



Standard Practice for Calculating Areas, Volume, and Linear Change of Refractory Shapes¹

This standard is issued under the fixed designation C 1407; 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 practice presents the methods of calculating areas, volumes and linear changes of irregularly shaped refractory specimens.

1.2 Areas of irregular (both conventional and shaped) specimens are required for determining the creep of certain refractory products.

1.3 Linear and volume changes of irregularly shaped refractories are required for determining reheat change.

1.4 The values stated in SI units are to be regarded as the standard.

1.5 *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:

C 20 Test Methods for Apparent Porosity, Water Absorption, Apparent Specific Gravity, and Bulk Density of Burned Refractory Brick and Shapes by Boiling Water²

C 113 Test Method for Reheat Change of Refractory Brick²

C 830 Test Method of Apparent Porosity, Liquid Absorption, Apparent Specific Gravity, and Bulk Density by Vacuum Pressure²

C 832 Test Method of Measuring the Thermal Expansion and Creep of Refractories Under Load²

E 691 Practice for Conducting and Interlaboratory Study to Determine the Precision of a Test Method³

3. Significance and Use

3.1 Fireclay steel-teeming nozzles and sleeves are classified by volume reheat change. Bloating of some refractories results in irregular reheat dimensions, which are difficult to measure. This practice determines the volume without depending upon physical linear measurements.

3.2 Blast furnace checkers that have irregular cross-sections are classified by "creep properties." This practice determines

the average cross-sectional area without requiring area measurements.

4. Procedure

4.1 The test specimens shall have their volume (V_A) predetermined using the standard procedure described in Test Methods C 20 or C 830.

4.2 Dry the specimens to constant weight.

4.3 Weigh the specimens to the nearest 0.1 g and record as W .

4.4 If the specimens have parallel faces (such as ground surfaces for applying load for creep data) measure the length to the nearest 0.005 in. (0.13 mm) and record as L .

5. Calculation

5.1 Area of Creep Specimens (Irregular Cross-Sections):

5.1.1

$$\text{area (A)} = \frac{\text{volume(V) (C 20 or C 830) cm}^3}{\text{length(L) (cm)}} = \text{cm}^2 (10^{-4} \text{ m}^2) \quad (1)$$

5.1.2

$$\text{volume(V)} = \frac{\text{weight(W) (g)}}{\text{bulk density (g/cm}^3)} = \text{cm}^3 (10^{-6} \text{ m}^3) \quad (2)$$

5.1.3 Illustration:

$$\begin{aligned} \text{Weight (W)} &= 375.2 \text{ g} \\ \text{Bulk Density} &= 2.56 \text{ g/cm}^3 (\text{Mg/m}^3) \\ \text{Length (L)} &= 10.795 \text{ cm} (10^{-2} \text{ m}) \end{aligned}$$

$$V = \frac{375.2}{2.56} = 146.56 \text{ cm}^3 (10^{-6} \text{ m}^3) \quad (3)$$

$$A = \frac{\text{Volume}}{\text{Length}} = \frac{146.56}{10.795 (10^{-2} \text{ m})} = 13.58 \text{ cm}^2 (10^{-4} \text{ m}^2) \quad (4)$$

5.2 Volume Change of Reheat Specimens:

$$\% \text{ volume change } (\Delta V) = \frac{V_B - V_A}{V_A} \times 100 \quad (5)$$

where:

V_A = original volume, $\text{cm}^3 (10^{-6} \text{ m}^3)$

V_B = final reheat volume, $\text{cm}^3 (10^{-6} \text{ m}^3)$, and

ΔV = ($V_B - V_A$) change in volume from State A to State B (volume obtained from either Test Method C 20 or Test Method C 830).

5.3 Converting % Volume Change ΔV to % Linear Change ΔL of Reheat Specimens:

5.3.1 If volume change is negative (shrinkage) then:

¹ This practice is under the jurisdiction of ASTM Committee C-8 on Refractories and is the direct responsibility of Subcommittee C08.03 on Physical Tests.

Current edition approved Sept. 10, 1998. Published December 1998.

² Annual Book of ASTM Standards, Vol 15.01.

³ Annual Book of ASTM Standards, Vol 14.02.

$$\% \text{ linear change } (\Delta L) = -[1 - (1 + \Delta V/100)^{1/3}] \times 100 \quad (6)$$

5.3.1.1 Illustrate for an -8 % volume change (shrinkage) as:

$$\% \text{ linear change } (\Delta L) = -[1 - (1 - 0.08)^{1/3}] \times 100 \quad (7)$$

$$= -[1 - (0.92)^{1/3}] \times 100$$

$$= -[1 - (0.973)] \times 100$$

$$= -0.027 \times 100 = -2.7 \%$$

5.3.2 If the volume change is positive (expansion) then:

$$\% \text{ linear change } (\Delta L) = [(1 + \% \Delta V/100)^{1/3} - 1] \times 100 \quad (8)$$

5.3.2.1 Illustrate for a + 8 % volume change (expansion) as:

$$\% \text{ linear change } (\Delta L) = [(1 + 0.08)^{1/3} - 1] \times 100 \quad (9)$$

$$= (1.026 - 1) \times 100$$

$$= 0.026 \times 100 = 2.6 \%$$

NOTE 1—The linear reheat change calculated from the volume change is only an approximation and may be different from a measured value.

6. Keywords

6.1 area; checkers; creep; Fireclay nozzle; Fireclay sleeves; irregular shapes; linear change; refractories; reheat change; volume; volume change

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 100 Barr Harbor Drive, West Conshohocken, PA 19428.