



Designation: C 150 – 02a

Standard Specification for Portland Cement¹

This standard is issued under the fixed designation C 150; 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 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.

1.2 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:*

C 33 Specification for Concrete Aggregates²

C 109/C 109M Test Method for Compressive Strength of

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.

Current edition approved Aug. 10, 2002. Published October 2002. Originally published as C 150 – 40 T. Last previous edition C 150 – 02.

² *Annual Book of ASTM Standards*, Vol 04.02.

Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)³

C 114 Test Methods for Chemical Analysis of Hydraulic Cement³

C 115 Test Method for Fineness of Portland Cement by the Turbidimeter³

C 151 Test Method for Autoclave Expansion of Portland Cement³

C 183 Practice for Sampling and the Amount of Testing of Hydraulic Cement³

C 185 Test Method for Air Content of Hydraulic Cement Mortar³

C 186 Test Method for Heat of Hydration of Hydraulic Cement³

C 191 Test Method for Time of Setting of Hydraulic Cement by Vicat Needle³

C 204 Test Method for Fineness of Hydraulic Cement by Air Permeability Apparatus³

C 219 Terminology Relating to Hydraulic Cement³

C 226 Specification for Air-Entraining Additions for Use in the Manufacture of Air-Entraining Hydraulic Cement³

C 266 Test Method for Time of Setting of Hydraulic Cement Paste by Gillmore Needles³

C 451 Test Method for Early Stiffening of Hydraulic Cement (Paste Method)³

C 452 Test Method for Potential Expansion of Portland-Cement Mortars Exposed to Sulfate³

C 465 Specification for Processing Additions for Use in the Manufacture of Hydraulic Cements³

C 563 Test Method for Optimum SO₃ in Hydraulic Cement Using 24-h Compressive Strength³

C 1038 Test Method for Expansion of Hydraulic Cement Mortar Bars Stored in Water³

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications⁴

3. Terminology

3.1 *Definitions*—See Terminology C 219.

³ *Annual Book of ASTM Standards*, Vol 04.01.

⁴ *Annual Book of ASTM Standards*, Vol 14.02.



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,
- 4.1.4 Type of setting-time test required, Vicat or Gillmore. If not specified, the Vicat shall be used, and
- 4.1.5 Any optional physical requirements from Table 3, 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 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 Air-entraining portland cement shall contain an inter-ground addition conforming 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 3—When comparing oxide analyses and calculated phases from different sources or from different historic times, be aware that they may

not have been reported on exactly the same basis. Chemical data obtained by Reference and Alternate Test Methods of Test Methods C 114 (wet chemistry) may include titania and phosphorus as alumina unless proper correction has been made (see Test Methods C 114), while data obtained by rapid instrumental methods usually do not. This can result in small differences in the calculated phases. Such differences are usually within the precision of the analytical methods, even when the methods are properly qualified under the requirements of Test Methods C 114.

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 109/M.
- 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).

TABLE 1 Standard Composition Requirements

Cement Type ^A	Applicable Test Method	I and IA	I and IIIA	III and IIIA	IV	V
Silicon dioxide (SiO ₂), min, %	C 114	...	20.0 ^{B,C}	...	...	...
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) is 8 % or less		3.0	3.0	3.5	2.3	2.3
When (C ₃ A) is more than 8 %		3.5	^E	4.5	^E	^E
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), max, %	See Annex	...	...	...	35 ^B	...
Dicalcium silicate (C ₂ S), min, %	See Annex	...	...	...	40 ^B	...
Tricalcium aluminate (C ₃ A), max, %	See Annex	...	8	15	7 ^B	5 ^C
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	...	...	...	...	25 ^C

^A See Note 2.

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

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

^D There 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.

^E Not applicable.



