
Standard Specification for Portland Cement

AASHTO Designation: M 85-24¹

Technically Revised: 2024

Technical Subcommittee: 3a, Cement, Lime, and Concrete Materials

ASTM Designation: C150/C150M-24



**American Association of State Highway and Transportation Officials
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1. SCOPE

- 1.1. *This specification covers seven types of portland cement as follows (see Note 1):*
- 1.1.1. *Type I*—For general 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 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; and
 - 1.1.7. *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 that 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. *AASHTO Standards:*
- M 327, Processing Additions for Use in the Manufacture of Hydraulic Cements
 - R 71, Sampling and Amount of Testing of Hydraulic Cement
 - R 80, Determining the Reactivity of Concrete Aggregates and Selecting Appropriate Measures for Preventing Deleterious Expansion in New Concrete Construction
 - T 105, Chemical Analysis of Hydraulic Cement

- T 106M/T 106, Compressive Strength of Hydraulic Cement Mortar (Using 50-mm or 2-in. Cube Specimens)
- T 131, Time of Setting of Hydraulic Cement by Vicat Needle
- T 137, Air Content of Hydraulic Cement Mortar
- T 153, Fineness of Hydraulic Cement by Air Permeability Apparatus
- T 154, Time of Setting of Hydraulic Cement Paste by Gillmore Needles
- T 186, Early Stiffening of Hydraulic Cement (Paste Method)

2.2. *ASTM Standards:*

- C33/C33M, Standard Specification for Concrete Aggregates
- C51, Standard Terminology Relating to Lime and Limestone (as used by the Industry)
- C226, Standard Specification for Air-Entraining Additions for Use in the Manufacture of Air-Entraining Hydraulic Cement
- C452, Standard Test Method for Potential Expansion of Portland-Cement Mortars Exposed to Sulfate
- C563, Standard Test Method for Approximation of Optimum SO₃ in Hydraulic Cement
- C1038/C1038M, Standard Test Method for Expansion of Hydraulic Cement Mortar Bars Stored in Water
- C1702, Standard Test Method for Measurement of Heat of Hydration of Hydraulic Cementitious Materials Using Isothermal Conduction Calorimetry
- E29, Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

3. TERMINOLOGY

3.1. *Definitions:*

3.1.1. *portland cement*—a hydraulic cement produced by pulverizing clinker, consisting essentially of hydraulic calcium silicates, and usually containing one or more of the following:

- water,
- calcium sulfate,
- up to 5 percent limestone, and
- processing additions.

3.1.2. *air-entraining portland cement*—a portland cement containing an interground air-entraining addition.

3.1.3. *hydraulic cement*—a cement that sets and hardens by chemical interaction with water and is capable of doing so under water.

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 is not carried in stock in some areas. In advance of specifying the use of other than Type I cement, determine whether the proposed type of cement is, or can be made, available.

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 shall not be exceeded.

Table 1—Standard Chemical Requirements^a

Cement Type	Applicable Test Method	I and IA	II and IIA	III and IIIA	V
Aluminum oxide (Al ₂ O ₃), max, %	T 105	—	6.0	—	—
Ferric oxide (Fe ₂ O ₃), max, %	T 105	—	6.0 ^b	—	—
Magnesium oxide (MgO), max, %	T 105	6.0	6.0	6.0	6.0
Sulfur trioxide (SO ₃), ^c max, %	T 105				
When (C ₃ A) ^d is 8% or less		3.0	3.0	3.5	2.3
When (C ₃ A) ^d is more than 8%		3.5	^e	4.5	^e
Loss on ignition, max, %	T 105				
When limestone is not an ingredient		3.0	3.0	3.0	3.0
When limestone is an ingredient		3.5	3.5	3.5	3.5
Insoluble residue, max, %	T 105	1.5	1.5	1.5	1.5
Equivalent alkalis (Na ₂ O + 0.658 K ₂ O), %	T 105	^f	^f	^f	^f
Tricalcium aluminate (C ₃ A), ^d max, %	See Annex A	—	8	15	5 ^b
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 A	—	—	—	25 ^b

^a See Note 2.

