Designation: C595/C595M – 11

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)

C311 Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete

C430 Test Method for Fineness of Hydraulic Cement by the 45-μm (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

[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.**

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 = 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.

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.

NOTE 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

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] It is permissible to exceed the values in the table for SO_3 content, provided it has been demonstrated by Test Method C1038 that the cement with the increased SO_3 will not develop expansion exceeding 0.020 % at 14 days. When the manufacturer supplies cement under this provision, supporting data shall be supplied to the purchaser. See Note 6.

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).

NOTE 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 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 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 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 9).

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

NOTE 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 activity index requirement of Table 3. Slag cement that is to be used for portland blast-furnace slag cements Type IS(< 25) or ternary blended cements Type IT(S<25) shall conform to the activity index requirement of Table 3. Such pozzolan, or granulated blast-furnace slag, or slag cement 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 portland-pozzolan cement, Type IP(< 15) and IP(< 15)-A or ternary blended cements Type IT(P<15) and Type IT(P<15)-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 Na_2O, calculated as $Na_2O + 0.658\ K_2O$, from that of the clinker with which the acceptance tests were carried out, the pozzolan shall be retested to show compliance with the requirements of Table 3.

9. Sampling

9.1 Sample the materials in accordance with the following methods:

9.1.1 *Sampling Blended Cements*—Practice C183.

9.1.1.1 When the purchaser desires that the cement be sampled and tested to verify compliance with this specification, perform sampling and testing in accordance with Practice C183.

9.1.1.2 Practice C183 is not designed for manufacturing quality control and is not required for manufacturer's certification.

9.1.2 *Sampling Pozzolan*—Test Methods C311. One 2 kg [4 lb] sample shall be taken from approximately each 360 Mg [400 tons] of pozzolan.

10. Test Methods

10.1 Determine the applicable properties enumerated in this specification in accordance with the following test methods:

10.1.1 *Chemical Analysis*—Test Methods C114, with the special provisions noted therein applicable to blended cement analyses.

10.1.2 *Fineness by Sieving*—Test Method C430.

10.1.3 *Fineness by Air-Permeability Apparatus*—Test Method C204.

10.1.4 *Autoclave Expansion*—Test Method C151, except that, in the case of portland blast-furnace slag cement IS(≥70) or ternary blended cement IT(S≥70), the test specimens shall remain in the moist cabinet for a period of 48 h before being measured for length, and the neat cement shall be mixed for not less than 3 min nor more than 3½ min.

10.1.5 *Time of Setting*—Test Method C191.

10.1.6 *Air Content of Mortar*—Test Method C185, using the actual specific gravity of the cement, if it differs from 3.15 by more than 0.05, in calculating the air content.

10.1.7 *Compressive Strength*—Test Method C109/C109M.

10.1.8 *Heat of Hydration*—Test Method C186.

10.1.9 *Normal Consistency*—Test Method C187, except that in the case of portland blast-furnace slag cement IS(≥70) or ternary blended cement IT(S≥70), the paste shall be mixed for not less than 3 min nor more than 3½ min.

10.1.10 *Specific Gravity*—Test Method C188.

10.1.11 *Water Requirement*—The mass of mixing water added to the six-cube batch in accordance with Test Method C109/C109M, as a percentage of the total cementing ingredients.

10.1.12 *Mortar Expansion of Blended Cement*—Test Method C227, using crushed Pyrex glass No. 7740[3] as aggregate and the grading prescribed in Table 4.

10.1.13 *Mortar Expansion of Pozzolan for Use in Portland-Pozzolan Cement Types IP(< 15) and IP(< 15)-A or Ternary Blended Cement Types IT(P<15) and IT(P<15)-A*—Using the pozzolan and the clinker or cement that are to be used together

[3] Pyrex Glass No. 7740 is available as lump cullet from the Corning Glass Works, Corning, NY; this is the sole source of supply of the apparatus known to the committee at this time. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

