Designation: C 595 – 02a

Standard Specification for Blended Hydraulic Cements[1]

This standard is issued under the fixed designation C 595; 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 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 Cement[2]
C 150 Specification for Portland Cement[2]
C 151 Test Method for Autoclave Expansion of Portland Cement[2]
C 157 Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete[3]
C 183 Practice for Sampling and the Amount of Testing of Hydraulic Cement[2]
C 185 Test Method for Air Content of Hydraulic Cement Mortar[2]
C 186 Test Method for Heat of Hydration of Hydraulic Cement[2]
C 187 Test Method for Normal Consistency of Hydraulic Cement[2]
C 188 Test Method for Density of Hydraulic Cement[2]
C 191 Test Method for Time of Setting of Hydraulic Cement by Vicat Needle[2]
C 204 Test Method for Fineness of Hydraulic Cement by Air Permeability Apparatus[2]
C 219 Terminology Relating to Hydraulic Cement[2]
C 226 Specification for Air-Entraining Additions for Use in the Manufacture of Air-Entraining Portland Cement[2]
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 Mortar[2]
C 430 Test Method for Fineness of Hydraulic Cement by the 45-µm (No. 325) Sieve[2]
C 465 Specification for Processing Additions for Use in the Manufacture of Hydraulic Cements[2]
C 563 Test Method for Optimum SO_3 in Hydraulic Cement Using 24-h Compressive Strength[2]
C 688 Specification for Functional Additions for Use in Hydraulic Cements[2]
C 821 Specification for Lime for Use with Pozzolans[2]
C 1012 Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution[2]
C 1157 Performance Specification for Hydraulic Cement[2]
IEEE/ASTM SI 10 Standard for Use of the International System of Units (SI): the Modern Metric System[4]

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 blastfurnace 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 SO_3 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 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_2O_3)	2
Calcium oxide (CaO)	3

NOTE 8—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.

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	3.0	4.0	4.0
Sulfide sulfur (S), 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
Water-soluble alkali, max, %	C 114	...	0.03[B]	...

[A] When it has been demonstrated by Test Method C 563 that the optimum SO_3 exceeds a value 0.5 % less than the specification limit, an additional amount of SO_3 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 SO_3, 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.

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 Na_2O, calculated as $Na_2O + 0.658\ K_2O$, from that of the clinker with which the

TABLE 2 Physical Requirements

Cement Type	Applicable Test Method	I(SM), IS, I(PM), IP	I(SM)-A, IS-A, I(PM)-A, IP-A	IS(MS) IP(MS)	IS-A(MS) IP-A(MS)	S	SA	P	PA
Fineness	C 204, C 430	A	A	A	A	A	A	A	A
Autoclave expansion, max, %	C 151	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Autoclave contraction, max, %[B]	C 151	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Time of setting, Vicat test:[C]	C 191								
Set, minutes, not less than		45	45	45	45	45	45	45	45
Set, hours, not more than		7	7	7	7	7	7	7	7
Air content of mortar, volume %	C 185	12 max	19 ± 3	12 max	19± 3	12 max	19 ± 3	12 max	19 ± 3
Compressive strength, min, MPa (psi):	C 109/C 109M								
3 days		13.0	10.0	11.0	9.0	...	...	...	...
		(1890)	(1450)	(1600)	(1310)	...	...	...	...
7 days		20.0	16.0	18.0	14.0	5.0	4.0	11.0	9.0
		(2900)	(2320)	(2610)	(2030)	(720)	(580)	(1600)	(1310)
28 days		25.0	20.0	25.0	20.0	11.0	9.0	21.0	18.0
		(3620)	(2900)	(3620)	(2900)	(1600)	(1310)	(3140)	(2610)
Heat of hydration:[D]	C 186								
7 days, max, kJ/kg		290	290	290	290	...	...	250	250
(cal/g)		(70)	(70)	(70)	(70)	...	...	(60)	(60)
28 days, max, kJ/kg		330	330	330	330	...	...	290	290
(cal/g)		(80)	(80)	(80)	(80)	...	...	(70)	(70)
Water requirement, max weight % of cement	C 109/C 109M	...	...	...	...	...	...	64	56
Drying shrinkage, max, %	C 157	...	...	...	...	...	...	0.15	0.15
Mortar expansion:[E]	C 227								
14 days, max, %		0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
8 weeks, max, %		0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
Sulfate resistance	C 1012								
Expansion at 180 days, max,%		(0.10)[F]	(0.10)[F]	0.10	0.10			(0.10)[F]	(0.10)[F]