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

^c It is permissible to exceed the values in the table for SO₃ content, provided it has been demonstrated by ASTM C1038/C1038M that the cement with the increased SO₃ will not develop expansion exceeding 0.020 percent at 14 days. When the manufacturer supplies cement under this provision, supporting data shall be supplied to the purchaser. See Note 7.

^d See Annex A for calculation.

^e Not applicable.

^f Report equivalent alkalis as part of the manufacturer's certification. See Note 5.

5.1.3. *Limestone*—This specification allows two types of limestone for use in portland cement: naturally occurring limestone, as defined according to ASTM C51, or manufactured mineral forms of calcium carbonate. The amount shall be not more than 5.0 percent by mass such that the chemical and physical requirements of this standard are met (see Note 3). The limestone shall consist of at least 40 percent by mass of one or more of the mineral forms of calcium carbonate, and at least 70 percent by mass total carbonate. The total carbonate content of limestone shall be determined as the sum of the calcium carbonate and magnesium carbonate. Calcium carbonate shall be determined by multiplying the CaO content (mass percent) of the limestone determined according to T 105 by a factor of 1.785, and magnesium carbonate shall be determined by multiplying the MgO content (mass percent) of the limestone determined according to T 105 by a factor of 2.092. If limestone is used, the manufacturer's report shall state the amount used, expressed as a percentage of cement mass, along with the oxide composition of the limestone, the calcium carbonate content of the limestone, and the total carbonate content 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.

Note 4—Manufactured mineral forms of calcium carbonate are any calcium carbonate that is not formed from geological processes. Although there are numerous manufacturing processes that could produce mineral forms of calcium carbonate, the specific chemical reactions are commonly either precipitation of calcium carbonate from a solution or reacting carbon dioxide fluids with calcium oxide-bearing solid waste.

Note 5—The procedure in Appendix X2 may be used to provide an approximation of the amount of limestone in the cement based on the CO₂ content of the limestone and finished cement. This procedure will typically overestimate the amount of limestone in the cement because it assumes that the limestone is the source of all CO₂ in the cement. Typically, there will be other sources of CO₂ in the cement from clinker, gypsum, or processing additions, as noted in Section X2.3.

5.1.4. *Inorganic Processing Additions*—The amount shall not be more than 5.0 percent by mass of cement. Not more than one inorganic processing addition shall be used at a time. For amounts greater than 1.0 percent, they shall have been shown to meet the requirements of M 327 for inorganic processing additions 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 6).

Note 6—These requirements are based on data and recommendations by Taylor (2008).²

5.1.5. *Organic Processing Additions*—These additions shall have been shown to meet the requirements of M 327 in the amounts used or greater, and the total amount of organic processing additions used shall not exceed 1.0 percent of the weight of portland cement clinker.

5.1.6. *Air-Entraining Addition (for Air-Entraining Portland Cement Only)*—The interground addition shall conform to the requirements of ASTM C226.

6. CHEMICAL COMPOSITION

6.1. Portland cement of each of the seven 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 7—The standard composition requirements in Table 1 require reporting of equivalent alkalis. Cements with a maximum of 0.60 percent equivalent alkalis were historically designated as “low-alkali cements” and recommended for use with aggregates susceptible to alkali–silica reaction (ASR). However, low-alkali cements (in the absence of other mitigation measures) may not be effective in mitigating ASR. Guidance on formulating concrete mixtures, including calculating alkali loading using equivalent alkali content of cement to minimize the potential for ASR, is provided in R 80.

Note 8—There are cases where performance of a cement is improved with SO₃ in excess of the Table 1 limits in this specification. ASTM 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, ASTM C1038/C1038M results provide evidence that excessive expansion does not occur at this higher sulfate content.