



## Standard Specification for Air-Entraining Additions for Use in the Manufacture of Air-Entraining Hydraulic Cement<sup>1</sup>

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*This specification has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by 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.

### 2. Referenced Documents

#### 2.1 ASTM Standards:

- C 33 Specification for Concrete Aggregates<sup>2</sup>
- C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens<sup>2</sup>
- C 109 Test Method for Compressive Strength of Hydraulic-Cement Mortars (Using 2-in. or 50-mm Cube Specimens)<sup>3</sup>
- C 114 Test Methods for Chemical Analysis of Hydraulic Cement<sup>3</sup>
- C 115 Test Method for Fineness of Portland Cement by the Turbidimeter<sup>3</sup>
- C 138 Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete<sup>2</sup>
- C 143 Test Method for Slump of Hydraulic Cement Concrete<sup>2</sup>
- C 150 Specification for Portland Cement<sup>3</sup>
- C 151 Test Method for Autoclave Expansion of Portland Cement<sup>3</sup>
- C 175 Specifications for Air-Entraining Portland Cement<sup>4</sup>
- C 185 Test Method for Air Content of Hydraulic Cement Mortar<sup>3</sup>
- C 187 Test Method for Normal Consistency of Hydraulic Cement<sup>3</sup>
- C 191 Test Method for Time of Setting of Hydraulic Cement by Vicat Needle<sup>3</sup>
- C 192 Practice for Making and Curing Concrete Test Specimens in the Laboratory<sup>2</sup>
- C 204 Test Method for Fineness of Portland Cement by Air Permeability Apparatus<sup>3</sup>

C 231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method<sup>2</sup>

C 293 Test Method for Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading)<sup>2</sup>

C 595/C 595M Specification for Blended Hydraulic Cements<sup>3</sup>

C 596 Test Method for Drying Shrinkage of Mortar Containing Portland Cement<sup>3</sup>

C 666 Test Method for Resistance of Concrete to Rapid Freezing and Thawing<sup>2</sup>

C 1157 Performance Specification for Blended Hydraulic Cement<sup>3</sup>

#### 2.2 ACI Standards:<sup>5</sup>

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

### 3. General Requirements

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

3.2 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.

3.3 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.

3.4 An air-entraining addition under this specification, when interground with hydraulic cement, shall produce a cement that complies with the appropriate Specification 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 with the following requirements as to the effect of the addition on the properties of the cement:

3.4.1 The time of setting of cement containing the addition shall not vary from the time of setting of the respective "control" cement by more than 50 %.

3.4.2 The percentage autoclave expansion for cement containing the addition shall not exceed the percentage autoclave expansion for the corresponding "control" cement by more than 0.1.

3.4.3 The compressive strength of standard mortar cubes made with cement containing the addition shall be not less

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<sup>2</sup> Annual Book of ASTM Standards, Vol 04.02.

<sup>3</sup> Annual Book of ASTM Standards, Vol 04.01.

<sup>4</sup> Discontinued, see 1949 Annual Book of ASTM Standards, Part 3.

<sup>5</sup> Available from the American Concrete Institute, P.O. Box 19150, Detroit, MI 48219.

than 80 % of the compressive strength of similar cubes made with the corresponding "control" cement.

3.4.4 The percentage length change of air-stored mortar bars made with cement containing the addition, based on an initial measurement at the age of 7 days, and expressed as a percentage change in length, shall be not more than 0.01 greater than that of similar mortar bars made with the corresponding "control" cement and similarly tested.

3.4.5 The percentage of air entrained in the concrete made with cement containing the addition shall exceed by at least 2.5 the percentage air in similar concrete prepared with the corresponding "control" cement. (See 4.1.1 for the limitation of air-entraining properties of the "control" cement.)

3.4.6 The compressive strength of the concrete made with cement containing the addition shall be not less than 80 % of the compressive strength of similar concrete made with the corresponding "control" cement.

3.4.7 The flexural strength of concrete made with cement containing the addition shall be not less than 85 % of the flexural strength of corresponding concrete made with the "control" cement.

3.4.8 In the freezing and thawing test, the durability factor of the concrete made with the cement containing the proposed addition shall be not less than 80 % of the durability factor of similar concrete made with the corresponding "control" cement and containing the reference addition as specified in 4.3. (See 11.1.3 for the method of calculating the durability factor.)

#### 4. Materials

##### 4.1 Cements:

4.1.1 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. 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.

4.1.2 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 4.1.1, the tests and test procedure shall be as specified in 4.1.1, except that the number of cements to be tested shall be limited to those under specific consideration.

4.1.3 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.

4.1.4 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.

##### 4.2 Aggregates:

4.2.1 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.

4.2.2 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.

4.2.3 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.

##### 4.3 Reference Addition:

4.3.1 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.

4.3.2 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.

4.3.3 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.

##### 4.3.4 Preparation of Standard Reference Solutions:

4.3.4.1 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.

4.3.4.2 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