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Standard Specification for Portland Cement¹

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

1. Scope*

1.1 This specification covers eight types of portland cement, as follows (see Note 2):

1.1.1 *Type I*—For use when the special properties specified for any other type are not required.

1.1.2 *Type IA*—Air-entraining cement for the same uses as Type I, where air-entrainment is desired.

1.1.3 *Type II*—For general use, more especially when moderate sulfate resistance or moderate heat of hydration is desired.

1.1.4 *Type IIA*—Air-entraining cement for the same uses as Type II, where air-entrainment is desired.

1.1.5 *Type III*—For use when high early strength is desired.

1.1.6 *Type IIIA*—Air-entraining cement for the same use as Type III, where air-entrainment is desired.

1.1.7 *Type IV*—For use when a low heat of hydration is desired.

1.1.8 *Type V*—For use when high sulfate resistance is desired.

~~NOTE 1—Some cements are designated with a combined type classification, such as Type I/II, indicating that the cement meets the requirements of the indicated types and is being offered as suitable for use when either type is desired.~~ 1—Some cements are designated with a combined type classification, such as Type I/II, indicating that the cement meets the requirements of the indicated types and is being offered as suitable for use when either type is desired.

NOTE 2—Cement conforming to the requirements for all types are not carried in stock in some areas. In advance of specifying the use of cement other than Type I, determine whether the proposed type of cement is, or can be made, available.

1.2 When both SI and inch-pound units are present, the SI units are the standard. The inch-pound units are approximations listed for information only.

1.3 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

2. Referenced Documents

2.1 *ASTM Standards:*²

C 33 [Specification for Concrete Aggregates](#)

C 51 [Terminology Relating to Lime and Limestone \(as used by the Industry\)](#)

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 115 [Test Method for Fineness of Portland Cement by the Turbidimeter](#)

C 151 [Test Method for Autoclave Expansion of Hydraulic Cement](#)

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 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 266 [Test Method for Time of Setting of Hydraulic Cement Paste by Gillmore Needles](#)

C 451 [Test Method for Early Stiffening of Hydraulic Cement \(Paste Method\)](#)

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.

- C 452 Test Method for Potential Expansion of Portland-Cement Mortars Exposed to Sulfate
- 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 24-h Compressive Strength
- C 1038 Test Method for Expansion of Hydraulic Cement Mortar Bars Stored in Water
- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

3. Terminology

3.1 *Definitions*—See Terminology C 219.

4. Ordering Information

- 4.1 Orders for material under this specification shall include the following:
 - 4.1.1 This specification number and date,
 - 4.1.2 Type or types allowable. If no type is specified, Type I shall be supplied,
 - 4.1.3 Any optional chemical requirements from Table 2, if desired, and
 - 4.1.4 Any optional physical requirements from Table 4, if desired.

~~NOTE 2—Cement conforming to the requirements for all types are not carried in stock in some areas. In advance of specifying the use of cement other than Type I, determine whether the proposed type of cement is, or can be made, available.~~

5. Additions

- 5.1 The cement covered by this specification shall contain no addition except as follows:
 - 5.1.1 Water or calcium sulfate, or both, if added, shall be in amounts such that the limits shown in Table 1, if desired.

5. Ingredients

- 5.1 The cement covered by this specification shall contain no ingredients except as follows:
 - 5.1.1 Portland cement clinker.
 - 5.1.2 Water or calcium sulfate, or both. The amounts shall be such that the limits shown in Table 1 for sulfur trioxide and loss-on-ignition are not exceeded.
 - 5.1.2 Processing additions used in the manufacture of the cement shall have been shown to meet the requirements of Specification C 465 in the amounts used or greater.
 - 5.1.3 Up to 5.0% limestone by mass is permitted in amounts such that the chemical and physical requirements of this standard are met (See Note 3).
 - 5.1.3 Limestone. The amount shall not be more than 5.0 % by mass such that the chemical and physical requirements of this standard are met (See Note 3). The limestone, defined in Terminology C 51, shall be naturally occurring, consisting of at least 70 % by mass of one or more of the mineral forms of calcium carbonate.

