

Method of Test for
RESISTIVITY VALUES OF SOILS AND WATER
DOTD Designation: TR 429

I. Scope

- A. Water: This method describes the laboratory determination of electrical resistivity of water.
- B. Soil: This method covers the laboratory procedure for determining the minimum resistivity of soil samples. The values obtained from this method are relatable to the corrosion potential that a soil may exhibit.
- C. Reference Documents
 - 1. DOTD TR 411- Dry Preparation of Disturbed Samples for Test
 - 2. AASHTO T 288- Determining Minimum Laboratory Soil Resistivity

II. Apparatus

- A. Resistivity Meter- An alternating (AC) meter or a 12-V direct current (DC) meter utilizing a Wien Bridge (AC bridge) with a phase sensitive detector and a square wave inverter that produces a nominal alternating signal at 97Hz.

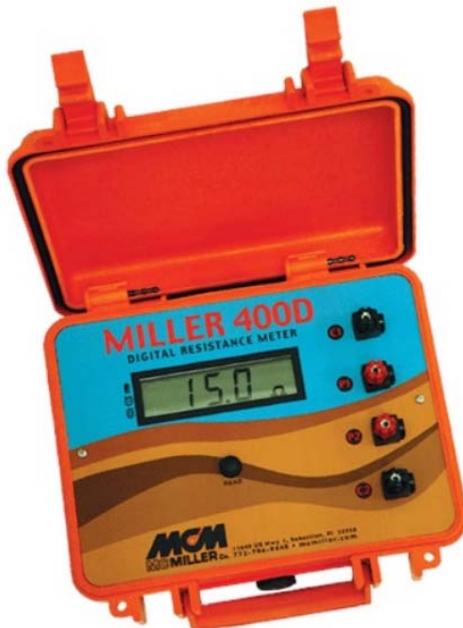


Figure 1

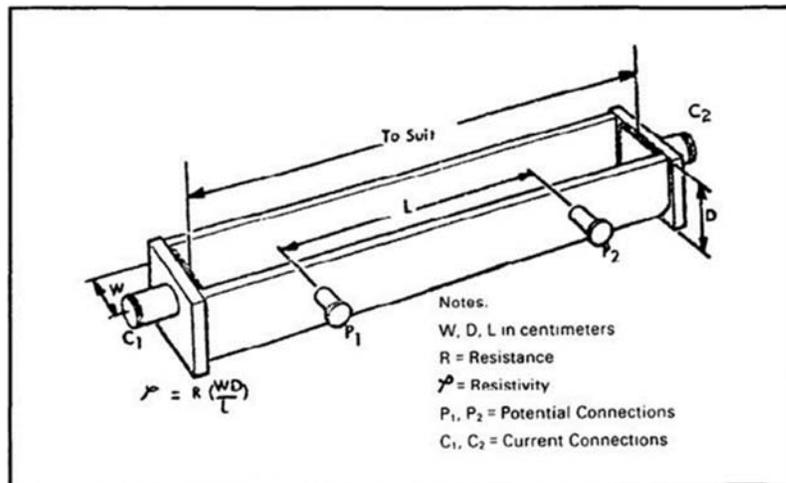


Figure 2

B. Soil Box- 4-Electrode Soil Box (Figure3&4), 2-Electrode Soil Box (Figures 5&6)



Figure 3



To Suit= 22.2cm

D= 7.6cm

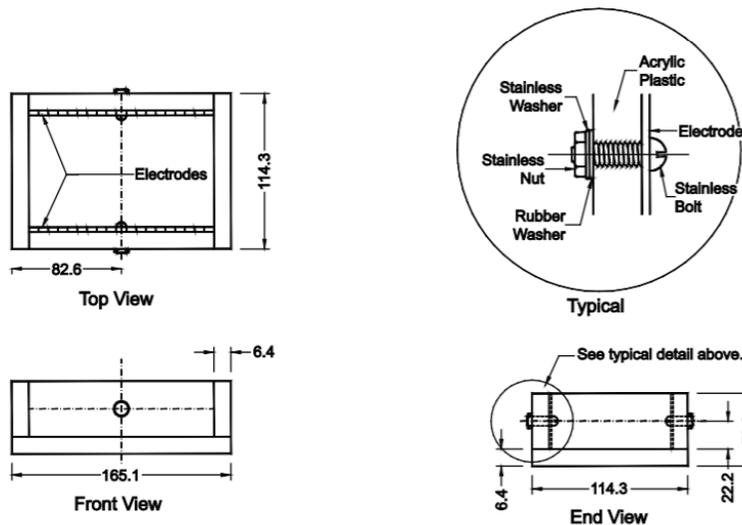
w= 1.40cm

L= 12.5cm

Figure 4



Figure 5



Materials

- Bottom: 1 pc. 165.1 mm × 114.3 mm × 6.4 mm
- Ends: 2 pcs. 114.3 mm × 44.45 mm × 6.4 mm
- Sides: 2 pcs. 152.4 mm × 44.45 mm × 6.4 mm
- Electrodes: 2 pcs. 0.9-mm stainless steel 152.4 mm × 44.45 mm
- 2 Each: M 4 × 0.5 × 19.0 mm (or longer) round head stainless steel machine bolt with rubber washer and stainless steel washer and nut

