Washington State Department of Transportation

WSDOT Test Method T 417

Method of Test for Determining Minimum Resistivity and pH of Soil and Water

1. Scope

a. This method covers the procedure for determining the minimum resistivity and pH of soil or water samples at metal culvert locations. These values are used to assist in determining the type of metal culvert materials and protective coating that are permissible at each location.

b. This test method is divided into the following parts:

(1) Method of field resistivity survey and sampling for laboratory tests.

(2) Method of determining pH of water.

(3) Method of determining pH of soil.

(4) Laboratory method of determining minimum resistivity.

2. Method of Field Resistivity Survey and Sampling for Laboratory Tests

a. Scope

The field resistivity test is an indication of the soluble salts in the soil or water; it is used primarily as a guide for selecting samples that will be tested in the laboratory. The natural soil in each channel or culvert location and the structural backfill material are tested by a portable earth resistivity meter, and samples are selected on the basis of these tests. These samples are tested in the laboratory using a soil box to determine the minimum resistivity that will be used in the culvert-type determination.

b. Apparatus and Materials

(1) Portable earth resistivity meter, suitable for rapid in-place determination of soil resistivity.

(2) Field probe(s).

(3) Steel starting rod, for making hole (in hard ground) for inserting probe(s).

(4) Sledge hammer 4 lbs (1.8 kg).

(5) Distilled, deionized, or other clean water that has a resistivity greater than 20,000 ohm-cm.

c. Recording Data

Record test data in a field record book for use in selecting samples and also for use in analyzing laboratory test data.

d. Test Procedures

(1) In the channel of a proposed culvert site, insert the field probe into the soil between 6 in (152.4 mm) and 12 in (304.8 mm) and measure the resistivity. Follow the manufacturer's instructions for use of the meter. Remove the field probe and pour about 2 oz (59 ml) of distilled water into the hole.

(2) Reinsert the probe while twisting to mix the water and soil, then measure the resistivity.

(3) Withdraw the probe and add an additional 2 oz (59 ml) of distilled water.

(4) Reinsert the probe and again measure the resistivity of the soil.

(5) Multiply the lowest probe reading by ten to determine the minimum field soil resistivity and record this result. Note the multiplication factor of **ten** for soil resistivity readings when using the field probe.

(6) In addition to the single probe method described above another method is available for determination of soil resistivity in the field. Refer to the manufacturer's instructions as well as ASTM G 57 if the 4 probe "Wenner" method is being employed to determine the soil resistivity in the field.

e. Selection of Soil Samples for Laboratory Tests

(1) Make sufficient resistivity determinations at various locations in the channel or culvert site area to adequately represent the entire area. Should the soil appear consistent at a test site, take two resistivity determinations to verify. Additional readings should be taken if different soils are present.

(2) If the resistivity is reasonably uniform within the limits of the project, soil samples from three different locations will be sufficient. If, however, some locations show resistivities that differ significantly from the average of the determinations for the area being surveyed, additional soil samples should be taken to represent these locations — particularly those with resistivities significantly below the average.

For example, if the soil resistivities throughout the surveyed area are all at or near an average value of 20 ohm meter, three samples will be enough. If any of the locations tested have resistivities markedly below this average, for example 8 ohm meter, then such "hot spots" should definitely be represented by additional samples. Scattered locations of higher resistivity, for example 30 ohm meter or more, do not require additional samples.

Judgment must be exercised both in the field testing and sampling, and in evaluating the laboratory tests. In all cases, take a minimum of three samples per project.

Samples should be about 10 lb (4.5 kg) each and should be identified as to material type and location.

3. Method of Determining pH of Water

a. Scope

This method is suitable for use in the field or laboratory for determining the pH of water samples.

b. Apparatus and Materials

(1) 5 oz. (148 ml) or larger nonmetallic wide-mouth container, e.g., glass jar, beaker, or wax coated paper cup.

(2) pH meter.

(3) pH standard solution of pH 7.

c. Recording Data

Record test data in a field record book and report the results to the Project Engineer and in the Regional Soils Report.

d. Method of Sampling

(1) To avoid contamination from container, dip the wide-mouth container into the water to be tested, swirl to rinse and pour out contents.

(2) Dip the container into the water again to obtain a sample.

(3) Pour off any film which is on the surface of the sample before testing.

e. Standardization of pH Meter

Follow the instructions provided with the pH meter.

f. Use of pH Meter to Determine pH of Water

Follow the instructions provided with the pH meter.

g. Precautions

Follow the manufacturer's instructions for use of the meter and observe the usual precautions for making chemical tests.

Note: Field pH readings may be taken at any period other than flood flow. For water which has a pH of less than 6, take a 1 L (minimum) sample for laboratory analysis.

4. Laboratory Method of Determining pH OF SOIL

a. Scope

This method covers the laboratory procedure for determining pH of soil samples selected as indicated in Section 2.

b. Apparatus and Materials

(1) pH meter suitable for laboratory testing.

