
Standard Method of Test for

Predicting Chloride Penetration of Hydraulic Cement Concrete by the Rapid Migration Procedure

AASHTO Designation: T 357-22¹

Technically Revised: 2022

Technical Subcommittee: 3c, Hardened Concrete



**American Association of State Highway and Transportation Officials
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1. SCOPE

- 1.1. This procedure is for the rapid evaluation of chloride penetration resistance of concrete, from non-steady-state migration experiments.
- 1.2. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

- 2.1. *AASHTO Standards:*
- < M 339M/M 339, Thermometers Used in the Testing of Construction Materials
 - < R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
 - < R 39, Making and Curing Concrete Test Specimens in the Laboratory
 - < R 100, Making and Curing Concrete Test Specimens in the Field
 - < T 24M/T 24, Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
 - < T 277, Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration
- 2.2. *ASTM Standards:*
- < D1193, Standard Specification for Reagent Water
 - < E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
 - < E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
 - < E2877, Standard Guide for Digital Contact Thermometers
- 2.3. *International Electrotechnical Commission Standard:*
- < IEC 60584-1:2013, Thermocouples - Part 1: EMF Specifications and Tolerances

3. TERMINOLOGY

3.1. Definitions:

- 3.1.1. *chloride penetration depth*—the distance between the surface exposed to chloride solution and the chloride penetration front where the color changes from white to brown after spraying of 0.1*N* silver nitrate solution.
- 3.1.2. *diffusion*—the movement of molecules or ions under a gradient of concentration, or more strictly speaking, chemical potential, from a high concentration zone to a low concentration zone.
- 3.1.3. *migration*—the movement of ions under the action of an external electrical field.

4. SUMMARY OF TEST METHOD

- 4.1. This test method uses electrical migration to accelerate the movement of chloride ions into a concrete specimen and a colorimetric indicator to measure the extent of chloride penetration. An external potential is applied axially across the specimen to force the chloride ions to migrate into the specimen. After a defined test duration, the specimen is axially split and a silver nitrate solution (colorimetric indicator for chloride) is sprayed on one of the fresh split surfaces. The chloride penetration depth is measured from the extent of the visible white silver chloride precipitate. From this penetration depth, the rate of chloride ion penetration is determined and used to rate the concrete.

5. SIGNIFICANCE AND USE

- 5.1. The results of this test can be used to rate concrete according to the relative ease with which chloride ions can penetrate into the concrete. This in turn gives an indication of the potential for corrosion of reinforcing steel due to chloride intrusion.

6. APPARATUS

- 6.1. Water-cooled diamond saw, capable of making cuts perpendicular to the axis of 100-mm diameter concrete cylinders or cores.
- 6.2. *Conditioning Equipment:*
 - 6.2.1. *Vacuum Desiccator*—250-mm diameter or larger (capable of containing at least three specimens), allowing two hose connections, each of which must be equipped with a stopcock.
 - 6.2.2. *Vacuum Pump*—Capable of maintaining a pressure of less than 5 kPa (37 mmHg) in the desiccator.
Note 1—Because the vacuum will be drawn over water, the pump should be protected with a cold trap, or the pump oil should be changed after each use.
 - 6.2.3. *Vacuum Gauge or Manometer*—Capable of reading vacuum levels as low as 1 kPa (5 mmHg).
- 6.3. Migration apparatus shown schematically in Figure 1 (Note 1). Detailed drawings may be found in Annex A1.