Figure 6

- C. Balance- Having a 2000g minimum capacity and sensitive to 1 gram or better.
- D. Drying Apparatus- Any suitable device capable of drying samples at a temperature not exceeding 60°C (140°F).
- E. Sieve- 2.00mm (No. 10)
- F. Resistors- 200-ohm, 1000-ohm, and 2000-ohm with a 5% tolerance
- G. Mixing Pan and Materials- Noncorrosive, e.g. stainless steel, plastic

- H. Graduated Cylinder- 100 mL capacity
- I. Straightedge
- J. Distilled Water that has a resistivity greater than 20,000 ohm-cm.
- K. Moisture Room- Capable of maintaining a temperature of $73\pm 3^{\circ}\text{F}$ at a minimum 95% relative humidity.
- L. Thermometer

III. Calibration of Meter

- A. Calibrate resistivity meter following the manufacturer's instructions.
- B. Calibrate the meter at least monthly and anytime an instrument malfunction is suspected.
- C. Connect the leads of the resistivity meter to the 200-ohm resistor and read the meter. Repeat this process with the 1000-ohm and 2000-ohm resistors.
Note: Use the leads that will be used during testing for calibration.
- D. If the readings are within 10 percent of the resistance of the resistor, the meter is functioning satisfactorily.
- E. If the reading is outside the 10 % range check one or all of the following:
 - a. Check the leads for poor connections and/or breaks.
 - b. Check the battery and replace if defective.
 - c. Check the resistor with another ohmmeter and replace if defective.

IV. Sample

- A. Water samples shall be of at least one quart in size, and stored in a watertight plastic container.
- B. Soil samples shall consist of at least 1300 grams of soil passing the No. 10 sieve prepared in accordance with DOTD designation: TR 411, Method A.

V. Procedure

- A. Thoroughly clean the box of all soil particles or other contaminants.
 - 1. Wash with tap water, rubbing lightly taking precautions not to scratch or damage the stainless steel electrodes.
 - 2. Rinse three times with distilled water.
 - 3. Fill the box to its capacity.
 - 4. Connect the leads to the terminals of the soil box.
 - a. 4-Electrode Soil Box: C1 and C2 are black, P1 and P2 are red. The lead colors should match the meter connections. The leads should be connected in accordance with Figure 7.
 - b. 2-Electrode Soil Box: C1 and C2 should be used. The red lead goes in one and the black one in the other. Each lead connects to opposite sides of the soil box.
 - 5. Take resistivity reading
 - a. 4-Electrode (M.C. Miller 400D): After the leads are connected to the soil box in accordance with Figure 7, press the Read button. The number in the display screen should be the number recorded.
 - b. 2-Electrode (Tinker & Rasor SR-2)
 - 1. After the leads are connected to the soil box be sure that the turn knob is lined up with Start Here.

2. Hold down the “PUSH TEST” button.
 3. If the reading is 1 release the button.
 4. Turn the knob to the first line, x1, and hold down the “PUSH TEST” button.
 5. Repeat steps 2-4 increasing the knob until a reading besides 1 appears in the screen.
- c. If the meter reads 20,000 ohm-cm or greater, then the box is clean.
 - d. If the distilled water in the box does not read 20,000 ohm-cm or greater, continue to rinse the box with distilled water until it is thoroughly clean.
 - e. If unable to obtain a resistance of 20,000 ohm-cm or greater reading, the purity of the distilled water should be checked by submitting a sample to the Material’s Laboratory for testing.
- B. Resistivity of Water
1. Agitate the water sample vigorously.
 2. Pour the water sample into the clean box to its full capacity.
 3. Connect the leads to the terminal box.
 - a. 4-Electrode Soil Box: C1 and C2 are black, P1 and P2 are red. The lead colors should match the meter connections. The leads should be connected in accordance with Figure 7.
 - b. 2-Electrode Soil Box: C1 and C2 should be used. The red lead goes in one and the black one in the other. Each lead connects to opposite sides of the soil box.
 4. Take resistivity reading
 - a. 4-Electrode (M.C. Miller 400D): After the leads are connected to the soil box in accordance with Figure 7, press the Read button. The number in the display screen should be the number recorded.
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 1. After the leads are connected to the soil box be sure that the turn knob is lined up with Start Here.
 2. Hold down the “PUSH TEST” button.
 3. If the reading is 1 release the button.
 4. Turn the knob to the first line, x1, and hold down the “PUSH TEST” button.
 5. Repeat steps 2-4 increasing the knob until a reading besides 1 appears in the screen.
 5. Record the reading in ohm-cm on the worksheet.
 - a. 4-Electrode (M.C. Miller 400D): The reading shown on the resistivity meter screen is ohm-cm because the multiplying factor of the box used is 1cm.
*Note: If the reading units reads $K\Omega = \text{reading} \times 1000$,
 $M\Omega = \text{reading} \times 1000000$.*
 - b. 2-Electrode (Tinker & Rasor SR-2): The resistivity should be determined using this formula:

Resistivity= Display Reading x knob position multiplier x multiplying constant

$$\text{Multiplying Constant} = \frac{\text{surface area of one electrode (cm}^2\text{)}}{\text{measured average distance between electrodes (cm)}}$$

Note: If using the 2-Electrode method measure the soil box and determine the multiplying constant.

