



Designation: C1876 – 24

Standard Test Method for Bulk Electrical Resistivity or Bulk Conductivity of Concrete¹

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1. Scope*

1.1 This test method covers the determination of the bulk electrical resistivity or conductivity of molded specimens or cored sections of hardened concrete after immersion in water saturated with a simulated pore solution in order to provide a rapid indication of its resistance to the penetration of fluids and dissolved aggressive ions.

1.2 The values stated in SI units are to be regarded as the standard. No other units of measurement are included in this standard. If required results obtained from another standard are not reported in the same system of units as used by this standard, it is permitted to convert those results using the conversion factors found in the SI Quick Reference Guide.²

1.3 The text of this standard references notes and footnotes that provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of this 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use. (Warning—Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.)³ For specific warning statement see 8.1.2.*

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 This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.66 on Concrete's Resistance to Fluid Penetration.

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² Annex A in Form and Style for ASTM Standards, www.astm.org/COMMIT/Blue_Book.pdf.

³ Section on Safety Precautions, Manual of Aggregate and Concrete Testing, Annual Book of ASTM Standards, Vol. 04.02.

2. Referenced Documents

2.1 ASTM Standards:⁴

C31/C31M Practice for Making and Curing Concrete Test Specimens in the Field

C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens

C42/C42M Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

C125 Terminology Relating to Concrete and Concrete Aggregates

C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

C1202 Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

C1556 Test Method for Determining the Apparent Chloride Diffusion Coefficient of Cementitious Mixtures by Bulk Diffusion

C1760 Test Method for Bulk Electrical Conductivity of Hardened Concrete (Withdrawn 2021)⁵

3. Terminology

3.1 Definitions:

3.1.1 For definitions of terms used in this standard, refer to Terminology C125.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *bulk electrical resistivity, n* —material property that quantifies how strongly the material opposes the flow of electrical charge when an electric field is applied using electrodes placed on opposite faces of a test specimen; measured in units of ohm-meter.

3.2.2 *bulk electrical conductivity, n* —material property that quantifies how strongly the material permits the flow of electrical charge when an electric field is applied using electrodes placed on opposite faces of a test specimen; measured in units of milli-siemens per meter (mS/m).

⁴ 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.

⁵ The last approved version of this historical standard is referenced on www.astm.org.

*A Summary of Changes section appears at the end of this standard

3.2.2.1 *Discussion*—Bulk electrical conductivity is the reciprocal of bulk electrical resistivity.

4. Summary of Test Method

4.1 The electrical resistance or conductance of a hardened concrete cylindrical specimen conditioned in accordance with this test method is determined on at least two specimens obtained from cores or cast in cylindrical molds, the ends are prepared, the dimensions measured, and then submerged in a simulated pore solution for at least 6 days, or from time of demolding in the case of molded cylinders. While the specimen is in the solution, the bulk resistivity or conductivity test device is verified over the expected range of resistivity or conductivity. Then the specimen is placed in the test device. In some testing apparatus, the voltage and current are measured such that the resistivity or conductivity can then be calculated. In other testing apparatus, the resistivity or conductivity is calculated directly once specimen dimensions are input.

5. Significance and Use

5.1 The electrical resistivity of a concrete is the opposition to the movement of ions under an applied electric field. The electrical conductivity of a concrete is a measure of how readily the ions in the pore solution can be transported through the concrete under an applied electric field (the higher the conductivity, the greater the rate of transport). The electrical resistivity or conductivity is a material property that depends upon the pore volume, the pore structure (size and connectivity), the pore solution composition, the degree of saturation of the concrete specimen, and the specimen's temperature. Concrete mixture characteristics that are known to affect concrete electrical resistivity, as well as resistance to chloride ion penetration, include water-cementitious materials ratio, pozzolans, slag cement, the presence of polymeric admixtures, air-entrainment, aggregate type, aggregate volume fraction, degree of consolidation, curing method, and age.

5.2 The bulk electrical resistivity of concrete is the inverse of its bulk electrical conductivity. Bulk electrical conductivity can also be measured by Test Method C1760, which uses the apparatus described in Test Method C1202. This test method, however, uses apparatus specifically designed to measure bulk conductivity or bulk resistivity.

5.3 The purpose of conditioning in a simulated pore solution is to bring the specimen to a level of near complete saturation of the capillary and gel pores. When comparing two different concrete specimens, it is important to condition both specimens as close as possible to a comparable saturation state, using the same solution for conditioning, so that values can be compared in a meaningful way. This is particularly true for using the measured resistivity or conductivity, along with other information, to estimate the diffusivity.

5.4 The bulk electrical resistivity or conductivity of concrete can provide a rapid indication of its resistance to chloride ion penetration and resistance to penetration of other fluids. Resistivity or conductivity measurements have shown good correlations with other electrical indication tests including Test

Method C1202 (1, 2, 3).⁶ Bulk electrical resistivity results have shown good correlation with bulk diffusion determined using Test Method C1556 on companion molded cylinders from the same concrete mixtures (4).

6. Interferences

6.1 If this test method is used to compare different concrete mixtures, the results can be misleading if certain admixtures containing water-soluble ionic compounds, such as calcium nitrite and calcium nitrate, are present in one of the concrete mixtures. Chemical admixtures such as calcium nitrite can contribute to a lower electrical resistivity because they increase the conductivity of the pore solution (Note 1). This effect can be independent of the overall quality of the concrete because it has been shown in long-term bulk diffusion tests that concretes with calcium nitrite can perform as well as control mixtures without the admixture and lower conductivity.

NOTE 1—Similarly, other admixtures containing water-soluble ionic compounds might affect the results of this test method. Long-term chloride ion diffusion tests are recommended if an admixture effect is suspected. Alternately, this interference can be minimized by expressing results as a formation factor (see Appendix X1).

6.2 Because the test results are a function of the electrical resistance or conductance of the specimen, the presence of reinforcing steel, metal fibers, or other embedded electrically conductive materials, including some types of aggregates, may yield unrepresentative results, as these will result in higher conductivity than a concrete of similar quality but with no embedded conductive material. The test is not applicable to specimens containing reinforcing steel positioned longitudinally that provide a continuous electrical path between the two ends of the specimen, and it is not applicable to specimens containing discrete metallic fibers.

6.3 Leaching of ions from the pore solution of concrete is known to affect measured resistivity or conductivity values. Even standard curing in water saturated with calcium hydroxide can influence the resistivity of the solution inside the pores of the concrete as potassium and sodium hydroxides are leached out. As such, concrete cylinders and cores are immersed in simulated pore solution for at least 6 days prior to testing.

6.4 The level of saturation of the concrete has a major impact on resistivity or conductivity because the electric current is mainly conducted through the liquid in the pores. Achieving full saturation is difficult, so while not perfect, the conditioning procedures used in this test method provide a methodology for achieving a high and reproducible level of saturation without allowing excessive leaching of alkalis.

6.5 Because concrete has a capacitive component, its electrical response is characterized by a magnitude and a phase difference that is a function of the AC frequency. This may have an effect on the measured test result. The desired quantity is the magnitude of the impedance that is measured at the frequency that yields the minimum phase difference between

⁶ The boldface numbers in parentheses refer to the list of references at the end of this standard.