Designation: G 109 – 99a$^{\epsilon 1}$

Standard Test Method for Determining the Effects of Chemical Admixtures on the Corrosion of Embedded Steel Reinforcement in Concrete Exposed to Chloride Environments[1]

This standard is issued under the fixed designation G 109; 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.

ϵ^1 NOTE—Paragraph 1.2 was corrected editorially in August 2000.

1. Scope

1.1 This test method describes a procedure for determining the effects of chemical admixtures on the corrosion of metals in concrete. This test method can be used to evaluate materials intended to inhibit chloride-induced corrosion of steel in concrete. It can also be used to evaluate the corrosivity of admixtures in a chloride environment.

1.2 The values stated in SI units are to be regarded as the standard. The inch-pound units in parentheses are provided for information only.

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.*

2. Referenced Documents

2.1 *ASTM Standards:*

A 615/A 615M Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement[2]

C 33 Specification for Concrete Aggregates[3]

C 143/C 143M Test Method for Slump of Hydraulic Cement Concrete[3]

C 150 Specification for Portland Cement[4]

C 173 Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method[3]

C 192/C 192M Practice for Making and Curing Concrete Test Specimens in the Laboratory[3]

C 231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method[3]

C 511 Specification for Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes[4]

C 876 Test Method for Half-Cell Potentials of Uncoated Reinforcing Steel in Concrete[3]

C 881 Specification for Epoxy-Resin-Base Bonding Systems for Concrete[3]

C 1152/C 1152M Test Method for Acid-Soluble Chloride in Mortar and Concrete[3]

D 448 Classification for Sizes of Aggregate for Road and Bridge Construction[5]

D 632 Specification for Sodium Chloride[5]

E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods[6]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[6]

G 3 Practice for Conventions Applicable to Electrochemical Measurements in Corrosion Testing[7]

G 15 Terminology Relating to Corrosion and Corrosion Testing[7]

G 33 Practice for Recording Data from Atmospheric Corrosion Tests of Metallic-Coated Steel Specimens[7]

G 46 Guide for Examination and Evaluation of Pitting Corrosion[7]

2.2 *NACE Standards:*

SSPC SP 5 (NACE No. 1) White Metal Blast Cleaning[8]

3. Significance and Use

3.1 This test method provides a reliable means for predicting the inhibiting or corrosive properties of admixtures to be used in concrete.

[1] This test method is under the jurisdiction of ASTM Committee G-1 on Corrosion, Deterioration, and Degradation of Materials and is the direct responsibility of Subcommittee G01.14 on Corrosion of Reinforcing Steel.

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[2] *Annual Book of ASTM Standards*, Vol 01.04.

[3] *Annual Book of ASTM Standards*, Vol 04.02.

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

[5] *Annual Book of ASTM Standards*, Vol 04.03.

[6] *Annual Book of ASTM Standards*, Vol 14.02.

[7] *Annual Book of ASTM Standards*, Vol 03.02.

[8] Available from Structural Steel Painting Council, Pittsburgh, PA.

3.2 This test method is useful for development studies of corrosion inhibitors to be used in concrete.

3.3 This test method has been used elsewhere with good agreement between corrosion as measured by this test method and corrosion damage on the embedded steel.[9,10,11,12] This test method might not properly rank the performance of different corrosion inhibitors, especially at concrete covers over the steel less than 40 mm (1.5 in.) or water-to-cement ratios above 0.45. The concrete mixture proportions and cover over the steel are chosen to accelerate chloride ingress. Some inhibitors might have an effect on this process, which could lead to results that would differ from what would be expected in actual use.[13]

4. Apparatus

4.1 The apparatus required for the evaluation of corrosion inhibitors includes a high impedance voltmeter (at least one Mohm) capable of measuring to 0.01 mV, a 100-ohm (± 5 %) resistor.

5. Reagents and Materials

5.1 *Cement*, that conforms to Type I or Type II of Specification C 150. Coarse aggregate shall conform to Specification C 33 and Classification D 448, with nominal maximum size between 9.5 and 19 mm (3/8and 3/4 in.).

NOTE 1—Preferred maximum size aggregate is 12.5 mm (0.5 in.).

5.2 *Steel Reinforcement Bars*, deformed, meeting the requirement of Specification A 615/A 615M, with a diameter between 10 mm (0.4 in.) and 16 mm (0.6 in.). A length of 360 mm (14 in.), drilled and tapped at one end to be fitted with coarse-thread stainless steel and nuts, as described in 5.3 and 5.4. These bars shall be used to manufacture the test specimens, as described in Section 6.

NOTE 2—Interlaboratory test program and statistical data in Section 11 are based upon 13-mm (0.5-in.) steel bars, 12.5-mm maximum size aggregate, and 19-mm (0.75-in.) and 25-mm (1 in.) cover

5.3 *316 Stainless Steel Screws*, with diameter smaller than bar diameter (coarse thread < 5 mm (0.2 in.)), 25 to 35-mm (1 to 1.5-in.) long (one per bar).