Typical Soil Box Multiplying Constant:

$$\frac{15.24\text{cm} \times 4.445\text{cm}}{10.16\text{cm}} = 6.67\text{cm}$$

C. Resistivity of Soil Samples

1. Add 150 mL of distilled water to the prepared soil. Mix the sample thoroughly and place in a moist room for a minimum of 12 hours.
2. Thoroughly mix and place the sample in the soil box in layers and compact until slightly overfilled (moderate compaction with the fingers is sufficient). Trim off the excess material with the straightedge. Cover the sample on the container.
3. Connect the leads to the terminal box.
 - a. 4-Electrode Soil Box (M.C. Miller 400D): C1 and C2 are black and P1 and P2 are red. The leads should be connected in accordance with Figure 7.
 - b. 2-Electrode Soil Box (Tinker & Rasor SR-2): C1 and C2 shall be used. The red lead goes in one and the black one in the other. One lead connects to one side of the box and one to the other side.
4. Take resistivity reading.
 - a. 4-Electrode (M.C. Miller 400D): After the leads are connected to the soil box in accordance with Figure 7, press the Read button. The number in the display screen shall be the number recorded.
 - b. 2-Electrode (Tinker & Rasor SR-2)
 1. After the leads are connected to the soil box be sure that the turn knob is lined up with Start Here.
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 5. Repeat steps 2-4 increasing the knob until a reading besides 1 appears in the screen.
5. Record the reading in ohm-cm on the worksheet.
 - a. 4-Electrode (M.C. Miller 400D): The reading shown on the resistivity meter screen is ohm-cm because the multiplying factor of the box used is 1cm.
 - b. 2-Electrode (Tinker & Rasor SR-2): The resistivity should be determined using this formula:

Soil Resistivity= Display Reading x knob position multiplier x multiplying constant

Note: If using the 2-Electrode method measure the soil box and determine the multiplying constant.

Typical Soil Box Multiplying Constant:
$$\frac{15.24\text{cm} \times 4.445\text{cm}}{10.16\text{cm}} = 6.67\text{cm}$$

- c. Remove and retain the soil in the box.
- d. Thoroughly clean the soil box, with 3 rinses with distilled water before next reading.
- e. Add 100 mL of distilled water to the soil sample and mix thoroughly.
Note: The temperature of the water added should be $73 \pm 3^{\circ}\text{F}$ ($23 \pm 1.7^{\circ}\text{C}$).
- f. Repeat the process of placing, compacting the soil in the box, then measure the resistance.
- g. The minimum value is reached when 2 consecutive resistivity readings fail to decrease.

VI. Report

- A. Report the minimum resistivity should be reported in units of ohm-cm.

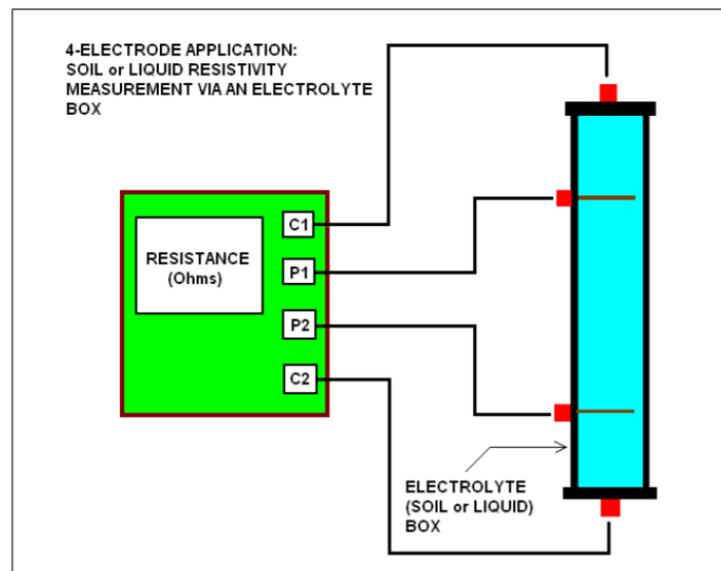


Figure 7

Rev. 02/21

Resistivity Values of Soil and Water (DOTD TR 429)

Project #: H.999999 Station #: 99+99
 Sample ID: d22b999999999999 Location: 99' Lt. E
 Sample #: 9 Depth: 0-9

Dry Mass of Sample (g): 1300 Water Temperature: 23°C

Water Added For Slaking= 150 mL (Initial)

H ₂ O Added (mL)	Meter Rdg. (ohm-cm)
Initial	49400
100	14700
200	10500
300	11200
400	11500
500	
600	
700	
800	
900	
1000	
1100	
1200	
1300	
1400	

Minimum Resistivity: 10500 ohm-cm
 Tested By: AA Date: 2/10/21
 Checked By: FBS Date: 2/12/21

Remarks: _____