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Standard Test Methods for Corrosivity of Water in the Absence of Heat Transfer (Electrical Methods)¹

This standard is issued under the fixed designation D 2776; 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 (e) indicates an editorial change since the last revision or reapproval.

^{e1} NOTE—1.5 was added editorially in February 1989.

1. Scope

1.1 These test methods cover the determination of the corrosivity of water by electrical methods. The rate of corrosion of a metal immersed in water is a function of the tendency for the metal to corrode and is also a function of the tendency for water and the materials it contains to promote (or inhibit) corrosion. The following test methods are included:

	Sections
Test Method A—Electrical Resistance	5 to 12
Test Method B—Polarization Resistance	13 to 20

1.2 The electrical resistance test method (Test Method A) measures the corrosion rate of a metal sample, mounted on a probe, by periodically determining its change in electrical resistance as the cross-sectional area of the metal sample decreases due to corrosion. The observed measurement is the change in resistance ratio between a measuring element exposed to water and a reference element in proximity to, but protected from, the corrosive environment. A corrosion rate measurement requires two or more successive readings over a period of time which is governed by actual rate of metal loss and measuring element sensitivity (that is, cross-sectional area).

1.3 The polarization resistance (PR) test method (Test Method B) operates on the principle that when a prescribed voltage (usually 5 to 30 mV in water) is impressed across the interface boundary between a metal electrode surface and a conductive liquid, the resulting current flow will be directly proportional to the corrosion occurring on the metal electrode surface, if the current measurement includes both anodic and cathodic polarization characteristics.

1.3.1 There are two types of PR measurements. One employs two identical electrodes and one employs three electrodes. In the vast majority of measurements in water-based systems, both the two-electrode and the three-electrode techniques will provide data with equal accuracy. Correction of data for either test method is only necessary when the product of corrosion rate reading and solution resistivity exceed certain maximum limits. These limits are almost

never reached when corrosion rate measurements are being made in water.

1.4 Correlation of corrosion rates obtained by these test methods with the performance of an actual system is necessary if the service life of metals in a given water is to be predicted.

1.5 *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 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:

- D 1125 Test Methods for Electrical Conductivity and Resistivity of Water²
- D 1129 Definitions of Terms Relating to Water²
- D 2688 Test Methods for Corrosivity of Water in the Absence of Heat Transfer (Weight Loss Methods)²
- G 59 Practice for Conducting Potentiodynamic Polarization Resistance Measurements³

3. Definitions

3.1 For definitions of terms used in these test methods, refer to Definitions D 1129.

4. Significance and Use

4.1 Since the two tendencies are inseparable for a metal to corrode and for water and the materials it contains to promote or (inhibit) corrosion, the corrosiveness of a material or the corrosivity of water must be determined in relative, rather than absolute, terms. The tendency for a material to corrode is normally determined by measuring its rate of corrosion and comparing it with the corrosion rates of other materials in the same water environment. Conversely, the relative corrosivity of water may be determined by comparing the corrosion rate of a material in the water with the corrosion rates of the same material in other waters. Such tests are useful, for example, for evaluating the effects of corrosion inhibitors on the corrosivity of water. Although these methods are intended to determine the corrosivity of

¹ These test methods are under the jurisdiction of ASTM Committee G-1 on Corrosion of Metals and are the direct responsibility of Subcommittee G01.12 on In-Plant Corrosion Tests.

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² Annual Book of ASTM Standards, Vol 11.01

³ Annual Book of ASTM Standards, Vol 03.02

water, they are equally useful for determining corrosiveness and corrosion rate of materials.

TEST METHOD A—ELECTRICAL RESISTANCE (1, 2)⁴

5. Summary of Test Method

5.1 Metal loss is measured by determining changes in resistance ratio between a probe measuring element and a protected reference element contained within the probe. A modified Kelvin bridge-type instrument is used to measure the change in resistance ratio. The instruments are calibrated to read in units of metal loss (or metal remaining) on the probe measuring element. Corrosion rate data may be obtained by use of a recording instrument that automatically reads the probe and adds a time dimension or individual readings may be manually plotted on graph paper to provide a visual slope of metal loss rate. A formula may be used to convert the resistance change data into corrosion rate information.

