ASTM C204

Standard Test Methods for Fineness of Hydraulic Cement by Air-Permeability – Staying Up To Standard

Understanding ASTM International Test Procedures for Cement and Concrete - Staying Up to Standard

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Related Procedures

- BS 4359 :1972 British Standard for the Determination of Specific Surface of Powders: Part 2: Air Permeability Methods

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Significance of ASTM C204 - Blaine

- Determine fineness of cement
- Very important physical property
  - Affects setting time, hydration rate, strength, shrinkage, heat of hydration, and permeability
- Increase in fineness
  - Increases rate of hydration, shortens setting time, increases early-age strength gain
  - Affects consistency of mixtures and admixture demand
- Required for ASTM C150 and C989

Fineness

- Requirements for Type I, II, IV & V
  - (No requirements for Type III)

	Air Permeability
Minimum, m^2/kg	280
Maximum, m^2/kg	400
Typical Values, m^2/kg	350-380 Type I 450-600 Type III

- No limits for blended cement (ASTM C 595), hydraulic cements (ASTM C 1157), or slag cement (ASTM C989) but values must be reported

Fineness Standards

ASTM C204 – Blaine Surface Area

ASTM C115 – Turbidimeter

ASTM C430 – No. 325 Sieve

Scope of Test Method

- Determination of fineness using Blaine air permeability apparatus
- Result is in surface area of cm^2/g or m^2/kg
- Results are considered relative values, not absolute
- Known to work well for portland cement. Should be used with caution on other materials.

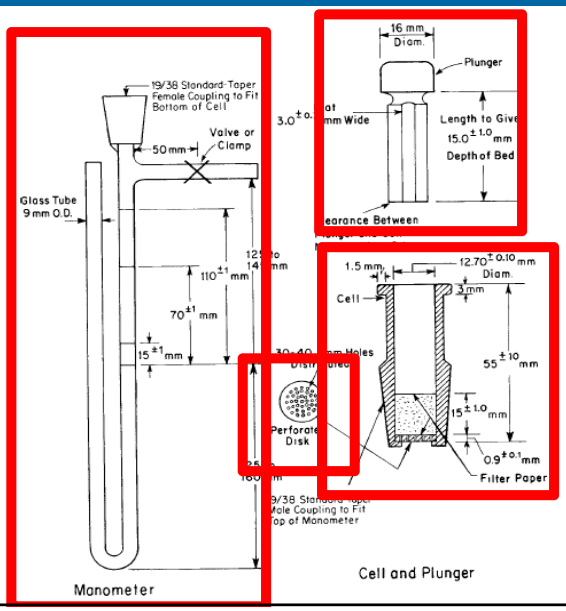
Nature of Apparatus

- The Blaine air-permeability apparatus consists essentially of a means of drawing a definite quantity of air through a prepared bed of cement of definite porosity. The number and size of the pores in a prepared bed of definite porosity is a function of the size of the particles and determines the rate of air flow through the bed.

Nature of Apparatus

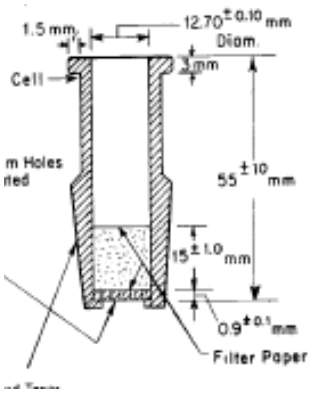
Apparatus: Blaine Apparatus

- Cell
- Perforated Disc
- Plunger
- Filter Paper
- Manometer
- Timer



Apparatus: Permeability Cell

- Stainless steel cylinder
- Air tight connection with manometer
- Inside ledge to hold perforated disc



Apparatus: Perforated Disc

- Non-corroding
- 30-40 holes, 1 mm diameter
- Marked on one side to maintain orientation between tests
- 0.9 mm thick (±0.1 mm)

Apparatus: Plunger

- Stainless steel
- Air vent 3.0 mm wide
- Sized to leave 15.0 mm gap between the bottom of the plunger and the perforated disc (the space to be occupied by the cement sample)

