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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 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 hydraulic 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:²

- C 109/C 109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)
- C 114 Test Methods for Chemical Analysis of Hydraulic Cement
- C 150 Specification for Portland Cement
- C 151 Test Method for Autoclave Expansion of Hydraulic Cement
- C 157/C 157M Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
- C 183 Practice for Sampling and the Amount of Testing of Hydraulic Cement
- C 185 Test Method for Air Content of Hydraulic Cement Mortar
- C 186 Test Method for Heat of Hydration of Hydraulic Cement
- C 187 Test Method for Normal Consistency of Hydraulic Cement
- C 188 Test Method for Density of Hydraulic Cement
- C 191 Test Methods for Time of Setting of Hydraulic Cement by Vicat Needle
- C 204 Test Methods for Fineness of Hydraulic Cement by Air-Permeability Apparatus
- C 219 Terminology Relating to Hydraulic Cement
- C 226 Specification for Air-Entraining Additions for Use in the Manufacture of Air-Entraining Hydraulic Cement
- C 227 Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)
- C 265 Test Method for Water-Extractable Sulfate in Hydrated Hydraulic Cement Mortar
- C 311 Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete
- C 430 Test Method for Fineness of Hydraulic Cement by the 45- μ (No. 325) Sieve
- C 465 Specification for Processing Additions for Use in the Manufacture of Hydraulic Cements
- C 563 Test Method for Approximation of Optimum SO₃ in Hydraulic Cement Using Compressive Strength
- C 688 Specification for Functional Additions for Use in Hydraulic Cements
- C 821 Specification for Lime for Use with Pozzolans
- C 1012 Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution
- C 1157 Performance Specification for Hydraulic Cement
- IEEE/ASTM SI 10 Standard for Use of the International System of Units (SI): the Modern Metric System

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 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. 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.

4.1.1.2 Type IP—Portland-pozzolan cement.

4.2 *Reporting*:

4.2.1 The naming practice for blended cements shall be made by adding the suffix (X) to the type designation under 4.1.1. Where (X) equals the targeted percentage of slag or pozzolan in the product expressed as a whole number by mass of the final blended product, within the allowable variation as stated in 14.3.

4.3 *Special Properties*:

4.3.1 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 is specified in combination with any of the other special properties where required.

NOTE 2—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.

4.3.2 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.

4.3.3 High sulfate resistance, when desired by the purchaser, shall be specified by adding the suffix (HS) to the type designation under 4.1.1.

NOTE 3—Special characteristics attributable to slag or pozzolan will vary based on quantities contained within the blended cements.

4.3.4 Low heat of hydration, when desired by the purchaser, shall be specified by adding the suffix (LH) 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,

5.1.2.1 Indicate allowable slag or pozzolan % maximum or minimum, or both, if required.

5.1.3 Optional special properties required (see 4.3):

5.1.3.1 MS if moderate sulfate resistance is required;

5.1.3.2 HS if high sulfate resistance is required;

5.1.3.3 MH if moderate heat of hydration is required;

5.1.3.4 LH if low heat of hydration is required;

5.1.3.5 A if air entraining is required;

5.1.3.6 Accelerating addition, if required;

5.1.3.7 Retarding addition, if required;

5.1.3.8 Water reducing addition, if required;

5.1.3.9 Water reducing and accelerating addition, if required; and

5.1.3.10 Water reducing and retarding addition, if required.

5.1.4 Certification, if desired (see Section 14).

NOTE 4—It is important to check for availability of various options. Some multiple options are mutually incompatible or unattainable.

6. Materials and Manufacture

6.1 *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.

6.2 *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.

6.3 *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 are not prohibited from use as long as the autoclave test limits for the blended cement are met.

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

6.5 *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.

6.6 *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.

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

6.8 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).

~~6.9 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~~

6.9 When functional additions (used at the sole option of the purchaser) 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 5).

~~NOTE 5—The 0.50% by mass is an arbitrarily selected value.~~

6.10 *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, if added, shall be in amounts so that the limits shown in Table 1 for sulfate reported as SO₃ and loss on ignition are not exceeded.

6.11 *Portland Blast-Furnace Slag Cement*—The portland blast-furnace slag cement shall consist of an intimate and uniform blend (see ~~Note 6~~ Note 5) 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 up to 95 % of the mass of portland blast-furnace slag cement. Portland blast-furnace slag cement with a slag content equal to or exceeding 70 % by mass [IS(≥ 70)] is permitted to contain hydrated lime.

~~NOTE 6—The 5—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 purchasers should assure themselves of the adequacy of the blending operation.~~

6.12 *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.

6.13 *Portland-Pozzolan Cement*—Portland-pozzolan cement shall be a hydraulic cement consisting of an intimate and uniform blend (see ~~Note 6~~ Note 5) 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 up to 40 mass % of the portland-pozzolan cement.

6.14 *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.

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 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 7~~ Note 6).

