



Standard Test Method for Potential Expansion of Portland-Cement Mortars Exposed to Sulfate¹

This standard is issued under the fixed designation C452; 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.

1. Scope*

1.1 This test method, which is applicable only to portland cements, covers the determination of the expansion of mortar bars made from a mixture of portland cement and gypsum in such proportions that the mixture has a sulfur trioxide (SO_3) content of 7.0 mass %.

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 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

Warning—Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.²

2. Referenced Documents

2.1 ASTM Standards:³

[C109/C109M Test Method for Compressive Strength of Hydraulic Cement Mortars \(Using 2-in. or \[50-mm\] Cube Specimens\)](#)

¹ This test method is under the jurisdiction of ASTM Committee C01 on Cement and is the direct responsibility of Subcommittee C01.29 on Sulfate Resistance.

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² Section on Safety, Manual of Cement Testing, *Annual Book of ASTM Standards*, Vol 04.01.

³ 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.

[C150 Specification for Portland Cement](#)
[C219 Terminology Relating to Hydraulic Cement](#)
[C230/C230M Specification for Flow Table for Use in Tests of Hydraulic Cement](#)
[C305 Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency](#)
[C471M Test Methods for Chemical Analysis of Gypsum and Gypsum Products \(Metric\)](#)
[C490 Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete](#)
[C511 Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes](#)
[C778 Specification for Sand](#)
[C1005 Specification for Reference Masses and Devices for Determining Mass and Volume for Use in the Physical Testing of Hydraulic Cements](#)
[D1193 Specification for Reagent Water](#)
[IEEE/ASTM SI 10 Practice for Use of the International System of Units \(SI\): The Modern Metric System](#)

3. Terminology

3.1 Definitions:

3.1.1 For definitions of terms used in this test method, refer to Terminology [C219](#).

4. Interferences

4.1 This test method is not suitable for establishing the sulfate resistance of blended hydraulic cements nor for combinations of portland cement and pozzolans or slag cement ([Note 1](#)).

NOTE 1—The main increase in sulfate resistance provided by blended hydraulic cements, pozzolans and slag cement occurs when concrete is exposed after the pozzolans or slag cement have had time to react.

5. Significance and Use

5.1 This test method is used primarily by those interested in research on methods for determining the potential sulfate resistance of portland cement. This test method is also used to establish that a sulfate-resisting portland cement meets the performance requirements of Specification [C150](#).

*A Summary of Changes section appears at the end of this standard

6. Apparatus

6.1 *Weights and Weighing Devices*, conforming to the requirements of Specification C1005.

6.2 *Flow Table*, conforming to the requirements of Specification C230/C230M.

6.3 *Mixer, Bowl, and Paddle*, conforming to the requirements of Practice C305.

6.4 *Trowel and Tamper*, conforming to the requirements of Test Method C109/C109M.

6.5 *Glass Graduates, Molds, and Length Comparator*, conforming to the requirements of Practice C490.

7. Temperature and Humidity

7.1 *Molding Room, Dry Materials, and Mixing Water*—Maintain the temperature of the molding room, dry materials, and mixing water at $23.0 \pm 4.0^\circ\text{C}$ [$73.5 \pm 7^\circ\text{F}$] and the relative humidity of the molding room at not less than 50 %.

7.2 *Moist Cabinet or Room*, conforming to the requirements of Specification C511.

8. Materials

8.1 Use graded sand that conforms to Specification C778 Table 1 Standard Sand Requirements for making the test mortar.

8.2 For the gypsum addition to portland cement, use high grade natural gypsum⁴ with 100 % passing the 150 μm (No. 100) sieve, at least 94 % passing the 75 μm (No. 200) sieve, and at least 90 % passing the 45 μm (No. 325) sieve. Calculate the percentage of cement and gypsum required to provide a mixture containing 7.0 mass % SO_3 as follows:

$$\text{Cement, \%} = [(g - 7.0)/(g - c)] \times 100 \quad (1)$$

$$\text{Gypsum, \%} = [(7.0 - c)/(g - c)] \times 100 \quad (2)$$

where:

c = SO_3 content of the portland cement, %,

g = SO_3 content of the gypsum, %, and

7.0 = SO_3 content of the cement-gypsum mixture, %.

8.3 If the SO_3 content of the gypsum is unknown, analyze the gypsum for SO_3 content using Test Methods C471M. Determine the SO_3 content to the nearest 0.1 %.

8.4 *Purity of Water*—Unless otherwise indicated, references to water mean reagent water conforming to Type IV of Specification D1193.

9. Number and Dimensions of Test Specimens

9.1 Make six 25 by 25 by 285 mm [or 1 by 1 by 11¼-in.] test specimens, three from each of two batches, for each cement.

9.2 In routine tests, 25 by 25 by 160 mm [or 1 by 1 by 6¼-in.] specimens may be used, but in case of dispute, results obtained with 25 by 25 by 285 mm [or 1 by 1 by 11¼-in.] specimens govern.

