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Standard Specification for Blended Hydraulic Cements[1]

This standard is issued under the fixed designation C595/C595M; 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 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 C1157 is a hydraulic cement specification in which performance criteria alone govern the products and their acceptance.

1.2 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. Values in SI units [or inch-pound units] shall be obtained by measurement in SI units [or inch-pound units] or by appropriate conversion, using the Rules for Conversion and Rounding given in IEEE/ASTM SI 10, of measurements made in other units [or SI units]. Values are stated in only SI units when inch-pound units are not used in practice.

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]

C109/C109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)
C114 Test Methods for Chemical Analysis of Hydraulic Cement
C150 Specification for Portland Cement
C151 Test Method for Autoclave Expansion of Hydraulic Cement
C157/C157M Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
C183 Practice for Sampling and the Amount of Testing of Hydraulic Cement
C185 Test Method for Air Content of Hydraulic Cement Mortar
C186 Test Method for Heat of Hydration of Hydraulic Cement
C187 Test Method for Amount of Water Required for Normal Consistency of Hydraulic Cement Paste
C188 Test Method for Density of Hydraulic Cement
C191 Test Methods for Time of Setting of Hydraulic Cement by Vicat Needle
C204 Test Methods for Fineness of Hydraulic Cement by Air-Permeability Apparatus
C219 Terminology Relating to Hydraulic Cement
C226 Specification for Air-Entraining Additions for Use in the Manufacture of Air-Entraining Hydraulic Cement
C227 Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)
~~C265 Test Method for Water-Extractable Sulfate in Hydrated Hydraulic Cement Mortar~~
C311 Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete

[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.**

C430 Test Method for Fineness of Hydraulic Cement by the 45-m (No. 325) Sieve
C465 Specification for Processing Additions for Use in the Manufacture of Hydraulic Cements
C563 Test Method for Approximation of Optimum SO_3 in Hydraulic Cement Using Compressive Strength
C688 Specification for Functional Additions for Use in Hydraulic Cements
C821 Specification for Lime for Use with Pozzolans
C1012 Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution
C1038 Test Method for Expansion of Hydraulic Cement Mortar Bars Stored in Water
C1157 Performance Specification for Hydraulic Cement
IEEE/ASTM SI 10 Standard for Use of the International System of Units (SI): the Modern Metric System

3. Terminology

3.1 *Definitions*—The terms used in this specification are defined in Terminology C219, except for the following terms:

3.1.1 *binary blended cement*, *n*—a blended hydraulic cement consisting of portland cement with either a slag cement or a pozzolan.

3.1.2 *ternary blended cement*, *n*—a blended hydraulic cement consisting of portland cement with either a combination of two different pozzolans, or slag cement and a pozzolan.

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.

4.1.1.3 *Type IT*—Ternary blended 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.

4.2.2 The naming practice for ternary blended cements shall be made by adding the suffixes (AX) and (BY) to the Type IT designation under 4.1.1, where:

A is either "S" for slag cement, or "P" for pozzolan, whichever is present in larger amount by mass, and
X is the targeted percentage by mass of constituent A, and
B is either "S" for slag cement, or "P" for pozzolan, and
Y is the targeted percentage by mass of constituent B.

Both X and Y values are expressed as a whole number by mass of the final blended product, within the allowable variation as stated in 14.3. If X and Y are the same, list the pozzolan content first.

NOTE 2—Examples of the naming practice per 4.2.1 and 4.3 are shown below (all percentages by mass):
Binary blended cement with 80 % portland cement and 20 % slag cement = Type IS(20).
Binary blended cement with 85 % portland cement and 15 % pozzolan ~~= IP(15).~~ = Type IP(15).
Ternary blended cement with 70 % portland cement, 20 % slag cement and 10 % pozzolan = Type IT(S20)(P10).
Ternary blended cement with 65 % portland cement, 25 % of one pozzolan and 10 % of another pozzolan = Type IT(P25)(P10).
Ternary blended cement with 60 % portland cement and 20 % of slag cement and 20 % pozzolan = Type IT(P20)(S20).

4.2.3 A simplified naming practice is used in this standard for practicality and clarity when referring to specific requirements for binary and ternary blended cements that are applicable to a range of products or in ternary blended cements when requirements are applicable to only one constituent within a specific range (%). (See Note 3)

NOTE 3—Examples of the simplified naming practices per 4.2.3 are shown below:
1) An example when requirements are applicable to a range of products can be found in Table 1, where the maximum SO_3 content of 3 % applies to: binary blended cements with slag cement contents <70 %, indicated as IS(<70); ternary blended cements with a pozzolan content less than the slag cement content and the slag cement content is less than 70 %, indicated as IT(P<S<70).
2) An example when requirements are applicable to only one constituent within a specific range (%) of that constituent can be found in 8.2, where testing is required only when the slag cement content is <25 %. Because the requirement is based on the slag cement content only with no relation to the pozzolan content, a simplified naming practice is employed and the range of ternary blended cements are indicated as Type IT(S<25).

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.

TABLE 1 Chemical Requirements

Cement Type[A]	Applicable Test Method	IS(< 70), IT(P<S<70)	IS(≥ 70), IT(S≥70)	IP, IT(P≥S)
Magnesium oxide (MgO), max, %	C114	...	...	6.0
Sulfate reported as SO_3, max, %[B]	C114	3.0	4.0	4.0
Sulfide reported as S^{2-}, max, %	C114	2.0	2.0	...
Insoluble residue, max, %	C114	1.0	1.0	...
Loss on ignition, max, %	C114	3.0	4.0	5.0

[A] The chemical requirements in this table are applicable to all air-entrained cement equivalents.