Apparatus: Filter Paper

- Type I, Grade B (ASTM Specification E8232)
- Circular and same diameter as inside of permeability cell

Apparatus: Manometer

- U-tube
- Air Shall be air tight with cell
- Midpoint line etched around the tube at 125 to 145 mm
- Liquid: Low density, nonvolatile liquid such as Dibutyl phthalate or light grade mineral oil

Calibration of Apparatus

- Calibration of the air permeability apparatus shall be made using the current lot of standard material:
  - NIST Standard Reference Material No. 114
- Determine Bulk Volume of compacted Bed of Powder by Physical Measurement:
  - Measure average diameter and average cell depth

$$\boldsymbol{Volume = \pi r^2 h}$$

Note: Bulk volume can also be determined by mercury displacement method. Not covered in this presentation.

Calibration of Apparatus

- Prepare sample by shaking in a sample jar, let stand for 2 minutes, gently stir the sample.
- Use equation to determine the mass of sample required to have a porosity of 0.500

$$\mathbf{W = \rho V(1 - \varepsilon)}$$

W = grams of sample required
ρ = density of sample for portland cement 3.15
V = bulk volume
ε = desired porosity of bed of cement 0.500 ± 0.005

Procedure: Preparation of Cement Bed

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- Seat the perforated disc
- Place filter paper on disc and press the edges down with a rod
- Measure cement mass to nearest 0.001 grams
- Place cement sample in the cell and tap the side to level the cement
- Place filter paper on top of cement
- Compress sample with plunger until plunger collar is in contact with top of cell
- Withdraw the plunger a short distance and rotate 90° and repress the sample and then withdraw plunger

Procedure: Preparation of Cement Bed (1/3)

1. Seat Perforated Disc

2. Place Filter Paper on Metal Disc

3. Press Edges Down with Rod

Procedure: Preparation of Cement Bed (2/3)

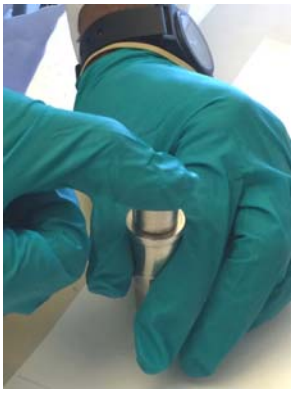
4. Measure Cement Mass to Nearest 0.001g

5. Place Cement Sample in Cell

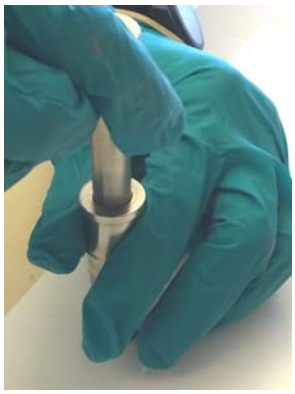
6. Tap Side to Level Cement

Procedure: Preparation of Cement Bed (3/3)

7. Place Filter Paper on Top of Cement



8. Compress Sample with Plunger Until Collar is in Contact with Top of Cell



9. Withdraw Short Distance, Rotate 90°, Recompress, and Withdraw

Procedure: Permeability Test

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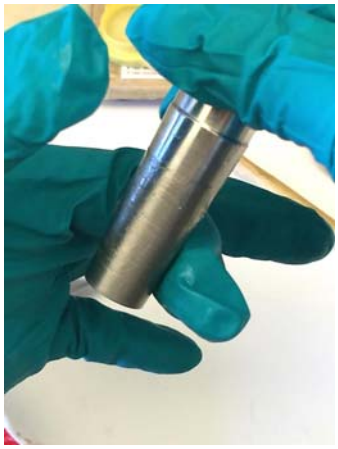
- Apply stopcock grease to standard tapered connection
- Attach cell to manometer with secure air-tight connection
- Evacuate the air from one arm until the liquid reaches the top mark and close the air valve
- Start the timer when the liquid reaches the next mark down from the top (2nd mark)
- Stop the timer when the liquid reaches the next mark down from the top (3rd mark)
- Record time for test and the temperature at the time of testing
- Repeat 3 times and recalibrate no less than every 2.5 years

