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Standard Specification for Blended Hydraulic Cements¹

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

1. Scope

1.1 This specification pertains to five classes of blended hydraulic cements for both general and special applications, using slag or pozzolan, or both, with portland cement or portland cement clinker or slag with lime.

NOTE 1—This specification prescribes ingredients and proportions, with some performance requirements whereas Performance Specification C 1157 is a blended cement specification in which performance criteria alone govern the products and their acceptance.

1.2 For properties where values are given in both SI and non SI units, the values in SI units are to be regarded as the standard. Values in SI units shall be obtained by measurement in SI units or by appropriate conversion, using the Rules for Conversion and Rounding given in Standard IEEE/ASTM SI 10, of measurements made in other units.

1.3 The text of this standard refers to notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) are not requirements of the standard.

2. Referenced Documents

2.1 ASTM Standards:

- C 109/C 109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)²
- C 114 Test Methods for Chemical Analysis of Hydraulic Cement²
- C 150 Specification for Portland Cement²
- C 151 Test Method for Autoclave Expansion of Portland Cement²
- C 157 Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete³
- C 183 Practice for Sampling and the Amount of Testing of Hydraulic Cement²
- C 185 Test Method for Air Content of Hydraulic Cement Mortar²

- C 186 Test Method for Heat of Hydration of Hydraulic Cement²
- C 187 Test Method for Normal Consistency of Hydraulic Cement²
- C 188 Test Method for Density of Hydraulic Cement²
- C 191 Test Method for Time of Setting of Hydraulic Cement by Vicat Needle²
- C 204 Test Method for Fineness of Hydraulic Cement by Air Permeability Apparatus²
- C 219 Terminology Relating to Hydraulic Cement²
- C 226 Specification for Air-Entraining Additions for Use in the Manufacture of Air-Entraining Portland Cement²
- C 227 Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)³
- C 265 Test Method for Water-Extractable Sulfate in Hydrated Hydraulic Cement Mortar²
- C 430 Test Method for Fineness of Hydraulic Cement by the 45- μ m (No. 325) Sieve²
- C 465 Specification for Processing Additions for Use in the Manufacture of Hydraulic Cements²
- C 563 Test Method for Optimum SO₃ in Hydraulic Cement Using 24-h Compressive Strength²
- C 688 Specification for Functional Additions for Use in Hydraulic Cements²
- C 821 Specification for Lime for Use with Pozzolans²
- C 1012 Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution²
- C 1157 Performance Specification for Hydraulic Cement²
- IEEE/ASTM SI 10 Standard for Use of the International System of Units (SI): the Modern Metric System⁴

3. Terminology

3.1 *Definitions*—The terms used in this specification are defined in Terminology C 219.

4. Classification

4.1 This specification applies to the following types of blended cement that generally are intended for use as indicated.

4.1.1 Blended hydraulic cements for general concrete construction.

4.1.1.1 Type IS—Portland blast-furnace slag cement.

¹ This specification is under the jurisdiction of ASTM Committee C01 on Cement and is the direct responsibility of Subcommittee C01.10 on Hydraulic Cements for General Concrete Construction.

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² *Annual Book of ASTM Standards*, Vol 04.01.

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

⁴ *Annual Book of ASTM Standards*, Vol 14.04.

4.1.1.2 Type IP—Portland-pozzolan cement.

4.1.1.3 Type P—Portland-pozzolan cement for use when higher strengths at early ages are not required.

4.1.1.4 Type I(PM)—Pozzolan—modified portland cement.

NOTE 2—Pozzolan-modified portland cement should not be used when special characteristics attributable to the larger quantities of pozzolan in portland-pozzolan cement are desired.

4.1.1.5 Type I(SM)—Slag-modified portland cement.

NOTE 3—Slag-modified portland cement should not be used when special characteristics attributable to the larger quantities of slag in portland blast-furnace slag cements are desired.

4.1.2 Type S—Slag cement for use in combination with portland cement in making concrete and in combination with hydrated lime in making masonry mortar.

4.2 Special Properties:

4.2.1 Air-entraining cement, when desired by the purchaser, shall be specified by adding the suffix (A) to any of the above types. The air-entraining option may be specified in combination with any of the other special properties.

NOTE 4—A given mass of blended cement has a larger absolute volume than the same mass of portland cement. This should be taken into consideration in purchasing cements and in proportioning concrete mixtures.

4.2.2 Moderate sulfate resistance or moderate heat of hydration, or both, when desired by the purchaser, shall be specified by adding the suffix (MS) or (MH), respectively, to the type designation under 4.1.1.

