Designation: C 563 – 03

Standard Test Method for Optimum SO_3 in Hydraulic Cement Using 24-h Compressive Strength[1]

This standard is issued under the fixed designation C 563; 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 describes the determination of optimum SO_3 for maximum 24-h compressive strength by measuring the change in strength produced in hydraulic cement mortar as a result of substituting calcium sulfate for a portion of the cement. Usually, but not always, the SO_3 content that produces the highest 24-h strength at 23°C also produces approximately the lowest expansion in water and the lowest contraction in air at that temperature.

1.2 This test method refers to the sulfur trioxide (SO_3) content of the cement only. Slag cements and occasionally other hydraulic cements can contain sulfide or other forms of sulfur. The determination of SO_3 content by rapid methods may include these other forms, and may therefore produce a significant error. If a significant error occurs, analyze the cement for SO_3 content using the reference test method of Test Methods C 114 for sulfur trioxide.

1.3 Values stated as SI units are to be regarded as standard.

1.4 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 109/C 109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)[2]

C 114 Test Methods for Chemical Analysis of Hydraulic Cement[2]

C 150 Specification for Portland Cement[2]

C 204 Test Method for Fineness of Hydraulic Cement by Air Permeability Apparatus[2]

C 305 Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency[2]

C 471M Test Methods for Chemical Analysis of Gypsum and Gypsum Products [Metric][2]

C 511 Specification for Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes[2]

C 595 Specification for Blended Hydraulic Cements[2]

C 778 Specification for Standard Sand[2]

C 1157 Performance Specification for Hydraulic Cement[2]

3. Significance and Use

3.1 The purpose of this test method is to estimate the SO_3 content for a hydraulic cement that gives maximum 24-h compressive strength in mortar made and cured at 23°C. The value obtained is used to establish the level of sulfate in the manufacture of cements specified in Specifications C 150, C 595 and C 1157. In Specifications C 150 and C 595 it is used to justify exceeding the prescriptive limits for SO_3.

3.2 The optimum SO_3 content for 24-h compressive strength is not necessarily the optimum SO_3 content for later ages or for volume change. Confirming tests can be made if the relationships between SO_3 and these properties are not known for the cement being tested.

3.3 This test method indicates optimum SO_3 content for cement in mortar made and cured at a standard temperature of 23.0 ± 2.0°C (73.5 ± 3.5°F). The optimum SO_3 increases with increasing temperature and may increase when water-reducing admixtures are used.

3.4 It should not be assumed that the optimum SO_3 estimated in this test method is the same SO_3 content for optimum performance of a concrete prepared from the cement.

3.5 The test method is applicable to cements specified in Specifications C 150, C 595, and C 1157.

4. Apparatus

4.1 Use the apparatus as specified in Test Method C 109/C 109M.

5. Materials

5.1 *Calcium Sulfate*—Use calcium sulfate for addition to the cement that is either a high-grade natural gypsum having an SO_3 content of at least 46 %,[3] or the calcium sulfate from the

[1] This test method is under the jurisdiction of ASTM Committee C01 on Cement and is the direct responsibility of Subcommittee C01.28 on Sulfate Content.

Current edition approved Jan. 10, 2003. Published February 2003. Originally approved in 1965. Last previous edition approved in 2002 as C 563-02.

[2] *Annual Book of ASTM Standards*, Vol 04.01.

[3] Terra Alba, available from the U.S. Gypsum Co., Southard, OK plant, meets these requirements for fineness and SO_3 content.

source used for the intended plant production. Grind the calcium sulfate to 100 % passing the 75-µm (No. 200) sieve, and at least 800 m^2/kg Blaine fineness (Test Method C 204). If the SO_3 content of the calcium sulfate is unknown, analyze it in accordance with Test Methods C 471M.

5.2 *Blended Standard Sand*—Use a blend of equal parts by mass of graded sand and 20–30 sand, both conforming to Specification C 778.

6. Test Specimens

6.1 Make six specimens from each batch of mortar. Make two rounds of three mixtures of mortar as described in 6.3. Make both rounds during the same day if possible. Make only complete rounds on any given day.

6.2 *Preparing Specimen Molds*—Prepare molds in accordance with the section on Preparation of Specimen Molds of Test Method C 109/C 109M.

