



Designation: C150/C150M – 17

## Standard Specification for Portland Cement<sup>1</sup>

This standard is issued under the fixed designation C150/C150M; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 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 III, 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]

<sup>1</sup> 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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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.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

### 2. Referenced Documents

2.1 *ASTM Standards*:<sup>2</sup>

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

C204 Test Methods for Fineness of Hydraulic Cement by

<sup>2</sup> 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

- 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** Guide for Approximation of Optimum SO<sub>3</sub> in Hydraulic Cement
- C1038** Test Method for Expansion of Hydraulic Cement Mortar Bars Stored in Water
- C1702** Test Method for Measurement of Heat of Hydration of Hydraulic Cementitious Materials Using Isothermal Conduction Calorimetry
- 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

- 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. If limestone is used, the manufacturer shall report the amount used, expressed as a percentage of cement mass, as determined using **Annex A2**, along with the oxide composition of the limestone.

**NOTE 3**—This standard permits portland cement to contain limestone, but does not require that limestone be an ingredient in the cement. Cement without ground limestone can be specified in the contract or order.

- 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

### 3. Terminology

3.1 *Definitions*—See Terminology **C219**.

### 4. Ordering Information

4.1 Orders for material under this specification shall include the following:

**TABLE 1 Standard Composition Requirements**

Cement Type <sup>A</sup>	Applicable Test Method	I and IA	II and IIA	II(MH) and II(MH)A	III and IIIA	IV	V
Aluminum oxide (Al <sub>2</sub> O <sub>3</sub> ), max, %	<b>C114</b>	...	6.0	6.0	...	...	...
Ferric oxide (Fe <sub>2</sub> O <sub>3</sub> ), max, %	<b>C114</b>	...	6.0 <sup>B</sup>	6.0 <sup>B,C</sup>	...	6.5	...
Magnesium oxide (MgO), max, %	<b>C114</b>	6.0	6.0	6.0	6.0	6.0	6.0
Sulfur trioxide (SO <sub>3</sub> ), <sup>D</sup> max, %	<b>C114</b>						
When (C <sub>3</sub> A) <sup>E</sup> is 8 % or less		3.0	3.0	3.0	3.5	2.3	2.3
When (C <sub>3</sub> A) <sup>E</sup> is more than 8 %		3.5	<sup>F</sup>	<sup>F</sup>	4.5	<sup>F</sup>	<sup>F</sup>
Loss on ignition, max, %	<b>C114</b>						
When limestone is not an ingredient		3.0	3.0	3.0	3.0	2.5	3.0
When limestone is an ingredient		3.5	3.5	3.5	3.5	3.5	3.5
Insoluble residue, max, %	<b>C114</b>	1.5	1.5	1.5	1.5	1.5	1.5
Tricalcium silicate (C <sub>3</sub> S) <sup>E</sup> , max, %	See <b>Annex A1</b>	...	...	...	...	35 <sup>C</sup>	...
Dicalcium silicate (C <sub>2</sub> S) <sup>E</sup> , min, %	See <b>Annex A1</b>	...	...	...	...	40 <sup>C</sup>	...
Tricalcium aluminate (C <sub>3</sub> A) <sup>E</sup> , max, %	See <b>Annex A1</b>	...	8	8	15	7 <sup>C</sup>	5 <sup>B</sup>
Sum of C <sub>3</sub> S + 4.75C <sub>3</sub> A <sup>G</sup> , max, %	See <b>Annex A1</b>	...	...	100 <sup>C,H</sup>	...	...	...
Tetracalcium aluminoferrite plus twice the tricalcium aluminate (C <sub>4</sub> AF + 2(C <sub>3</sub> A)), or solid solution (C <sub>4</sub> AF + C <sub>2</sub> F), as applicable, max, %	See <b>Annex A1</b>	...	...	...	...	...	25 <sup>B</sup>

<sup>A</sup> See **Note 2**.

<sup>B</sup> Does not apply when the sulfate resistance limit in **Table 4** is specified.

<sup>C</sup> Does not apply when the heat of hydration limit in **Table 4** is specified.

