
Standard Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

AASHTO Designation: T 277-23¹

Technically Revised: 2023

Editorially Revised: 2023

Technical Subcommittee: 3c, Hardened Concrete

ASTM Designation: C1202-22^{ε1}



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1. SCOPE

- 1.1. This test method covers the determination of the electrical conductance of concrete to provide a rapid indication of its resistance to the penetration of chloride ions. This test method is applicable to types of concrete where correlations have been established between this test procedure and long-term chloride ponding procedures such as those described in T 259. Examples of such correlations are discussed in Berke et al. (1988), Ozyildirim and Halstead (1988), Whiting (1981 and 1988), and Whiting and Dziedzic (1989).
- 1.2. The values stated in SI units are to be regarded as the standard.
- 1.3. The text of this standard references notes and endnotes which provide explanatory materials. These notes and endnotes (excluding those in tables and figures) shall not be considered as requirements of the 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.*
- 1.5. 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.
- 1.6. *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 39M/R 39, Making and Curing Concrete Test Specimens in the Laboratory
- < R 100M/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 259, Resistance of Concrete to Chloride Ion Penetration

2.2. *ASTM Standards:*

- < C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
- < C802, Standard Practice for Conducting an Interlaboratory Test Program to Determine the Precision of Test Methods for Construction Materials
- < C1542/C1542M, Standard Test Method for Measuring Length of Concrete Cores
- < 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

2.4. *Other Documents:*

- < Berke, N. S., D. W. Pfeifer, and T. G. Weil. Protection against Chloride-Induced Corrosion. *Concrete International*. Vol. 10, No. 12, December 1988, pp. 45–55.
- < Bouzoubaa, N., A. Bilodeau, S. Vasanthy, B. Fournier, and D. Golden. Development of Ternary Blends for High-Performance Concrete. *ACI Materials Journal*, Vol. 101, No. 1, 2004, pp. 19–29.
- < Obla, K. H. and C. L. Lobo. Acceptance Criteria for Durability Tests. *ACI Concrete International*, Vol. 29, No. 5, May 2007, pp. 43–48.
- < Ozyildirim, C. Effects of Temperature on the Development of Low Permeability in Concretes. VTRC R98-14. Virginia Transportation Research Council, Charlottesville, VA, 1998.
- < Ozyildirim, C. and W. J. Halstead. *Use of Admixtures to Attain Low Permeability Concretes*. Final Report No. FHWA/VA-88-R11. Virginia Transportation Research Council, NTIS No. PB 88201264, February 1988.
- < Whiting, D. *Rapid Determination of the Chloride Permeability of Concrete*. Final Report No. FHWA/RD-81/119. Federal Highway Administration, NTIS No. PB 82140724, August 1981.
- < Whiting, D. Permeability of Selected Concrete. *Permeability of Concrete*. SP-108, American Concrete Institute, Detroit, MI, 1988, pp. 195–222.
- < Whiting, D. and W. Dziedzic. *Resistance to Chloride Infiltration of Superplasticized Concrete as Compared with Currently Used Concrete Overlay Systems*. Final Report No. FHWA/OH-89/009. Construction Technology Laboratories, May 1989.

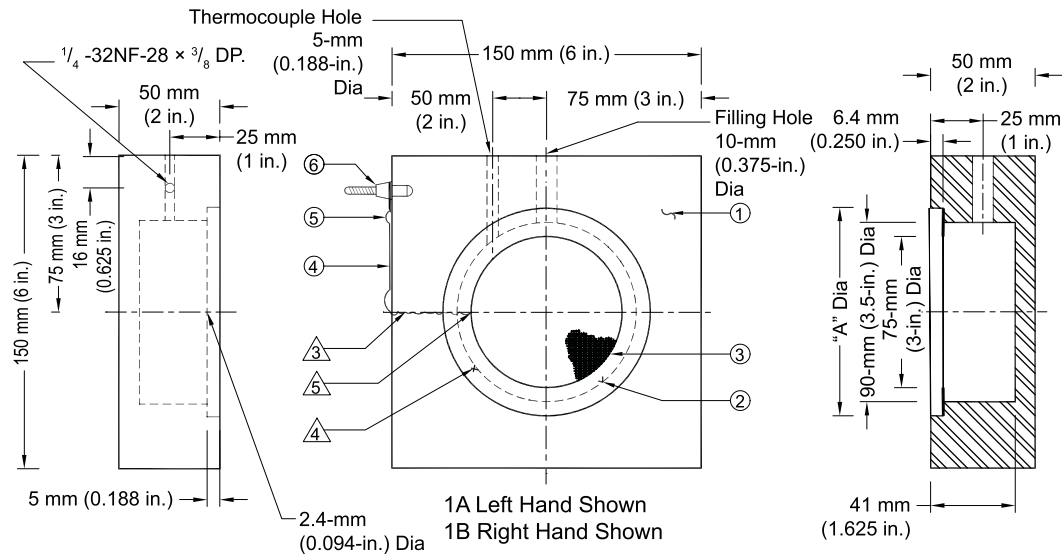
3. SUMMARY OF TEST METHOD

- 3.1. This test method consists of monitoring the amount of electrical current passing through 50-mm (2-in.) thick slices of 100-mm (4-in.) nominal diameter cores or cylinders during a 6-h period. A potential difference of 60 V dc is maintained across the ends of the specimen, one of which is immersed in a sodium chloride solution and the other in a sodium hydroxide solution. The total

charge passed, in coulombs, has been found to be related to the resistance of the specimen to chloride ion penetration.

