ceramics should be stressed this way in use. This test is a measure of the potential load-bearing usefulness of a ceramic.

PROCEDURE A

4. Apparatus

4.1 *Testing Machine*—Any testing machine conforming to Practices E4 and to the requirements for speed of testing prescribed in Sections 5 and 12 of this test method, may be used.

4.2 *Spherical Bearing Block*—In vertical testing machines, the spherical bearing block shall be spring suspended from the upper head of the machine in such a manner that the upper platen of the machine (lower face of the spherical bearing block) remains in a central position (spherical surfaces in full contact) when not loaded. The spherical surfaces shall be well lubricated, and the center of curvature shall lie on the lower face of the platen. The diagonal or diameter of the platen shall be only slightly greater than the diagonal of the 1½-in. (38.1 mm) square contact blocks to facilitate accurate centering of the specimens.

4.3 *Contact Blocks*—Cold-rolled steel contact blocks shall be used between the test specimen and the platens of the machine. These blocks shall be 1½ in. (38.1 mm) square by ⅝ to ¾ in. (15.9 to 19.1 mm) thick, and the contact faces shall be surface ground until plane and parallel. The contact blocks shall be resurfaced, if necessary, after each strength test, and may be reused only so long as the thickness remains over ½ in. (12.7 mm). If the contact block is cracked during testing, it shall be replaced.

4.4 *Cushion Pads*—Cushion pads shall be used between the test specimens and the contact blocks to aid in distributing the load. New cushion pads shall be used for each specimen. Suitable materials for cushion pads, selected in accordance with the compressive strength range of the material being tested, are shown in the following below:

Compressive Strength Range, psi (MPa)	Cushion Pad
5000 to 50 000 incl (34.5 to 345)	blotting paper, 1/64 in. (0.4 mm) thick
Over 50 000 to 150 000 incl (345 to 1030.0)	mild steel, 1/32 in. (0.8 mm) thick (65 HRB max)

[1] This test method is under the jurisdiction of ASTM Committee C21 on Ceramic Whitewares and Related Products and is the direct responsibility of Subcommittee C21.03 on Methods for Whitewares and Environmental Concerns.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

TABLE 1 Typical Loading Rates to Cause Failure in 1 min

NOTE 1—The loading rate of 16 000 lbf/min (70 kN/min) shall be used for the first three tests of an unknown material to determine the general strength classification group. Some specimens crack before ultimate failure; the load at which the first audible crack occurs shall be noted, but only the load on the specimen at ultimate failure shall be used for calculation of compressive strength.

Compressive Strength, psi (MPa)	Specimen Diameter, in. (mm)	Loading Rate, lbf/min (kN/min)
10 000 (69)	1.00 (25.4)	8000 (35)
50 000 (345)	0.64 (16.3)	16 000 (70)
150 000 (1034)	0.45 (11.5)	24 000 (105)

5. Procedure

5.1 Dye-check specimens in accordance with Practice E165/E165M before testing. Discard any pieces exhibiting cracks or flaws visible to the unaided eye.

5.2 Clean the test specimens with a suitable solvent after grinding and immerse in an ultrasonic bath filled with hot detergent solution. Then rinse specimens in hot water, dry at 110 ± 2 °C (230 ± 4 °F) for 2 h and cool to room temperature in a desiccator.

5.3 Carefully center the specimen in the machine between the contact blocks. Place an appropriate guard around the specimen to contain flying fragments at failure; eye protection should be used by the operator.

5.4 Apply the load continuously and without impact shock until ultimate failure. The rate of loading to be used shall depend on the compressive strength of the material being tested, as shown in Table 1.

6. Calculation

6.1 Calculate the compressive strength of each specimen as follows:

$$C = P/A \tag{1}$$

where:

C = compressive strength of the specimen, psi or MPa,
P = total load on the specimen at failure, lbf or N, and
A = calculated area of the bearing surface of the specimen, in.^{2} or mm^2.

7. Report

7.1 Report the following information:

7.1.1 The procedure used,

7.1.2 Type of testing machine (hydraulic or screw),

7.1.3 Material and size of contact blocks or of cushioning materials,

7.1.4 Description of material being tested (Note 1),

7.1.5 Rate of loading,

7.1.6 Number of specimens tested,

7.1.7 Dimensions and load at failure of each specimen, and

7.1.8 Compressive strength of each specimen tested, rounded off to the nearest 100 psi (1.0 MPa), together with the average compressive strength of the sample tested and the standard deviation.

NOTE 1—It is desirable to include details of the origin of the specimen and subsequent treatment.

8. Precision and Bias

8.1 *Interlaboratory Test Data*—An interlaboratory test was run in 1979 in which randomly drawn samples of six materials were tested in each of five laboratories. One operator in each laboratory tested ten specimens of each material. The components of variance for compressive strength results expressed as coefficients of variation were calculated as follows:

single-operator component	1.50 % of the average
between-laboratory component	8.80 % of the average

8.2 *Critical Differences*—For the components of variance reported in 8.1, two averages of observed values should be considered significantly different at the 95 % probability level if the difference equals or exceeds the following critical differences listed below:

	Critical Difference, % of Grand Average[A]	
Number of Observations in Each Average	Single-operator Precision	Between-laboratory Precision
10	4.16	24.40

[A] The critical differences were calculated using $t = 1.960$ which is based on infinite degrees of freedom.

