Designation: C233/C233M – 14

Standard Test Method for Air-Entraining Admixtures for Concrete[1]

This standard is issued under the fixed designation C233/C233M; 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 the testing of materials proposed for use as air-entraining admixtures in the field.

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

1.3 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. Some values have only SI units because the inch-pound equivalents are not used in practice.

NOTE 1—Sieve size is identified by its standard designation in Specification E11. The alternative designation given in parentheses is for information only and does not represent a different standard sieve size.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C33 Specification for Concrete Aggregates
C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens
C78 Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
C136 Test Method for Sieve Analysis of Fine and Coarse Aggregates
C143/C143M Test Method for Slump of Hydraulic-Cement Concrete
C150 Specification for Portland Cement
C157/C157M Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
C172 Practice for Sampling Freshly Mixed Concrete
C173/C173M Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
C185 Test Method for Air Content of Hydraulic Cement Mortar
C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory
C231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
C232 Test Methods for Bleeding of Concrete
C260 Specification for Air-Entraining Admixtures for Concrete
C403/C403M Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance
C666/C666M Test Method for Resistance of Concrete to Rapid Freezing and Thawing
C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
D75 Practice for Sampling Aggregates
D1193 Specification for Reagent Water
E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves
E70 Test Method for pH of Aqueous Solutions With the Glass Electrode

2.2 *ACI Standards:*

ACI 211.1 Recommended Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete[3]

3. Significance and Use

3.1 This test method is used to develop data for comparison with the requirements of Specification C260. These tests are based on arbitrary stipulations permitting highly standardized testing in the laboratory, and are not intended to simulate actual job conditions.

4. Materials

4.1 *Cement*—The cement used in any series of tests shall be either the cement proposed for specific work in accordance

[1] This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregatesand is the direct responsibility of Subcommittee C09.23 on Chemical Admixtures.

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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.

[3] American Concrete Institute Manual of Concrete Practice, Part 1, pp. 211-1 to 211-38 (1993).

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

with 4.4, a Type I or Type II cement conforming to Specification C150, or a blend of two or more cements, in equal parts. Each cement of the blend shall conform to the requirements of either Type I or Type II, Specification C150. If a blend of cements is used, it shall be a combination which produces an air content of less than 10 % when tested in accordance with Test Method C185 (Note 5).

4.2 *Aggregates*—Except when tests are made in accordance with 4.4, using the aggregates proposed for specific work, the fine and coarse aggregates used in any series of tests shall come from single lots of well-graded, sound materials that conform to the requirements of Specification C33, except that the grading of the aggregates shall conform to the following requirements:

4.2.1 *Fine Aggregate Grading*—The fine aggregate shall meet the requirements for the fine aggregate in Specification C33.

4.2.2 *Coarse Aggregate Grading*—The coarse aggregate grading shall meet the Size 57 grading requirements of Specification C33.

NOTE 2—Take care in loading and delivery to avoid segregation.

4.2.3 The coarse aggregate used for the reference concrete and test concretes shall be essentially the same. Provide sufficient coarse aggregate for the reference concrete, the test concrete, and for the grading analysis. Concrete consists of one reference concrete and as many test admixture-containing concretes as are intended to be compared.

4.2.3.1 Prepare required quantities of coarse aggregate as follows: Fill tared containers, one for sieve analysis, one for a batch of reference concrete, and one for a batch of test concrete, to the required mass from the aggregate stockpile (See Note 3). Accomplish this by placing equal quantities into each container, successively, and repeat the procedure until all the containers have their required mass (See Note 3).

NOTE 3—See the Appendix of Practice D75, Sampling from Stockpiles, and the section on Sampling Aggregates in the Manual of Aggregate and Concrete Testing[4] for guidance on procedures for sampling from stockpiles.

4.2.4 Perform sieve analysis on the coarse aggregate sample prepared in 4.2.3.1 by Test Method C136. Discard any set for which the sample does not comply with Size 57. Average test results for samples that comply with Size 57 for each sieve size. Discard any set for which the sample deviates from this average by more than the amount shown in column 3. Continue the process of preparation, testing and averaging until sufficient sets of aggregate within tolerance are obtained.

Sieve	Specification C33, No. 57 Percent Passing	Maximum variation from average/ passing
37.5 mm (1½ in.)	100	00
25.0 mm (1.00 in.)	95 to 100	1.0
12.5 mm (½ in.)	25 to 60	4.0
4.75 mm (No. 4)	0 to 10	4.0
2.36 mm (No. 8)	0 to 5	1.0

[4] Manual of Aggregate and Concrete Testing, *Annual Book of ASTM Standards* , Vol 04.02.

