Designation: C 134 – 95 (Reapproved 2005)

Standard Test Methods for Size, Dimensional Measurements, and Bulk Density of Refractory Brick and Insulating Firebrick[1]

This standard is issued under the fixed designation C 134; 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 procedures for measuring size, dimensional measurement, bulk density, warpage, and squareness of rectangular dense refractory brick and rectangular insulating firebrick. More precise determination of bulk density of refractory brick can be made by Test Methods C 20. Stack height is generally determined only for dense refractories.

NOTE 1—Test Methods C 830 and Test Method C 914 are also used to determine bulk density of refractory brick, by different procedures.

1.2 The test methods appear in the following order:

	Sections
Size and Bulk Density	4 through 7
Warpage of Refractory Brick	8 through 10
Squareness of Refractory Brick	11 through 14

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

C 20 Test Methods for Apparent Porosity, Water Absorption, Apparent Specific Gravity, and Bulk Density of Burned Refractory Brick and Shapes by Boiling Water

C 830 Test Methods for Apparent Porosity, Liquid Absorption, Apparent Specific Gravity, and Bulk Density of Refractory Shapes by Vacuum Pressure

C 914 Test Method for Bulk Density and Volume of Solid Refractories by Wax Immersion

3. Significance and Use

3.1 Refractory brick are used as modular units in furnace construction and should not deviate significantly from the intended configuration with respect to size, bulk density, flat surfaces, and right angles. These test methods are particularly suited for use under field conditions and provide a means to determine whether the brick meets the requirements considered necessary to assure a satisfactory refractory construction.

SIZE AND BULK DENSITY

4. Apparatus

4.1 *Rule*, steel, hook, 12 in. (305 mm) in length, graduated in 0.02-in. (0.5-mm) divisions, for use in measuring individual brick. The rule has a rigid hardened steel hook consisting of a right-angled piece on one end to fix the zero point of the scale against one face of the brick. The hook is about ¼ in. (6 mm) in width and extends about ¼ in. beyond the back face or, preferably, the edge of the rule.

4.2 *Rule*, stiff steel, hook, 36 in. (914 mm) in length, graduated from each end in 0.02-in. (0.5-mm) divisions, for use in measuring stack height and the larger individual brick. The 36-in. rule has the same design as the 12-in (305-mm) rule.

NOTE 2—Check the hook rules periodically to determine that they have not become worn or distorted in use. Other measuring equipment may be used, provided the results are at least as accurate as those obtained with the hook rule.

4.3 *Weighing Scale*, having a capacity of 20 lb (9 kg) or more and a sensitivity under load of at least 0.01 lb (4.5 g).

5. Sampling

5.1 A sample consists of ten brick selected at random.

[1] These test methods are under the jurisdiction of ASTM Committee C08 on Refractories and are the direct responsibility of Subcommittee C08.03 on Physical Properties.

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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.

5.2 *Preparation of Specimens*—Remove any blisters or fins from the specimens by lightly rubbing them together. Omit this step in the case of insulating firebrick.

6. Procedure

6.1 *Length and Width*—Measure the length and width of each of the ten specimens across the middle of each of the faces of largest area to the nearest 0.02 in. (0.5 mm). Make and record the individual measurements of the two opposite faces of each specimen.

6.2 *Thickness*—Determine the thickness of insulating firebrick and record in the same manner as the length and width, as indicated in 6.1. Make the thickness measurements at the centers of the longer sides of the brick. Determine the thickness of dense refractory brick in the same manner or, when required by specification, calculate the average thickness from the stack height determined as in 6.3.

6.3 *Stack Height*—Stack the ten specimens vertically on a plane surface with their faces of largest area together to form a smooth column, without regard to the position of any brand marks on the specimens. Measure the height of the stack to the nearest 0.02 in. (0.5 mm) from the plane surface to the top of the stack at the center of each side. Record the individual measurements of the four sides of the stack.

6.4 *Weight*—Dry at 230°F (110°C), cool, and weigh each of the specimens to the nearest 0.01 lb (4.5 g), and record the weight.

7. Calculation and Report

7.1 *Size*—Report the individual measurements and the calculated average for the two individual measurements for length, width, and thickness for each specimen.

7.2 *Stack Height and Average Thickness*—Report the individual measurements and the calculated stack height as the average of the individual measurements of the four sides of the stack if required. Report "average thickness by stack height" as the average stack height divided by ten. For bricks over 3½ in. (89 mm) in thickness, report the average thickness of the individual specimens.

7.3 *Bulk Density*—Calculate and report the bulk density for each specimen, using Eq 1 or Eq 2 as appropriate and the average dimensions obtained in accordance with 7.1 and the weight obtained in accordance with 6.4.

$$(\text{lb/ft}^3)B = (d \times 1728/l \times w \times t) \quad (1)$$

or

$$B = (d/l \times w \times t) \quad (2)$$

where:
B = bulk density, lb/ft^3(g/cc),
d = dry weight, lb (g),
l = length, in. (mm),
w = width, in. (mm), and
t = thickness, in. (mm).

