Designation: G200 – 09 (Reapproved 2014)

Standard Test Method for
Measurement of Oxidation-Reduction Potential (ORP) of Soil[1]

1. Scope

1.1 This test method covers a procedure and related test equipment for measuring oxidation-reduction potential (ORP) of soil samples removed from the ground.

1.2 The procedure in Section 9 is appropriate for field and laboratory measurements.

1.3 Accurate measurement of oxidation-reduction potential aids in the analysis of soil corrosivity and its impact on buried metallic structure corrosion rates.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 *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]

D1498 Test Method for Oxidation-Reduction Potential of Water

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

G3 Practice for Conventions Applicable to Electrochemical Measurements in Corrosion Testing

G15 Terminology Relating to Corrosion and Corrosion Testing (Withdrawn 2010)[3]

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

G187 Test Method for Measurement of Soil Resistivity Using the Two-Electrode Soil Box Method
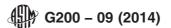
3. Terminology

3.1 The terminology used in this test method, if not specifically defined otherwise, shall be in accordance with Terminology G15.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *calibration solution, n*—commercially available solution with a stable ORP used for calibrating an ORP measuring system (meter and probe).

3.2.2 *ORP*—abbreviation for oxidation-reduction potential.

3.2.3 *ORP electrode (probe), n*—commercially available combination two-element electrode (probe) specifically designed for the measurement of ORP when used in conjunction with a compatible ORP meter.

3.2.3.1 *Discussion*—The combination probe consists of a platinum electrode and a reference electrode, which are generally silver/silver chloride. For soil measurements, the probe must be sufficiently robust to withstand the rigors of the measurement. Regardless, the often fragile probe should be used with caution to avoid damage and maintain measurement reliability.

3.2.4 *ORP meter, n*—commercially available electrical meter specifically designed for the measurement of ORP with internal impedance greater than 10 Ω. Often, the meter is capable of measuring ORP and pH when used in conjunction with the appropriate electrode.

3.2.4.1 *Discussion*—Standard voltmeters or multimeters with internal impedances typically less than 10 Ω are not suitable for soil ORP measurements. Pocket style meters where the electrode is an integral part of the meter housing are also not suitable.

3.2.5 *oxidation-reduction potential (soil), n*—electrical potential measurement to determine the tendency of a soil to transfer electrons between its chemical species. It is the measured potential of an inert metal electrode (generally platinum) with respect to a reference electrode such as silver/silver chloride.

3.2.5.1 *Discussion*—A soil with a higher, more positive potential has an increased tendency to acquire electrons and be reduced (aerobic soil conditions). A soil with a lower positive or negative potential has an increased tendency to lose electrons and be oxidized (anaerobic soil conditions). Soil oxidation-reduction potential is typically reported in units of millivolts (mV) or volts (1 volt = 1000 mV). Sign convention and reference electrodes conform to Practice G3.

3.2.6 *redox potential, n*—synonym for oxidation-reduction potential.

3.2.7 *soil sample, n*—sample of soil to be tested. The minimum (typical) sample size is 1 qt.

4. Summary of Test Method

4.1 The measurement procedure, as described in Section 9 of this test method for determining the ORP of a soil sample, aids in determining the corrosivity of that sample.

4.2 Soil ORP can be measured in a field or laboratory setting.

4.3 While the primary purpose of this test method is measuring soil ORP, it may also be used as a general indicator of ORP in groundwater. Test Method D1498 was specifically developed for accurate ORP measurements of aqueous samples.

5. Significance and Use

5.1 Soil ORP, in conjunction with other soil characteristics such as electrical resistivity (see Test Methods G57 and G187), is used to predict corrosion tendencies of buried metallic structures (for example, pipelines and culverts. The ORP of the soil is one of many factors that influence structure service life. Its measurement is used in the design of new buried structures and in the evaluation of existing buried structures.

5.2 Soil ORP is a time-sensitive measurement. For an accurate indication of soil corrosivity, the measurement should be made as soon as practicable after removal of the soil sample from the ground.

5.3 The user of this test method is responsible for determining the significance of reported ORP measurements. ORP alone should typically not be used in characterizing the corrosivity of a particular soil. ORP measurements are appropriate when evaluating oxygen related reactions.

5.4 ORP measurements can sometimes be quite variable and non-reproducible. This is related, in part, to the general heterogeneity of a given soil. It is also related to the introduction of increased oxygen into the sample after extraction. The interpretation of soil ORP should be considered in terms of its general range rather than as an absolute measurement.

5.5 ORP measurements can be used to determine if a particular soil has the propensity to support microbiologically influenced corrosion (MIC) attack. These measurements can also be used to provide an indication of whether soil conditions will be aerobic or anaerobic. Appendix X1 provides reference guidelines for general interpretation of ORP data.

6. Apparatus

6.1 The equipment required for the measurement of soil ORP, either in the field or in the laboratory, consists of:

6.1.1 *ORP Meter.*

6.1.2 *Compatible Two-Electrode Combination ORP Electrode (Probe)*—A main probe and a backup probe are recommended.

NOTE 1—This test method calls for soil ORP measurements to utilize a commercially available combination electrode (inert metal and reference combined in one probe). Commercially available ORP combination electrodes are generally platinum (inert metal) with silver/silver chloride (reference) in a 3.5 to 4 M KCl electrolyte.

6.1.3 *Operating Instructions*—For ORP meter and ORP electrode.

6.1.4 *Calibration Solution(s)*—For verification of measuring system accuracy within the range of expected ORP values. Calibration solutions should remain uncontaminated. They typically have a published shelf life of no more than 1 year and should not be used once the shelf life is exceeded. Calibration solutions can be obtained commercially or may be mixed in the laboratory using standard pH buffers (4 and 7) and quinhydrone.

NOTE 2—Commercially available ORP calibration solution values should be appropriate for the combination electrode (platinum and silver/silver chloride) used. Calibration kits utilizing pH buffers and quinhydrone solutions are generally used for the platinum and silver/silver chloride combination electrode.

6.1.5 *Clear Plastic or Polyethylene Bags*—1 gal (3.785 L) size is typical, or other convenient means to collect the soil sample and to compress the sample while under test. One clean and dry bag should be used for each sample. Do not reuse.

6.1.6 *Squirt Bottle and Soft Toothbrush*—Bottle with gooseneck (or similar) filled with distilled or deionized water and soft toothbrush (or similar) for cleaning ORP electrode after each measurement. Cleaning procedures should be in accordance with the probe manufacturer's written instructions and should in no way damage the probe or otherwise compromise the ORP measurement.

7. Sampling

7.1 Generally, collected soil samples to be tested in the laboratory shall be placed in an appropriate sealable container or polyethylene type bag. This allows containers to be identified by location, date/time sample was collected, etc.

7.2 Soil samples shall be representative of the area of interest. Where the stratum of interest contains a variety of soil types, it is desirable to sample each type separately. Soil samples to be tested in the laboratory shall be allowed to reach room temperature, approximately 68°F (20°C), prior to the ORP measurement. Field measurements shall reflect the soil's temperature during testing.

8. Calibration and Standardization

8.1 Turn on the ORP meter in accordance with the meter manufacturer's written instructions. Allow sufficient warm-up/stabilization time as specified by the manufacturer.

8.2 Check the meter "zero" by shorting the input connection in accordance with the manufacturer's instructions. For a BNC