



Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing¹

This standard is issued under the fixed designation G51; 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 (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers a procedure for determining the pH of a soil in corrosion testing. The principle use of the test is to supplement soil resistivity measurements and thereby identify conditions under which the corrosion of metals in soil may be accentuated (see G57–78(1984)).

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*²

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

G57 Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method

3. Significance and Use

3.1 Information on pH of soil is used as an aid in evaluating the corrosivity of a soil environment. Some metals are more sensitive to the pH of their environment than others, and

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² 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.

information on the stability of a metal as a function of pH and potential is available in the literature.³

4. Apparatus

4.1 *pH Meters*—A portable, battery-powered pH meter is necessary for field measurements. Most instruments can also function as a high-impedance voltmeter. An LCD display is preferred for its readability in a bright, outdoor environment.

4.2 Calomel and Glass Electrodes:

4.2.1 Use a saturated calomel reference electrode or its equivalent in the pH determination. A few crystals of solid potassium chloride should always be present within the chamber surrounding the calomel to assure that the solution is saturated under the conditions of use. The design of the electrode must permit the formation of a fresh liquid junction between the solution of potassium chloride and the buffer or test soil for each test and allow traces of soil to be readily removed by washing.

4.2.2 A glass electrode of rugged construction is required. The performance of the glass electrode is satisfactory if it furnishes the correct pH value (± 0.1 pH unit) for standard buffered solutions.

4.2.3 A combination electrode consisting of a saturated calomel reference electrode and a glass electrode (4.2.1 and 4.2.2) combined as a single electrode is acceptable. However, the requirements outlined above are equally applicable to the electrodes used in this combination unit.

4.3 *Subsurface Probe*—When pH measurements below the surface of the soil are required, it is necessary to use a probe of suitable length which will allow measurements to be made at the depth of interest. This probe consists of a glass electrode or a combination electrode in a rubber housing at the end of a plastic tube. One type of probe is illustrated in Fig. 1.

4.4 *Soil Thermometer*—Some pH electrodes have temperature compensation built in as part of the pH electrode, but most

³ Pourbaix, M., *Atlas of Electrochemical Equilibria in Aqueous Solutions*, Pergamon Press, 1966.

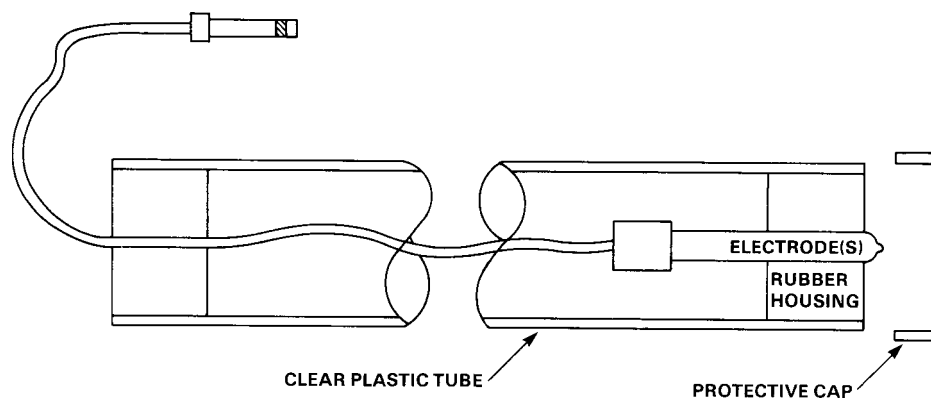


FIG. 1 Subsurface Probe

do not (see manufacturer's specifications). A thermometer of rugged construction is required for soil use, and a stainless steel sheathed thermometer is preferred. Metal sheathed thermometers come in different lengths, and a length appropriate for the depth of interest should be chosen.

5. Reagents and Materials

5.1 During the calibration procedure for the pH meter, standard buffered solutions of known pH are necessary. These solutions, or tablets to make up these solutions, can be purchased from chemical supply companies or pH equipment manufacturers.

6. Sampling

6.1 By the nature of the measurement, pH is determined for a small volume of soil at each reading, and it is important that at least three measurements at different locations be made and a simple average calculated. The regions of interest, surface, subsurface, or both, where applicable, must be sampled.

7. Calibration and Standardization

7.1 *Test for Linearity*—Prior to field use, or periodically when used extensively in the field, test the apparatus for linearity of response. This procedure is as follows:

7.1.1 Turn on the instrument, allow to warm up thoroughly, and bring to electrical balance in accordance with the manufacturer's instructions. Before use, clean and rinse the glass and calomel electrodes in distilled water.⁴

7.1.2 At least two standard buffered pH solutions that span the soil pH to be measured are required. From practical experience standard solutions of pH 4, 7, and 8 are recommended. For the test, the temperature of these solutions shall not differ from each other by more than 5°C. A laboratory thermometer can be used for these measurements.

7.1.3 Adjust the temperature compensating dial on the pH meter to the standard solution temperature.

7.1.4 Immerse the electrodes in a small volume of the first known standard solution. Now adjust the pH meter to read this known pH.

7.1.5 Remove the electrodes from the first standard solution, and rinse in distilled water. Immerse the electrodes in the second known standard solution and read the pH value. Judge the system to be operating satisfactorily if the reading obtained for the second standard agrees within ± 0.1 unit of the assigned pH.

