

Standard Test Method for Rapid Determination of Corrosion Rate of Uncoated Steel in Reinforced Concrete

AASHTO Designation TP11-95^{1,2}

1. Scope

1.1 This test method describes a procedure for determining the instantaneous corrosion rate of uncoated steel in reinforced concrete. It employs the use of any one of three types of devices to electrochemically determine the instantaneous corrosion rate of uncoated steel reinforcing bars, plain or deformed reinforced steel in concrete.

1.2 This standard applies to reinforced concrete having (1) a smooth (not scarred, cracked, or uneven) plain (no liquid-impermeable overlays or coatings) surface, (2) a depth of concrete cover over the uncoated steel of less than 100 mm (4 in.), and (3) reinforcing steel that is not coated with epoxy, hot-dip zinc (galvanized), or any other coatings.

1.3 This standard applies to (1) steel in direct contact with concrete (e.g., the ducts, but not the strands in ducts, of post-tensioned systems), (2) reinforced concrete systems that are not cathodically protected by means of externally applied electric currents, and (3) reinforced concrete is not located near areas of stray electric currents (e.g., power transmission lines) or strong magnetic fields.

1.4 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 AASHTO Standards

R9 Acceptance Sampling Plans for Highway Construction

2.2 ASTM Standards

C876 Half-Cell Potentials of Uncoated Reinforcing Steel in Concrete

D3665 Random Sampling of Construction Materials

E105 Probability Sampling of Materials

E122 Choice of Sample Size to Estimate the Average Quality of a Lot or Process

E141 Acceptance of Evidence Based on the Results of Probability Sampling

3. Description of Terms

3.1 Polarization resistance, R_p -- the slope of the polarization curve at the origin

3.2 Reinforcing steel grid -- the layout of the reinforcing steel bars encased in concrete

4. **Summary of Test Method** - The instantaneous corrosion rate is determined for a specific area of reinforcing steel, and the rate is expressed in current density units $\mu\text{A}\cdot\text{cm}^{-2}$ ($\text{mA}\cdot\text{ft}^{-2}$).

5. Significance and Use

5.1 Instantaneous corrosion rate of steel in reinforced concrete is needed to project the potential damage to the concrete due to reinforcing steel corrosion.

5.2 Successive measurement of instantaneous corrosion rates of uncoated steel in reinforced concrete at prescribed time intervals provides data for the estimation of service life.

6. Interferences

6.1 Stray currents, from causes such as power transmission lines or externally applied cathodic currents, may produce erratic results due to interference with each of the test instruments.

¹ This standard is based on SHRP Product 2001.

² Approved in December 1995, this provisional standard was first published in June 1996.

6.2 Water-impermeable coatings and overlays will interfere with results.

6.3 High electrical resistance of the concrete, as might result from unusually dry conditions or concrete impregnation with dielectric materials, will interfere with obtaining accurate test results.

6.4 Readings taken closer than about 300 mm (12 in.) from edges, joints, or other discontinuities that will disrupt current flow will give erroneously high values for the polarization resistance.

7. Apparatus

7.1 Corrosion Rate Measurement Device (three types of device are described):

7.1.1 Type I device-A manually operated device equipped with a large counter electrode (CE) 170 mm (6.75 in.) long without current confinement. Polarization is applied by a continuous increase of cathodic current, and values of the current are recorded for polarization values of 4, 8, and 12 mV. Only polarization resistance is determined with the type I device (not the concrete resistance).

7.1.2 Type II device-An automatically operated device equipped with a probe containing an Ag/AgCl reference electrode and a central CE(counter electrode) with a 35 mm (1.4 in.) outer diameter, which is surrounded by a ring guard electrode (GE) that has a 60 mm (2.4 in.) outer diameter. The type II device is assembled in a manner that superimposes two current pulses of low and high frequencies, respectively, and enables the determination of both the polarization resistance and concrete resistance.

7.1.3 Type III device-An automatically operated device equipped with a central CE(counter electrode) with an 80 mm (3 in.) diameter, and an external ring GE (guard electrode), which confines the current to an area 140 mm (5.5 in.) in diameter. The type III device is assembled and equipped in a manner that provides data on polarization resistance, corrosion current density (corrosion rate), and concrete resistance.

Note 1 - All three devices (Types I, II, and III) operate by measuring the polarization resistance, R_p . Corrosion current, I_c , is then calculated from the equation $I_c = B/R_p$, where B equals 0.026 V when I_c is expressed in $A \cdot cm^{-2}$ and R_p is expressed in $ohm \cdot cm^2$.

7.2 Half Cell - A half cell as described in ASTM C876 for determining half-cell potentials of reinforcing steel

7.3 Voltmeter - A voltmeter having an input resistance greater than 10 MΩ for measuring corrosion potentials

7.4 Covermeter - A covermeter for locating reinforcing steel in concrete structures

7.5 Temperature Measurement Device - A thermometer or other device capable of measuring ambient temperatures within a range of 0 to 50°C

8. Materials and Reagents

8.1 Sponges - Sponges shall be used to provide a low electrical resistance liquid junction between the concrete surface and the device for the corrosion rate measurements, and/or a half cell. Sponges for the Type II device, the Type III device, and the half cell shall be about 5 mm (0.2 in.) thick. The sponge configuration must match the footprint of the probe.

8.2 Electrical Contact Solutions - An electrical contact solution shall be used to wet the concrete surface and the sponges.

8.2.1 When operating the Type I device, use the electrical contact solution described in ASTM C876, a mixture of 95 mL of common liquid household detergent and 19 L of potable water.

8.2.2 When operating the Type II device, use potable water saturated with potassium chloride.

8.2.3 When operating the Type III device use potable water.

8.3 Electrical Lead Wires - Electric lead wires as specified in ASTM C876 shall be used.

8.4 Chalk - Chalk or other nonconductive, nonmetallic, water permeable marker

8.5 Miscellaneous Tools - Miscellaneous tools for establishing electrical connection with the reinforcing steel

9. Sampling