Designation: C 226 – 02

Standard Specification for Air-Entraining Additions for Use in the Manufacture of Air-Entraining Hydraulic Cement[1]

This standard is issued under the fixed designation C 226; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers the requirements and methods for establishing the suitability of a material for use as an air-entraining addition to be interground with the clinker in the manufacture of air-entraining hydraulic cement conforming to Specifications C 150, C 595, and C 1157.

1.2 The values stated in SI units are to be regarded as the standard.

1.3 *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.* (**Warning—**Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.[2])

2. Referenced Documents

2.1 *ASTM Standards:*

C 33 Specification for Concrete Aggregates[3]

C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens[3]

C 109/C 109M Test Method for Compressive Strength of Hydraulic-Cement Mortars (Using 2-in. or 50-mm Cube Specimens)[4]

C 114 Test Methods for Chemical Analysis of Hydraulic Cement[4]

C 115 Test Method for Fineness of Portland Cement by the Turbidimeter[4]

C 138 Test Method for Density, (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete[3]

C 143 Test Method for Slump of Hydraulic Cement Concrete[3]

C 150 Specification for Portland Cement[4]

C 151 Test Method for Autoclave Expansion of Portland Cement[4]

C 175 Specifications for Air-Entraining Portland Cement[5]

C 185 Test Method for Air Content of Hydraulic Cement Mortar[4]

C 187 Test Method for Normal Consistency of Hydraulic Cement[4]

C 191 Test Method for Time of Setting of Hydraulic Cement by Vicat Needle[4]

C 192 Practice for Making and Curing Concrete Test Specimens in the Laboratory[3]

C 204 Test Method for Fineness of Hydraulic Cement by Air Permeability Apparatus[4]

C 231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method[3]

C 293 Test Method for Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading)[3]

C 595 Specification for Blended Hydraulic Cements[4]

C 596 Test Method for Drying Shrinkage of Mortar Containing Hydraulic Cement[4]

C 666 Test Method for Resistance of Concrete to Rapid Freezing and Thawing[3]

C 1157 Performance Specification for Hydraulic Cement[4]

2.2 *ACI Standards:*[6]

ACI 211.1-77 Recommended Practice for Selecting Proportions for Normal and Heavyweight Concrete

3. Materials

3.1 *Cements*:

3.1.1 In cases where it is desired that the proposed air-entraining addition be accepted for general use, tests shall be made on six lots of cement ground at cement plants, using commercial grinding equipment. From each of three different samples of clinkers, two lots of cement shall be ground, representing respectively: a Type I portland cement containing not less than 9 % tricalcium aluminate (C_3A), calculated as specified in Table 1 of Specification C 150 and a Type II and a Type III portland cement conforming to Specification C 150.

[1] This specification is under the jurisdiction of ASTM Commitee C01 on Cement and is the direct responsibility of Subcommittee C01.20 on Additions.

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[2] See the section on Safety, Manual of Cement Testing, *Annual Book of ASTM Standards*, Vol 04.01.

[3] *Annual Book of ASTM Standards,* Vol 04.02.

[4] *Annual Book of ASTM Standards,* Vol 04.01.

[5] Discontinued, see 1949 *Annual Book of ASTM Standards*, Part 3.

[6] Available from the American Concrete Institute, P.O. Box 19150, Detroit, MI 48219.

One lot, the "control" shall be ground without the proposed air-entraining addition; the proposed addition shall be interground with the other lot, using the addition in such amounts as to produce the air/entrainment required in Specification C 150. Not more than two of the three clinkers shall be produced by or ground at the same mill.

3.1.2 In cases where it is desired that the proposed air-entraining addition be limited in use to specific types of cement in specific cement manufacturing plants, either or both less in number than required in 3.1.1, the tests and test procedure shall be as specified in 3.1.1, except that the number of cements to be tested shall be limited to those under specific consideration.

3.1.3 The two companion cements made from any one clinker shall be ground to the same fineness (within 50 cm^2/g) as measured by the turbidimeter test (7.1.3) or (within 100 cm^2/g) as measured by the air permeability apparatus, and the sulfur trioxide (SO_3) content expressed as a percentage of the cement weight and reported to the nearest 0.01 %, shall differ by no more than 0.24 for all types of cement. Each "control" cement shall comply with all of the requirements applicable to that type of cement, as prescribed in Specification C 150.