NOTE 4—All of the results required for demonstrating compliance under this specification are dependent on the uniformity of the aggregate samples prepared and used. Careful, skilled and well-supervised work is essential.

4.3 *Reference Admixture*—For this test method, unless otherwise requested by the purchaser, the reference admixture used in the concrete mixture specified in Section 4 shall be "neutralized Vinsol resin."[5]

4.4 *Materials for Tests for Specific Uses*—When it is desired to test an air-entraining admixture for use in specific work, the cement and aggregates used shall be representative of those proposed for use in the work, and the concrete mixtures shall be designed to have the cement content specified for use in the work (Note 5). If the maximum size of coarse aggregate is greater than 25.0 mm [1 in.], the freshly mixed concrete shall be screened over a 25.0-mm (1-in.) sieve prior to fabricating the test specimens in accordance with the wet sieving procedure described in Practice C172.

4.5 *Preparation and Weighing*—All materials shall be prepared and all weighings shall be made as prescribed in Practice C192/C192M.

NOTE 5—It is recommended that whenever practicable, tests be made in accordance with 4.4 using the cement and pozzolanic or chemical admixtures, if any, proposed for specific work.

5. Concrete Mixtures

5.1 *Proportions*—Using ACI 211.1, all concrete shall be proportioned to conform to the following requirements:

5.1.1 The cement content shall be 307 ± 3 kg/m^3 [517 ± 5 lb/yd^3] except when tests are being made for specific uses (see 4.4).

5.1.2 The first trial mixture shall contain the amount of coarse aggregate shown in Table 6.3.6 of ACI 211.1 for the maximum size of aggregate and for the fineness modulus of the sand being used.

NOTE 6—The volumes of coarse aggregate recommended in ACI 211.1 are intended to ensure workable mixtures with the least favorable combinations of aggregate likely to be used. It is suggested, therefore, that for a closer approximation of the proportions required for this test, the recommended values in ACI 211.1 be multiplied by 1.07 for the first trial mixture.

5.1.3 The air content used in the computation of proportions for all concrete shall be 5.5 % except where the admixture under test is for use in specific work (see 4.4). In this case the air content used in selecting proportions shall be the median of the range to be permitted in the work. If lightweight aggregates are to be used in specific work, the unit weight of concrete used in selecting proportions shall be the median of the range permitted in the work.

5.1.4 The water content and sand content shall be adjusted to obtain a slump of 90 ± 15 mm [3½ ± ½ in.]. The

[5] The sole source of supply of Vinsol resin known to the committee at this time is Hercules Inc., Wilmington, DE. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend. Neutralization may be accomplished by treating 100 parts of the Vinsol resin with 9 to 15 parts of NaOH by weight. In an aqueous solution, the ratio of reagent water (See Specification D1193) to the resinate shall not exceed 12:1 by weight.

workability of the concrete mixture shall be suitable for consolidation by hand rodding and the concrete mixture shall have the minimum water content possible. These conditions shall be achieved by final adjustments in the proportion of fine aggregate to total aggregate, in the amount of total aggregate, or both, while maintaining the yield and slump in the required ranges.

5.2 *Conditions*—Concrete mixtures shall be prepared both with the air-entraining admixture under test and with the reference admixture. For the reference mixture, the reference admixture shall be added in amounts necessary to produce an average air content of 5.5 ± 0.5 %, or within the range permitted for the specific work in accordance with 5.1.3. For the test mixture, the test admixture shall be added in amounts necessary to produce an average air content within 0.5 % of the average air content of the reference mixture.

NOTE 7—As an example, if three batches of the reference mixture have air contents of 5.2, 5.3, and 5.2 %, and three batches of the test mixture have air contents of 5.6, 5.9, and 5.7 %, the reference and test mixtures would be in compliance with Section 5.2 because the average air content of the reference mixture, 5.2 %, falls between 5.5 ± 0.5 %, and the average air content of the test mixture, 5.7 %, is within 0.5 % of the average air content of the reference mixture.

6. Mixing

6.1 Machine mix the concrete as prescribed in Practice C192/C192M.

7. Tests and Properties of Freshly Mixed Concrete

7.1 Test samples of freshly mixed concrete from at least three separate batches for each condition of concrete in accordance with the following methods and the minimum number of tests shall be as prescribed in Table 1.

7.1.1 *Slump*—Test Method C143/C143M.

7.1.2 *Air Content*—Test Method C231. When lightweight aggregates, air-cooled blast furnace slag, or aggregates of high porosity, for which the aggregate correction factor defined in Test Method C231 exceeds 0.5 %, are used under the provisions of 4.4, use Test Method C173/C173M.

