Designation: C876 – 09

StandardTest Method for Corrosion Potentials of Uncoated Reinforcing Steel in Concrete[1]

This standard is issued under the fixed designation C876; 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 covers the estimation of the electrical corrosion potential of uncoated reinforcing steel in field and laboratory concrete, for the purpose of determining the corrosion activity of the reinforcing steel.

1.2 This test method is limited by electrical circuitry. Concrete surface in building interiors and desert environments lose sufficient moisture so that the concrete resistivity becomes so high that special testing techniques not covered in this test method may be required (see 5.1.4.1). Concrete surfaces that are coated or treated with sealers may not provide an acceptable electrical circuit. The basic configuration of the electrical circuit is shown in Fig. 1.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered 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:*[2]

G3 Practice for Conventions Applicable to Electrochemical Measurements in Corrosion Testing

G15 Terminology Relating to Corrosion and Corrosion Testing (Withdrawn 2010)[3]

G16 Guide for Applying Statistics to Analysis of Corrosion Data

3. Terminology

3.1 For definitions of terms used in this test method, refer to Terminology G15.

4. Significance and Use

4.1 This test method is suitable for in-service evaluation and for use in research and development work.

4.2 This test method is applicable to members regardless of their size or the depth of concrete cover over the reinforcing steel. Concrete cover in excess of 3 in. (75 mm) can result in an averaging of adjacent reinforcement corrosion potentials that can result in a loss of the ability to discriminate variation in relative corrosion activity.

4.3 This test method may be used at any time during the life of a concrete member.

4.4 The results obtained by the use of this test method shall not be considered as a means for estimating the structural properties of the steel or of the reinforced concrete member.

4.5 The potential measurements should be interpreted by engineers or technical specialists experienced in the fields of concrete materials and corrosion testing. It is often necessary to use other data such as chloride contents, depth of carbonation, delamination survey findings, rate of corrosion results, and environmental exposure conditions, in addition to corrosion potential measurements, to formulate conclusions concerning corrosion activity of embedded steel and its probable effect on the service life of a structure.

5. Apparatus

5.1 The testing apparatus consists of the following:

5.1.1 *Reference Electrode:*

5.1.1.1 The reference electrode selected shall provide a stable and reproducible potential for the measurement of the corrosion potential of reinforcing steel embedded in concrete over the temperature range from 32 to 120°F (0 to 49°C).

5.1.1.2 For the purposes of this standard, corrosion potentials shall be based upon the half-cell reaction Cu→ Cu++ +

[1] This test method is under the jurisdiction of ASTM Committee G01 on Corrosion of Metalsand is the direct responsibility of Subcommittee G01.14 on Corrosion of Metals in Construction Materials.

Current edition approved April 1, 2009. Published May 2009. Originally approved in 1977. Last previous edition approved in 1999 as C876–91(1999), which was withdrawn September 2008 and reinstated in April 2009. DOI: 10.1520/C0876-09.

[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] The last approved version of this historical standard is referenced on www.astm.org.