6.3 *Proportioning, Consistency, and Mixing of Mortar*—Proportion the dry material for the standard mortar as one part of cement to one part of blended sand by mass. Mix the following quantities of dry materials at one time for a 6-cube batch:

Mixture No. 1—940 g cement
470 g graded sand
470 g 20–30 sand
Mixture No. 2—930 g cement
10 g calcium sulfate
470 g graded sand
470 g 20–30 sand
Mixture No. 3—920 g cement
20 g calcium sulfate
470 g graded sand
470 g 20–30 sand

6.3.1 Use an amount of mixing water that is 30 % by mass of cement plus calcium sulfate for all types of hydraulic cement, except for Type III cement where the amount shall be 36 %.

6.3.2 Mix mechanically in accordance with the section on Procedure for Mixing Mortars of Practice C 305, except as follows:

6.3.2.1 Add the calcium sulfate to the water; then start the mixer and mix at slow speed (140 ± 5 rpm) for 15 s; then stop the mixer and add the cement to the water; then start the mixer and mix at slow speed (140 ± 5 rpm) for 30 s.

6.4 *Molding of Test Specimens*—Mold specimens in accordance with the Procedure Section of Test Method C 109/C 109M.

6.5 *Storage of Test Specimens*—Immediately upon completion of molding, place the test specimens in the moist closet or moist room. Keep all test specimens, immediately after molding, in the molds on the base plates in the moist closet or moist room for 20 to 24 h with their upper surfaces exposed to the moist air but protected from dripping water. If the specimens are removed from the molds before 24 h, keep them on the shelves of the moist closet or moist room until they are 24-h old.

7. Temperature and Humidity

7.1 The temperature and humidity of the moist cabinet or moist room shall be as specified in Specification C 511.

7.2 The temperature and humidity of the mixing room shall be as specified in Test Method C 109/C 109M.

8. Procedure

8.1 Test the specimens at the age of 24 ± ¼ h from the time the cement and water made contact during mixing, immediately after removal from the moist closet in accordance with Test Method C 109/C 109M. If more than one specimen at a time is removed from the moist closet, keep these specimens covered with a damp cloth until time of testing. Note and observe precautions regarding testing and retesting given in the applicable sections of Test Method C 109/C 109M.

9. Calculation

9.1 Calculate and record the strength of specimens as described in the section on Calculation in Test Method C 109/C 109M.

9.1.1 Calculate the indicated optimum SO_3 content as follows:

$$G = [a/(a - b)]\,c + d + c/2$$

where:

G = optimum percent SO_3,
a = average strength both rounds of Mixture No. 2 minus Mixture No. 1,
b = average strength both rounds of Mixture No. 3 minus Mixture No. 2,
c = (percent SO_3 in calcium sulfate)/100, and
d = percent SO_3 in test cement.

10. Retest

10.1 Regard the results obtained as suspect and repeat the test under any of the following conditions:

10.1.1 If a and b both are positive and the ratio a/b is less than 2.00,

10.1.2 If a and b both are negative and the ratio a/b is greater than 0.500, or

10.1.3 If a is negative and b is positive.

11. Report

11.1 If repeat tests confirm that the ratio of a/b departs from the limiting values as stated above, report the SO_3 content of the cement as "above optimum" or "below optimum" as the data may indicate, but without stating the numerical value of optimum SO_3.

11.2 If the test data indicate that the cement is "below optimum" but do not permit a computation of the percentage of SO_3 required for optimum, an additional series of tests involving greater substitutions of gypsum for part of the cement should yield results that will permit an acceptable calculation of the percentage of SO_3 required for optimum. If the test data indicate that the cement is "above optimum" but do not permit a computation of the percentage of SO_3 required for optimum, in order to establish the required percentage of SO_3 for optimum, it is necessary to make tests of a new sample of similar cement but having an original SO_3 content lower than that of the original cement.

12. Precision and Bias

12.1 *Precision*—The coefficient of variation for this test method, using 6 cubes per batch and testing at 24-h age, is very similar to that for Test Method C 109/C 109M compression cubes tested at later ages. Refer to Test Method C 109/C 109M for suitable values.

12.2 *Bias*—Since there is no accepted reference material suitable for determining optimum SO_3, bias has not been determined.

13. Keywords

13.1 blended hydraulic cement; calcium sulfate; cement; compressive strength; gypsum; hydraulic cement; optimum sulfate content (of cement); portland cement; strength (of cement); sulfate content (of cement)