TABLE 2 Physical Requirements

Cement Type[A]	Applicable Test Method	IS(< 70), IT(P<S<70), IP, IT(P≥S)	IS(< 70) (MS), IT(P<S<70) (MS), IP (MS), IT(P≥S) (MS)	IS(< 70) (HS), IT(P<S<70) (HS), IP (HS), IT(P≥S) (HS)	IS(≥ 70), IT(S≥70)	IP (LH),[B] IT(P≥S) (LH)[B]
Fineness	C204, C430	[C]	[C]	[C]	[C]	[C]
Autoclave expansion, max, %	C151	0.80	0.80	0.80	0.80	0.80
Autoclave contraction, max, %[D]	C151	0.20	0.20	0.20	0.20	0.20
Time of setting, Vicat test:[E]	C191					
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 %, max[A]	C185	12	12	12	12	12
Compressive strength, min[A], MPa [psi]:	C109/C109M					
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]	25.0 [3620]	25.0 [3620]	11.0 [1600]	21.0 [3050]
Heat of hydration, max, kJ/kg [cal/g]:	C186					
7 days		290 [70][F]	290 [70][F]	290 [70][F]	...	250 [60]
28 days		330 [80][F]	330 [80][F]	330 [80][F]	...	290 [70]
Water requirement, max weight % of cement	C109/C109M	...	...	...	...	64
Drying shrinkage, max, %	C157/C157M	...	...	...	...	0.15
Mortar expansion, max, %:[G]	C227					
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, max, %:[H]	C1012					
Expansion at 180 days		...	0.10	0.05	...	...[I]
Expansion at 1 year		...	...	0.10	...	...[I]

[A] Air-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.

[B] Applicable only when higher strengths at early ages are not required or when low heat is required.

[C] Both amount retained when wet sieved on 45-μm (No. 325) sieve and specific surface by air permeability apparatus, m^2/kg, shall be reported on all mill test reports requested under 14.4.

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

[E] Time of setting refers to initial setting time in Test Method C191. 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.

[F] Applicable only when moderate heat of hydration (MH) is specified, in which case the strength requirements shall be 80 % of the values shown in the table.

[G] The 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.

[H] In 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.

[I] If specifically invoked, the optional sulfate resistance criterion that applies for MS is a maximum of 0.10% expansion at 180 days and for HS is a maximum of 0.05% expansion at 180 days or a maximum of 0.10% expansion at one year (see Footnote H).

TABLE 3 Requirements for Pozzolan for Use in Blended Cements and for Slag for Use in Portland Blast-Furnace Slag Cement Type IS(< 25) and Ternary Blended Cement Type IT(S<25)

Pozzolan and Slag, as applicable	Applicable Test Method	
Fineness:	C430	
Amount retained when wet-sieved on 45-μm (No. 325) sieve, max, %		20.0
Alkali reactivity of pozzolan for use in Types IP(< 15); IT(P<15) and IP(< 15)-A; IT(P<15)-A cements, six tests, mortar bar	C227	
expansion at 91 days, max, %		0.05
Activity index with portland cement, at 28 days, min, %	(see Annex A1)	75

in the production of the blended cement, prepare portland-pozzolan cements Types IP(< 15) and IP(< 15)-A or Ternary Blended Cement Types IT(P<15) and IT(P<15)-A containing 2.5, 5, 7.5, 10, 12.5, and 15 mass % of the pozzolan. These blends shall be tested in accordance with Test Method C227 using a sand judged to be a nonreactive by the mortar bar test in Test Method C227. The expansion of the mortar bars shall be measured at 91 days, and all the six blends shall meet the expansion requirement in Table 3.

10.1.14 *Drying Shrinkage*—Test Method C157/C157M. Make three specimens using the proportion of dry materials of 1 part of cement to 2.75 parts of Test Method C109/C109M graded Ottawa sand. Use a curing period of 6 days and an air storage period of 28 days. Report the linear contraction during air storage based on an initial measurement after the 6-day water-curing period.

10.1.15 *Activity Index with Portland Cement*—Test in accordance with Annex A1.

10.1.16 *Sulfate Resistance*—see Test Method C1012.

11. Testing Time Requirements

11.1 The following periods from time of sampling shall be allowed for the completion of testing:

3-day test	8 days
7-day test	12 days
14-day test	19 days
28-day test	33 days
8-week test	61 days

12. Inspection

12.1 Facilities shall be provided to the purchaser for careful inspection and sampling of the finished cement. Inspection and sampling of finished cement shall be at the mill or distribution site controlled by the manufacturer, or at any other location as agreed by the purchaser and seller.