7.2 *Calibration of pH Meter*—Calibrate the pH meter immediately before use. If a series of measurements are to be made, repeat the calibration procedure at intervals of about 30 min. Perform the pH meter calibration as follows:

7.2.1 Use a standard pH solution in the range of the pH of the soil to be tested, if such information is known beforehand. Otherwise, begin with a standard solution having a pH of 7. Stabilize the temperature of the solution so that it matches the temperature of the soil to within 10°C.

7.2.2 Immerse the electrodes in the known standard solution and calibrate the meter in accordance with the manufacturer's instructions.

8. Procedure

8.1 Soil Preparation for pH Determination:

8.1.1 Ideally the pH measurement should be made in the field with the glass electrode contacting the soil at the specific depth of interest. If the surface soil pH is desired, then the soil can be broken up if compacted so as to accept the electrodes. If a subsurface pH is desired, then a boring or an excavation must be done so that the electrode can be placed in the soil at the desired depth. The subsurface probe (Fig. 1) is ideal for use with a boring tool such as hand auger. After boring through the soil to the depth of interest, carefully lower the probe into the cavity without further preparation of the soil.

8.1.2 Soil samples can be brought to the surface with a boring tool or a post-hole digger, and the measurement made in the field on the soil thus obtained. This technique is less desirable than the probe method described in this section.

8.1.3 The least desirable pH measurement of soil is that which is based on a soil sample transported to a laboratory for evaluation. However, if this must be done, then make the pH measurement as quickly as possible after the soil is taken from the field. Place the sample in a clean, airtight, glass container or plastic bag so that the soil is not in contact with any metal. If the pH measurement is not made within 24 h from the time

⁴ Before use, condition new glass electrodes and those that have been stored dry in accordance with the manufacturer's recommendations.

the soil sample is taken, then it is recommended that the soil sample be packed in dry ice to retard any change in pH due to chemical or biological reactions. Make the pH measurement on the soil at room temperature and as received.

8.1.3.1 The addition of water to the soil is not recommended for any case because some soils are so poorly buffered that added moisture will change their pH. However, if a soil is extremely dry with a resistivity exceeding $10^6 \Omega\text{-cm}$, a condition not normally encountered, then the pH measurement cannot and should not be made. This situation will manifest itself with a random drifting of the pH meter reading.

8.1.3.2 If the soil is frozen, it must be thawed prior to making the measurement. Frozen soil manifests itself by random drifting of the pH meter reading and is verified by the soil temperature measurement.

8.2 Determination of pH of Soil:

8.2.1 Complete the meter calibration procedure (7.2). The standard solution temperature must match the temperature of the soil within 10°C . Soil temperature can be determined by inserting a metal sheathed thermometer into the soil to the depth of interest.

8.2.2 Clean the electrode surface by washing with distilled water.

8.2.3 Press the contact area of the glass electrode or combination electrode, as the case may be, against undisturbed soil at the location of interest. This step is important, since poor soil contact or electrode movement can affect stability of the measurement.

8.2.4 The reference electrode should be placed in contact with the soil near the glass electrode (this step is not required when using a combination-type electrode). An electrode separation of about 30 cm is suggested for surface measurements. For subsurface readings, the reference electrode may be placed on the surface about 30 cm from the bore hole entry.

8.2.5 With the electrode(s) in place, set the meter to read pH, allowing 1 or 2 min for equilibrium to be established, then take the meter reading.

8.2.6 After approximately 1 min, repeat the meter reading. In general, the values will agree within 0.2 pH units. If the range of values is as large as 0.4, then repeat 8.2.3. If the problem persists, check your equipment to verify that it is operating properly, and check your measurement technique as

described in Procedure, Section 8, in this test method. Where a soil is extremely dry, it may not be possible to make a pH measurement as stated in 8.1.3.1. Where the soil is frozen, it must be thawed as indicated in 8.1.3.2. Repeat Calibration of pH Meter (7.2) if equipment malfunction is suspected, which may cause erratic pH readings. Finally, if erratic readings persist, it may be necessary to repeat the measurement at a new location in the vicinity of interest.

9. Precision and Bias

9.1 *Interlaboratory Test Program*—An interlaboratory round robin was run during the May 1993 ASTM G1 meeting in Atlanta, GA, in which the pH of two soils, randomly selected from the grounds of the hotel, was measured with equipment brought to the meeting by each of the nine participants. Except for the use of only two materials, Practice E691 was followed for the design and analysis of the data. Details of the design and analysis of the data are given in the research report.⁵

9.2 *Test Result*—The precision information given below in units of pH is for the comparison of two test results, each of which is an average of three determinations.

9.3 Precision:

	Material A	Material B
Average Test Value	4.53	4.20
95 % repeatability limit (within lab)	0.27	0.16
95 % reproducibility limit (between labs)	0.52	0.22

The above terms (repeatability limit and reproducibility limit) are used as specified in Practice E177. The respective standard deviation among test results may be obtained by dividing the above limit values by 2.8.

9.4 *Bias*—The procedure in this test method for measuring pH of soil has no bias because the value of pH is defined only in terms of this test method.

10. Keywords

10.1 corrosion of metals in soil; field measurement of pH; measurement of pH; pH of soil; soil pH for corrosion testing; test method for soil pH; underground corrosion

⁵ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:G01-1011.

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