



STANDARD OPERATING PROCEDURES

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SOIL CONDUCTIVITY DETERMINATION

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1.0 SCOPE AND APPLICATION

This standard operating procedure (SOP) describes the measurement of electrical conductivity (EC) of a saturated soil extract using a Cole-Parmer Model Number 19220-00 digital conductivity meter.

2.0 METHOD SUMMARY

The EC of the soil extract is read directly from a digital display of a temperature compensating conductivity meter. The electromotive force (EMF) produced in the platinum/epoxy electrode system varies linearly with the EC. This linear relationship may be observed by plotting the measured EMF against the EC of various concentrations of standards.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

The amount to be collected and the proper sample container type (i.e., glass, plastic) and storage requirements are discussed in SERAS SOP #2003, *Sample Storage, Preservation and Handling*. Sample extracts and calibration standards should be allowed to equilibrate to ambient temperature prior to analysis. Analyses on the sample extracts are typically performed at 20 to 25 degrees Centigrade (°C) as soon as possible.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

The platinum/epoxy combination electrode is relatively free from interference from color, turbidity, colloidal matter, oxidants and reductants. To prevent the precipitation of calcium carbonate upon standing, sodium hexametaphosphate (NaPO_3)₆ is added to the soil extract. The amount of (NaPO_3)₆ solution added increases the sodium concentration to approximately 0.5 parts per million (ppm), which is inconsequential to the possible loss of CaCO_3 by precipitation.

Soil samples should not be oven-dried because heating to 105°C converts at least a part of the gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) to plaster of Paris ($\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$). The latter hydrate has a higher solubility in water than does the former.

Special precautions should be taken when preparing a saturated soil paste with peat or muck soils, or very fine or very coarse-textured soils. If possible, organic soils should not be allowed to dry following collection because of changes in the saturation water content.

Coarse or woody organic soils require an overnight water absorption period to obtain a definite saturation endpoint. After the first wetting, pastes of these soils usually stiffen upon standing. Adding water and remixing gives a mixture that usually retains the characteristics of a saturated paste.

With fine-textured soils, enough water should be added immediately, with a minimum of mixing, to bring the sample nearly to saturation. This minimizes the formation of clumps of soil during stirring, speeds the mixing process, and helps to attain a more definite endpoint.

The EC of the solution varies with temperature. The automatic temperature compensation (ATC) of the conductivity meter adjusts measurements to factor out changes in readings caused by temperature. Readings are usually referenced to or normalized at a standard temperature (20 to 25°C). Using an ATC,



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the conductivity meter displays a reading that is the equivalent of the conductivity of a solution normalized at a specific temperature. This feature allows EC measurements from various temperatures to be compared.

5.0 EQUIPMENT/APPARATUS

The following are standard materials and equipment required for soil conductivity determinations:

- Conductivity meter, Cole-Parmer Model No. 19820-00
- Epoxy platinum electrode with automatic temperature compensator
- Plastic jar with lid, 500-milliliter (mL)
- Stainless steel spatula
- Balance, capable of weighing up to 1 kilogram (kg)
- Buchner funnel
- Vacuum line and suction flask
- Filter paper, Whatman No. 2 or equivalent

6.0 REAGENTS

- Sodium Hexametaphosphate (NaPO_3)₆ Solution, 0.1% - Dissolve 0.1 grams (g) of (NaPO_3)₆ in deionized water and dilute to 100 mL.
- Standard Potassium Chloride (KCl) Solution, 0.100 N - Dissolve 7.456 g of KCl in deionized water and dilute to 1 L. Theoretical conductivity = 12.900 milliSiemens/centimeter (mS/cm) at 25°C.
- Standard KCl Solution, 0.010 Normal (N) - Dissolve 0.7456 g of KCl in deionized water and dilute to 1 L. Theoretical conductivity = 1.412 mS/cm at 25°C.
- Deionized/Distilled Water, conductivity < 1.0 microSiemens/centimeter ($\mu\text{S/cm}$)

7.0 PROCEDURES

7.1 Soil Saturation Extract

- 1 Weigh 200 to 400 g of air-dried soil into a 500-mL plastic container having a snap-tight lid. Weigh the container and the contents.
- 2 Add deionized or distilled water to the soil while stirring until it is nearly saturated. Allow the mixture to stand uncovered for several hours to permit the soil to absorb the water, and then add more water to achieve a uniformly saturated soil-water paste.

NOTE: At this point, the soil paste glistens as it reflects light, flows slightly when the container is tipped, slides freely and cleanly off a spatula, and consolidates easily by tapping or jarring the container after a trench is formed in the paste with the side of the spatula.

- 3 Mix and allow the sample to stand for a minimum of four hours (preferably overnight). Check, to be sure, that free water does not collect on the soil surface, and that the paste



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does not stiffen or lose its glisten. If the paste is still too wet, add additional air-dried soil to the paste mixture. Allow the mixture to stand for at least four more hours.

4. Upon attainment of saturation, reweigh the container and contents. Record the increase in weight to determine the amount of water added (1 g of water is equal to [=] one mL).
5. Transfer to a Buchner funnel fitted with highly retentive filter paper.
6. Apply vacuum and collect the filtrate in a test tube or bottle. If the initial filtrate is turbid, refilter or discard it. Terminate filtration when the air begins to pass through the filter.
7. Add one drop of 0.1% $(\text{NaPO}_3)_6$ solution for each 25 mL of filtered extract recovered.
8. In general, from one-fourth to one-third of the water in the saturated soil paste can be removed by vacuum filtration.

7.2 Zero Adjustment

Zero adjustment is only required when the meter does not display “zero” when the probe is dry and in the air (not in solution). Refer to the manufacturer’s operating instructions for zero adjustment, if necessary.

