Designation: G109 – 21

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

This standard is issued under the fixed designation G109; 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 These test methods cover a procedure for determining the effects of chemical admixtures on the corrosion of metals in concrete. These test methods 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 standard. The values given in parentheses after SI units are provided for information only and are not considered standard.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

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:*[2]

A615/A615M Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
C33/C33M Specification for Concrete Aggregates
C143/C143M Test Method for Slump of Hydraulic-Cement Concrete
C150/C150M Specification for Portland Cement
C173/C173M Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory
C231/C231M Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
C511 Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes
C876 Test Method for Corrosion Potentials of Uncoated Reinforcing Steel in Concrete
C881/C881M Specification for Epoxy-Resin-Base Bonding Systems for Concrete
C1152/C1152M Test Method for Acid-Soluble Chloride in Mortar and Concrete
D448 Classification for Sizes of Aggregate for Road and Bridge Construction
D632 Specification for Sodium Chloride
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
G3 Practice for Conventions Applicable to Electrochemical Measurements in Corrosion Testing
G193 Terminology and Acronyms Relating to Corrosion
G33 Practice for Recording Data from Atmospheric Corrosion Tests of Metallic-Coated Steel Specimens
G46 Guide for Examination and Evaluation of Pitting Corrosion

2.2 *SSPC/NACE Standards:*[3]

SSPC-SP 5/NACE No. 1 White Metal Blast Cleaning

3. Significance and Use

3.1 These test methods provide a reliable means for predicting the inhibiting or corrosive properties of admixtures to be used in concrete.

[1] These test methods are under the jurisdiction of ASTM Committee G01 on Corrosion of Metals and is the direct responsibility of Subcommittee G01.14 on Corrosion of Metals in Construction Materials.

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[2] 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.

[3] Available from The Association for Materials Protection and Performance (AMPP), 800 Trumbull Drive, Pittsburgh, PA 15205, https://www.ampp.org.

3.2 The total integrated (coulombs) current is calculated to provide an indication of the corrosion that occurs due to the macrocell corrosion.

3.3 These test methods are useful for development studies of corrosion inhibitors to be used in concrete.

3.4 These test methods have been used elsewhere with good agreement between corrosion as measured by these test methods and corrosion damage on the embedded steel (**1-4**).[4] These test methods 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 (**5**).

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 0.001 mV, a 10 Ω (±5 %) resistor.

4.2 *Reference Electrode,* such as a saturated silver/silver chloride or saturated calomel electrode for measuring the corrosion potential of the bars, as defined in Terminology G193.

5. Reagents and Materials

5.1 *Cement,* that conforms to Type I or Type II of Specification C150/C150M. Coarse aggregate shall conform to Specification C33/C33M and Classification D448, with nominal maximum size between 9.5 mm and 19 mm (⅜ in. and ¾ 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 A615/A615M; with a diameter between 10 mm (0.4 in.) and 16 mm (0.6 in.), and 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 < 5mm (0.2 in.)), 25 mm to 35 mm (1 in. 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*[5,6]—This epoxy shall meet the chemical resistance requirements of a Type IV, Grade 3, Class E of Specification C881/C881M.

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

5.7 *Electroplater's Tape.*[7,6]

5.8 *Neoprene Tubing,* with 3 mm (⅛ in.) wall thickness and the same ID as the diameter of the bar used.

5.9 *Sodium Chloride,* complying with Specification D632.

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 C881/C881M.[8,6]

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 (⅛ ± 1/32 in.).

5.13 *Silicone Caulk,* for sealing the outside of the plastic dam to the top of the concrete specimen.[9,6]

5.14 *Hexane.*

6. Preparation of Test Specimens

6.1 *Method A Mill Scale Removed:*

6.1.1 Power wire brush or sand blast the bars to near white metal (see SSPC-SP 5/NACE No. 1), clean by soaking in hexane, and allow to air dry.

NOTE 3—Pickling the bars with 10 % sulfuric acid for 10 min 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 *Method B Mill Scale Not Removed:*

6.2.1 Bars with mill scale shall be chosen so that no visible rust is present in the portion of the bar that will not be protected at the ends.

6.2.2 Ends to be protected shall have mill scale removed as in 6.1.

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

6.4 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

[4] The boldface numbers in parentheses refer to a list of references at the end of this standard.

[5] The sole source of supply of the apparatus known to the committee at this time is PC-Epoxy, made by Protective Coating Co., Allentown, PA.

[6] 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.

[7] The sole source of supply of the apparatus known to the committee at this time is Minnesota Mining and Manufacturing Company (3M).

[8] The sole source of supply of the apparatus known to the committee at this time is Epoxy Concrete Scaler # 12560, made by Devcon.

[9] The sole source of supply of the apparatus known to the committee at this time is 3M Marine Adhesive 5200.