Designation: C1407 – 23

Standard Practice for Calculating Areas, Volume, and Linear Change of Refractory Shapes[1]

This standard is issued under the fixed designation C1407; 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 The specimens must have a constant cross-sectional area over a length (*L*).

1.3 The values stated in SI units are to be regarded as the 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, 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]

C20 Test Methods for Apparent Porosity, Water Absorption, Apparent Specific Gravity, and Bulk Density of Burned Refractory Brick and Shapes by Boiling Water

C830 Test Methods for Apparent Porosity, Liquid Absorption, Apparent Specific Gravity, and Bulk Density of Refractory Shapes 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.

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

4. Procedure

4.1 The test specimens shall have their dry weight (*W*) and volume (*V*) measured using the standard procedure described in Test Methods C20 or C830.

4.2 Measure the length to the nearest 0.02 in. (0.5 mm) and record as *L*.

5. Calculation

5.1 *Area of Specimens:*

5.1.1

$$\text{area}\,(A) = \frac{\text{volume}(V)\ (C20\ \text{or}\ C830)\ \text{cm}^3}{\text{length}(L)\ (\text{cm})} = \text{cm}^2\ (10^{-4}\ \text{m}^2) \quad (1)$$

5.1.2

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

5.1.3 *Illustration:*

Weight (W) = 375.2 g
Bulk Density = 2.56 g/cm^3 (Mg/m^3)
Length (L) = 10.80 cm (10^{-2} m)

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

$$A = \frac{\text{Volume}}{\text{Length}} = \frac{146.56}{10.80\ (10^{-2}\ \text{m})} = 13.58\ \text{cm}^2\ (10^{-4}\quad \text{m}^2) \quad (4)$$

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, cm^3 (10^{-6} m^3)
V_B = final reheat volume, cm^3 (10^{-6} m^3), and
ΔV = (V_B - V_A) change in volume from State A to State B (volume obtained from either Test Method C20 or Test Method C830).

[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.

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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.

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

5.3.1 If volume change is negative (shrinkage) then:

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

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

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

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

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

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

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

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

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

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

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

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

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