7.1.3 *Bleeding*—Test Methods C232.

7.1.4 *Time of Setting*—Test Method C403/C403M, except that the temperature of each of the ingredients of the concrete mixtures, just prior to mixing, and the temperature at which the time of setting specimens are stored during the test period shall be 23.0± 2 °C [73.5 ± 3.5 °F].

8. Preparation of Test Specimens

8.1 Specimens for test of hardened concrete, representing each test and age of test and each condition of concrete being compared, shall be made from at least three separate batches, and the minimum number of specimens shall be as prescribed in Table 1. On a given day at least one specimen shall be made for each test and age of test from each condition of concrete except that at least two specimens for the freezing and thawing test shall be made from each condition of concrete. The preparation of all specimens shall be completed in three days of mixing.

8.2 *Manifestly Faulty Specimens*—Each group of specimens representing a given test or a given age of test, including tests of freshly mixed concrete, shall be examined visually before or during the test, or both, whichever is appropriate. Discard any specimen found to be manifestly faulty by such examination without testing. Visually examine all specimens representing a given test at a given age after testing, and should any specimen be found to be manifestly faulty, the test results thereof shall be disregarded. Should more than one specimen representing a given test at a given age be found manifestly faulty, either before or after testing, the entire test shall be disregarded and repeated. The test result reported shall be the average of the individual test results of the specimens tested or, in the event that one specimen or one result has been discarded, it shall be the average of the test results of the remaining specimens.

9. Test Specimens of Hardened Concrete

9.1 *Number of Specimens*—Make six or more test specimens for the freezing and thawing test and three or more test specimens for each other type of test and age of test specified in Table 1 for each condition of concrete to be compared.

TABLE 1 Types and Minimum Number of Specimens and Tests

Test	Number of Types of Specimens[A]	Number of Test Ages	Number of Conditions of Concrete[B]	Minimum Number of Specimens
Slump	1	1	2	[C]
Air content	1	1	2	[C]
Bleeding	1	1	2	6
Time of setting	1	[D]	2	6
Compressive strength	1	3	2	18
Flexural strength[E]	1	3	2	18
Freezing and thawing	1	1	2	12[F]
Length change[E]	1	1	2	6

[A] See Section 7 and 9.2.
[B] See 4.2.
[C] Determined on each batch of concrete mixed.
[D] See 7.1.4.
[E] Optional tests, see 10.1.5.
[F] Specimens for duplicate tests from each batch.

9.2 *Types of Specimens*—Prepare specimens made from concrete with and without the air-entraining admixture under test in accordance with the following:

9.2.1 *Compressive Strength*—Make and cure test specimens in accordance with Practice C192/C192M.

9.2.2 *Flexural Strength*—Make and cure test specimens in accordance with Practice C192/C192M.

9.2.3 *Resistance to Freezing and Thawing*—Test specimens shall consist of prisms made and cured in accordance with the applicable requirement of Practice C192/C192M. Test specimen dimensions shall be as required by Test Method C666/C666M. Make one set of specimens from the concrete mixture containing the air-entraining admixture under test and from the reference concrete mixture, the air content of each mixture being as specified in 5.2.

9.2.4 *Length Change*—Make and cure test specimens in accordance with Test Method C157/C157M. The moist-curing period, including the period in the molds, shall be 14 days.

10. Tests on Hardened Concrete

10.1 Test specimens of hardened concrete in accordance with the following test methods:

10.1.1 *Compressive Strength*—Test Method C39/C39M. Test specimens at ages of 3, 7, and 28 days. Calculate the compressive strength of the concrete containing the admixture under test as a percentage of the compressive strength of the reference concrete as follows:

10.1.1.1 Divide the average compressive strength of the specimens made from the concrete containing the admixture under test at a given age of test by the average compressive strength of the specimens made from the reference concrete at the same age of test and multiply the quotient by 100.

10.1.2 *Flexural Strength*—Test Method C78. Test specimens at ages 3, 7, and 28 days. Calculate the flexural strength of the concrete containing the admixture under test as a percentage of the flexural strength of the reference concrete as follows:

10.1.2.1 Divide the average flexural strength of the specimens made from the concrete containing the admixture under test at a given age of test by the average flexural strength of the specimens made from the reference concrete at the same age of test, and multiply the quotient by 100.

10.1.3 *Resistance to Freezing and Thawing*—Procedure A of Test Method C666/C666M. Place specimens under test at the age of 14 days.

10.1.4 *Length Change*—Test Method C157/C157M. The drying period shall be 14 days.