5. Ordering Information

5.1 Orders for material under this specification shall include the following:

5.1.1 Specification number,

5.1.2 Type or types required,

5.1.3 Optional special properties required (see 4.2):

5.1.3.1 MS if moderate sulfate resistance is required;

5.1.3.2 MH if moderate heat of hydration is required;

5.1.3.3 LH if low heat of hydration is required, (Type P only);

5.1.3.4 A if air entraining is required;

5.1.3.5 Accelerating addition, if required;

5.1.3.6 Retarding addition, if required;

5.1.3.7 Water reducing addition, if required;

5.1.3.8 Water reducing and accelerating addition, if required; and

5.1.3.9 Water reducing and retarding addition, if required.

5.1.4 Certification, if desired (see Section 14).

NOTE 5—It is important to check for availability of various options. Some multiple options are mutually incompatible or unattainable.

6. Materials and Manufacture

6.1 *Portland Blast-Furnace Slag Cement*—The portland blast-furnace slag cement shall consist of an intimate and uniform blend (see Note 6) of portland cement and fine granulated blast-furnace slag produced either by intergrinding portland cement clinker and granulated blast-furnace slag, or by blending portland cement and finely ground granulated blast-furnace slag, or a combination of intergrinding and

blending, in which the slag constituent is between 25 and 70 % of the mass of portland blast-furnace slag cement.

NOTE 6—The attainment of an intimate and uniform blend of two or more types of fine materials is difficult. Consequently, adequate equipment and controls must be provided by the manufacturer. The purchaser should assure himself of the adequacy of the blending operation.

6.2 *Air-Entraining Portland Blast-Furnace Slag Cement*—Air-entraining portland blast-furnace slag cement shall be portland blast-furnace slag cement to which sufficient air-entraining addition has been added so that the resulting product complies with the air content of mortar requirements.

6.3 *Slag-Modified Portland Cement*—Slag-modified portland cement shall be an intimate and uniform blend of portland cement and granulated blast-furnace slag produced either by intergrinding portland cement clinker and granulated blast-furnace slag (see Note 6), by blending portland cement and finely ground granulated blast-furnace slag, or a combination of intergrinding and blending in which the slag constituent is less than 25 % of the mass of the slag-modified portland cement.

6.4 *Air-Entraining Slag-Modified Portland Cement*—Air-entraining slag-modified portland cement shall be slag-modified portland cement to which sufficient air-entraining addition has been added so that the resulting product complies with the air content of mortar requirements.

6.5 *Blast-Furnace Slag*—Blast-Furnace slag shall be the nonmetallic product, consisting essentially of silicates and aluminosilicates of calcium and other bases, that is developed in a molten condition simultaneously with iron in a blast furnace.

6.6 *Granulated Blast-Furnace Slag*—Granulated blast-furnace slag shall be the glassy granular material formed when molten blast-furnace slag is rapidly chilled, as by immersion in water.

6.7 *Portland Cement*—See Terminology C 219. For purposes of this specification, portland cement meeting the requirements of Specification C 1157 or Specification C 150 are suitable. Portland cement or other hydraulic materials, or both, containing high free lime may be used as long as the autoclave test limits for the blended cement are met.

6.8 *Portland Cement Clinker*—Portland cement clinker shall be partially fused clinker consisting primarily of hydraulic calcium silicates.

6.9 *Portland-Pozzolan Cement*—Portland-pozzolan cement shall be a hydraulic cement consisting of an intimate and uniform blend (see Note 6) of portland or portland blast-furnace slag cement and fine pozzolan produced either by intergrinding portland cement clinker and pozzolan, by blending portland cement or portland blast-furnace slag cement and finely divided pozzolan, or a combination of intergrinding and blending, in which the pozzolan constituent is between 15 and 40 mass % of the portland-pozzolan cement.

6.10 *Air-Entraining Portland-Pozzolan Cement*—Air-entraining portland-pozzolan cement shall be portland-pozzolan cement to which sufficient air-entraining addition has been added so that the resulting product complies with the air content of mortar requirements.

6.11 *Pozzolan-Modified Portland Cement*—Pozzolan-modified portland cement shall be an intimate and uniform blend (see Note 6) of portland cement or portland blast-furnace slag cement and fine pozzolan produced either by intergrinding portland cement clinker and pozzolan, by blending portland cement or portland blast-furnace slag cement and finely divided pozzolan, or a combination of intergrinding and blending, in which the pozzolan constituent is less than 15 mass % of the pozzolan-modified portland cement.

6.12 *Air-Entraining Pozzolan-Modified Portland Cement*—Air-entraining pozzolan-modified portland cement shall be pozzolan-modified portland cement to which sufficient air-entraining addition has been added so that the resulting product complies with the air content of mortar requirements.

6.13 *Pozzolan*—Pozzolan shall be a siliceous or siliceous and aluminous material, which in itself possesses little or no cementitious value but which will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties.

6.14 *Slag Cement*—Slag cement shall be hydraulic cement consisting mostly of an intimate and uniform blend (see Note 6) of granulated blast-furnace slag and portland cement, or hydrated lime, or both, in which the slag constituent is at least 70 % of the mass of the slag cement.