[A] 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.
[B] 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.
[C] Time 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.
[D] Applicable 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.
[E] The test for mortar expansion is an optional requirement to be applied only at the purchaser's request and should not be requested unless the cement will be used with alkali-reactive aggregate.
[F] Optional sulfate resistance criterion that applies only if specifically invoked.

TABLE 3 Requirements for Pozzolan for Use in Blended Cements and for Slag for Use in Slag-Modified Portland Cements

Pozzolan	Applicable Test Method	
Fineness:	C 430	
Amount retained when wet-sieved on 45-µm (No. 325) sieve, max, %		20.0
Alkali reactivity of pozzolan for use in Types I(PM) and I(PM)-A cements, six tests, mortar bar expansion at 91 days, max, %	C 227	0.05
Activity index with portland cement, at 28 days, min, %	(see Annex)	75

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 C 183.

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 C 183.

9.1.1.2 Practice C 183 is not designed for manufacturing quality control and is not required for manufacturer's certification.

9.1.2 *Sampling Pozzolan*—Test Methods C 311. 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 C 114, with the special provisions noted therein applicable to blended cement analyses.

10.1.2 *Fineness by Sieving*—Test Method C 430.

10.1.3 *Fineness by Air-Permeability Apparatus*—Test Method C 204.

10.1.4 *Autoclave Expansion*—Test Method C 151, except that, in the case of slag cement, 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 3½min.

10.1.5 *Time of Setting*—Test Method C 191.

10.1.6 *Air Content of Mortar*—Test Method C 185, 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 C 109/C 109M.

10.1.8 *Heat of Hydration*—Test Method C 186.

10.1.9 *Normal Consistency*—Test Method C 187, except that in the case of slag cement the paste shall be mixed for not less than 3 min nor more than 3½ min.

10.1.10 *Specific Gravity*—Test Method C 188.

10.1.11 *Water Requirement*—The mass of mixing water added to the six-cube batch in accordance with Test Method C 109, as a percentage of the total cementing ingredients.

10.1.12 *Mortar Expansion of Blended Cement*—Test Method C 227, using crushed Pyrex glass No. 7740[5] as aggregate and the grading prescribed in Table 4.

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

10.1.13 *Mortar Expansion of Pozzolan for Use in Pozzolan-Modified Portland Cement Types I(PM) and I(PM)-A*—Using the pozzolan and the clinker or cement that are to be used together in the production of the blended cement, prepare pozzolan-modified portland cements 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 C 227 using a sand judged to be a nonreactive by the mortar bar test in Test Method C 227. 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 C 157. Make three specimens using the proportion of dry materials of 1 part of cement to 2.75 parts of Test Method C 109 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 C 1012.

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.

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 C 465 and of any such functional addition with the provisions of Specification C 688, and of any such air-entraining addition with the provisions of Specification C 226.

14.3 In the case of portland-pozzolan cement or pozzolan-modified portland cement at the request of the purchaser, the manufacturer shall also state in writing that the amount of pozzolan 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,”“ pozzolan-modified portland cement,” “slag-modified portland cement” or “slag 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

[5] Pyrex Glass No. 7740 is available as lump cullet from the Corning Glass Works, Corning, NY.

in 5.1.3.4-5.1.3.9, 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 cement; slag; granulated blast furnace

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 Method C 109/C 109M. The portland cement used in the control mix shall meet the requirements of Specification C 150, 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 ± 1.7°C 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 ± 1.7°C for 27 days. Allow the specimens to cool to 23 ± 1.7°C 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 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.)[6]

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 C 109/C 109M.

A1.4 Calculation

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

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

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 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 should not 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.

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