(2) Suitable containers constructed of glass or wax coated paper, with moisture proof covers.

(3) pH buffer solutions of pH 4.0, 7.0 & 10.0 (or those recommended by the pH meter manufacturer for meter standardization.)

(4) Distilled water and wash bottle.

(5) Thermometer (if required) readable to 0.2°F (0.1°C).

(6) U.S. No. 8 (2.36 mm) sieve.

(7) Balance, with sufficient capacity and readable to 0.1% of the sample mass, or better, conforming to the requirements of AASHTO M 231.

(8) Oven capable of maintaining a temperature of 140°F (60°C) around sample.

(9) Glass stirring rod.

c. Initial Preparation of Test Samples

(1) As received samples are to be tested for pH in a "moist" condition. If the soil as received is too wet to facilitate proper screening and reduction to test size it shall be air dried or dried to a "moist" condition in an oven at a temperature not to exceed 140°F (60°C).

(2) Split or quarter a sufficient amount of the moist sample to yield approximately 100g of material after the material has been pulverized or mulled, taking care not to crush rock particles or naturally occurring grains, and screened over a U.S. No. 8 (2.36 mm) sieve. Discard any material retained on the U.S. No. 8 sieve. Only natural material passing the U.S. No. 8 sieve is to be used for the test.

d. Procedure for pH Determination

(1) Place a 30.0 ± 0.1 gram sample of prepared soil into the test container.

(2) Add 30.0 ± 0.1 grams of distilled water to the soil sample. Stir the sample to obtain a slurry and cover.

(3) Allow the sample to stand for a minimum of 1 hour, stirring every 10 to 15 minutes.

(4) Standardize the pH meter in accordance with the manufacturer's instructions.

(5) Stir the sample with a glass rod immediately prior to placing the pH meter electrode into the sample. Place the electrode in the sample taking precaution to ensure good contact between the electrode and the soil slurry. DO NOT place the electrode into any soil that may have accumulated in the bottom of the container, only into the soil slurry.

(6) Allow the electrode to remain immersed in the soil slurry for a sufficient time for the meter to stabilize. Refer to the manufacturer's instructions for recommended pH determination procedure and stabilization time.

(7) Read and record the pH of the sample to the nearest tenth of a whole number. If the meter reads to the hundredth place it shall be rounded to the nearest tenth place.

(8) Clean pH meter electrode and store in accordance with the manufacturer's instructions.

e. Precautions

(1) Follow all manufacturer's recommendations regarding proper use of the pH meter.

f. Report

(1) Report the pH value to the nearest tenth of a whole number.

5. Laboratory Method of Determining Minimum Soil Resistivity

a. Scope

This method covers the procedure for determining the minimum resistivity of soil samples selected as indicated in Section 2.

b. Apparatus and Materials

(1) Resistivity meter suitable for laboratory testing.

(2) Soil box calibrated for use with resistivity meter.

(3) U.S. No. 8 (2.36 mm) sieve.

(4) Non-absorbent pans, bowls or other containers of sufficient size to eliminate spilling during mixing, moisture conditioning, and sample handling.

(5) Oven capable of maintaining a temperature of 140°F (60°C) around sample.

(6) Balance, with sufficient capacity and readable to 0.1% of the sample mass, or better, and conform to the requirements of AASHTO M 231.

(7) Distilled or deionized water.

(8) Spoon or spatula.

(9) Graduated cylinder or other suitable device of sufficient size to accurately add quantities of moisture to sample.

(10) Straightedge

c. Preparation of Soil Samples

(1) Dry the sample as received from the field to a constant mass at a temperature not to exceed 140°F (60°C). (Air drying is also acceptable.) Split or quarter a sufficient amount of the dried material to yield a suitable sample after the material has been pulverized or mulled, taking care not to crush rock particles or naturally occurring grains, and screened over a U.S. No. 8 (2.36 mm) sieve. Discard any material retained on the U.S. No. 8 sieve. Only natural material passing the U.S. No. 8 sieve is to be used for the test.

d. Measuring the Resistivity of Soil Sample

(1) Split or quarter an amount of prepared soil that will fill approximately 4 times the volume of the soil box being utilized to determine resistivity.

(2) Add approximately 10% by weight of distilled water to the sample and mix thoroughly. Allow the sample to stand in a moisture proof container for a minimum of 12 hours.

(3) Re-mix the sample and immediately compact it (moderate compaction with the fingers is sufficient) slightly over the top of the soil box that has been cleaned with distilled water prior to use. Strike the material level to the top of the soil box with a straightedge.

(4) Measure the resistivity of the soil in accordance with the instructions furnished with the meter *and record the value.*

(5) Remove the soil from the soil box and recombine it with the remainder of the original sample then add an additional 5% by *original dry soil* weight of distilled water and thoroughly mix.

(6) Rinse the soil box with distilled water then immediately place the soil in the soil box and compact as described in step 3.