<sup>D</sup> It is permissible to exceed the values in the table for SO<sub>3</sub> content, provided it has been demonstrated by Test Method **C1038** that the cement with the increased SO<sub>3</sub> 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**.

<sup>E</sup> See **Annex A1** for calculation.

<sup>F</sup> Not applicable.

<sup>G</sup> See **Note 5**.

<sup>H</sup> In addition, three-day heat of hydration testing by Test Method **C1702** 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<sup>A</sup>**

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 <sub>3</sub> A) <sup>B</sup> , max, %	See <b>Annex A1</b>	...	...	...	8	...	...	for moderate sulfate resistance
Tricalcium aluminate (C <sub>3</sub> A) <sup>B</sup> , max, %	See <b>Annex A1</b>	...	...	...	5	...	...	for high sulfate resistance
Equivalent alkalis (Na <sub>2</sub> O + 0.658K <sub>2</sub> O), max, %	<b>C114</b>	0.60 <sup>C</sup>	0.60 <sup>C</sup>	0.60 <sup>C</sup>	0.60 <sup>C</sup>	0.60 <sup>C</sup>	0.60 <sup>C</sup>	low-alkali cement

<sup>A</sup> These optional requirements apply only when specifically requested. Verify availability before ordering. See **Note 2**.

<sup>B</sup> See **Annex A1** for calculation.

<sup>C</sup> 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.

**TABLE 3 Standard Physical Requirements**

Cement Type <sup>A</sup>	Applicable Test Method	I	IA	II	IIA	II(MH)	II(MH)A	III	IIIA	IV	V
Air content of mortar, <sup>B</sup> volume %:	<b>C185</b>										
max		12	22	12	22	12	22	12	22	12	12
min		...	16	...	16	...	16	...	16	...	...
Fineness, specific surface, m <sup>2</sup> /kg											
Air permeability test	<b>C204</b>										
min		260	260	260	260	260	260	...	...	260	260
max		...	...	...	...	430 <sup>C</sup>	430 <sup>C</sup>	...	...	430	...
Autoclave expansion, max, %	<b>C151</b>	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: <sup>D</sup>											
Compressive strength, MPa [psi]:	<b>C109/ C109M</b>										
1 day		...	...	...	...	...	...	12.0	10.0	...	...
3 days		12.0 [1740]	10.0 [1450]	10.0 [1450]	8.0 [1160]	10.0 [1450] 7.0 <sup>E</sup> [1020] <sup>E</sup>	8.0 [1160] 6.0 <sup>E</sup> [870] <sup>E</sup>	24.0 [3480]	19.0 [2760]	...	8.0 [1160]
7 days		19.0 [2760]	16.0 [2320]	17.0 [2470]	14.0 [2030]	17.0 [2470] 12.0 <sup>E</sup> [1740] <sup>E</sup>	14.0 [2030] 9.0 <sup>E</sup> [1310] <sup>E</sup>	...	...	7.0 [1020]	15.0 [2180]
28 days		...	...	...	...	...	...	...	...	17.0 [2470]	21.0 [3050]
Time of setting; Vicat test: <sup>F</sup>	<b>C191</b>										
Time of setting, min, not less than		45	45	45	45	45	45	45	45	45	45
Time of setting, min, not more than		375	375	375	375	375	375	375	375	375	375

<sup>A</sup> See **Note 2**.

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

<sup>C</sup> Maximum fineness limits do not apply if the sum of C<sub>3</sub>S + 4.75C<sub>3</sub>A is less than or equal to 90.

<sup>D</sup> The strength at any specified test age shall be not less than that attained at any previous specified test age.

<sup>E</sup> When the optional heat of hydration in **Table 4** is specified.

<sup>F</sup> The time of setting is that described as initial setting time in Test Method **C191**.