[B] When ilt ha is b peen dermonistratedsiby Tles t Metho exceedC563 the values in t the op timumable for SO_3 exceeds a value 0.5% less thaonthe specification limit, an additional amount of SO_3 is permissible provided it hat, whs ben the cement with the a dditiemonal calciumsulfate is tesrated by Test Method C2651038, the calcium sulfate in the hydrat cedmorentar a wit 24 ± ¼h, thexp increassed as SO_3,will not develop esxpansiotn exceeding 0.50 g/L20 % at 14 days. When the manufacturer supplies cement under this provision, he will, upon reque st, supply supporting data shall be supplied to the purchaser. See Note 6.

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.

4.3.2 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.

NOTE5—Special characteristics attributable to slag or pozzolan will vary based on quantities contained within the blended cements. 5—Special characteristics attributable to slag or pozzolan will vary based on quantities contained within the blended cements.

NOTE 6—There are cases where performance of a cement is improved with SO_3 in excess of the Table 1 limits in this specification. Test Method C563 is one of several methods a manufacturer can use to evaluate the effect of sulfate content on cement characteristics. Whenever SO_3 content of a cement exceeds Table 1 limits, Test Method C1038 results provide evidence that excessive expansion does not occur at this higher sulfate content.

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).

NOTE6—It 7—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 *Slag Cement*—See Terminology C219.

6.4 *Portland Cement*—See Terminology C219. For purposes of this specification, portland cement meeting the requirements of Specification C1157 or Specification C150 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.

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

6.6 *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.

6.7 *Hydrated Lime*—Hydrated lime used as part of a blended cement shall meet the requirements of Specification C821, except that when interground in the production process there shall be no minimum fineness requirement.

6.8 *Air-Entraining Addition*—When air-entraining cement is specified, an addition meeting the requirements of Specification C226 shall be used.

6.9 When processing additions are used in the manufacture of cement, they shall have been shown to meet the requirements of Specification C465 in the amounts used or greater, (see Section 14.2).

6.10 When functional additions (used at the sole option of the purchaser) are used they shall have been shown to meet the requirements of Specification C688 when tested with the cement to be used, in the amount used or greater, (see Section 14.2).

6.11 *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 C219), or both, if added, shall be in amounts so that the limits shown in Table 1 for sulfate reported as SO_3 and loss on ignition are not exceeded.

6.12 *Binary Blended Cement*—Binary blended cement shall be a hydraulic cement consisting of an intimate and uniform blend (see ~~Note 7) produced either by intergrinding portland cement clinker with a pozzolan or a granulated blast-furnace slag, or a slag cement, or by blending portland cement with a pozzolan or a slag cement, or a combination of intergrinding and blending. The maximum constituent requirements of~~ Note 8) produced either by intergrinding portland cement clinker with a pozzolan or a granulated blast-furnace slag, or a slag cement, or by blending portland cement with a pozzolan or a slag cement, or a combination of intergrinding and blending. Any granulated blast-furnace slag, slag cement, or pozzolan used as an ingredient or addition in portland cement used to manufacture a binary blended cement shall be included in the total amount of those materials reported in 4.2 or 14.1. The maximum constituent requirements of 6.14 and 6.16 shall apply.

6.13 *Ternary Blended Cement*—Ternary blended cement shall be a hydraulic cement consisting of an intimate and uniform blend (see Note ~~7~~8) produced either by intergrinding portland cement clinker with 1) two different pozzolans, 2) granulated blast-furnace slag or slag cement and a pozzolan; or by blending portland cement with 1) two different pozzolans or 2) slag cement and a pozzolan, or 3) a combination of intergrinding and blending. Any granulated blast-furnace slag, slag cement, or pozzolan used as an ingredient or addition in portland cement used to manufacture a ternary blended cement shall be included in the total amount of those materials reported in 4.2 or 14.1. Ternary cement type IT(P≥S) and Type IT(P<S<70) shall have a maximum pozzolan content of 40 % by mass of the blended cement and the total content of pozzolan and granulated blast-furnace slag or slag cement shall be less than 70 % by mass of the blended cement.

6.14 *Portland Blast-Furnace Slag Cement*—Portland blast-furnace slag cement shall be a hydraulic cement in which the slag cement constituent is up to 95 % by mass of the blended cement. Binary or ternary blended cement with a slag cement content equal to or exceeding 70 % by mass, is permitted to contain hydrated lime.

NOTE ~~7—The~~ 8—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.

6.15 *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.

6.16 *Portland-Pozzolan Cement*—Portland-pozzolan cement shall be a hydraulic cement in which the pozzolan constituent is up to 40 % by mass of the blended cement.

6.17 *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 8~~Note 9).

	Tolerance, ± %
Silicon dioxide (SiO_2)	3
Aluminum oxide (Al_2O_3)	2
Calcium oxide (CaO)	3

NOTE ~~8—This~~ 9—This means that if the manufacturer's statement of the composition says "SiO_2: 32 %," the cement when analyzed, shall be found to contain between 29 and 35 % SiO_2.

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 granulated blast-furnace slag or slag cement 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