TABLE 1 Chemical Requirements

Cement Type ^A	Applicable Test Method	IS (< 70)	IS (≥ 70)	IP
Magnesium oxide (MgO), max, %	C 114	...	...	6.0
Sulfate reported as SO ₃ , max, % ^B	C 114	3.0	4.0	4.0
Sulfide reported as S ²⁻ , max, %	C 114	2.0	2.0	...
Insoluble residue, max, %	C 114	1.0	1.0	...
Loss on ignition, max, %	C 114	3.0	4.0	5.0

^AThe chemical requirements in this table are applicable to all air-entrained cement equivalents.

^B 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.

Tolerance, ± %

Silicon dioxide (SiO ₂)	3
Aluminum oxide (Al ₂ O ₃)	2
Calcium oxide (CaO)	3

NOTE 7—This 6—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

TABLE 2 Physical Requirements

Cement Type ^A	Applicable Test Method	IS (< 70), IP	IS (< 70) (MS) IP (MS)	IS (< 70) (HS) IP (HS)	IS (≥ 70)	IP (LH) ^B
Fineness	C 204, C 430	<i>c</i>	<i>c</i>	<i>c</i>	<i>c</i>	<i>c</i>
Autoclave expansion, max, %	C 151	0.80	0.80	0.80	0.80	0.80
Autoclave contraction, max, % ^D	C 151	0.20	0.20	0.20	0.20	0.20
Time of setting, Vicat test: ^E	C 191					
Set, minutes, not less than		45	45	45	45	45
Set, hours, not more than		7	7	7	7	7
Air content of mortar, volume % ^A	C 185	12 max	12 max	12 max	12 max	12 max
Air content of mortar, volume %, max ^A	C 185	12	12	12	12	12
Compressive strength, min ^A , MPa (psi):	C 109/C 109M					
3 days		13.0 (1890)	11.0 (1600)	11.0 (1600)	...	...
7 days		20.0 (2900)	18.0 (2610)	18.0 (2610)	5.0 (720)	11.0 (1600)
28 days		25.0 (3620) (3620)	25.0 (3620) (3620)	25.0 (3620) (3620)	11.0 (1600) (1600)	21.0 (3140) (3050)
Heat of hydration: ^F	C 186					
Heat of hydration, max, kJ/kg (cal/g): ^F	C 186					
7 days, max, kJ/kg		290	290	290	...	250
7 days		290	290	290	...	250
(cal/g)		(70)	(70)	(70)	...	(60)
28 days, max, kJ/kg		330	330	330	...	290
28 days		330	330	330	...	290
(cal/g)		(80)	(80)	(80)	...	(70)
Water requirement, max weight % of cement	C 109/C 109M	...	...	...	...	64
Drying shrinkage, max, %	C 157/C 157M	...	...	...	...	0.15
Mortar expansion: ^G	C 227					
Water requirement, max weight % of cement	C 109/C 109M	...	...	...	...	64
Drying shrinkage, max, %	C 157/C 157M	...	...	...	...	0.15
Mortar expansion, max, %: ^G	C 227					
14 days, max, %		0.020	0.020	0.020	0.020	0.020
8 weeks, max, %		0.060	0.060	0.060	0.060	0.060
14 days,		0.020	0.020	0.020	0.020	0.020
8 weeks,		0.060	0.060	0.060	0.060	0.060
Sulfate resistance: ^H	C 1012					
Expansion at 180 days, max, %		(0.10) ^I	0.10	0.05		(0.10) ^I
Sulfate resistance, max, %: ^H	C 1012					
Expansion at 180 days		(0.10) ^I	0.10	0.05		(0.10) ^I
Expansion at 1 year, max, %				0.10		
Expansion at 1 year				0.10		

^AAir-entrained cements shall have a mortar air content of 19 ± 3 % by volume and the minimum compressive strength shall be no less than 80 % of the comparable non-air-entrained cement type.

^BApplicable only when higher strengths at early ages are not required or when low heat is required.

^CBoth amount retained when wet sieved on 45-µm (No. 325) sieve and specific surface by air permeability apparatus, m²/kg, shall be reported on all mill test reports requested under 14.4.

^DThe specimens shall remain firm and hard and show no signs of distortion, cracking, checking, pitting, or disintegration when subjected to the autoclave expansion test.

^ETime of setting refers to initial setting time in Test Method C 191. The time of setting of cements containing a user-requested accelerating or retarding functional addition need not meet the limits of this table, but shall be stated by the manufacturer.

^FApplicable only when moderate (MH) or low (LH) heat of hydration is specified, in which case the strength requirements shall be 80 % of the values shown in the table.

^GThe test for mortar expansion is an optional requirement to be applied only at the purchaser’s request and is not required unless the cement will be used with alkali-reactive aggregate.

^HIn the testing of HS cement, testing at one year shall not be required when the cement meets the 180-day limit. An HS cement failing the 180-day limit shall not be rejected unless it also fails the one-year limit.

^IOptional sulfate resistance criterion that applies only if specifically invoked.