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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 ten 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 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 II(MH)*—For general use, more especially when moderate heat of hydration and moderate sulfate resistance are desired.

1.1.6 *Type II(MH)A*—Air-entraining cement for the same uses as Type II(MH), where air-entrainment is desired.

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

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

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

1.1.10 *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.

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 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 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

C33 [Specification for Concrete Aggregates](#)

C51 [Terminology Relating to Lime and Limestone \(as used by the Industry\)](#)

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](#)

C115 [Test Method for Fineness of Portland Cement by the Turbidimeter](#)

C151 [Test Method for Autoclave Expansion of Hydraulic Cement](#)

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](#)

C191 [Test Methods for Time of Setting of Hydraulic Cement by Vicat Needle](#)

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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.

- 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
- C266 Test Method for Time of Setting of Hydraulic-Cement Paste by Gillmore Needles
- C451 Test Method for Early Stiffening of Hydraulic Cement (Paste Method)
- C452 Test Method for Potential Expansion of Portland-Cement Mortars Exposed to Sulfate
- C465 Specification for Processing Additions for Use in the Manufacture of Hydraulic Cements
- C563 Test Method for Approximation of Optimum SO₃ in Hydraulic Cement Using Compressive Strength
- C1038 Test Method for Expansion of Hydraulic Cement Mortar Bars Stored in Water
- E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- IEEE/ASTM SI 10 American National Standard for Use of the International System of Units (SI): The Modern Metric System

3. Terminology

3.1 *Definitions*—See Terminology C219.

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.

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.

5.1.3 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 C51, shall be naturally occurring and consist of at least 70 % by mass of one or more of the mineral forms of calcium carbonate.

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.

TABLE 1 Standard Composition Requirements

Cement Type ^A	Applicable Test Method	I and IA	II and IIA	II(MH) and II(MH)A	III and IIIA	IV	V
Aluminum oxide (Al ₂ O ₃), max, %	C114	...	6.0	6.0	...	...	...
Ferric oxide (Fe ₂ O ₃), max, %	C114	...	6.0 ^B	6.0 ^{B,C}	...	6.5	...
Magnesium oxide (MgO), max, %	C114	6.0	6.0	6.0	6.0	6.0	6.0
Sulfur trioxide (SO ₃), ^D max, %	C114						
When (C ₃ A) ^E is 8 % or less		3.0	3.0	3.0	3.5	2.3	2.3
When (C ₃ A) ^E is more than 8 %		3.5	^F	^F	4.5	^F	^F
Loss on ignition, max, %	C114	3.0	3.0	3.0	3.0	2.5	3.0
Insoluble residue, max, %	C114	0.75	0.75	0.75	0.75	0.75	0.75
Tricalcium silicate (C ₃ S) ^E , max, %	See Annex A1	...	...	...	...	35 ^C	...
Dicalcium silicate (C ₂ S) ^E , min, %	See Annex A1	...	...	...	...	40 ^C	...
Tricalcium aluminate (C ₃ A) ^E , max, %	See Annex A1	...	8	8	15	7 ^C	5 ^B
Sum of C ₃ S + 4.75C ₃ A ^G , max, %	See Annex A1	...	...	100 ^{C,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 ^B

^A See Note 2.

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

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

^D It is permissible to exceed the values in the table for SO₃ content, provided it has been demonstrated by Test Method C1038 that the cement with the increased SO₃ 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.

^E See Annex A1 for calculation.

^F Not applicable.

^G See Note 5.

^H In addition, 7-day heat of hydration testing by Test Method C186 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	II(MH) and II(MH)A	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
Equivalent alkalis (Na ₂ O + 0.658K ₂ O), max, %	C114	0.60 ^C	0.60 ^C	0.60 ^C	0.60 ^C	0.60 ^C	0.60 ^C	low-alkali cement

^A These optional requirements apply only when specifically requested. Verify availability before ordering. See Note 2.

^B See Annex A1 for calculation.

^C Specify 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 C33 for information on potential reactivity of aggregates.

5.1.4 Inorganic processing additions. The amount shall be not more than 5.0 % by mass of cement. Not more than one inorganic processing addition shall be used at a time. For amounts greater than 1.0 %, they shall have been shown to meet the requirements of Specification C465 for the inorganic processing addition in the amount used or greater. If an inorganic processing addition is used, the manufacturer shall report the amount (or range) used, expressed as a percentage of cement mass, along with the oxide composition of the processing addition. See Note 4.

