



Designation: C231/C231M – 22

Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method¹

This standard is issued under the fixed designation C231/C231M; 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 test method covers determination of the air content of freshly mixed concrete from observation of the change in volume of concrete with a change in pressure.

1.2 This test method is intended for use with concretes and mortars made with relatively dense aggregates for which the aggregate correction factor can be satisfactorily determined by the technique described in Section 6. It is not applicable to concretes made with lightweight aggregates, air-cooled blast-furnace slag, or aggregates of high porosity. In these cases, Test Method C173/C173M should be used. This test method is also not applicable to nonplastic concrete such as is commonly used in the manufacture of pipe and concrete masonry units.

1.3 The text of this test method references notes and footnotes that provide explanatory information. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of this standard.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use. (Warning—Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.²)*

1.6 *This international standard was developed in accordance with internationally recognized principles on standard-*

¹ This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.60 on Testing Fresh Concrete.

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² Section on Safety Precautions, Manual of Aggregate and Concrete Testing, *Annual Book of ASTM Standards*, Vol 04.02.

ization 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:*³

C31/C31M Practice for Making and Curing Concrete Test Specimens in the Field

C138/C138M Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete

C143/C143M Test Method for Slump of Hydraulic-Cement Concrete

C172/C172M Practice for Sampling Freshly Mixed Concrete

C173/C173M Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method

C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

C1758/C1758M Practice for Fabricating Test Specimens with Self-Consolidating Concrete

3. Significance and Use

3.1 This test method covers the determination of the air content of freshly mixed concrete. The test determines the air content of freshly mixed concrete exclusive of any air that may exist inside voids within aggregate particles. For this reason, it is applicable to concrete made with relatively dense aggregate particles and requires determination of the aggregate correction factor (see 6.1 and 9.1).

3.2 This test method and Test Method C138/C138M and C173/C173M provide pressure, gravimetric, and volumetric procedures, respectively, for determining the air content of freshly mixed concrete. The pressure procedure of this test method gives substantially the same air contents as the other two test methods for concretes made with dense aggregates.

³ 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.

*A Summary of Changes section appears at the end of this standard

3.3 The air content of hardened concrete may be either higher or lower than that determined by this test method. This depends upon the methods and amount of consolidation effort applied to the concrete from which the hardened concrete specimen is taken; uniformity and stability of the air bubbles in the fresh and hardened concrete; accuracy of the microscopic examination, if used; time of comparison; environmental exposure; stage in the delivery, placement and consolidation processes at which the air content of the unhardened concrete is determined, that is, before or after the concrete goes through a pump; and other factors.

4. Apparatus

4.1 Air Meters—There are available satisfactory apparatus of two basic operational designs employing the principle of Boyle’s law. For purposes of reference herein these are designated Meter Type A and Meter Type B.

4.1.1 Meter Type A—An air meter consisting of a measuring bowl and cover assembly (see Fig. 1) conforming to the requirements of 4.2 and 4.3. The operational principle of this meter consists of introducing water to a predetermined height above a sample of concrete of known volume, and the application of a predetermined air pressure over the water. The determination consists of the reduction in volume of the air in the concrete sample by observing the amount the water level is lowered under the applied pressure, the latter amount being calibrated in terms of percent of air in the concrete sample.

4.1.2 Meter Type B—An air meter consisting of a measuring bowl and cover assembly (see Fig. 2) conforming to the requirements of 4.2 and 4.3. The operational principle of this meter consists of equalizing a known volume of air at a known pressure in a sealed air chamber with the unknown volume of air in the concrete sample, the dial on the pressure gauge being calibrated in terms of percent air for the observed pressure at