5.4 *316 Stainless Steel Nuts*, two per bar to fit stainless steel screws, as described in 5.3.

5.5 *Two-part Waterproof Epoxy*[14]— This epoxy shall meet the chemical resistance requirements of a Type IV, Grade 3, Class E of Specification C 881.

5.6 *Sulfuric Acid*, 10 % by mass, for pickling (optional).

5.7 *Electroplater's Tape*[15]

5.8 *Neoprene Tubing*, with 3-mm (1/8-in.) wall thickness and the same ID as the diameter of the bar used.

5.9 *Sodium Chloride*, complying with Specification D 632.

5.10 *Salt Solution*, prepared by dissolving 3 parts of sodium chloride (as described in 5.9) in 97 parts of water mass.

5.11 *Epoxy Sealer*, for application to the concrete specimens after manufacture. This sealer shall be of Type III, Grade 1, Class C in accordance with Specification C 881.[16]

5.12 *Plastic Dams*, 75-mm (3-in.) wide and 150-mm (6-in.) long with a minimum height of 75 mm (3 in.) for placement on the test specimens. The wall thickness shall be ± 1 mm (1/8 ± 1/32 in.

5.13 *Silicone Caulk*, for sealing the outside of the plastic dam to the top of the concrete specimen.[17]

5.14 *Reference Electrode*, such as a saturated calomel or silver/silver chloride electrode for measuring the corrosion potential of the bars, as defined in Terminology G 15.

5.15 *Hexane*

6. Preparation of Test Specimens

6.1 Power wire brush or sand blast the bars to near white metal (see Specification SSPC SP-50), clean by soaking in hexane, and allow to air dry.

NOTE 3—Pickling the bars with 10 % sulfuric acid for 10 to 15 min and rinsing with potable water prior to wire brushing is recommended when the bars have an excessive amount of rust.

6.2 Use the same method to clean all bars in the test program.

6.3 Drill and tap one end of each bar, attach a stainless steel screw and two nuts, as described in 5.3 and 5.4, and tape each end of the bar with electroplater's tape so that a 200-mm (8-in.) portion in the middle of the bar is bare. Place a 90-mm (3.5 in.) length of neoprene tubing, as described in 5.8, over the electroplater's tape at each end of the bar, and fill the length of tubing protruding from the bar ends with the two-part epoxy, as described in 5.5.

NOTE 4—For example, for a 12.5-mm (0.5 in.) aggregate, place the top bar 25 mm (1 in.) from the surface. For a 9.5-mm (0.375-in.) aggregate, place the bar 19 mm (.75 in.) from the top surface.

6.4 Specimen size is 280 × 150 × 115 mm (11 × 6 × 4.5 in.).

6.5 Place the bars in the molds so that 40 mm (approximately 1.5 in.) of the bars are protected within each exit end from the concrete (minimizes edge effects). This will expose 200 mm (8 in.) of steel. Place the bars with the longitudinal ribs

[9] Berke, N. S., Shen, D. F., and Sundberg, K. M., "Comparison of the Polarization Resistance Technique to the Macrocell Corrosion Technique," *Corrosion Rates of Steel in Concrete, ASTM STP 1065*, N. S. Berke, V. Chaker, and D. Whitney, editors, ASTM, August 1990, pp. 38–51.

[10] Berke, N. S. and Hicks, M. C., "Electrochemical Methods of Determining the Corrosivity of Steel in Concrete," *Corrosion Testing and Evaluation: Silver Anniversary Volume*, Babraiam/Dean editors, ASTM STP 1000, ASTM, November 1990, pp. 425–440.

[11] Virmani, Y. P., Clear, K. C., and Pasko, T. J., "Time-to Corrosion of Reinforcing Steel in Concrete Slabs, Volume 5: Calcium Nitrite Admixture or Epoxy-Coated Reinforcing Bars as Corrosion Protection Systems," Report No. FHWA/RD-83/-12, Federal Highway Administration, Washington DC, 1983, pp. 71.

[12] Berke, N. S., Pfeifer, D. W., and Weil, T. G., "Protection Against Chloride-Induced Corrosion," *Concrete International*, December 1988, pp. 45–55.

[13] Berke, N. S., Hicks, M. C., Hoopes, R. J., and Tourney, P. J., "Use of Laboratory Techniques to Evaluate Long-Term Durability of Steel Reinforced Concrete Exposed to Chloride Ingress," ACI SP 145-16, 1994, pp. 299-328.

[14] PC-Epoxy made by Protective Coating Co., Allentown, PA, has been found to be suitable for this purpose.

[15] Minnesota Mining and Manufacturing Company (3M), 1999 Mt. Read Boulevard, Rochester, NY 14615, has been found suitable for this purpose.

[16] Epoxy Concrete Scaler # 12560 made by Devcon has been found to be suitable for this purpose.

[17] 3M Marine Adhesive 5200 has been found to be suitable for this purpose.