8.3 *Confidence Limits*—For the components of variance noted in 8.1, single averages of observed values have the following 95 % confidence limits:

	Width of 95 % Confidence Limits, % of Grand Average[A]	
Number of Observations in Each Average	Single-operator Precision	Between-laboratory Precision
10	±2.94	±17.26

[A] The confidence limits were calculated using $t = 1.960$ which is based on infinite degrees of freedom.

8.4 *Bias*—No statement on bias is being made due to lack of an accepted standard reference material.

9. Test Specimens

9.1 *Preparation*—The test specimens shall be right cylinders. They may be formed and matured for the purpose of compression testing, or they may be cut from matured whiteware by sawing or coredrilling. The ends of all specimens shall be ground or lapped to yield plane and parallel faces. These faces shall be perpendicular to the axis of the specimen, and parallel within 15 min of arc (0.044 rad).

9.2 *Size*—The size of the specimen should be no larger than to require more than 80 % of the rated capacity of the testing machine. Examples of specimen size limitations are shown in Table 2.

9.3 *Number of Specimens*—The number of specimens shall not be less than ten.

PROCEDURE B

10. Apparatus

10.1 *Testing Machine*—Any fixed-head testing machine conforming to Practices E4 and to the requirements for speed of testing prescribed in 12.3 may be used. A spherical head must not be used.

TABLE 2 Maximum Specimen Diameter in Inches (Millimetres) to Use 80 % of Rated Capacity of Testing Machine

NOTE 1—The ratio of length to diameter of the test specimens may vary between 1.9 and 2.1. Diameters shall be measured to the nearest 0.001 in. (0.03 mm).

Maximum Compressive Strength, psi (MPa)	Testing Machine Capacity, lbf (kN)		
	10 000 (44)	20 000 (89)	30 000 (134)
	in. (mm)	in. (mm)	in. (mm)
10 000 (69)	1.0 (25.4)	1.43 (36.3)	1.75 (44.4)
50 000 (345)	0.45 (11.5)	0.64 (16.3)	0.78 (19.8)
150 000 (1034)	0.26 (6.6)	0.37 (9.4)	0.45 (11.5)

10.2 *Bearing Plates*—Hardened steel 60 HRC bearing plates shall be used between the contact cylinders and the platens of the machine. These plates shall be approximately 2.5 in. (63.5 mm) in diameter by 1 in. (25.4 mm) thick. The contact faces shall be surface ground until flat and parallel within 0.001 in. (0.025 mm) total indicator reading. The bearing plates shall be resurfaced as necessary to retain their tolerance and to remove any surface damage resulting from testing high-strength materials.

10.3 *Contact Cylinders*—Ceramic contact cylinders of the same material as the specimens to be tested shall be used between the bearing plates and the test specimen to aid in distributing the load and to minimize detrimental "end effects." These contact cylinders shall be ½ in. (12.7 mm) high and ⅝ in. (15.9 mm) in diameter. The contact faces shall be flat and parallel to within 0.0005 in. (0.013 mm) total indicator reading. Two new contact cylinders should be used for each specimen to prevent a damaged contact cylinder failing prematurely and thereby giving an erroneous reading. By using contact blocks made of the same, or similar, material as the test specimen itself there is less deformation and less frictional resistance at the interfaces.

NOTE 2—Ceramic contact cylinders of similar composition to that of the test specimen may be used so long as the contact cylinders have a similar elastic modulus and equal or higher tensile strength to that of the test specimen.

11. Test Specimens

11.1 *Preparation*—Grind the test specimens to right cylinders. Grind the ends of all specimens with a 100-grit or finer diamond wheel, until parallel and perpendicular to the axis, within 0.0005 in. (0.013 mm) total indicator reading.

11.2 Clean the test specimens with a suitable solvent after grinding and follow by immersion in an ultrasonic bath filled with hot detergent solution. Then rinse the specimens in hot water, dry at 110 ± 2 °C (230 ± 4 °F) for 2 h and cool to room temperature in a desiccator.

NOTE 3—In the event that water-sensitive specimens, such as MgO, are being cleansed, a substitute for water should be used.

11.3 *Size*—Specimens shall be 0.250 ± 0.001 in. (6.350 ± 0.025 mm) in diameter and 0.500 ± 0.002 in. (12.70 ± 0.05 mm) in length.

11.4 *Number of Specimens*—The number of test specimens shall be not less than ten.

12. Procedure

12.1 Dye-check specimens and contact cylinders in accordance with Practice E165/E165M before testing. Discard any parts exhibiting cracks or flaws visible to the unaided eye.

12.2 Center the specimen carefully in the machine between the bearing plates (Fig. 1) to avoid eccentric loading. Place an appropriate guard around the specimen to contain flying fragments at failure; eye protection should be used by the operator.

12.3 Apply the load continuously and without impact shock at a rate of 10 000 lbf/min (45 kN/min), within 20 %. Use only the load on the specimen at ultimate failure for calculation of the compressive strength.

13. Keywords

13.1 compressive strength; fired whiteware materials