WARPAGE OF REFRACTORY BRICK

8. Apparatus

8.1 *Steel Straightedge*, stiff, having sufficient length to span the diagonal of the largest shape to be measured, and graduated in 0.02-in. (0.5-mm) divisions.

8.2 *Measuring Wedges*, two, steel, 2.5-in. (64-mm) long by 0.5 in. (13 mm) wide by 0.5 in. thick at one end, and tapered from a line 0.5 in. from one end to zero thickness at the other end. The wedge shall be graduated and numbered along the slope to show the thickness of the wedge between base *AB* and slope *AC* in 0.02-in. (0.5-mm) divisions (Fig. 1).

8.2.1 *Similar Wedges*, of equivalent size and slope (that is, rising 1 mm vertically for each 4 mm horizontally), and graduated along the slope to show the thickness of the wedge between base *AB* and the slope *AC* in SI units may be employed in conjunction with a straightedge calibrated in SI units.

9. Procedure

9.1 *Measuring a Concave Surface*:

9.1.1 Measure and record the length of the diagonal of a concave surface to the nearest 0.1 in. (3 mm) with the graduated straightedge. Place the straightedge across the diagonal. Insert the wedge (Fig. 2) at the point of maximum warpage, and record the maximum obtainable reading to the nearest 0.02 in. (0.5 mm).

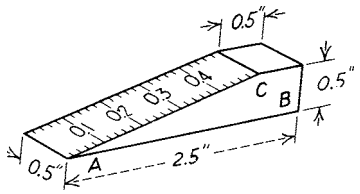
9.1.2 Repeat the procedure in 9.1.1 for the other diagonal.

9.2 *Measuring a Convex Surface*:

9.2.1 Measure and record the length of the diagonal of a convex surface to the nearest 0.1 in. (3 mm) with a caliper or hook rule. Place the straightedge across the diagonal, and insert one wedge at each end of the straightedge (Fig. 3). Adjust the wedges so that equal readings are obtained on each, making certain that the straightedge is in contact with the brick surface at the point of maximum convexity. Record the reading to the nearest 0.02 in. (0.5 mm).

9.2.2 Repeat the procedure in 9.2.1 for the other diagonal.

9.2.3 Alternatively, set the shape on its convex surface, on a plane surface, and insert one wedge at each end of a diagonal



NOTE—SI Equivalents (Dimensions are in inchs.)

in.	mm
0.5	13
2.5	64

FIG. 1 Measuring Wedge

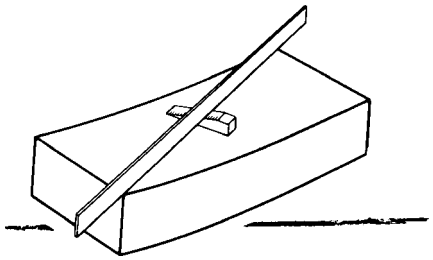


FIG. 2 Method of Measuring Warpage of a Concave Surface

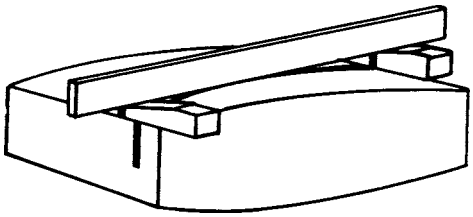


FIG. 3 Method of Measuring Warpage of a Convex Surface

until each wedge is in contact with the diagonal (Fig. 4). Adjust until equal readings are obtained on each wedge, making certain that contact is maintained at the vertices of the diagonal and at the point of maximum convexity. Record the reading to the nearest 0.02 in. (0.5 mm).

9.2.4 Repeat the procedure in 9.2.3 for the other diagonal.

10. Calculation and Report

10.1 Calculate the percent warpage for each of the diagonal positions using Eq 3:

$$W = (R/D) \times 100 \quad (3)$$

where:

W = warpage, %,
R = wedge reading, in. (mm), and
D = length of diagonal, in. (mm).

10.2 Consider the larger of the warpage figures as that of the specimen. Report the warpage values for the individual specimens to two significant figures.

SQUARENESS OF REFRACTORY BRICK

11. Apparatus

11.1 *Metal Plate*, 24 by 24 by 1-in. (610 by 610 by 25 mm) thick, with one surface ground to a flatness of ±0.005 in. (0.13 mm), or an equivalent abrasion-resistant flat surface.

11.2 *Precision Square*, 12 by 9 in. (305 by 229 mm).

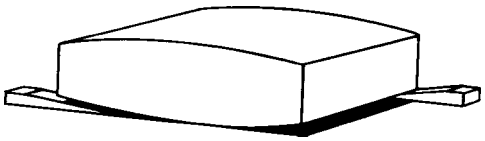


FIG. 4 Alternative Method of Measuring Warpage of a Convex Surface

11.3 *Measuring Wedge*, steel, 2.5 in. (64 mm) long by 0.5 in. (13 mm) wide by 0.5 in. thick at one end, and tapered from a line 0.5 in. at one end to zero thickness at the other end. The wedge shall be graduated and numbered along the slope to show the thickness of the wedge between base *AB* and slope *AC* in 0.02 in. (0.5 mm) divisions (Fig. 1).