10. Preparing Specimen Molds

10.1 Prepare the molds in accordance with Practice C490.

11. Proportioning, Consistency, and Mixing of Mortar

11.1 Use 400 g (cement plus gypsum) and 1100 g of sand for each batch. Use 194 mL of mixing water for all non-air-entraining portland cements, and 184 mL of mixing water for all air-entraining portland cements.

11.2 Mix the mortar according to the procedure for mixing mortars of Practice C305, except after placing the mixing water in the bowl, add the gypsum and mix at the slow speed for 15 s, then stop the mixer, add the cement, and continue as prescribed in Practice C305.

12. Procedure

12.1 *Molding Test Specimens*:

12.1.1 Immediately upon completion of the flow test, return the mortar to the bowl, scrape down into the batch any mortar on the side of the bowl, and remix at the medium speed (285 ± 10 r/min) for 15 s. Remove the paddle and the bowl from the mixer and shake the excess mortar from the paddle into the bowl. Fill the mold in two layers, each layer being compacted with the tamper. Work the mortar into the corners, around the gauge studs, and along the surfaces of the mold with the tamper until a homogeneous specimen is obtained. After the top layer has been compacted, cut the mortar off flush with the top of the mold and smooth the surface with a few strokes of the trowel.

12.2 *Storage of Test Specimens*:

12.2.1 *Initial Storage*—Cure the specimens in the molds in the moist closet at $23 \pm 2^\circ\text{C}$ [$73.5 \pm 3.5^\circ\text{F}$] for 22 to 23 h. Then remove them from the molds, properly identify, and place in water at $23 \pm 2^\circ\text{C}$ [$73.5 \pm 3.5^\circ\text{F}$] for at least 30 min prior to making the initial length measurement.

12.2.2 *Subsequent Storage*—After the bars have been removed from the molds and measured, store them horizontally in water at $23 \pm 2^\circ\text{C}$ [$73.5 \pm 3.5^\circ\text{F}$]. Store the specimens with at least 6 mm [¼-in.] clearance on all sides except for the necessary supports. Cover the specimens with at least 13 mm [½ in.] of water. Use a volume of water that does not exceed 5 times the volume of the bars to prevent excessive leaching. Replenish the water with fresh water every 7 days for the first 28 days and every 28 days thereafter.

13. Length Measurement

13.1 Measure the specimens for length by means of the length comparator. Remove them from the water storage, one at a time, and wipe with a damp cloth before measuring.

13.2 Make the first reading at the age of $24 \text{ h} \pm 15 \text{ min}$ from the time the cement and water are mixed together. Measure the specimen again at the age of 14 days.

NOTE 2—Additional information of value may be obtained by returning the specimen to water storage after the 14-day test and making additional

⁴ The sole source of supply of the apparatus known to the committee at this time is Terra Alba No. 1, available from the U.S. Gypsum Co., Southard, OK plant. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,¹ which you may attend.

measurements at later ages.

14. Calculation

14.1 Calculate the difference in length of the specimen at 24 h and at 14 days to the nearest 0.001 % of the effective gauge length and report as the expansion of the specimen at that period. All specimens remaining after 14 days must comprise a set having at least three specimens with a permissible range depending on the number of the remaining specimens, as follows:

No. of Specimens	Maximum Permissible Range, %
3	0.010
4	0.011
5	0.012
6	0.012

15. Report

15.1 Report the average of the specimens comprising the set to the nearest 0.001 %.

16. Precision and Bias

16.1 Precision:

16.1.1 The single-operator standard deviation has been found to be: 0.003 % for expansions between 0.01 and 0.04 %.

Therefore, results of two properly conducted tests by the same operator on the same material should not differ from each other by more than 0.009 %.

16.1.2 The multilaboratory standard deviation has been found to be 0.005 % for expansions between 0.01 and 0.04 %. Therefore, results of two properly conducted tests on the same material in two different laboratories should not differ from each other by more than 0.014 %.

16.1.3 The precision of this test method has been evaluated by cooperative testing.⁵

16.2 *Bias*—Since there is no accepted reference material suitable for determining the bias for this test method, no statement on bias is being made.

17. Keywords

17.1 calcium sulfate; expansion; gypsum; portland cement; sulfate resistance

⁵ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C01-1004.

For additional useful information on details of cement test methods, reference may be made to the “Manual of Cement Testing,” which appears in the *Annual Book of ASTM Standards*, Vol 04.01.

SUMMARY OF CHANGES

Committee C01 has identified the location of selected changes to this standard since the last issue (C452/C452M – 10) that may impact the use of this standard. (Approved Aug. 1, 2015.)

(1) Added Section 3.

(3) Added Section 4.

(2) Added Terminology C219 to Section 2.

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