4. SIGNIFICANCE AND USE

- 4.1. This test method covers the laboratory evaluation of the electrical conductance of concrete samples to provide a rapid indication of their resistance to chloride ion penetration. In most cases, the electrical conductance results have shown good correlation with chloride ponding tests, such as T 259, on companion slabs cast from the same concrete mixtures (Whiting, 1981, 1988, and 1989; Berke et al., 1988; Ozyildirim and Halstead, 1988).
- 4.2. This test method is suitable for evaluation of materials and material proportions for design purposes and research and development.
- 4.3. Sample age has significant effects on the test results, depending on the type of concrete and the curing procedure. Most concretes, if properly cured, become progressively and significantly less permeable with time.
- 4.4. This test method was developed originally for evaluation of alternative materials, but in practice its use has evolved to applications such as quality control and acceptance testing. Factors such as ingredient materials used in concrete mixtures and the method and duration of curing test specimens affect the results of this test (see Note 1). When this method is used for mixture qualification and acceptance testing, it is imperative that the curing procedures and the age at time of testing be clearly specified.
- Note 1**—When using this test for determining acceptability of concrete mixtures, statistically based criteria and test age for prequalification or for acceptance based on jobsite samples should be stated in project specifications. Acceptance criteria for this test should consider the sources of variability affecting the result and ensure balanced risk between supplier and purchaser. The anticipated exposure conditions and time before a structure will be put into service should be considered. One approach to establishing criteria is discussed in Obla and Lobo (2007).
- 4.5. Table X1 in Appendix X1 provides a qualitative relationship between the results of this test and the chloride ion penetrability of concrete.
- 4.6. Care should be taken in interpreting results of this test when it is used on surface-treated concretes; for example, concretes treated with penetrating sealers. The results from this test on some such concretes indicate low resistance to chloride ion penetration, while 90-day chloride ponding tests on companion slabs show a higher resistance.
- 4.7. The details of the test method apply to 100-mm (4-in.) nominal diameter specimens. This includes specimens with actual diameters ranging from 95 mm (3.75 in.) to 100 mm (4 in.). Other specimen diameters may be tested with appropriate changes in the applied voltage cell design. (See Section 7.5 and Figure 1.)
- 4.7.1. For specimen diameters other than 95 mm (3.75 in.), the test result value for total charge passed must be adjusted following the procedure in Section 11.2. For specimens with diameters less than 95 mm (3.75 in.), particular care must be taken in coating and mounting the specimens to ensure that the conductive solutions are able to contact the entire end areas during the test.



- △ Notes:
1. Outside Diameter "A" should be 3.2 mm (0.125 in.) larger than outside diameter of specimen.
 2. Not to scale
 3. Seal Wire in hole with Silicon Rubber Caulk.
 4. Screen soldered between Shims.
 5. Solder Wire to Brass Shims.
 6. Polymethylmethacrylate, e.g., Plexiglas

Equivalents

Item	Qty.	Nomenclature	Specification
1.A	1	Cell block end	DMMA sheet
1.B	1		
2	4	Shim, brass	0.5 mm (0.02 in.) THK
3	2	Screen, brass	0.85 mm (No. 20) mesh. "A" diameter
4	2	Wire, copper	14, solid Nyclad
5	2	Terminal	12-10-1/4
6	2	Banana plug	6.4 mm (0.25 in.) male insulated

Figure 1—Applied Voltage Cell (Construction Drawing)

5. INTERFERENCES

- 5.1. This test method can produce misleading results when calcium nitrite has been admixed into a concrete. The results from this test on some such concretes indicate higher coulomb values, that is, lower resistance to chloride ion penetration, than from tests on identical concrete mixtures (controls) without calcium nitrite. However, long-term chloride ponding tests indicate the concretes with calcium nitrite were at least as resistant to chloride ion penetration as the control mixtures.

Note 2—Other admixtures might affect results of this test similarly. Long-term ponding tests are recommended if an admixture effect is suspected.

- 5.2. Since the test results are a function of the electrical resistance of the specimen, the presence of reinforcing steel or other embedded electrically conductive materials may have a significant effect. The test is not valid for specimens containing reinforcing steel positioned longitudinally; that is, providing a continuous electrical path between the two ends of the specimen.