12. Procedure

12.1 Place the test specimen on the metal plate so that it rests securely on a width face (Fig. 5).

12.2 Abut the square at about midpoint of the long dimension.

12.3 Insert the steel wedge at the point of maximum departure between the square and brick surface (Fig. 5).

12.4 Read and record the deviation to the nearest 0.02 in. (0.5 mm).

12.5 Repeat the procedures in 12.2, 12.3, and 12.4 for the opposite vertical face and each end.

12.6 Reposition the specimen to rest securely on a thickness face.

12.7 Repeat the procedures in 12.2, 12.3, and 12.4 for both major vertical faces and each end.

13. Report

13.1 Report the following:

13.1.1 Brick brand and nominal size.

13.1.2 Individual deviation obtained from each measured face for each specimen in the sampling.

14. Precision and Bias

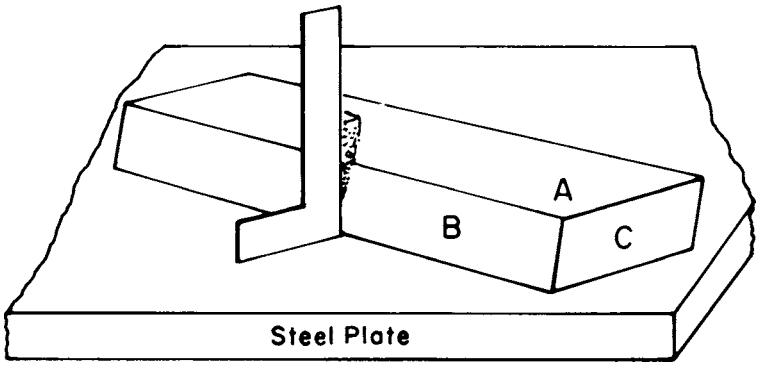
14.1 *Precision*:

14.1.1 *Interlaboratory Test Program*—An interlaboratory study was conducted by six laboratories on ten specimens using two replications and two duplicate runs on the same specimen. The specimens were stiff mud extruded and pressed super duty brick.

14.1.2 *Repeatability*—The maximum permissible difference due to test error between two test results obtained by one operator on the same material is given by the repeatability interval and the relative repeatability interval (coefficient of variation). The 95% repeatbility intervals are given in Table 1. Two test results that do not differ by more than the repeatability interval will be considered the same, and, conversely, two test results that do differ by more than the repeatability interval will be considered different.

14.1.3 *Reproducibility*—The maximum permissible difference due to test error between two test results obtained by two operators in different laboratories on the same type of material using the same type of test equipment is given by the reproducibility interval and relative reproducibility interval (coefficient of variation). The 95% reproducibility intervals are given in Table 1. Two test results that do not differ by more than the reproducibility interval will be considered the same and, conversely, two test results that do differ by more than the reproducibility interval will be considered different.

14.2 *Bias*—No justifiable bias statement is possible since the true values of the properties of the reference material are not defined.



A—Width face
B—Thickness face
C—End face

FIG. 5 Method of Measuring Squareness

TABLE 1 Precision Statistics

		Precision Data				Relative Precision Data			
Attribute	Average, in.	Std. Deviation within Lab Sr	Std. Deviation between Lab SR	Repeatability Interval	Reproducibility Interval R	Within Lab Vr	Between Lab VR	Relative Repeatability, % r	Relative Reproducibility, % R
Length	8.941	0.007	0.01	0.017	0.028	0.072	0.11	0.199	0.308
Width	4.356	0.007	0.011	0.017	0.027	0.135	0.227	0.38	0.631
Thickness	2.96	0.01	0.01	0.02	0.02	0.020	0.25	0.56	0.69
Diagonal Warpage	0.265	0.079	0.124	0.22	0.348	30.099	52.529	84.277	147.08
Squareness of Width	0.022	0.011	0.015	0.035	0.043	69.39	84.731	194.29	237.247
Squareness Max Deviation Midpoint of Length	0.04	0.018	0.019	0.053	0.056	50.043	53.23	140.121	149.045
Squareness Max Deviation Midpoint of Thickness	0.032	0.012	0.012	0.032	0.039	36.413	44.168	101.96	123.67
Squareness Max Deviation Midpoint of Width	0.034	0.01	0.011	0.027	0.034	29.549	36.674	82.736	99.89
10 High Stack Oriented	29.83	0.02	0.04	0.04	0.1	0.05	0.12	0.14	0.35
10 High Stack Random	29.83	0.02	0.03	0.06	0.9	0.07	0.11	0.19	0.30
Bulk Density Pounds per Cubic Foot	138.036	0.427	0.729	1.196	2.046	0.31	0.529	0.866	1.482

15. Keywords

15.1 bulk density; dimension; insulating firebrick; refractories; size; squareness; warpage