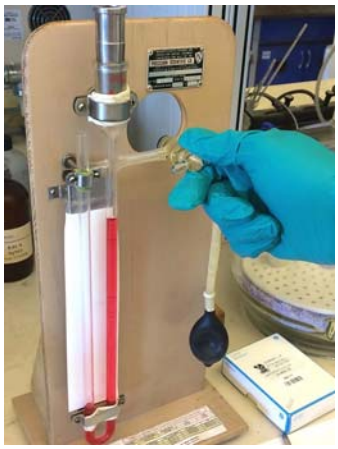
Procedure: Permeability Test (1/4)



1. Apply Stopcock Grease to Tapered Connection

2. Attach Cell to Manometer Tube

Procedure: Permeability Test (2/4)



3. Evacuate Air from One Arm Until Liquid Reaches Top Mark

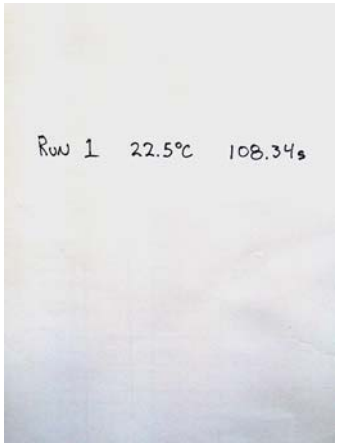
4. Close Air Valve

Procedure: Permeability Test (3/4)

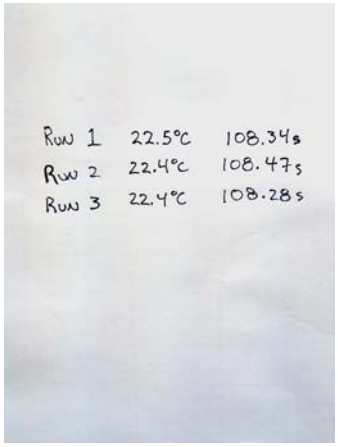
5. Start Timer when Liquid Reaches Next Mark Down from Top (2nd Mark)

6. Stop Timer when Liquid Reaches Next Mark Down from Top (3rd mark)

Procedure: Permeability Test (4/4)



7. Record Time Interval for Test in Seconds and Temperature at Time of Testing in °C.



8. Repeat 3 Times and Recalibrate No Less than Every 2.5 Years

Procedure: About Cement and Other Materials

- Cement shall be at room temperature for test
- Same weight of sample as used with calibration sample:
  - For type III cement, or other fine ground cements, the bulk of material will be too great for thumb pressure on plunger to compress sample – use a porosity of 0.530 for sample mass calculation
  - For other materials, or cements where 0.500 and 0.530 won't work, adjust mass of sample such that a firm bed of material is produced with thumb pressure only. Plunger must not rebound once thumb is removed.

Calculation (section 6) and Report (section 7)

$$S = \frac{S_s\sqrt{T}}{\sqrt{T_s}}$$

- Round values to nearest 10 cm^2/g or nearest 1 m^2/kg
- Report results of single trial
- For high fineness materials report the average of 2 trials (if trials are within 2% of each other). If trials are not within 2% discard values and repeat until 2 values are within 2%

Method B: Automated Apparatus (sections 9-13)

- Automated device based on
  - Blaine Air permeability method
  - Lea and Nurse Method
- Device specific calibration procedures
- Qualify device using 2 different cement samples tested in triplicate (with densities differing by no more than $0.06 g/cm^3$
- Standardization between samples using 5 reference samples

Limitations and Errors

- Specific surface area does NOT characterize the particle size distribution of a cement.
- Watch for air leaks, continuous loss of pressure in the manometer.
- Care should be taken when testing other materials than portland cement.
- Reporting temperature and comparing it to calibration temperature.

Questions & Answers