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), max, %	See Annex	...	...	8	...	...	for moderate sulfate resistance
Tricalcium aluminate (C ₃ A), max, %	See Annex	...	...	5	...	...	for high sulfate resistance
Sum of tricalcium silicate and tricalcium aluminate, max, %	See Annex	...	58 ^B	...	...	...	for moderate heat of hydration
Equivalent alkalis (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

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

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

^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 C 33 for information on potential reactivity of aggregates.

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	160
Air permeability test, min	C 204	280	280	280	280	...	...	280	280
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: ^D									
Compressive strength, MPa (psi):	C 109/ C 109M								
1 day		...	...	...	...	12.0 (1740)	10.0 (1450)	...	...
3 days		12.0 (1740)	10.0 (1450)	10.0 (1450) 7.0 ^E (1020) ^E	8.0 (1160) 6.0 ^E (870) ^E	24.0 (3480)	19.0 (2760)	...	8.0 (1160)
7 days		19.0 (2760)	16.0 (2320)	17.0 (2470) 12.0 ^E (1740) ^E	14.0 (2030) 9.0 ^E (1310) ^E	...	...	7.0 (1020)	15.0 (2180)
28 days		...	...	...	...	...	...	17.0 (2470)	21.0 (3050)
Time of setting (alternative methods): ^F									
Gillmore test:	C 266								
Initial set, min, not less than		60	60	60	60	60	60	60	60
Final set, min, not more than		600	600	600	600	600	600	600	600
Vicat test: ^G	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

^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 turbidimetric method shall govern.

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

^E When the optional heat of hydration or the chemical limit on the sum of the tricalcium silicate and tricalcium aluminate is specified.

^F The time-of-setting test required shall be specified by the purchaser. In case he does not so specify, the requirements of the Vicat test only shall govern.

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

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.

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



TABLE 4 Optional Physical Requirements^A

Cement Type ^A	Applicable Test Method	I	IA	II	IIA	III	IIIA	IV	V
False set, final penetration, min, %	C 451	50	50	50	50	50	50	50	50
Heat of hydration:	C 186								
7 days, max, kJ/kg (cal/g)		...	...	290 (70) ^B	290 (70) ^B	...	...	250 (60) ^C	...
28 days, max, kJ/kg (cal/g)		...	...	...	...	...	...	290 (70) ^C	...
Strength, not less than the values shown:									
Compressive strength, MPa (psi)	C 109/ C 109M								
28 days		28.0 (4060)	22.0 (3190)	28.0 (4060) 22.0 ^B (3190) ^B	22.0 (3190) 18.0 ^B (2610) ^B	...	...	...	...
Sulfate resistance, ^D 14 days, max, % expansion	C 452	...	...	...^E	... ^E	...	...	...	0.040

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

^B The optional limit for the sum of the tricalcium silicate and tricalcium aluminate in Table 2 shall not be requested when this optional limit is requested. These strength requirements apply when either heat of hydration or the sum of tricalcium silicate and tricalcium aluminate requirements are requested.

^C When the heat of hydration limit is specified, it shall be instead of the limits of C₃S, C₂S, C₃A, SiO₂, and Fe₂O₃ listed in Table 1.

^D When the sulfate resistance is specified, it shall be instead of the limits of C₃A, C₄AF + 2 C₃A, SiO₂, and Fe₂O₃ listed in Table 1.

^E Cement meeting the high sulfate resistance limit for Type V is deemed to meet the moderate sulfate resistance requirement of Type II.

determining the mass of 50 packages selected at random, is less than that marked on the packages, the entire shipment shall be rejected.

12. Manufacturer's Statement

12.1 At the request of the purchaser, the manufacturer shall state in writing the nature, amount, and identity of any air-entraining addition and of any processing addition used, and also, if requested, shall supply test data showing compliance of such air-entraining addition with Specification C 226 and of such processing addition with Specification C 465.