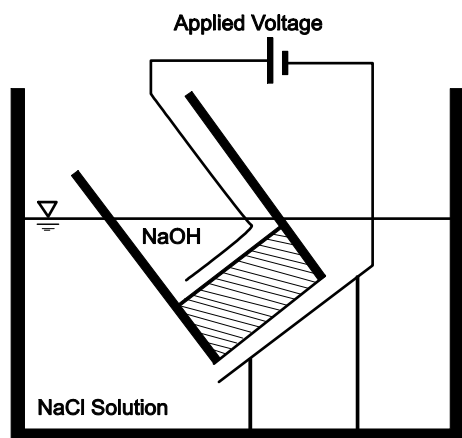


Figure 1—Schematic of Migration Apparatus

- 6.3.1. *Silicon Rubber Sleeve*—Inner/outer diameter 100/115 mm, about 150 mm long.
- 6.3.2. *Two Stainless Steel Clamps*—20 mm wide with diameter range of 105 to 115 mm. (See Figure 2.)
- 6.3.3. *Plastic Container (Catholyte Reservoir)*—370 by 270 by 280 mm (*L* by *W* by *H*).
- 6.3.4. Plastic support with 0.5-mm thick stainless steel plate (cathode) attached. (See Figures A1.1 through A1.5.)
- 6.3.5. *Stainless Steel Mesh or Plate (Anode)*—With holes, about 0.5 mm thick. (See Figure A1.5.)
Note 2—Other designs are acceptable provided that temperatures of the specimen and solutions during the test can be maintained in the range of 20 to 25°C. Test cells for T 277 have been used successfully in this procedure. Use of T 277 cells requires test specimens to be coated as specified in T 277 before conditioning.
- 6.4. Power supply capable of supplying 0- to 60-V direct current (DC)-regulated voltage with the accuracy ± 0.1 V.
- 6.5. *Ammeter*—Capable of displaying current to ± 1 mA.
- 6.6. *Thermometer or Thermocouple*—With readout device capable of reading to $\pm 1^\circ\text{C}$.
- 6.7. Any device suitable for splitting the specimen longitudinally, e.g., compression testing machine with split tensile test apparatus.
- 6.8. *Slide Caliper*—With 0.1-mm resolution and ruler for measuring.

7. REAGENTS AND MATERIALS

- 7.1. *Purity of Reagents*—Reagent-grade chemicals shall be used in all tests. Unless otherwise indicated, all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

- 7.2. *Purity of Water*—Unless otherwise indicated, water shall be reagent-grade water as defined by Type III of ASTM D1193.
- 7.3. *Reagents:*
- 7.3.1. *Sodium Chloride Solution, 10 Percent by Mass*—dissolve 100 g sodium chloride (NaCl) in 900 g tap water.
- 7.3.2. *Sodium Hydroxide Solution, 0.3 N*—dissolve approximately 12 g sodium hydroxide in 1 L distilled or deionized water.
- 7.3.3. Silver nitrate (AgNO₃) solution, 0.1 M.
- 7.4. *Sealant:*
- 7.4.1. Five-minute epoxy or other suitable sealant for coating specimen sides, if required by the test apparatus. (See Note 2.)

8. SAMPLING, TEST SPECIMENS, AND TEST UNITS

- 8.1. The method requires cylindrical specimens with a diameter of 100 mm and a thickness of 50 mm, sliced from cast cylinders or drilled cores with a minimum original length of 100 mm. The cylinders or cores should meet the requirements described in R 39, R 100, or T 24M/T 24. Three specimens should be used in the test.
- 8.2. *Obtaining Test Specimens:*
- 8.2.1. If a drilled core is used, an outer (i.e., closest to the original surface) layer of the concrete (approximately 10–20 mm thick) should be cut off (Note 3), after which a 50 ± 2 mm thick slice should be cut from the remaining core length to be used as the test specimen. The end surface of the test specimen that was closest to the original surface (i.e., the end surface that was adjacent to the discarded outer layer) should be exposed to the chloride solution (catholyte).
- 8.2.2. If a cast cylinder is used, an outer (i.e., closest to the troweled surface) layer of the concrete approximately 25 mm thick should be cut off (Note 3), after which a 50 ± 2 mm thick slice should be cut from the remaining length of the cylinder to be used as the test specimen. The end surface closest to the original troweled surface should be exposed to the chloride solution (catholyte).
- 8.2.3. The thickness should be measured to the nearest 0.1 mm with a slide caliper at four locations equally spaced around the specimen. All four thickness measurements shall be 50 ± 2 mm.
- Note 3**—The term “cut” here means to saw perpendicularly to the axis of a core or cylinder by means of a water-cooled diamond saw.

9. CONDITIONING

- 9.1. Brush and wash away any burrs from the surfaces of the specimen. Wipe excess water from the surfaces of the specimens.
- 9.2. Coat specimen sides with 5-min epoxy or other suitable sealant if required.
- 9.3. *Preconditioning (Vacuum Saturation):*
- 9.3.1. Place surface-dry specimens in the vacuum desiccator. Both end surfaces must be exposed.