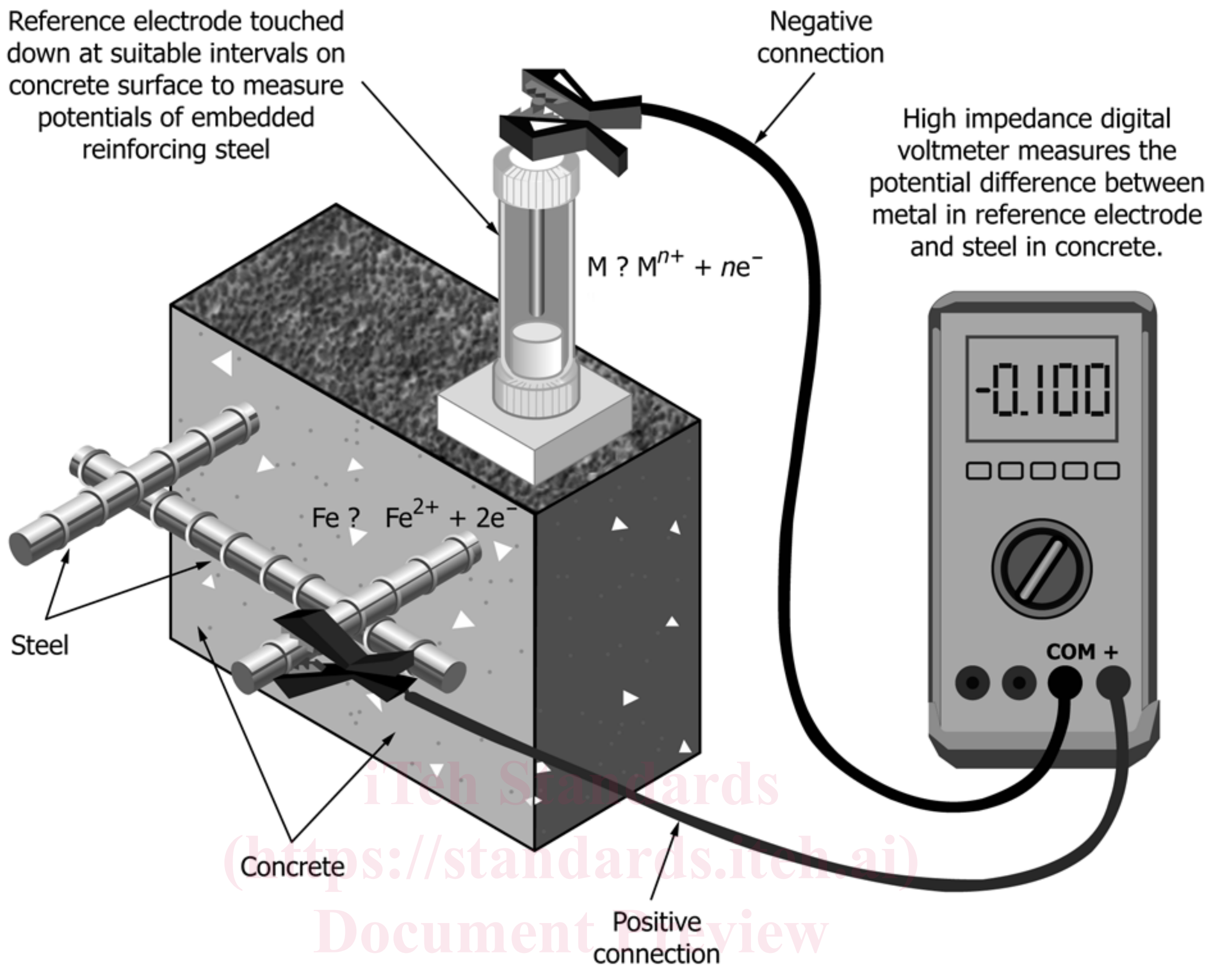

FIG. 1 Reference Electrode Circuitry

2e- corresponding to the potential of the saturated copper-copper sulfate reference electrode as referenced to the hydrogen electrode being –0.30 V at 72°F (22.2°C).[4] The copper-copper sulfate reference electrode has a temperature coefficient of approximately 0.0005 V more negative per °F for the temperature range from 32 to 120°F (0 to 49°C).

5.1.1.3 Other reference electrodes having similar measurement range, accuracy, and precision characteristics to the copper-copper sulfate electrode may also be used. Calomel reference electrodes have been used in laboratory studies. For concrete submerged in seawater, using silver-silver chloride reference electrodes avoids chloride contamination problems that may occur with copper-copper sulfate electrodes. Silver/silver chloride/potassium chloride reference electrodes are also applied to atmospherically exposed concrete. Potentials measured by reference electrodes other than saturated copper-copper sulfate should be converted to the copper-copper sulfate

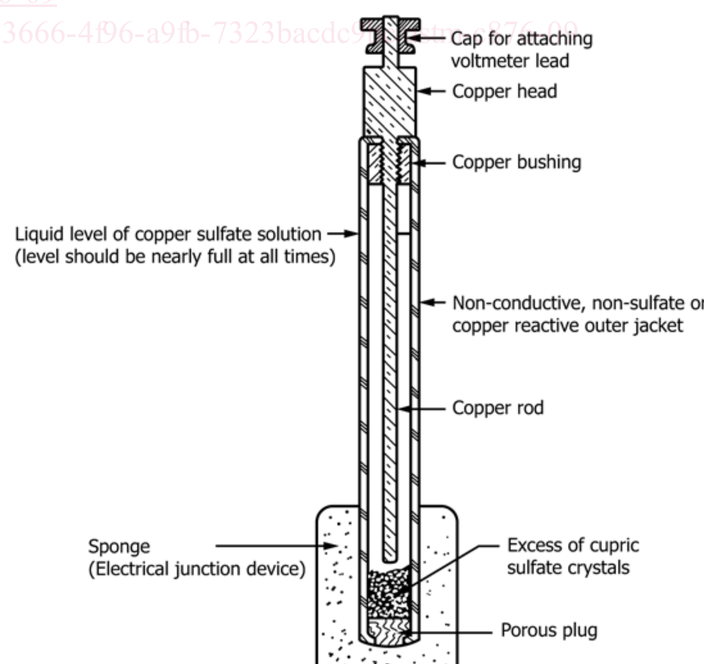

FIG. 2 Sectional View of a Copper-Copper Sulfate Reference Electrode

[4] Hampel, C. A., *The Encyclopedia of Electrochemistry*, Reinhold Publishing Co., New York, 1964, p. 433.

equivalent potential. The conversion technique can be found in Practice G3 and "Reference Electrodes, Theory and Practice" by Ives and Janz.[5]

5.1.2 *Electrical Junction Device*—An electrical junction device shall be used to provide a low electrical resistance liquid bridge between the surface of the concrete and the reference electrode. It shall consist of a sponge or several sponges pre-wetted with a low electrical resistance contact solution. The sponge may be folded around and attached to the tip of the reference electrode so that it provides electrical continuity between the porous plug and the concrete member. The minimum contact area of the electrochemical junction device shall be the area equivalent of a circle with 3× the nominal diameter of the concrete coarse aggregate to a maximum of 16 $in.^2$ (0.01 m^2).

