Designation: C 150 – 07

# Standard Specification for Portland Cement[1]

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.

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)

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

[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 May 1, 2007. Published June 2007. Originally approved in 1940. Last previous edition approved in 2005 as C 150 – 05.

[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 563 Test Method for Approximation of Optimum $SO_3$ in Hydraulic Cement Using 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.

## 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 C 51, 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.

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, $C_3S + 4.75C_3A$, 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.



**TABLE 1 Standard Composition Requirements**

| Cement Type[A] | Applicable Test Method | I and IA | II and IIA | III and IIIA | IV | V |
|---|---|---|---|---|---|---|
| Aluminum oxide ($Al_2O_3$), max, % | C 114 | ... | 6.0 | ... | ... | ... |
| Ferric oxide ($Fe_2O_3$), 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 $(C_3A)^E$ is 8 % or less | | 3.0 | 3.0 | 3.5 | 2.3 | 2.3 |
| When $(C_3A)^E$ 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 $(C_3S)^E$, max, % | See Annex A1 | ... | ... | ... | 35[B] | ... |
| Dicalcium silicate $(C_2S)^E$, min, % | See Annex A1 | ... | ... | ... | 40[B] | ... |
| Tricalcium aluminate $(C_3A)^E$, max, % | See Annex A1 | ... | 8 | 15 | 7[B] | 5[C] |
| Sum of $C_3S + 4.75C_3A^G$, max, % | See Annex A1 | ... | 100[H] | ... | ... | ... |
| Tetracalcium aluminoferrite plus twice the tricalcium aluminate ($C_4AF + 2(C_3A)$), or solid solution ($C_4AF + C_2F$), as applicable, max, % | See Annex A1 | ... | ... | ... | ... | 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 $SO_3$ (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 $SO_3$ 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 $SO_3$ 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] See Annex A1 for calculation.
[F] Not applicable.
[G] See Note 4.
[H] In 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 ($C_3A$)[B], max, % | See Annex A1 | ... | ... | 8 | ... | ... | for moderate sulfate resistance |
| Tricalcium aluminate ($C_3A$)[B], max, % | See Annex A1 | ... | ... | 5 | ... | ... | for high sulfate resistance |
| Equivalent alkalies ($Na_2O + 0.658K_2O$), 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.
[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 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 | 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 | 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] | | | | | | | | | |
| 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[H] (1020)[H] | 8.0 (1160) 6.0[H] (870)[H] | 24.0 (3480) | 19.0 (2760) | ... | 8.0 (1160) |
| 7 days | | 19.0 (2760) | 16.0 (2320) | 17.0 (2470) 12.0[H] (1740)[H] | 14.0 (2030) 9.0[H] (1310)[H] | ... | ... | 7.0 (1020) | 15.0 (2180) |
| 28 days | | ... | ... | ... | ... | ... | ... | 17.0 (2470) | 21.0 (3050) |
| Time of setting; Vicat test:[I] | 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]Average value shall be determined on the last consecutive five samples from a source.
[E]The value of any one sample shall be the result of a test or average of tests on any one sample.
[F]Maximum average and maximum single sample fineness limits do not apply if the sum of $C_3S + 4.75C_3A$ is less than or equal to 90.
[G]The strength at any specified test age shall be not less than that attained at any previous specified test age.
[H]When the optional heat of hydration in Table 4 is specified.
[I]The time of setting is that described as initial setting time in Test Method C 191.



## 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.

**TABLE 4 Optional Physical Requirements[A]**

| Cement Type | 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 |
| 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 |

[A] These optional requirements apply only when specifically requested. Verify availability before ordering. See Note 2.
[B] The limit for the sum of $C_3S + 4.75C_3A$ in Table 1 shall not apply when this optional limit is requested. These strength requirements apply when the optional heat of hydration requirement is requested.
[C] When the heat of hydration limit is specified, it shall be instead of the limits of $C_3S$, $C_2S$, $C_3A$, and $Fe_2O_3$ listed in Table 1.
[D] When the sulfate resistance is specified, it shall be instead of the limits of $C_3A$, $C_4AF + 2\ C_3A$, and $Fe_2O_3$ 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.

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 $SO_3$*—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 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.

12.2 When limestone is used, the manufacturer shall state in writing the amount thereof and, if requested by the purchaser, shall supply comparative test data on chemical and physical properties of the cement with and without the limestone (See Note 5). The comparative tests do not supersede the normal testing to confirm that the cement meets chemical and physical requirements of this standard. The amount of limestone in cement shall be determined in accordance with Annex A2.

NOTE 5—Comparative test data may be from qualification tests performed by the manufacturer during formulation of the cement with limestone.

## 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 6—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.