13. Packaging and Package Marking

13.1 When the cement is delivered in packages, the words "Portland Cement," the type of cement, the name and brand of the manufacturer, and the mass of the cement contained therein shall be plainly marked on each package. When the cement is an air-entraining type, the words "air-entraining" 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.

NOTE 4—With the change to SI units, it is desirable to establish a standard SI package for portland cements. To that end 42 kg (92.6 lb) provides a convenient, even-numbered mass reasonably similar to the traditional 94-lb (42.6-kg) package.

14. Storage

14.1 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 weather-tight building that will protect the cement from dampness and minimize warehouse set.

15. Manufacturer's Certification

15.1 Upon request of the purchaser in the contract or order, a manufacturer's report shall be furnished at the time of shipment stating the results of tests made on samples of the material taken during production or transfer and certifying that the cement conforms to applicable requirements of this specification.

16. Keywords

16.1 hydraulic cement; portland cement; specification



ANNEX

(Mandatory Information)

A1. CALCULATION OF POTENTIAL CEMENT PHASE COMPOSITION

A1.1 All values calculated as described in this annex shall be rounded according to Practice E 29. When evaluating conformance to a specification, round values to the same number of places as the corresponding table entry before making comparisons. The expressing of chemical limitations by means of calculated assumed phases does not necessarily mean that the oxides are actually or entirely present as such phases.

A1.2 When expressing phases, C = CaO, S = SiO₂, A = Al₂O₃, F = Fe₂O₃. For example, C₃A = 3CaO·Al₂O₃. Titanium dioxide and phosphorus pentoxide (TiO₂ and P₂O₅) shall not be included with the Al₂O₃ content. See Note 3.

A1.3 When the ratio of percentages of aluminum oxide to ferric oxide is 0.64 or more, the percentages of tricalcium silicate, dicalcium silicate, tricalcium aluminate, and tetracalcium aluminoferrite shall be calculated from the chemical analysis as follows:

$$\begin{aligned} \text{Tricalcium silicate} = & (4.071 \times \% \text{CaO}) - \\ & (7.600 \times \% \text{SiO}_2) - (6.718 \times \% \text{Al}_2\text{O}_3) - \\ & (1.430 \times \% \text{Fe}_2\text{O}_3) - (2.852 \times \% \text{SO}_3) \end{aligned}$$

$$\begin{aligned} \text{Dicalcium silicate} = & (2.867 \times \% \text{SiO}_2) \\ & - (0.7544 \times \% \text{C}_3\text{S}) \end{aligned}$$

$$\begin{aligned} \text{Tricalcium aluminate} = & (2.650 \times \% \text{Al}_2\text{O}_3) \\ & - (1.692 \times \% \text{Fe}_2\text{O}_3) \end{aligned}$$

$$\text{Tetracalcium aluminoferrite} = 3.043 \times \% \text{Fe}_2\text{O}_3$$

A1.3.1 When the alumina-ferric oxide ratio is less than 0.64, a calcium aluminoferrite solid solution (expressed as ss(C₄AF + C₂F)) is formed. Contents of this solid solution and of tricalcium silicate shall be calculated by the following formulas:

$$\text{ss (C}_4\text{AF + C}_2\text{F)} = (2.100 \times \% \text{Al}_2\text{O}_3) + (1.702 \times \% \text{Fe}_2\text{O}_3) \quad (\text{A1.1})$$

$$\begin{aligned} \text{Tricalcium silicate} = & (4.071 \times \% \text{CaO}) - (7.600 \times \% \text{SiO}_2) - (4.479 \\ & \times \% \text{Al}_2\text{O}_3) - (2.859 \times \% \text{Fe}_2\text{O}_3) - (2.852 \\ & \times \% \text{SO}_3) \end{aligned} \quad (\text{A1.2})$$

A1.3.2 No tricalcium aluminate will be present in cements of this composition. Dicalcium silicate shall be calculated as previously shown.