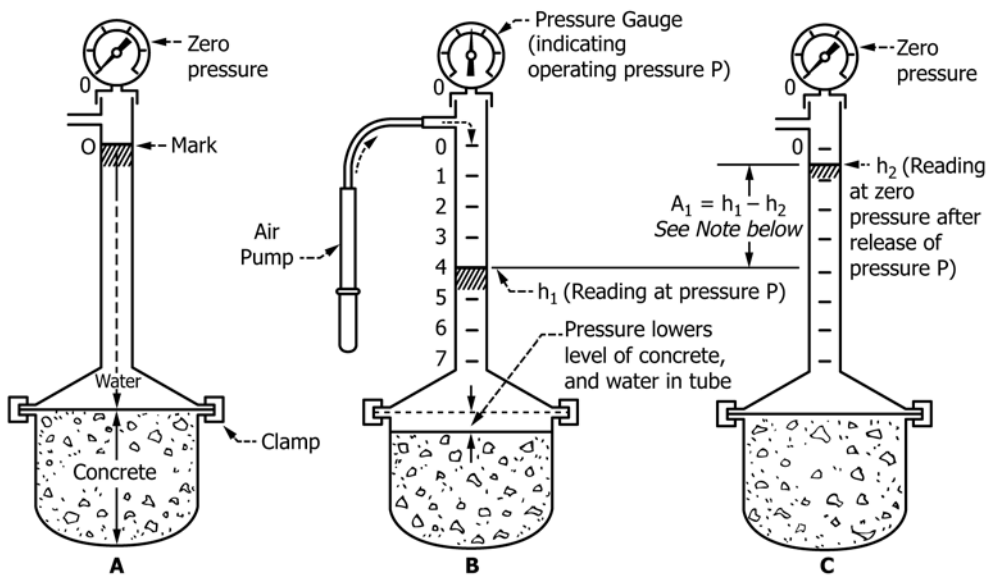
which equalization takes place. Working pressures of 50 kPa to 205 kPa [7.5 psi to 30.0 psi] have been used satisfactorily.

4.2 Measuring Bowl—The measuring bowl shall be essentially cylindrical in shape, made of steel, hard metal, or other hard material not readily attacked by the cement paste, having a minimum diameter equal to 0.75 to 1.25 times the height, and a capacity of at least 6.0 L [0.20 ft³]. It shall be flanged or otherwise constructed to provide for a pressure tight fit between measuring bowl and cover assembly. The interior surfaces of the measuring bowl and surfaces of rims, flanges, and other component fitted parts shall be machined smooth. The measuring bowl and cover assembly shall be sufficiently rigid to limit the expansion factor, *D*, of the apparatus assembly (Section A1.5) to not more than 0.1 % of air content on the indicator scale when under normal operating pressure.

4.3 Cover Assembly:

4.3.1 The cover assembly shall be made of steel, hard metal, or other hard material not readily attacked by the cement paste. It shall be flanged or otherwise constructed to provide for a pressure-tight fit between measuring bowl and cover assembly and shall have machined smooth interior surfaces contoured to provide an air space above the level of the top of the measuring bowl. The cover shall be sufficiently rigid to limit the expansion factor of the apparatus assembly as prescribed in 4.2.

4.3.2 The cover assembly shall be fitted with a means of direct reading of the air content. The cover for the Type A meter shall be fitted with a standpipe, made of a transparent graduated tube or a metal tube of uniform bore with a glass water gauge attached. In the Type B meter, the dial of the pressure gauge shall be calibrated to indicate the percent of air. Graduations shall be provided for a range in air content of at least 8 % readable to 0.1 % as determined by the proper air pressure calibration test.



Note: $A_1 = h_1 - h_2$ when measuring bowl contains concrete as shown in this figure; when measuring bowl contains only aggregate and water, $h_1 - h_2 = G$ (aggregate correction factor). $A_1 - G = A$ (entrained air content of concrete)