TABLE 1 Standard Composition Requirements

Cement Type ^A	Applicable Test Method	I and IA	II and IIA	III and IIIA	IV	V
Aluminum oxide (Al ₂ O ₃), max, %	C 114	...	6.0	...	...	...
Ferric oxide (Fe ₂ O ₃), max, %	C 114	...	6.0 ^{B,C}	...	6.5	...
Magnesium oxide (MgO), max, %	C 114	6.0	6.0	6.0	6.0	6.0
Sulfur trioxide (SO ₃), ^D max, %	C 114					
When (C ₃ A) ^E is 8 % or less		3.0	3.0	3.5	2.3	2.3
When (C ₃ A) ^E is more than 8 %		3.5	^F	4.5	^F	^F
Loss on ignition, max, %	C 114	3.0	3.0	3.0	2.5	3.0
Insoluble residue, max, %	C 114	0.75	0.75	0.75	0.75	0.75
Tricalcium silicate (C ₃ S) ^F , max, %	See Annex A1	...	...	...	35 ^B	...
Dicalcium silicate (C ₂ S) ^F , min, %	See Annex A1	...	...	...	40 ^B	...
Tricalcium aluminate (C ₃ A) ^F , max, %	See Annex A1	...	8	15	7 ^B	5 ^C
Sum of C ₃ S + 4.75C ₃ A ^G , max, %	See Annex A1	...	100 ^H	...	...	...
Tetracalcium aluminoferrite plus twice the tricalcium aluminate (C ₄ AF + 2(C ₃ A)), or solid solution (C ₄ AF + C ₂ F), as applicable, max, %	See Annex A1	...	...	...	...	25 ^C

^ASee Note 2.

^BDoes not apply when the heat of hydration limit in Table 4 is specified.

^CDoes not apply when the sulfate resistance limit in Table 4 is specified.

^DThere are cases where optimum SO₃ (using Test Method C 563) for a particular cement is close to or in excess of the limit in this specification. In such cases where properties of a cement can be improved by exceeding the SO₃ limits stated in this table, it is permissible to exceed the values in the table, provided it has been demonstrated by Test Method C 1038 that the cement with the increased SO₃ will not develop expansion in water exceeding 0.020 % at 14 days. When the manufacturer supplies cement under this provision, he shall, upon request, supply supporting data to the purchaser.

^ESee Annex A1 for calculation.

^FNot applicable.

^GSee Note 4.

^HIn addition, 7-day heat of hydration testing by Test Method C 186 shall be conducted at least once every six months. Such testing shall not be used for acceptance or rejection of the cement, but results shall be reported for informational purposes.

TABLE 2 Optional Composition Requirements^A

Cement Type	Applicable Test Method	I and IA	II and IIA	III and IIIA	IV	V	Remarks
Tricalcium aluminate (C ₃ A) ^B , max, %	See Annex A1	...	...	8	...	...	for moderate sulfate resistance
Tricalcium aluminate (C ₃ A) ^B , max, %	See Annex A1	...	...	5	...	...	for high sulfate resistance
Sum of tricalcium silicate and tricalcium aluminate (C ₃ S + C ₃ A), max, %	See Annex A1	...	58 ^C	...	...	...	for moderate heat of hydration
Equivalent alkalies (Na ₂ O + 0.658K ₂ O), max, %	C 114	0.60 ^D	0.60 ^D	0.60 ^D	0.60 ^D	0.60 ^D	low-alkali cement
Equivalent alkalies (Na ₂ O + 0.658K ₂ O), max, %	C 114	0.60 ^C	0.60 ^C	0.60 ^C	0.60 ^C	0.60 ^C	low-alkali cement

^AThese optional requirements apply only when specifically requested. Verify availability before ordering. See Note 2 in Section 4.

^BSee Annex A1 for calculation.

^CThe optional limit for heat of hydration in Table 4 shall not be requested when this optional limit is requested.

^DSpecify this limit when the cement is to be used in concrete with aggregates that are potentially reactive and no other provisions have been made to protect the concrete from deleteriously reactive aggregates. Refer to Specification C 33 for information on potential reactivity of aggregates.

NOTE 3—The standard permits up to 5 % by mass of the final cement product to be naturally occurring, finely ground limestone, but does not require that limestone be added to the cement. Cement without ground limestone can be specified in the contract or order.

5.1.4 Air-entraining portland cement shall contain an interground addition conforming to the requirements of Specification C 226 or greater.

5.1.4 Processing additions. They shall have been shown to meet the requirements of Specification C 465 in the amounts used or greater.

5.1.5 Air-entraining addition (for air-entraining portland cement only). The interground addition shall conform to the requirements of Specification C 226.

6. Chemical Composition

6.1 Portland cement of each of the eight types shown in Section 1 shall conform to the respective standard chemical requirements prescribed in Table 1. In addition, optional chemical requirements are shown in Table 2.

NOTE 4—The limit on the sum, C₂S + 4.75C₃A, in Table 1 provides control on the heat of hydration of the cement and is consistent with a Test Method C 186 7-day heat of hydration limit of 335 kJ/kg (80 cal/g).

7. Physical Properties

7.1 Portland cement of each of the eight types shown in Section 1 shall conform to the respective standard physical requirements prescribed in Table 3. In addition, optional physical requirements are shown in Table 4.

8. Sampling

8.1 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.

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

9. Test Methods

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

9.1.1 *Air Content of Mortar*—Test Method C 185.

9.1.2 *Chemical Analysis*—Test Methods C 114.

9.1.3 *Strength*—Test Method C 109/C 109M.

9.1.4 *False Set*—Test Method C 451.

9.1.5 *Fineness by Air Permeability*—Test Method C 204.

9.1.6 *Fineness by Turbidimeter*—Test Method C 115.

