THERMAL PROPERTIES MEASUREMENTS IN SOILS

With all sample types, it is necessary to allow the sensor needle to equilibrate with the sample and the surrounding environment. Temperature differences between the sensor, sample, and surroundings could give erroneous readings.

SENSOR RECOMMENDATIONS

For soil samples, we recommend using the TR-3 sensor to make thermal resistivity and thermal conductivity measurements. If a soil is particularly hard, a pilot hole should be pre-drilled in the sample before inserting the sensor needle. If a diffusivity measurement is desired, the SH-3 dual-needle sensor can be used. If the soil being measured is composed of large particles, then care should be taken to remove contact resistance.

SAMPLE COLLECTION

The two factors that can be changed during sample collection that affect the thermal properties of a sample are moisture content and the compaction of a sample. Care should be taken not to compact or pack a sample as it is taken. If the bulk density of a low-strength, porous sample decreases, then the heat capacity and thermal conductivity will also decrease. Likewise, the resistivity of the sample will increase. The same is true of moisture content if the sample is allowed to dry. It is for this reason that we recommend taking an intact soil core and sealing it immediately after it is taken.

Intact soil cores should be collected in a shelby tube or equivalent thin-walled tube. The minimum sample dimensions for a typical ASTM D5334 thermal resistivity test using our instrument are 4.5” (11 cm) length and 1.5” (3.8 cm) diameter. Samples with a larger diameter are preferred as heat will move radially from the center into the sample. If the heat pulse reaches the sample tubing, it could skew the measurement.

Water content in soils is highly dynamic and can change frequently in normal field conditions. To preserve the moisture content of the sample, the ends of the tube should be capped and sealed. Even if a sample will be used to create a thermal dryout curve, it is still advisable to cap the ends so loose soils do not fall out in transport.

LAB MEASUREMENTS

Though there are many measurements that can be made once a sample is retrieved. In most cases, we recommend creating a thermal dryout curve by measuring multiple points and modeling a curve. This will require the measurement of a saturated and oven dry sample.

IN-SITU MEASUREMENTS

In-situ soil measurements can be made with our thermal properties instruments, however, it should be noted that a single-point measurement is not necessarily representative of the thermal properties of the soil at all times. Moisture content, which changes frequently in most field conditions, can increase the thermal resistivity by a factor of five or more. This is especially important to consider when installing buried power cables or a geothermal heat pump.

BURIED POWER CABLES

For a variety of reasons it is now common practice to bury power cables. The thermal resistivity of the soil is a large factor in the long-term success of a buried power line. As energy flows through these buried power lines, the electric current creates heat. If the soil characteristics are not carefully considered, this can lead to a process called “thermal runaway.” In this process, heat dissipates into the surrounding soil, moving through soil particles, water, and air pockets in the soil. Heat causes the soil to dry out—making it more resistive. If the more resistive soil cannot carry heat away from the cable faster than the cable produces it, then the temperature of the cable will continue to increase. Eventually the cable will melt itself underground—with the soil acting as insulation.

FROZEN SOILS

Our thermal properties instruments are well-suited for measuring frozen soils. If the frozen sample is unsaturated and made up of loose material, then there could be contact-resistance errors created by air pockets between the needle and the material. This can be offset by using a longer read time to force the measurement deeper into the material. As with all samples, we recommend taking multiple measurements.

Another important consideration when measuring frozen samples is temperature. If the heat pulse from the sensor needle causes a phase change, the energy from the phase change will be interpreted as conductivity. For this reason, it is important that samples are either colder than -3 °C or warmer than 0 °C.

See "How to collect samples for thermal analysis".