7.3 Conductivity Meter Calibration

There are two calibration ranges available for measurement of conductivity with the epoxy platinum probe and three using a glass/platinum electrode (Table 1, Appendix A). A single point calibration can be performed in each of the calibration ranges depending on the anticipated EC of the soil extracts.

1. Turn on the meter and press MODE to select the conductivity mode. The COND indicator will be visible in the lower left hand corner of the display.
2. Select a calibration standard near the sample value to be measured and within the conductivity range prior to measuring the conductivity of any soil extracts.
3. Pour a small volume of the calibration standard into a clean container. The tip of the conductivity probe must be immersed in the standard solution approximately ½ inch.
4. Rinse the probe with distilled or deionized water, and then with a small amount of calibration standard.
5. Immerse the probe into the calibration standard and press CAL (calibrate). The CAL indicator will flash in the upper right hand corner of the display.
6. Use the MI/□ or MR/□ to scroll the display to the correct value of the calibration standard. Be sure to use the value for the normalization temperature for which the meter is set, typically 25°C. Under the default condition, all readings are normalized to 25°C.



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The normalized temperature may be changed to 20°C, if needed.

7. Press ENTER to store the calibration. Return to the MEAS (measure) mode to confirm the value. Document the reading and the temperature in a laboratory logbook.
8. Rinse the probe with distilled or deionized water and repeat the above steps to calibrate the other ranges, if necessary.

7.4 Sample Extract Conductivity Measurement

1. Rinse the probe with distilled or deionized water before use to remove any impurities adhering to the probe. Shake the probe or air dry prior to any measurement.
2. Insert the probe and temperature sensor (ATC) into the sample extract, making sure that the tip of the probe is completely immersed. To ensure that there are no air bubbles trapped in the slot of the probe, shake the probe gently while the electrode tip is immersed.
3. Stir the probe gently in the sample extract to create a homogeneous sample and to dislodge any air bubbles in the probe.
4. Allow a few seconds for the temperature reading to reach the solution temperature and record the reading. When the meter is set for READY mode operation, the READY annunciator appears in the top left corner of the display when the reading has stabilized. The READY mode is the default mode of operation.

7.5 Conductivity Probe Care and Maintenance

1. The conductivity probe must be kept clean to obtain accurate measurements. Rinse the probe with distilled or deionized water prior to storage.
2. Never scratch the platinum portions of the probe with a hard substance. Do not strike the probe against any hard surface.
3. Avoid immersing the probe in oily solutions.
4. Clean the probe by stirring it in a mild detergent bath, thoroughly rinsing first with tap water, and finally with distilled or deionized water. Wipe the probe with soft tissue paper or air dry.

8.0 CALCULATIONS

The value displayed is read directly as EC in mS/cm. The temperature of the calibration standards and samples should be identical to ensure accuracy.

Precision as relative percent difference (RPD) is calculated using the following equation:



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$$\% \text{RPD} = \frac{|\text{SR} - \text{SDR}|}{\frac{\text{SR} + \text{SDR}}{2}}$$

where:

SR = sample result

SDR = sample duplicate result

The relationship between EC and salt concentration, or EC and osmotic pressure may be approximated as follows:

- Total cation (or anion) concentration, milliequivalents/liter (meq/L) $10 \times \text{EC}$ in mS/cm
- Salt concentration, mg/L $640 \times \text{EC}$ in mS/cm
- Osmotic pressure, bars at 25°C $0.39 \times \text{EC}$ in mS/cm

9.0 QUALITY ASSURANCE/QUALITY CONTROL

The following general quality assurance/quality control (QA/QC) procedures apply:

1. All data must be documented on field data sheets or in site notebooks.
2. All instrumentation must be operated in accordance with the manufacturer's instructions. Equipment check-out procedures and calibration activities must be performed.
3. Duplicate samples must be processed with the frequency of one in 20 samples and will be used to determine precision as %RPD. The %RPD must be 20%.
4. Ensure the calibration standards are within their expiration dates, if purchased, or prepared every six months.

10.0 DATA VALIDATION

An accuracy of $\pm 1.0\%$ of full scale is attainable with a properly maintained and calibrated conductivity probe. Temperature is accurate to $\pm 0.5^\circ\text{C}$.

All data will be reviewed by the SERAS Task Leader prior to release.

11.0 HEALTH AND SAFETY

General laboratory safety practices should be followed. Waste samples must be handled with care due to the uncertainty of the composition. All excess samples, used samples, and waste generated during analysis on site will be disposed of in accordance with approved waste disposal methods.

When working with potentially hazardous materials, follow United States Environmental Protection Agency (U.S. EPA), Occupational Safety and Health Administration (OSHA), and corporate health and safety procedures.



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12.0 REFERENCES

Cole-Parmer Instrument Company. *Hand-Held Conductivity Meters Operating Instructions*. Model 19820-00.

Rhoades, J.D. 1982. Soluble Salts, *Methods of Soil Analysis, Part 2, Chemical and Microbiological Properties*. American Society of Agronomy Monograph No. 9, 2nd ed.

13.0 APPENDICES

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TABLE 1. Conductivity Specifications

	Conductivity	TDS	Temperature
Ranges:	0.00 - 19.99 \square S	0.00 - 9.99 ppm	0 - 80°C
	0.0 - 199.9 \square S	10.0 - 99.9 ppm	(Epoxy platinum probe)
	0 - 1999 \square S	100 - 999 ppm	0 - 100°C
	0.00 - 19.99 mS	1.00 - 9.99 ppt	(Glass/platinum probe)
	0.0 - 199.9 mS	10.0 - 99.9 ppt	

μ S = microSiemens
mS = milliSiemens
ppm = parts per million
ppt = parts per trillion