



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 covers 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:*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 by Vacuum Pressure

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.

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

Current edition approved March 1, 2005. Published March 2005. Originally approved in 1998. Last previous edition approved in 1998 as C 1407 - 98.

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.

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:*

Weight (W) = 375.2 g
Bulk Density = 2.56 g/cm³(Mg/m³)
Length (L) = 10.795 cm (10⁻² m)

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

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

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, cm³(10⁻⁶ m³)

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:

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

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

$$\begin{aligned} \% \text{ linear change } (\Delta L) &= -[1 - (1 - 0.08)^{1/3}] \times 100 \quad (7) \\ &= -[1 - (0.92)^{1/3}] \times 100 \\ &= -[1 - (0.973)] \times 100 \\ &= -0.027 \times 100 = -2.7\% \end{aligned}$$

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:

$$\begin{aligned} \% \text{ linear change } (\Delta L) &= [(1 + 0.08)^{1/3} - 1] \times 100 \quad (9) \\ &= (1.026 - 1) \times 100 \\ &= 0.026 \times 100 = 2.6\% \end{aligned}$$

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

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