NOTE 4—These requirements are based on data and recommendations by Taylor.³

5.1.5 Organic Processing additions. They shall have been shown to meet the requirements of Specification C465 in the amounts used or greater and the total amount of organic processing additions used shall not exceed 1.0 % by mass of cement.

5.1.6 Air-entraining addition (for air-entraining portland cement only). The interground addition shall conform to the requirements of Specification C226.

6. Chemical Composition

6.1 Portland cement of each of the ten 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 5—The limit on the sum, C₃S + 4.75C₃A, in Table 1 provides control on the heat of hydration of the cement and is consistent with a Test Method C186 7-day heat of hydration limit of 335 kJ/kg [80 cal/g].

NOTE 6—There are cases where performance of a cement is improved with SO₃ 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 SO₃ 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.

7. Physical Properties

7.1 Portland cement of each of the ten 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 C183.

8.2 Practice C183 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 C185.~~

9.1.2 ~~Chemical Analysis—Test Methods C114.~~

9.1.2 ~~Air Content of Mortar—Test Method C185.~~

9.1.3 ~~Strength—Test Method C109/C109M~~ Fineness by Air Permeability—Test Method C204.

9.1.4 ~~False Set—Test Method C451~~ Autoclave Expansion—Test Method C151.

9.1.5 ~~Fineness by Air Permeability—Test Method C204~~ Strength—Test Method C109/C109M.

9.1.6 ~~Fineness by Turbidimeter—Test Method C115~~ Time of Setting by Vicat Needles—Test Method C191.

9.1.7 ~~False Set—Test Method C451.~~

³ Taylor, P., "Specifications and Protocols for Acceptance Tests on Processing Additions in Cement Manufacturing," NCHRP Report 607, Transportation Research Board, Washington, DC 20008, 96 pp. Available at www.trb.org.



TABLE 3 Standard Physical Requirements

Cement Type ^A	I	IA	II	IIA	II(MH)	II(MH)A	III	IIIA	IV	V
Applicable Test Method										
Air content of mortar, ^B volume %:										
max	12	22	12	22	12	22	12	22	12	12
min	...	16	...	16	...	16	...	16	...	...
Fineness, ^C specific surface, m ² /kg (alternative methods):										
Turbidimeter test	450	450	450	450	450	450	...	...	450	450
—min	...	...	...	...	245 ^D	245 ^D	...	...	245	...
—max	260	260	260	260	260	260	...	...	260	260
Air permeability test										
—min	...	...	...	...	430 ^D	430 ^D	...	...	430	...
—max	...	...	...	...	430 ^C	430 ^C	...	...	430	...
Autoclave expansion, max, %	0.80	0.80	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: ^D										
Strength, not less than the values shown for the ages indicated as follows: ^D										
Compressive strength, MPa [psi]:										
1 day	...	...	...	...	...	...	12.0 [1740]	10.0 [1450]	...	...
—3 days	42.0 [1740]	40.0 [1450]	40.0 [1450]	8.0 [1160]	40.0 [1450]	8.0 [1160]	24.0 [3480]	49.0 [2760]	...	8.0 [1160]
—3 days	12.0 [1740]	10.0 [1450]	10.0 [1450]	8.0 [1160]	10.0 [1450]	8.0 [1160]	24.0 [3480]	19.0 [2760]	...	8.0 [1160]
—7 days	49.0 [2760]	46.0 [2320]	47.0 [2470]	44.0 [2030]	47.0 [2470]	44.0 [2030]	...	...	7.0 [1020]	45.0 [2180]
—7 days	19.0 [2760]	16.0 [2320]	17.0 [2470]	14.0 [2030]	17.0 [2470]	14.0 [2030]	...	...	7.0 [1020]	15.0 [2180]
28 days	...	...	...	...	...	...	...	...	17.0 [2470]	21.0 [3050]
Time of setting—Vicat test: ^G										
Time of setting, Vicat test: ^F	45	45	45	45	45	45	45	45	45	45
Time of setting, min, not less than	375	375	375	375	375	375	375	375	375	375
Time of setting, min, not more than	...	...	...	...	...	...	...	...	...	...

^A See Note 2.

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

^C The 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 turbidimeter method shall govern.

^D Maximum fineness limits do not apply if the sum of C₃S + 4.75C₃A is less than or equal to 90.

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

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

^G The time of setting is that described as initial setting time in Test Method C191.