3.1.4 The percentage of each of the following constituents shall be determined for each lot of cement tested: silicon dioxide (SiO_2), aluminum oxide (Al_2O_3), iron oxide (Fe_2O_3), calcium oxide (CaO), magnesium oxide (MgO), SO_3, ignition loss, insoluble residue, sodium oxide (Na_2O), and potassium oxide (K_2O). There shall also be calculated the potential percentages of the following compounds: tricalcium silicate, dicalcium silicate, tricalcium aluminate, and tetracalcium aluminoferrite. Determinations for the percentage of addition shall be made on the cements containing the addition, using the method proposed therefore by the maker or seller of the addition.

3.2 *Aggregates*:

3.2.1 The fine and coarse aggregates used in the tests shall conform to the requirements of Specification C 33, except that the grading of the aggregates shall conform to the requirements given in Table 1.

3.2.2 The coarse aggregate shall be carefully separated on the 25.0-mm (1-in.), 19.0-mm (¾-in.), 12.5-mm (½-in.), 9.5-mm (⅜-in.), and 4.75-mm (No. 4) sieves, and then recombined, using equal quantities by weight of each of the resulting four sizes.

3.2.3 The fine and coarse aggregates used in the tests of any two companion cements (that is, a cement containing the addition and the corresponding "control" cement) shall each come from a single lot of such aggregate.

TABLE 1 Grading Requirements of Aggregates

Sieve	Percentage Passing
Fine Aggregate	
4.75-mm (No. 4)	100
1.18-mm (No.16)	65 to 75
300-µm (No. 50)	15 to 20
150-µm (No. 100)	2 to 5
Coarse Aggregate	
25.0-mm (1-in.)	100
19.0-mm (¾-in.)	75
12.5-mm (½-in.)	50
9.5-mm (⅜-in.)	25
4.75-mm (No.4)	0

3.3 *Reference Addition*:

3.3.1 The reference addition used in the concrete mixture specified in Section 8, from which specimens will be made for tests for resistance to freezing and thawing as specified in 10.2.3, shall be any one of the four materials (Vinsol resin, Darex, N-TAIR, or Airalon) that have been declared acceptable by ASTM under the former Specifications C 175 – 48 T.

3.3.2 The reference addition to be used will be designated by the person or agency for whom the testing will be performed. If no reference addition is designated, the material known commercially as "Vinsol resin" shall be used. The Vinsol resin used shall be neutralized with 15 percent by mass of sodium hydroxide (NaOH). The air contents of the concrete containing the reference addition and the concrete containing the proposed addition shall agree within 0.5 percentage points.

3.3.3 The reference addition, used as an admixture, is intended for use with control cements only in concrete for freezing-and-thawing tests to establish the durability factor by means of which the concretes containing the addition under test may be evaluated.

3.3.4 *Preparation of Standard Reference Solutions*:

3.3.4.1 Place 50 g (total solids in the case of solution or pastes) of the designated reference addition in 500 mL of freshly distilled water in a 1000-mL flask and mix thoroughly until the solids are completely dissolved or the paste or solution is uniformly diluted. After surface foam has been dissipated, dilute to 1000 mL and mix thoroughly.

3.3.4.2 In the case of Vinsol resin, the neutralized solution shall be made as follows: Dissolve 7.50 g of cp NaOH in 100 mL of distilled water. Add a few drops of this solution to 300 to 350 mL of distilled water contained in a 600-mL beaker. Add 50.00 g of dry, unneutralized Vinsol resin in pulverized form to the beaker and stir until all of the resin is wetted and well dispersed. Then add all of the NaOH solution to this suspension and stir until all of the resin is in solution. Transfer to a measuring flask, dilute to 1000 mL and mix thoroughly. From this stock standard solution prepare a dilute standard solution by diluting 100 mL of the stock solution to 1000 mL.

4. General Requirements

4.1 Air-entraining additions shall conform to the respective requirements prescribed in this specification.

4.2 The trade name, source, and character of the material, and means for the quantitative identification of the proposed addition in the finished cement, shall be furnished by the maker or seller of the addition, and that information shall form a part of the record of tests of the addition.

4.3 Air-entraining additions shall be evaluated by testing cements ground with and without the additions. The cements ground without the additions shall be referred to in this specification as "control" cements.

4.4 An air-entraining addition under this specification, when interground with hydraulic cement, shall produce a cement that complies with the appropriate Specifications C 150, C 595, or C 1157 and when evaluated by the results of tests made according to the procedures herein described, shall also comply