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

9.1.8 *Autoclave Expansion*—Test Method C 151.

9.1.9 *Time of Setting by Gillmore Needles*—Test Method C 266.

9.1.10 *Time of Setting by Vicat Needles*—Test Method C 191.

9.1.11 *Sulfate Resistance*—Test Method C 452 (sulfate expansion).

9.1.12 *Calcium Sulfate (expansion of) Mortar*—Test Method C 1038.

9.1.13 *Optimum SO₃*—Test Method C 563.

10. Inspection

10.1 Inspection of the material shall be made as agreed upon between the purchaser and the seller as part of the purchase contract.

11. Rejection

11.1 The cement shall be rejected if it fails to meet any of the requirements of this specification.

TABLE 3 Standard Physical Requirements

Cement Type ^A	Applicable Test Method	I	IA	II	IIA	III	IIIA	IV	V
Air content of mortar, ^B volume %:	C 185								
max		12	22	12	22	12	22	12	12
min		...	16	...	16	...	16	...	...
Fineness, ^C specific surface, m ² /kg (alternative methods):									
Turbidimeter test, min	C 115	160	160	160	160	...	...	160	...
Turbidimeter test	C 115	...	...	...	...	...	...	...	...
Average value, min ^D		160	160	160	160	...	...	160	160
Any one sample, min ^E		150	150	150	150	...	...	150	150
Average value, max ^D		...	...	240 ^F	240 ^F	...	...	240	...
Any one sample, max ^E		...	...	245 ^F	245 ^F	...	...	245	...
Air permeability test, min	C 204	280	280	280	280	...	...	280	...
Air permeability test	C 204	...	...	...	...	...	...	...	...
Average value, min ^D		280	280	280	280	...	...	280	280
Any one sample, min ^E		260	260	260	260	...	...	260	260
Average value, max ^D		...	...	420 ^F	420 ^F	...	...	420	...
Any one sample, max ^E		...	...	430 ^F	430 ^F	...	...	430	...
Autoclave expansion, max, %	C 151	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Strength, not less than the values shown for the ages indicated as follows: ^G									
Strength, not less than the values shown for the ages indicated as follows: ^G									
Compressive strength, MPa (psi):	C 109/ C 109M								
1 day		...	...	...	...	12.0 (1740)	10.0 (1450)	...	...
1 day		...	...	...	...	12.0 (1740)	10.0 (1450)	...	...
3 days		12.0 (1740)	10.0 (1450)	10.0 (1450)	8.0 (1160)	24.0 (3480)	19.0 (2760)	...	8.0 (1160)
3 days		12.0 (1740)	10.0 (1450)	10.0 (1450)	8.0 (1160)	24.0 (3480)	19.0 (2760)	...	8.0 (1160)
7 days		19.0 (2760)	16.0 (2320)	17.0 (2470)	14.0 (2030)	...	...	7.0 (1020)	15.0 (2180)
7 days		19.0 (2760)	16.0 (2320)	17.0 (2470)	14.0 (2030)	...	...	7.0 (1020)	15.0 (2180)
28 days		...	...	...	...	...	...	17.0 (2470)	21.0 (3050)
28 days		...	...	...	...	...	...	17.0 (2470)	21.0 (3050)
Time of setting; Vicat test: ^F	C 191								
Time of setting; Vicat test: ^F	C 191								
Time of setting, min, not less than		45	45	45	45	45	45	45	45
Time of setting, min, not more than		375	375	375	375	375	375	375	375

^ASee Note 2.

^BCompliance with the requirements of this specification does not necessarily ensure that the desired air content will be obtained in concrete.

^CThe testing laboratory shall select the fineness method to be used. However, when the sample fails to meet the requirements of the air-permeability test, the turbidimeter test shall be used, and the requirements in this table for the turbidimetric method shall govern.

^DThe average strength at any specified test age shall be not less than that attained at any previous specified test age.

^EWhen the optional value of heat of hydration or the same sample shall be taken on the result of a test on the residue of the same sample after 24 hours of curing.

^FMaximum average and maximum single sample fineness limits do not apply if the sum of C₃S + 4.75C₂A is less than or equal to 90.

^GThe strength at any specified test age shall be not less than that attained at any previous specified test age.

^HWhen the optional heat of hydration in Table 4 is specified.

^IThe time of setting is that described as initial setting time in Test Method C 191.

11.2 At the option of the purchaser, retest, before using, cement remaining in bulk storage for more than 6 months or cement in bags in local storage in the custody of a vendor for more than 3 months after completion of tests and reject the cement if it fails to conform to any of the requirements of this specification. Cement so rejected shall be the responsibility of the owner of record at the time of resampling for retest.

11.3 Packages shall identify the mass contained as net weight. At the option of the purchaser, packages more than 2 % below the mass marked thereon shall be rejected and if the average mass of packages in any shipment, as shown by determining the mass of 50 packages selected at random, is less than that marked on the packages, the entire shipment shall be rejected.