12.2 The manufacturer shall provide suitable facilities to enable the inspector to check the relative masses of the constituents used, and the intergrinding or blending operation used to produce the cement. The plant facilities for intergrinding or blending and inspection shall be adequate to ensure compliance with the provisions of this specification.

13. Rejection

13.1 At the option of the purchaser, cement shall be rejected if it fails to meet any of the requirements of this specification applicable to the cement. Such rejection shall apply to an optional requirement only if that option has been invoked for the cement.

13.2 When the purchaser requires, cement in bulk storage for a period greater than six months shall be resampled and retested and, at the option of the purchaser, shall be rejected if it fails to meet any of the applicable requirements of this specification. Cement so rejected shall be the responsibility of the owner of record at the time of sampling for retest.

13.3 When the purchaser requires, packages more than 2 % below the mass marked thereon shall be rejected; or if the average mass of packages in any shipment, as shown by determining the mass of 50 packages taken at random, is less than that marked on the packages, the entire shipment, at the option of the purchaser, shall be rejected.

TABLE 4 Aggregate Grading Requirements for Mortar Expansion Test

Sieve Size		Weight %
Passing	Retained on	
4.75-mm (No. 4)	2.36-mm (No. 8)	10
2.36-mm (No. 8)	1.18-mm (No 16)	25
1.18-mm (No. 16)	600-μm (No. 30)	25
600-μm (No. 30)	300-μm (No. 50)	25
300-μm (No. 50)	150-μm (No. 100)	15

14. Certification

14.1 At the request of the purchaser, the manufacturer shall state in writing the source, amount, and composition of the essential constituents used in manufacture of the finished cement and the composition of the blended cement purchased.

14.2 At the request of the purchaser, the manufacturer shall state in writing the nature, amount, and identity of any processing, functional, or air-entraining addition used; and also, if requested, shall supply test data showing compliance of any such processing addition with the provisions of Specification C465 and of any such functional addition with the provisions of Specification C688, and of any such air-entraining addition with the provisions of Specification C226.

14.3 At the request of the purchaser, the manufacturer shall also state in writing that the amount of pozzolan or slag in the finished cement will not vary more than ± 5.0 mass % of the finished cement from lot to lot or within a lot.

14.4 Upon request of the purchaser in the contract or order, a manufacturer's certification shall be furnished indicating that the material was tested during production or transfer in accordance with this specification, that it complies with this specification, and a report of the test results shall be furnished at the time of shipment (to include both amount retained on the 45-μm (No. 325) sieve and specific surface by the air permeability method).

15. Packaging and Package Marking

15.1 When the cement is delivered in packages, the words, "portland blast-furnace slag cement," "portland-pozzolan cement," or "ternary blended cement" as appropriate; the type of cement, name and brand of the manufacturer, and the mass of the cement contained therein, shall be plainly marked on each

package. When the cement contains a functional addition listed in 5.1.3.5-5.1.3.10, the type of functional addition shall be plainly marked on each package. Similar information shall be provided in the shipping documents accompanying the shipment of packaged or bulk cement. All packages shall be in good condition at the time of inspection.

16. Storage

16.1 The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment, and in a suitable weathertight building that will protect the cement from dampness and minimize warehouse set.

17. Keywords

17.1 blended hydraulic cement; fly ash cement; hydraulic cement; portland blast-furnace slag cement; portland pozzolan cement; pozzolanic cement; slag; granulated blast furnace slag

ANNEX

(Mandatory Information)

A1. ACTIVITY INDEX WITH PORTLAND CEMENT

A1.1 Specimen Preparation

A1.1.1 Mold, cure, and test the specimens from a control mix and from a test mix in accordance with Test Method C109/C109M. The portland cement used in the control mix shall meet the requirements of Specification C150, and shall be the type, and if available, the brand of cement to be used in the work. Make three-cube batches as follows: (For 6- or 9-cube batches, double or triple, respectively, the amounts of dry ingredients.)