6.15 *Air-Entraining Slag Cement*—Air-entraining slag cement shall be slag cement to which sufficient air-entraining addition has been added so that the resulting product complies with the air content of mortar requirements.

6.16 *Hydrated Lime*—Hydrated lime used as part of a blended cement shall meet the requirements of Specification C 821, except that when interground in the production process there shall be no minimum fineness requirement.

6.17 *Air-Entraining Addition*—When air-entraining cement is specified, an addition meeting the requirements of Specification C 226 shall be used.

6.18 When processing additions are used in the manufacture of cement, they shall have been shown to meet the requirements of Specification C 465 in the amounts used or greater, (see Section 14.2).

6.19 When functional additions (used at the sole option of the purchaser, and in amounts not to exceed 0.50 % by mass of the cement) are used they shall have been shown to meet the requirements of Specification C 688 when tested with the cement to be used, in the amount used or greater, (see Section 14.2 and Note 7).

NOTE 7—The 0.50 % by mass is an arbitrarily selected value.

6.20 *Other Additions*—The cement covered by this specification shall contain no additions except as provided for above except that water or calcium sulfate (see Terminology C 219), or both, may be added in amounts so that the limits shown in Table 1 for sulfate reported as SO₃ and loss on ignition are not exceeded.

7. Chemical Composition

7.1 Cement of the type specified shall conform to the applicable chemical requirements prescribed in Table 1.

7.2 If the purchaser has requested the manufacturer to state

TABLE 1 Chemical Requirements

Cement Type	Applicable Test Method	I(SM), I(SM)-A, IS, IS-A	S, SA	I(PM), I(PM)-A, P, PA, IP, IP-A
Magnesium oxide (MgO), max, %	C 114	6.0
Sulfur reported as sulfate (SO ₃), max, % ^A	C 114	6.0
Sulfide sulfur (S), max, %	C 114	3.0	4.0	4.0
Insoluble residue, max, %	C 114	2.0	2.0	...
Loss on ignition, max, %	C 114	1.0	1.0	...
Water-soluble alkali, max, %	C 114	3.0	4.0	5.0
	C 114	...	0.03 ^B	...

^A When it has been demonstrated by Test Method C 563 that the optimum SO₃ exceeds a value 0.5 % less than the specification limit, an additional amount of SO₃ is permissible provided that, when the cement with the additional calcium sulfate is tested by Test Method C 265, the calcium sulfate in the hydrated mortar at 24 ± ¼ h, expressed as SO₃, does not exceed 0.50 g/L. When the manufacturer supplies cement under this provision, he will, upon request, supply supporting data to the purchaser.

^B Applicable only when the cement is specified to be nonstaining to limestone. The amount and nature of the staining material in limestone vary with the stone. The alkali in any cement may, therefore, induce markedly different staining on different stone, even though the stone may have come apparently from the same source. The amount of alkali permitted by the specification should not cause stain unless stone high in staining material has been used, or unless insufficient means have been used to prevent infiltration of water into the masonry.

in writing the composition of the blended cement purchased, the composition of the cement furnished shall conform to that shown in the statement within the following tolerances (see Note 8).

	Tolerance, ± %
Silicon dioxide (SiO ₂)	3
Aluminum oxide (Al ₂ O ₃)	2
Calcium oxide (CaO)	3

NOTE 8—This means that if the manufacturer's statement of the composition says "SiO₂: 32 %," the cement when analyzed, shall be found to contain between 29 and 35 % SiO₂.

8. Physical Properties

8.1 *Blended Cement*—Blended cement of the type specified shall conform to the applicable physical requirements prescribed in Table 2.

8.2 *Pozzolan or Slag*—Pozzolan or slag that is to be blended with cement shall be tested in the same state of subdivision as that in which it is to be blended. Pozzolan shall conform to the fineness requirement and the pozzolanic activity requirement of Table 3. Slag that is to be used for slag-modified portland cements shall conform to the slag activity requirement of Table 3. Such pozzolan or slag that is to be interground with portland cement clinker shall, before testing for conformance with requirements of Table 3, be ground in the laboratory to a fineness at which it is believed to be present in the finished cement. It is the manufacturer's responsibility to decide on the fineness at which the testing is to be carried out, and when requested to do so by a purchaser, to report the information upon which the decision was based.

8.3 Pozzolan for use in the manufacture of pozzolan-modified portland cement, Type I(PM) and I(PM)-A, shall meet the requirements of Table 3 when tested for mortar expansion of pozzolan as described in 10.1.13. If the alkali content of the clinker to be used for the production lots changes by more than 0.2 % total as equivalent Na₂O, calculated as Na₂O + 0.658 K₂O, from that of the clinker with which the