FIG. 1 Illustration of the Pressure Method for Air Content—Type-A Meter

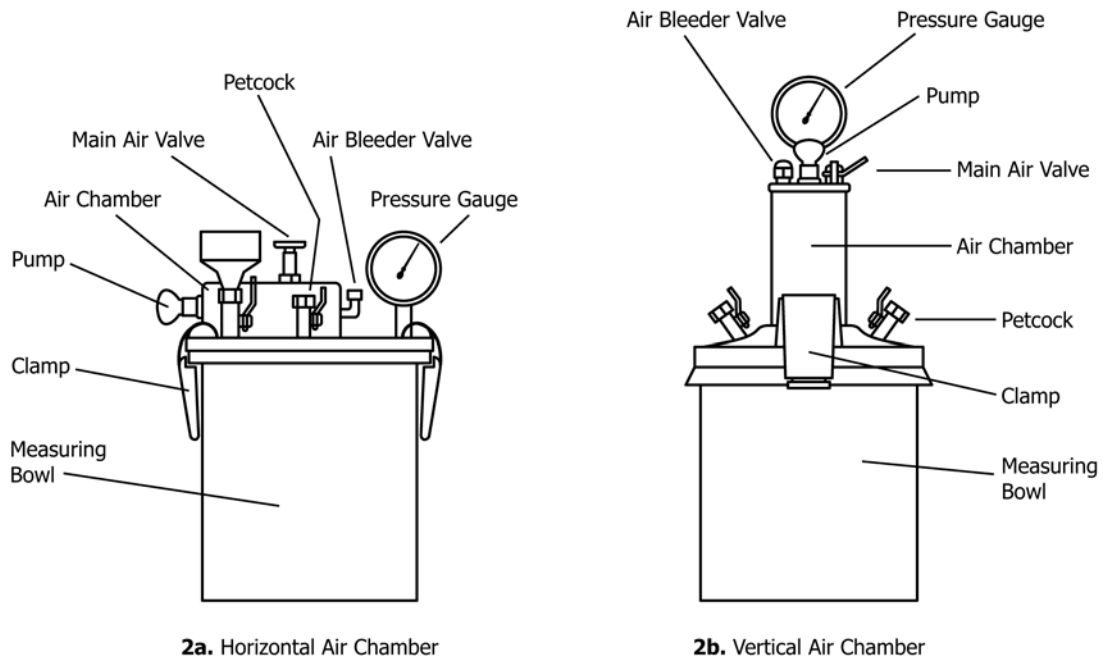


FIG. 2 Schematic Diagram—Type-B Meter

4.3.3 The cover assembly shall be fitted with air valves, air bleeder valves, and petcocks for bleeding off or through which water may be introduced as necessary for the particular meter design. Suitable means for clamping the cover to the measuring bowl shall be provided to make a pressure-tight seal without entrapping air at the joint between the flanges of the cover and measuring bowl. A suitable hand pump shall be provided with the cover either as an attachment or as an accessory.

4.4 *Calibration Vessel*—A measure having an internal volume equal to a percent of the volume of the measuring bowl corresponding to the approximate percent of air in the concrete to be tested; or, if smaller, it shall be possible to check calibration of the meter indicator at the approximate percent of air in the concrete to be tested by repeated filling of the measure. When the design of the meter requires placing the calibration vessel within the measuring bowl to check calibration, the measure shall be cylindrical in shape.

NOTE 1—A satisfactory calibration vessel to place within the measuring bowl may be machined from No. 16 gauge brass tubing, of a diameter to provide the volume desired, to which a brass disk 13 mm [$\frac{1}{2}$ in.] in thickness is soldered to form an end. When design of the meter requires withdrawing of water from the water-filled measuring bowl and cover assembly, to check calibration, the measure may be an integral part of the cover assembly or may be a separate cylindrical measure similar to the above-described cylinder.

4.5 The designs of various available types of air meters are such that they differ in operating techniques; therefore, all of the items described in 4.6 – 4.16 may not be required. The items required shall be those necessary for use with the particular design of apparatus used to satisfactorily determine air content in accordance with the procedures prescribed herein.

4.6 *Coil Spring or Other Device for Holding Calibration Cylinder in Place.*

4.7 *Spray Tube*—A brass tube of appropriate diameter, which may be an integral part of the cover assembly, or which may be provided separately. It shall be so constructed that when water is added to the container, it is sprayed to the walls of the cover in such a manner as to flow down the sides causing a minimum of disturbance to the concrete.

4.8 *Trowel*—A standard brick mason’s trowel.

4.9 *Tamping Rod*—A round, smooth, straight steel rod, with a 16 mm [$\frac{5}{8}$ in.] \pm 2 mm [$\frac{1}{16}$ in.] diameter. The length of the tamping rod shall be at least 100 mm [4 in.] greater than the depth of the measuring bowl in which rodding is being performed, but not greater than 600 mm [24 in.] in overall length (see Note 2). The rod shall have the tamping end or both ends rounded to a hemispherical tip of the same diameter as the rod.

NOTE 2—A rod length of 400 mm [16 in.] to 600 mm [24 in.] meets the requirements of the following: Practice C31/C31M, Test Method C138/C138M, Test Method C143/C143M, Test Method C173/C173M, and Test Method C231/C231M.

4.10 *Mallet*—A mallet (with a rubber or rawhide head) weighing approximately 0.60 kg \pm 0.25 kg [1.25 lb \pm 0.50 lb] for use with measures of 14 L [0.5 ft³] or smaller, and a mallet weighing approximately 1.0 kg \pm 0.25 kg [2.25 lb \pm 0.50 lb] for use with measures larger than 14 L [0.5 ft³].

4.11 *Strike-Off Bar*—A flat straight bar of steel or other suitable metal at least 3 mm [$\frac{1}{8}$ in.] thick and 20 mm [$\frac{3}{4}$ in.] wide by 300 mm [12 in.] long.

4.12 *Strike-Off Plate*—A flat rectangular metal plate at least 6 mm [$\frac{1}{4}$ in.] thick or a glass or acrylic plate at least 13 mm [$\frac{1}{2}$ in.] thick with a length and width at least 50 mm [2 in.] greater than the diameter of the measure with which it is to be used. The edges of the plate shall be straight and smooth within a tolerance of 1.5 mm [$\frac{1}{16}$ in.].