**TABLE 4 Optional Physical Requirements<sup>A</sup>**

Cement Type	Applicable Test Method	I and II	IA and IIA	II(MH)	II(MH)A	III	IIIA	IV	V
False set, final penetration, min, %	<b>C451</b>	50	50	50	50	50	50	50	50
Heat of hydration <sup>B</sup> (alternative methods):									
Isothermal Conduction Calorimetry:									
3 days, max, kJ/kg [cal/g]	<b>C1702</b>	...	...	255 [60] <sup>C</sup>	255 [60] <sup>C</sup>	...	...	200 [50] <sup>D</sup>	...
7 days, max, kJ/kg [cal/g]		...	...	...	...	...	...	225 [55] <sup>D</sup>	...
Heat of solution:									
7 days, max, kJ/kg [cal/g]	<b>C186</b>	...	...	290 [70] <sup>C</sup>	290 [70] <sup>C</sup>	...	...	250 [60] <sup>D</sup>	...
28 days, max, kJ/kg [cal/g]		...	...	...	...	...	...	290 [70] <sup>D</sup>	...
Strength, not less than the values shown:									
Compressive strength, MPa [psij]	<b>C109/C109M</b>								
28 days		28.0 [4060]	22.0 [3190]	28.0 [4060] 22.0 <sup>C</sup> [3190] <sup>C</sup>	22.0 [3190] 18.0 <sup>C</sup> [2610] <sup>C</sup>	...	...	...	...
Sulfate resistance, <sup>E</sup> 14 days, max, % expansion	<b>C452</b>	... <sup>F</sup>	... <sup>F</sup>	... <sup>F</sup>	... <sup>F</sup>	...	...	...	0.040
Gillmore test:	<b>C266</b>								
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
Turbidimeter test	<b>C115</b>								
min		150	150	150	150	...	...	150	150
max		...	...	245 <sup>G</sup>	245 <sup>G</sup>	...	...	245	...

<sup>A</sup> These optional requirements apply only when specifically requested. Verify availability before ordering. See **Note 2**.

<sup>B</sup> The method used shall be identified on all test reports that include this data. If test results do not meet requirements of the heat of solution method, the isothermal conduction calorimetry method shall be used, and the requirements for the isothermal conduction calorimetry method shall govern.

<sup>C</sup> The limit for the sum of C<sub>3</sub>S + 4.75C<sub>3</sub>A 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.

<sup>D</sup> When the heat of hydration limit is specified, it shall be instead of the limits of C<sub>3</sub>S, C<sub>2</sub>S, C<sub>3</sub>A, and Fe<sub>2</sub>O<sub>3</sub> listed in **Table 1**.

<sup>E</sup> When the sulfate resistance is specified, it shall be instead of the limits of C<sub>3</sub>A, C<sub>4</sub>AF + 2 C<sub>3</sub>A, and Fe<sub>2</sub>O<sub>3</sub> listed in **Table 1**.

<sup>F</sup> Cement meeting the high sulfate resistance limit for Type V is deemed to meet the moderate sulfate resistance requirement of Type II and Type II(MH).

<sup>G</sup> Maximum fineness limits do not apply if the sum of C<sub>3</sub>S + 4.75 C<sub>3</sub>A is less than or equal to 90.

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 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.<sup>3</sup>

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, C<sub>3</sub>S + 4.75C<sub>3</sub>A, in **Table 1** provides control on the heat of hydration of the cement and is consistent with a Test Method **C186** seven-day heat of hydration limit of 335 kJ/kg [80 cal/g], or

<sup>3</sup> 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](http://www.trb.org).

a Test Method **C1702** three-day heat of hydration limit of 315 kJ/kg [75 cal/g].

**NOTE 6**—There are cases where performance of a cement is improved with SO<sub>3</sub> in excess of the **Table 1** limits in this specification. Guide **C563** is one of several methods a manufacturer can use to evaluate the effect of sulfate content on cement characteristics. Whenever SO<sub>3</sub> 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 *Chemical Analysis*—Test Methods **C114**.

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

9.1.3 *Fineness by Air Permeability*—Test Method **C204**.

9.1.4 *Autoclave Expansion*—Test Method **C151**.

9.1.5 *Strength*—Test Method **C109/C109M**.

9.1.6 *Time of Setting by Vicat Needles*—Test Method **C191**.