A1.1.1.1 *Control Mix*:

250 g of portland cement
687.5 g of graded Ottawa sand
X mL of water required for flow of 100 to 115

A1.1.1.2 *Pozzolan Test Mix*:

162.5 g of portland cement
g of pozzolan:
87.5 × sp gr of the sample/sp gr of the portland cement
687.5 g of graded Ottawa sand
Y mL of water required for flow of 100 to 115

A1.1.1.3 *Slag Test Mix*:

75 g of portland cement
g of slag:
175 × sp gr of the slag/sp gr of the portland cement
687.5 g of graded Ottawa sand
Z mL of water required for flow of 100 to 115

A1.2 Storage of Specimens

A1.2.1 After molding, place the specimens and molds (on the base plates) in the moist room or closet at 23.0 ± 2.0 °C [73.5 ± 3.5 °F] for 20 to 24 h. While in the moist room or closet, protect the surface from dripping water. Remove the molds from the moist room or closet and remove the cubes from the molds. Place the cubes in close-fitting metal or glass containers (Note A1.1), seal the containers airtight, and store at 38.0 ± 2.0 °C [100.0 ± 3.5 °F] for 27 days. Allow the specimens to cool to 23.0 ± 2.0 °C [73.5 ± 3.5 °F] before testing.

NOTE A1.1—Use any metal container having a capacity of three cubes if it can be sealed airtight by soldering. Containers of light-tinned sheet metal with inside dimensions of 52 by 52 by 160 mm [2 by 2 by 6.25 in.] have been found to be satisfactory. Wide-mouth Mason jars of 1-L capacity have been found to be satisfactory, provided care is taken to prevent breakage.

(**Warning**—Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.)[4]

A1.3 Compressive Strength Test

A1.3.1 Determine the compressive strength of the three specimens of the control mix and of the test mix at an age of 28 days in accordance with Test Method C109/C109M.

A1.4 Calculation

A1.4.1 Calculate the activity index with portland cement as follows:

$$\text{Activity index with portland cement} = (A/B) \times 100 \quad \text{(A1.1)}$$

where:

A = average compressive strength of test mix cubes, MPa, and
B = average compressive strength of control mix cubes, MPa.

A1.5 Precision and Bias

A1.5.1 *Precision*—Single operator precision, on blended cements using fly ash is essentially the same as on fly ash/cement blends in Research Report C09-1001[5] and it was found to have 3.8 % coefficient of variation (1s %). This indicates that results of two properly conducted tests by the same operator are not expected to differ by more than 10.7 % (d2s) of the average of two results. Since the test is performed solely for the purpose of manufacturer certification of raw material quality, no multilaboratory precision is applicable.

A1.5.2 *Bias*—Since there are no standard reference materials, bias cannot be determined.

[4] Section on Safety, Manual of Cement Testing, *Annual Book of ASTM Standards*, Vol 04.01.

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C09-1001.

SUMMARY OF CHANGES

Committee C01 has identified the location of selected changes to this standard since the last issue (C595/C595M–10) that may impact the use of this standard. (Approved April 1, 2011.)

(*1*) Revised Footnote B in Table 1.
(*2*) Added Note 6.
(*3*) Revised Table 2.
(*4*) Revised 6.12 and 6.13.

Committee C01 has identified the location of selected changes to this specification since the last issue, C595/C595M–09, that may impact the use of this specification. (Approved April 1, 2010)

(*1*) Revised 4.2.2, Note 2, 6.13, Table 1, and Table 2.

Committee C01 has identified the location of selected changes to this specification since the last issue, C595–08a, that may impact the use of this specification. (Approved June 15, 2009)

(*1*) Revised Sections 3, 4, 6, 8, 10, 15, and Tables 1-3.
(*2*) Revised the standard as a dual-units specification.

Committee C01 has identified the location of selected changes to this specification since the last issue, C595–08, that may impact the use of this specification. (Approved December 15, 2008)

(*1*) Revised 6.10.
(*2*) Deleted old Note 5 and renumbered subsequent notes.
(*3*) Revised the "IP(LH)" value for "Compressive strength, min: 28 days" in Table 2.