APPENDIX

(Nonmandatory Information)

X1. MANUFACTURER'S CERTIFICATION (MILL TEST REPORT)

X1.1 To provide uniformity for reporting the results of tests performed on cements under this specification, as required by Section 15 of Specification C 150 entitled "Manufacturer's Certification," an example Mill Test Report is shown in Fig. X1.1.

X1.2 The identity information given should unambiguously identify the cement production represented by the Mill Test Report and may vary depending upon the manufacturer's designation and purchaser's requirements.

X1.3 The Manufacturer's Certification statement may vary depending upon the manufacturer's procurement order, or legal requirements, but should certify that the cement shipped is represented by the certificate and that the cement conforms to applicable requirements of the specification at the time it was tested (or retested) or shipped.

X1.4 The sample Mill Test Report has been developed to

reflect the chemical and physical requirements of this specification and recommends reporting all analyses and tests normally performed on cements meeting Specification C 150. Purchaser reporting requirements should govern if different from normal reporting by the manufacturer or from those recommended here.

X1.5 Cements may be shipped prior to later-age test data being available. In such cases, the test value may be left blank. Alternatively, the manufacturer can generally provide estimates based on historical production data. The report should indicate if such estimates are provided.

X1.6 In reporting limits from the tables in Specification C 150 on the Mill Test Report, only those limits specifically applicable should be listed. In some cases, Specification C 150 table limits are superseded by other provisions.



ABC Portland Cement Company
Qualitytown, N. J.

Plant Example Cement Type II Date March 9, 1998

Production Period March 2, 1998 - March 8, 1998

STANDARD REQUIREMENTS
ASTM C 150 Tables 1 and 3

CHEMICAL			PHYSICAL		
Item	Spec. Limit	Test Result	Item	Spec. Limit	Test Result
SiO ₂ (%)	20.0 min	21.3	Air content of mortar (volume %)	12 max	8
Al ₂ O ₃ (%)	6.0 max	4.6	Fineness (m ² /kg) (Air permeability)	280 min	377
Fe ₂ O ₃ (%)	6.0 max	3.4		Autoclave expansion (%)	0.80 max	0.04
CaO (%)	<i>A</i>	63.2	Compressive strength (MPa) min: 1 Day 3 Days 7 Days 28 Days	<i>A</i>	
MgO (%)	6.0 max	2.2		7.0	23.4
SO ₃ (%)	3.0 max	2.7		12.0	29.8
Loss on ignition (%)	3.0 max	1.2		<i>A</i>	
Na ₂ O (%)	<i>A</i>	0.19	Time of setting (minutes) (Vicat) Initial	Not less than 45	124
K ₂ O (%)	<i>A</i>	0.50		Not more than 375	
Insoluble residue (%)	0.75 max	0.27			
Potential compounds (%)					
C ₃ S	<i>A</i>	52			
C ₂ S	<i>A</i>	22			
C ₃ A	8 max	6			
C ₄ AF	<i>A</i>	10			
C ₄ AF+2(C ₃ A)	<i>A</i>	22			

^ANot applicable.

OPTIONAL REQUIREMENTS
ASTM C 150 Tables 2 and 4

CHEMICAL			PHYSICAL		
Item	Spec. Limit	Test Result	Item	Spec. Limit	Test Result
C ₃ S + C ₃ A (%)	58 max	58	False set (%)	50 min	82
Equivalent alkalies(%)	<i>B</i>	0.52	Heat of hydration (kJ/kg) 7 days	<i>B</i>	300
			Compressive strength (MPa) 28 days	28.0 min	39.7

^BLimit not specified by purchaser. Test result provided for information only.

^CTest result for this production period not yet available.

We certify that the above described cement, at the time of shipment, meets the chemical and physical requirements of the ASTM C 150-97 or (other) _____ specification.

Signature: _____ Title: _____

FIG. X1.1 Example Mill Test Report

**NOTICE: This standard has either been superceded and replaced by a new version or discontinued.
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