10.1.5 The flexural strength and length change tests are applicable only when specifically required by the purchaser.

11. Check Tests for Uniformity

11.1 The check tests enumerated in Specification C260 in the section on Optional Uniformity Requirements shall be determined as follows:

11.1.1 *pH*—The pH of liquid air-entraining admixtures shall be determined in accordance with Test Method E70. Non-liquid admixtures shall be prepared in solution to determine pH. Unless there is reason to do otherwise, dissolve the material in reagent water in the proportions specified for job use as shown on the package or in other manufacturer's instructions.

11.1.2 *Air Content of Mortar*—Using the same amounts of successive lots of air-entraining admixtures with the same cement, determine the air contents of mortars in accordance with Test Method C185. The air-entraining admixture shall be combined with the mixing water prior to the start of the mixing procedure. The determinations for both the check test sample and acceptance sample shall be made on the same day.

12. Procedure for Residue by Oven Drying

12.1 Determine the mass of an aluminum dish (about 60 mm diameter, 15 mm height, and about 1 g in weight) to the nearest 0.0001 g. Using a pipet, evenly distribute 1 mL of the liquid air entraining admixture in the dish, and weigh to the nearest 0.0001 g. Place the weighing dish in a drying oven (12.2). Dry for 25 ± 2 min at 125 ± 1 °C. At the end of the drying period transfer the weighing dish to a desiccator, cool to room temperature, and weigh to the nearest 0.0001 g.

12.2 The drying oven shall be either a forced circulation type or one with provision for free access of air. There shall be precise control of temperature and time of drying so that the degree of volatilization of the material other than water from sample to sample will not vary.

12.3 *Calculation:*

12.3.1 Record the following weights:

M_1 = mass of weighing dish and admixture prior to heating,
M_2 = mass of empty weighing dish,
M_3 = $M_1 - M_2$ = mass of sample,
M_4 = mass of weighing dish and dried residue, and
M_5 = $M_4 - M_2$ = mass of dried residue.

12.3.2 Calculate the residue by using the following equation:

$$\text{Residue by oven drying (\% by mass)} = (M_5 \times 100)/M_3 \quad (1)$$

13. Report

13.1 Report the following information:

13.1.1 Results of the tests specified in this method as compared with the requirements of Specification C260,

13.1.2 Brand name, manufacturer's name and lot number, character of the material, and quantity represented by the sample of the admixture under test,

13.1.3 Brand name, manufacturer's name, and other data on the reference admixture,

13.1.4 Brand name, manufacturer's name, type, and test data on the portland cement or cements used,

13.1.5 Description of, and test data on the fine and coarse aggregates used,

13.1.6 Detailed data on the concrete mixtures used, including amounts and proportions of admixtures used, actual cement factors, water-cement ratios, ratios of fine to total aggregate, consistency, and air content.

13.1.7 In reporting on check tests for uniformity, report both the initial and current air contents of mortar for the acceptance sample, and the air content of the check test sample, all as determined by Test Method C185.

14. Precision and Bias[6]

14.1 *Precision:*

14.1.1 The single-laboratory coefficient of variation of residue by oven drying has been found to be 0.79 %. Therefore, the results of two properly conducted tests on the same material in the same laboratory are not expected to differ by more than 2.24 % of their average.[7]

NOTE 8—As an example, two tests conducted on the same material yield residues by oven drying of 6.14 % and 6.04 %, respectively. The average of these two measurements is 6.09 %. The acceptable range of results is then 2.24 % of 6.09 % or ±0.136 %. As the difference between 6.14 % and 6.04 % is 0.10 % the results are within the acceptable range.

14.1.2 The multilaboratory coefficient of variation of residue by oven drying has been found to be 2.35 %. Therefore, the results of two properly conducted tests on the same material in different laboratories are not expected to differ by more than 6.65 % of their average.[7]

14.1.3 Other procedures referenced in this test method use results obtained from other ASTM test methods listed in Section 2. These documents are to be referred to for their respective precision statements.

14.2 *Bias*—Since there is no accepted reference material suitable for determining the bias of this test method, no statement on bias is made.

15. Keywords

15.1 air content; air-entraining admixture; cement; concrete; pH; residue; specific gravity

[6] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C09-1005.

[7] These numbers represent, respectively, the (1s %) and (d2s %) limits as described in Practice C670.

SUMMARY OF CHANGES

Committee C09 has identified the location of selected changes to this test method since the last issue, C233/C233M–11, that may impact the use of this test method. (Approved October 1, 2014)

(1) Note 7 has been added after 5.2 to further clarify that it is the average air contents of the reference and test mixtures that are to be compared to verify compliance with the requirement in 5.2.