5.1.3 *Electrical Contact Solution*—In order to standardize the potential drop through the concrete portion of the circuit, an electrical contact solution shall be used to wet the electrical junction device. One such solution is composed of a mixture of 95 mL of wetting agent (commercially available wetting agent) or a liquid household detergent thoroughly mixed with 5 gal (19 L) of potable water. Under working temperatures of less than about 50°F (10°C), approximately 15 % by volume of either isopropyl or denatured alcohol must be added to prevent clouding of the electrical contact solution, since clouding may inhibit penetration of water into the concrete to be tested. Conductive gels may be employed to reduce drift in the measured corrosion potential that can derive from dynamic liquid junction potentials. On large horizontal reinforced concrete, such as bridges, preliminary cleaning of the concrete surface with "street sweepers" has proven successful.

5.1.4 *Voltmeter*—The voltmeter shall allow dc voltage readings, have the capacity to be battery operated, and provide adequate input impedance and ac rejection capability for the environment where this test method is applied.

5.1.4.1 Prior to commencing testing, a digital voltmeter with a variable input impedance ranging from 10 to 200 MΩ may be used to determine the input impedance required to obtain precision readings. The use of a meter with variable input impedance avoids meter loading errors from high concrete resistivity. An initial reading is taken in the 10 MΩ position and then switching to successively higher impedances while watching the meter display until the reading remains constant through two successive increases. Then decrease the impedance on setting to reduce noise and provide the most precise readings. If the voltmeter does not display a constant reading through 200 MΩ, then the use of galvanometer with input impedance of 1 or 2 GΩ should be considered. Logging voltmeters may also be used.

5.1.4.2 Electromagnetic interference or induction resulting from nearby ac power lines or radio frequency transmitters can produce error. When in the proximity of such interference sources, the readings may fluctuate. An oscilloscope can be used to define the extent of the problem and be coupled with the dc voltmeter manufacturer's specification for ac rejection capability to determine resolution of induced ac interference with successful application of this test method.

5.1.5 *Electrical Lead Wires*—The electrical lead wire shall be of such dimension that its electrical resistance for the length used will not disturb the electrical circuit by more than 0.0001 V. This has been accomplished by using no more than a total of 500 linear ft (150 m) of at least AWG No. 24 wire. The wire shall be coated with a suitable insulation such as direct burial type of insulation.

5.1.6 In addition to single reference electrodes connected to a voltmeter, multiple electrode arrays, reference electrodes with a wheel junction device and logging voltmeters that record distance and potential may also be used.

6. Calibration and Standardization

6.1 *Care of the Reference Electrode*—Follow the manufacturer's instructions for storage, calibration, and maintenance. Electrodes should not be allowed to dry out or become contaminated. The porous plug (salt bridge) shall be covered when not in use for long periods to ensure that it does not become dried to the point that it becomes a dielectric (upon drying, pores may become occluded with crystalline filling solution).

6.2 *Calibration of the Reference Electrode*—Reference electrodes shall be calibrated against an approved standard traceable to a national standard at regular intervals. If cells do not produce the reproducibility or agreement between cells described in Section 12, cleaning may rectify the problem. If reproducible and stable readings are not achieved the reference electrode should be replaced.

6.3 *Calibration of the Voltmeter*—The voltmeter shall be calibrated against an approved standard traceable to a national standard at regular intervals.

7. Procedure

7.1 *Spacing Between Measurements*—While there is no pre-defined minimum spacing between measurements on the surface of the concrete member, it is of little value to take two measurements from virtually the same point. Conversely, measurements taken with very wide spacing may neither detect corrosion activity that is present nor result in the appropriate accumulation of data for evaluation. The spacing shall therefore be consistent with the member being investigated and the intended end use of the measurements (Note 1).

NOTE 1—A spacing of 4 ft (1.2 m) has been found satisfactory for rapid evaluation of structures with large horizontal surfaces like bridge decks. Generally, larger spacings increase the probability that localized corrosion areas will not be detected. Measurements may be taken in either a grid or a random pattern. Spacing between measurements should generally be reduced where adjacent readings exhibit reading differences exceeding 50 mV (areas of high corrosion activity). Cracks, cold joints, and areas with dynamic structural activity can produce areas of localized corrosion activity where the corrosion potential can change several hundred millivolts in less than 1 ft (300 mm) and care must be given that relatively large spacing between readings does not miss areas of localized corrosion activity. For small, lightly reinforced members, it may be advantageous to map the reinforcement locations with a cover meter and place the reference electrode over the bars on a suitable grid.

7.2 *Electrical Connection to the Steel:*

[5] Ives, D. J. G., and Janz, G. J., *Reference Electrodes Theory and Practice*, Academy Press, NY, 1961.