6. Interferences

6.1 Results are representative for general corrosion. On wire form measuring elements a pitting attack may be indicated by rapid rate increases after 50 % of full range of the instrument is passed. The larger tubular measuring elements are not sensitive to pitting attack.

6.2 It should be recognized that deviations in water temperature, in the velocity and direction of flow, in metal composition and surface preparation of probes, and in composition between probes and corresponding material of construction, and the presence of extraneous materials (such as corrosion products) on the probes, are factors that may affect the accuracy and the reliability of the results.

6.3 It should also be recognized that corrosion rate results obtained in steam condensate systems treated with octadecylamine or other similar film-forming compounds may be of questionable accuracy.

6.4 Flexing of the specimen due to flow conditions may cause erroneous results.

6.5 Tests after several days exposure are usually more representative than the initial corrosion rate indicated by the probe.

7. Apparatus

7.1 *Electrical Resistance Corrosion Probes*⁵—A probe is composed of two elements of identical material. One is a measuring element and the other is a protected reference element.

7.2 *Modified Kelvin-Bridge Type Instruments*, either manual or automatic, for measurement of change of electrical resistance of probes.⁵

⁴ The boldface numbers in parentheses refer to the references at the end of these test methods.

⁵ Equipment manufactured by Rohrbach Instruments, 11861 E. Telegraph Rd., Santa Fe Springs, Calif. 90670 as Model CK-3 and Model 4800 Corrosometer® has been found satisfactory for this purpose. The probes have a maximum temperature rating of 150°C. The laboratory-type probe may be used at atmospheric pressure, a fixed process probe, at a maximum gage pressure of 6.9 MPa (1000 psi), and a retractable process probe, at a maximum gage pressure of 3.4 MPa (500 psi).

8. Probe Preparation

8.1 Commercial probes are generally received in sealed plastic bags to protect dust-blasted surfaces or other specifically prepared surfaces. Care should be taken to avoid handling the probes as grease on one's hands can affect the result.

9. Probe Installation

9.1 Install the probe in a position as representative of the corrosive environment as possible without causing deleterious effects (not transversely in a high-flow pipe line without shielding) (see 6.2).

9.2 Do not install the probe in a dead-end section where concentration cell effects are controlling.

10. Procedure

10.1 Manual Instrument:

10.1.1 Check the probe circuit and the internal calibration circuit of the instrument for proper functioning, as recommended in the manufacturer's instructions.

10.1.2 Connect the instrument to the probe, log the measuring element readings, and check element reading.

10.1.3 Take readings more frequently in the case of more rapidly corroding probes, as hourly or daily rather than weekly.

10.2 Automatic Instrument:

10.2.1 Check the probe circuit and the internal calibration circuit of the instrument for proper functioning, as recommended in the manufacturer's instructions.

10.2.2 Connect the instrument to the probe.

10.2.3 Probe readings are taken automatically and continuously and plotted on the built-in recorder.

11. Calculation

11.1 Plot the measured resistance data against time to obtain the slope and changes in slopes.

11.2 Determine the corrosion rate from the slope of interest as follows:

$$P = 0.00927 F (\Delta R / \Delta T)$$

where:

P = corrosion rate, mm/year,⁶

ΔR = change in corrosion meter reading,

ΔT = time in days over which ΔR occurred, and

F = probe multiplier (varies from 0.5 to 25, is a function of the type of probe, and is supplied with the probe by the manufacturer).

12. Precision

12.1 Precision is a function of each individual system. Therefore, a general statement regarding this property is not practical at this time.

TEST METHOD B—POLARIZATION RESISTANCE (3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15)

13. Summary of Test Method

13.1 In the polarization resistance method (Practice G 59)

⁶ To convert to mils/yr, multiply by 39.37. To convert to mdd, see 15.2 of Test Methods D 2688.