(7) Measure the resistivity of the soil in accordance with the instructions furnished with the meter and record the value.

(8) Repeat steps 5 through 7 until a minimum value can be determined.

(9) Record the lowest value measured during the repeated measurements in the soil box. The multiplication factor for the soil box is one, *(do not assume this as this value should be verified or reconciled with the manufacturer's recommendations provided with the soil box)* so a direct reading of the meter is the value used.

(10) Report the minimum resistivity of the soil in ohms-cm.

6. Laboratory Method of Determining Water Resistivity

a. Measuring the Resistivity of a Water Sample

(l) Thoroughly clean the soil box of all soil particles and rinse the soil box a minimum of three times with distilled water.

(2) Fill the soil box with distilled water and measure its resistivity.

(3) If the distilled water in the soil box measures infinite resistivity, empty the soil box of distilled water, fill with the test water, measure its resistivity, and record the measured value.

(4) If the distilled water in the soil box measures less than infinite resistivity, continue to rinse with distilled water until the box is absolutely clean. This condition is indicated by an infinite resistivity measurement when the box is filled with distilled water.

b. Recording Data

Record data in a field record book and report the results to the Project Engineer and in the Regional Soils Report.

7. Minimum Requirements

a. Metal pipe may be used at locations where the pH and soil resistivity are within the limits specified in the *Hydraulics Manual* M 23-01 for Aluminum (Aluminum Coated) Steel Pipe, Aluminum Pipe, and Galvanized (Zinc Coated) Steel Pipe.

Performance Exam Checklist

Method T 417 Checklist
Determining Minimum Resistivity and pH of Soil and Water

Participant Name _____ Exam Date _____

Procedure Element	**Yes**	**No**
Determining pH of H_2O.		
1. pH meter standardized in accordance with manufacturer's instructions?	☐	☐
2. H_2O sample placed in suitable non-metallic container for testing?	☐	☐
3. pH of H_2O determined in accordance with pH meter manufacturer's instructions?	☐	☐
4. pH recorded and reported to the nearest one tenth of a whole number?	☐	☐
Determining pH of soil.		
1. Sample dried (if required) to a moist condition at a temperature not to exceed 140°F (60°C)?	☐	☐
2. Sample cooled, pulverized or mulled, and screened over a U.S. #8 sieve?	☐	☐
3. Only natural material passing U.S. #8 sieve used for test?	☐	☐
4. Approximately 100 grams of passing #8 material selected for testing?	☐	☐
5. 30 ± 0.1 grams of soil and 30 ± 0.1 grams of distilled H_2O added to suitable non-metallic testing container?	☐	☐
6. Sample immediately stirred to produce slurry and covered?	☐	☐
7. Sample allowed to stand for 1 hour, stirring every 10 to 15 minutes?	☐	☐
8. pH meter standardized in accordance with manufacturer's instructions?	☐	☐
9. Soil stirred immediately prior to pH determination?	☐	☐
10. pH of soil slurry correctly determined?	☐	☐
11. pH of soil read, rounded (if necessary) and reported to the nearest one tenth of a whole number?	☐	☐

Determining minimum resistivity of soil.	**Yes**	**No**
1. As received sample dried to a constant mass at a temperature not to exceed 140°F (60°C)?	☐	☐
2. Sample cooled, pulverized or mulled, and screened over a U.S. #8 sieve?	☐	☐
3. Only natural material passing U.S. #8 sieve used for test?	☐	☐
4. Approximately 4 times the volume of the soil box of material passing the U.S. #8 sieve split or quartered for testing?	☐	☐
5. 10% by weight of distilled H_2O added to sample?	☐	☐
6. Sample mixed, covered and allowed to stand for a minimum of 12 hours in a moisture proof container?	☐	☐
7. Sample re-mixed, moderately compacted in soil box and resitivity determined?	☐	☐
8. Resistivity value recorded?	☐	☐
9. Sample from soil box removed, placed with remainder of sample and additional 5% by original dry soil weight of distilled H_2O added?	☐	☐
10. Sample remixed and resistivity determined and recorded?	☐	☐
11. Steps 8 and 9 repeated until minimum resistivity can be determined?	☐	☐
12. Minimum resistivity of soil reported in ohms/cm?	☐	☐

Determination of H_2O resistivity.		
1. Soil box thoroughly cleaned and rinsed at least three times with distilled H_2O?	☐	☐
2. Soil box filled level full with distilled H_2O and resistivity determined?	☐	☐
3. Resistivity from step #2 measures as infinite?	☐	☐
4. If yes, soil box emptied and resistivity of test sample determined and recorded?	☐	☐
5. If no, soil box further cleaned until condition described in step 3 satisfied?	☐	☐
6. Resistivity of H_2O sample reported in ohms/cm?	☐	☐

First Attempt: Pass Fail Second Attempt: Pass Fail

Signature of Examiner

Comments: