geotech

Borehole Resistivity System

Installation and Operation Manual

Rev 3/29/12 Part # 12250066

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DOCUMENTATION CONVENTIONS

This uses the following conventions to present information:

WARNING

An exclamation point icon indicates a **WARNING** of a situation or condition that could lead to personal injury or death. You should not proceed until you read and thoroughly understand the **WARNING** message.

CAUTION

A raised hand icon indicates **CAUTION** information that relates to a situation or condition that could lead to equipment malfunction or damage. You should not proceed until you read and thoroughly understand the **CAUTION** message.

NOTE

A note icon indicates **NOTE** information. Notes provide additional or supplementary information about an activity or concept.

Section 1: System Description

Function and Theory

The Geotech Borehole Resistivity (BR) System has been designed for logging shallow vertical wells. The instrument enables the user to obtain the Spontaneous Potential (SP) curve, three “normal” and two “lateral” resistivity curves. The BR system is hand operated, with the well probe manually lowered and raised in the well. Readings are taken point by point up the well bore and recorded by the operator. These data points are then plotted on a logging form to obtain the graphical log needed for interpretation.

The well probe consists of a current electrode and three potential electrodes. The resistivity instrument, at the surface, enables the operator to read the SP in millivolts and the resistivity in ohm-feet. The reel capacity is approximately 500 feet (152 m) of cable. An additional 500 feet (152 m) of cable can be obtained to permit working to depths of 1000 feet (305 m). A test set is also provided for checking the operation of the instrument.

System Components

Well Probe

The well probe contains the brass current electrode and the potential electrodes. The potential electrodes are spaced at .25, 2.5, and 10 feet from the current electrode. Each electrode is internally insulated from the others and each is connected to the surface by a separate conductor. The current electrode is drilled so that an insulated “sinker rod” can be attached to the probe, by means of a non-conductive material, if greater weight is needed to carry the probe to the bottom of the well. The well probe is attached to the 500 foot (152 m) cable by means of waterproof connectors.

Resistivity Instrument

The resistivity instrument utilizes direct current and is of the “null” reading type. The instrument reads directly in ohm-feet. The use and operation of the various controls on the instrument panel are listed below.

Meter

It is a zero centered micro-ammeter and all operations of the instrument involve returning the meter needle to its zero position.

Probe (STD/MUD)

Probe Selector Switch, on units modified for mud logging. This switch is located in the bottom right corner. This switch allows the operator to select either the standard probe with the .25, 2.5, and 10 foot electrode spacing or the mud probe for monitoring conditions in the mud pit or bore hole.

Self-Potential Dial

Self-Potential Dial, balances out the SP which always exists between any pair of potential electrodes. This must first be done before making any resistivity reading. Balance is indicated when the meter needle goes to zero. If the SP curve is desired, merely record the dial reading. Each small division equals 1 millivolt; full scale equals 1000 millivolts.

SP Polarity Reversing Switch (-/+)

This is located directly below the Self-Potential Dial; It indicates the polarity of the particular cable electrode being used and enables the operator to change the polarity of the injected voltage as required by borehole conditions.

Function Switch

The function switch is the four position selector switch located to the right of the meter. Its four positions are OFF, CURR (current), CAL (calibrate), and LOG. The CUR position is used when checking the system to ascertain whether the proper amount of current is being used. The CAL position is used when calibrating the instrument (as required at the start of the logging operation and after every 50 feet (15 m) of logging). The LOG position is used during the logging operation. Always be sure to turn switch to the OFF position when not in use, to retain the battery life.

Current

The CURRENT push button switch is located on the bottom middle of the control panel. It turns on the electric current needed for the resistivity measurements. It has a spring return feature that prevents the current from being left on accidentally.

CAL ADJ

The calibration adjustment is located to the right of the meter. It is used to zero the meter when calibrating the instrument.

Resistivity

The resistivity dial reads earth resistivity directly in ohm-feet. When the reading is made with the electrode selector switch in the .25 feet “normal” position, each division equals 1 ohm-feet; full scale equals 1000 ohm feet. When the reading is made in the 2.5 feet “normal” position, each division equals 10 ohm feet, full scale equals 10,000 ohm feet. When the reading is made in the 10 feet “normal” position, each division equals 40 ohm feet; full scale equals 40,000 ohm feet.

Electrode Selector Switch

This five position switch is located between the SP and Resistivity dials. On the right side it makes circuit connections for either the .25 or 2.5 feet “normal” arrangement, as marked. When the switch points straight up, the connections are for the 10 feet “normal” arrangement. On the left side the connections are the .25 and 2.5 feet “lateral” arrangements, as marked. In the “lateral” arrangements the 10 feet electrode serves as the reference in both cases.

Cable Connector

The cable connector is the four-pin receptacle located directly above the meter. The connector from the cable reel jumper is plugged in here, thus connecting the instrument to the well probe.

Potential

This black plug receptacle is used for making the connection between the Control Panel and the “Potential” stake using the surface lines.

Current

This red plug receptacle is used for making the connection between the Control Panel and the “Current” stake using the surface lines.

Test Set

The test set provides a means of checking the instrument operation and condition of the batteries without using the logging cable and the well probe. To use: plug it into the cable connector; the single red plug is then plugged into “Current” receptacle and the black plug into “Potential” receptacle. Then follow the usual logging procedure. The resistivity should be approximately the value marked on the test set. You will, of course, have little or no SP. The electrode selector switch may be in any of the “normal” logging positions.

Power Supply

Three sources of power are required, having voltages of 1, 5, 9, and 45 volts. These are obtained using readily available batteries. The 1.5 volts are provided by a standard size “C” cell; the 9 and 45 volts by means of (6) standard 9 volt batteries.

Logging Cable

The cable used to lower the probe has four conductors covered with a tough and durable jacket. The cable is very resistant to abrasion and will provide flexibility at low temperatures. The high breaking strength of the cable - 320 pounds (145 kg) - is made possible by use of “Copperweld” (copper coated steel) for the individual conductors. The cable is marked at 5 foot (1.5 m) intervals with numbered markers.

Standard Cable Reel

The reel and frame are made of steel and aluminum. A slip ring is employed to make the connection between the logging cable on the rotating reel to the jumper cable on the frame.

Extender Cable Reel

This cable is used in situations when logging to depths in excess of 500 feet (152 m) may be encountered. This cable must be used first. Around the 500 foot (152 m) marker, the second waterproof connector is attached to the cable reel. This connector will be located at the hub of the extender cable reel assembly. This need only be disconnected and attached to the second 500 feet of cable in the same manner that the probe is connected at the 15 foot (1.5 m) marker. The second cable is then connected to the instrument by means of the jumper cable.

Surface Lines

Two 50 foot (15 m) lengths of insulated wire are included with the unit. The white wire terminates with a plug to the Current receptacle on the control panel, and a clamp (for fastening on to the steel stake) at the other end. The black wire terminates with a plug to the Potential receptacle on the control panel, and a clamp (for fastening on to the steel stake) at the other end. If these lines should become worn or broken they can be replaced with any 18-20 gauge (standard conductor) insulated wire. The surface lines are stored on two reels (mounted on the lid of the control panel case).

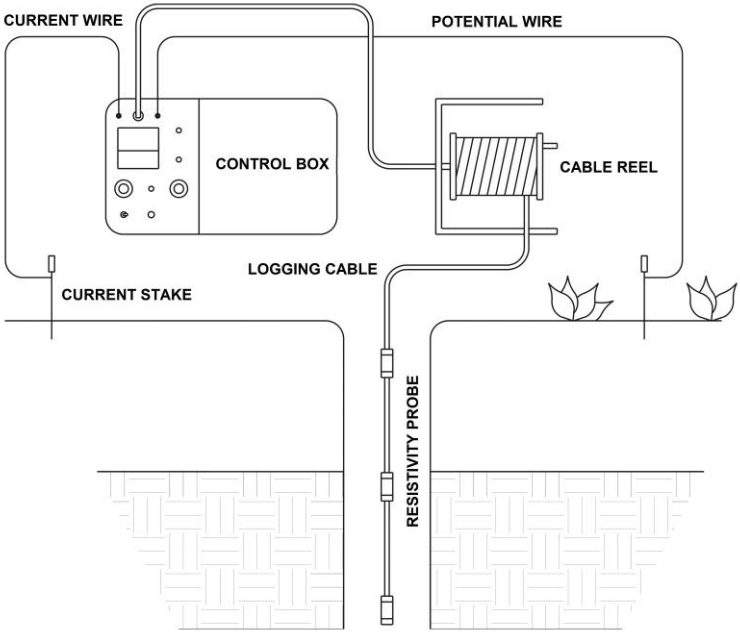
Section 2: System Installation

Installation with "Normal" Arrangement

The equipment required to log a well includes the control panel, the logging cable, the probe assembly, the surface potential wire (black), the surface current wire (white) and (2) surface stakes.

In preparing to log a well, first plant the surface stakes on opposite sides of the well, with each about 50 feet (15 m) from the well, as shown in the drawing below. The black surface wire plugs into the Potential receptacle on the control panel and then clips to the other surface stake. The red wire plugs into the Current receptacle on the control panel and then clips to the other surface stake. It may be necessary to moisten the ground around the surface stakes to provide a better current flow.

Plug the cable from the reel into the cable connector on the control panel. Then connect the probe assembly to the logging cable only if the waterproof connectors and their pins and sockets are clean. If the connectors do not mate easily after the pins are aligned, a silicone (spray or grease) should be applied to the surfaces. The connectors are mated properly when a "pop" is heard. The locking rings should then be secured. Then lower the probe to the desired depth in the well. On units equipped with a mud probe option, place probe selector switch in STD position.



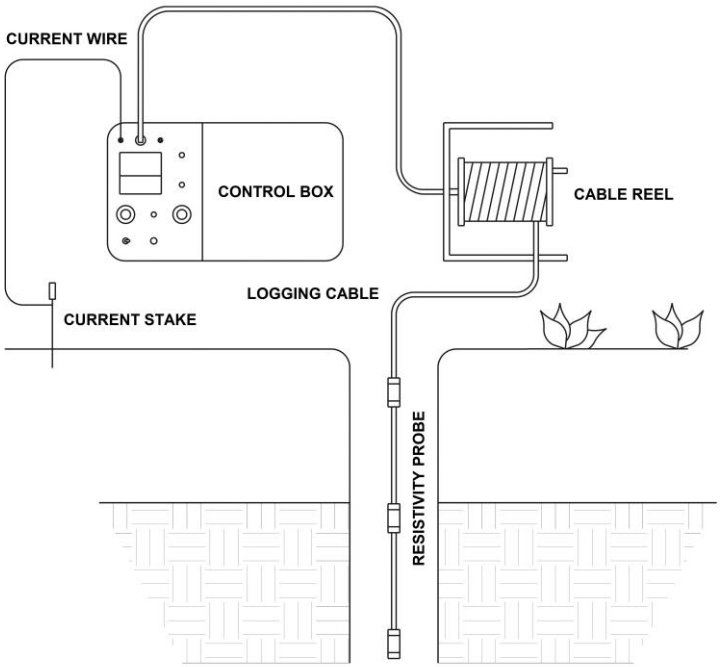
When using an extender cable for logging to depths in excess of 500 feet (152.4m), the extender cable must be used first (i.e., connected to the probe).

Installation with "Lateral" Arrangement

In areas having extremely high resistive surface materials or large and varying ground potentials, it may not be possible to make a normal log (i.e., where a large thickness of dry sand is found at the surface or in highly industrialized areas where large DC generators are in use). The lateral log will generally overcome these difficulties.

The setup is similar to the "normal" arrangement except that the POTENTIAL surface stake and black wire are not required, as shown in the figure below. Furthermore, the CURRENT circuit may be completed by attaching the red wire to the well casing or any other good ground. The electrode selector switch must be in one of the two lateral positions. The procedure for making the reading is then the same as described for the "normal" arrangement (see Installation with "Normal" Arrangement). Please note, however, that the multiplication factor for each spacing as follows:

.25 feet lateral, the factor is 1.025
2.5 feet lateral, the factor is 13.33



Section 3: System Operation

Logging with the "Normal" Arrangement

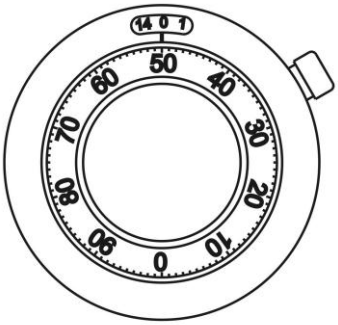
Calibrating

With the function switch in the CAL position, the electrode selector switch in one of the normal positions, and holding the current push button in, zero the meter needle by adjusting the CAL ADJ knob. This should be done at the start of each job and repeated after every 50 feet (15 m) of logging.

If unable to zero the meter it is likely that you do not have enough current flow. See the section on trouble shooting.

Logging

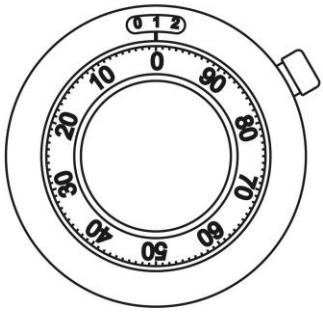
1. **Balancing out SP:** With the electrode selector switch in the .25 feet "normal" position, turn the function switch to the log position and zero the meter needle by adjusting the SELF POTENTIAL dial; this dial reading is the SP in millivolts with the polarity of the probe electrode as indicated on the reversing switch (see example below). If unable to zero the meter, reverse the polarity switch and try again. If still unable to zero, see pages 12-14.



Example:
This dial shows a reading of + 50 mV

SELFPOTENTIAL

2. **Measuring Resistivity:** Having balanced the SP, hold the CURRENT push button in and return the meter needle to zero by adjusting the RESISTIVITY dial. Now release the CURRENT switch. The reading on the RESISTIVITY dial is the resistivity, in ohm feet (each division equals 1 ohm feet), for the .25 "normal" electrode spacing (see example below).



RESISTIVITY

Example:
This dial shows a
Reading of 100 ohm - ft

3. Next, turn the electrode selector switch to the 2.5 feet position and repeat steps 1 and 2. The reading on the RESISTIVITY dial now needs to be multiplied by 10 to obtain the apparent earth resistivity for this electrode spacing.

In some cases, as for example a large borehole or exceedingly high formation resistivity, it may be an advantage to use the 10 feet "normal" position. The reading on the RESISTIVITY dial now needs to be multiplied by 40 to obtain the apparent earth resistivity for this electrode spacing.

The .25 and 2.5 feet "normal" readings are preferred logs for most wells. If an SP curve is desired it should be read with the electrode selector switch in the .25 position.

Practice in these procedures may be obtained by using the Test Set that is provided with each instrument.

In logging mud-filled or deep holes, a sinker rod should be attached to the probe so that the operator will be able to feel the bottom of the well. If you use a metal weight, all surfaces must be covered with electrical tape, and should be attached to the probe by means of a non-conductive strap.

The spacing between readings is dependant upon the amount of detail desired. For most situations, readings every 2.5 feet are adequate.

Remember that in order to obtain a log, the well probe must be below the water level in the well. When the probe is pulled out of the water, the resistivity instrument will go "dead". A quick means of checking depth to the fluid level is by turning the function switch to the CUR position and holding the CURRENT switch in the ON position. When the well probe is pulled out of the water, the meter needle will return to its zero position.

Logging with the MUD Probe

Calibration

Unit calibration is an internal factory set adjustment and is adjusted for the mud logger probe furnished with the unit; however, the CAL ADJ knob will require some adjustment to accommodate changes due to temperature and battery condition.

As long as the internal panel adjustments are not tampered with and the meter needle remains within two minor divisions of zero when calibrating, the instrument will be 10% of the obtained reading.

Checking the operation of the instrument in the MUD mode of operation with the test set may be done as in the normal mode with the results as follows:

CUR Position - @ 10 Divisions

CAL Position – Within 2 divisions of zero.
Adjustment with CAL ADJ knob.

LOG Position – Reading on the RESISTIVITY dial of about 1/10 value marked on test set.

Electrode switch must be in one of the normal positions and the SP dial must be at 0.

Setting up the Equipment

Since the electrode array is contained within the mud probe, the surface lines are not utilized. A jumper makes the proper electrical connections between the unit and the cable reel.

Place the probe selector switch in the MUD position. If not already accomplished, instrument calibration in the MUD mode of operation with the test set may be done at this time with the CAL ADJ knob. Refer to the Mud Logger Calibration Section on page 12.

Connect the mud probe to the 500 foot (150 m) cable (press connectors until a “pop” is heard indicating that the waterproof sealing surfaces are mated) and secure the threaded locking rings. Attach the logging cable jumper between the instrument and the cable reel. Place the unit in any of the NORMAL logging positions (i.e., .25, 2.5, 10 feet “normal”). Pack the probe with mud or lower into the borehole.

Place the function switch in the CAL position, energize the CURRENT switch, and ascertain that the meter needle is centered. If the needle swings fully left, place the function switch in the CUR position and check for probe current. The needle should deflect approximately ten divisions to the right of zero indicating that approximately 1mA of current is flowing. Should no deflection be noted, then the probe electrodes have not made contact with the material to be measured.

If proper indication is obtained in the CAL or CUR positions, then place the function switch in the LOG position and adjust SP dial for 0 on the meter. Then momentarily energize the CURRENT switch and simultaneously adjust the RESISTIVITY dial until minimal or no deflection of the meter is noticed.

Should the CURRENT switch be kept energized, as opposed to momentary manipulation, the meter needle may start to swing to the left as an induced voltage is set up in the probe. This may be verified by a swing of the meter needle back to the right an amount approximately equal to the left swing showing up as an SP on releasing the CURRENT switch.

MUD Logger Calibration (with a known salt solution)

1. Place the instrument in the Mud Mode
2. Connect the well probe to the instrument, via the cable reel.
3. Lock the SP dial at zero.
4. Place the function switch to the Log position.
5. Put the probe in a known concentration of NaCl and distilled H20.
6. Take the temperature of the water sample.
7. Clean the probe in distilled H20 if, necessary.
8. Refer to a resistivity/concentration/temperature chart to determine the resistivity of the sample with the known concentration and temperature. If the resistivity is in ohm-meters, multiply it by 3.28 feet/meter to get ohm feet.
9. Set the resistivity dial to this reading and lock.
10. Set the function switch to the LOG position.
11. Center the CAL ADJ knob on the front panel to the center of its travel.
12. Energize the CURRENT switch momentarily and adjust the potentiometer marked LOG (this potentiometer is on the circuit board located on the back of the meter) to null the needle.
13. Place the function switch to the CAL position and rotate the potentiometer marked CAL (this potentiometer located on the circuit board on the back of the meter) to null the needle in the same manner as above (i.e., upon energizing the CURRENT switch).
14. Recheck the log position and readjust both potentiometers if necessary until proper readings are obtained.

Interpretation of Electric Logs

Preparation of the Log

Basic to a proper interpretation of the electric log data is the preparation of the graphical log. Any suitable graph may be used.

In preparing the log, the .25 feet normal arrangement reading should be plotted at the depth as read from the marked cable and the 2.5 feet readings about one foot above this point. This is because the cable markings have been measured from the current electrode. For the lateral arrangement, the values are plotted just as is the case for the normal arrangement. If the 10 feet normal is used, its reading should be plotted about 5 feet above the marked cable reading.

Significance of .25 feet spacing

The reading obtained with the .25 feet spacing is heavily influenced by the fluid in the borehole and hence it reads only some fraction of the formation resistivity. However, the short spacing enables you to see changes in resistivity with greater detail. With this electrode spacing, formations having a thickness of about 6 inches (15 cm) or greater can be detected. Because of this ability to see small detail, the .25 feet curve should be used to “pick” the formation boundaries.

Significance of 2.5 feet spacing

The 2.5 feet spacing provides very nearly the true formation resistivity for wells having diameters up to about 16 inches (40.6 cm) and for formations thicker than about 5 feet (1.5 m). For larger diameter wells or thinner formations, the measured resistivity will depart somewhat from the true resistivity. For qualitative interpretation this departure is not significant. Because the 2.5 feet curve provides you with the formation resistivity, it is used to identify the type of material penetrated.

Significance of the Lateral Log

The lateral log obtained with the DR instrument is made by a combination of either the .25 or 2.5 feet electrode with the 10 feet electrode. Because the 10 feet electrode is at a distance fairly large compared with either of the other two, the interpretation is essentially the same as for the normal log after using the appropriate correction factors.

For the .25 lateral log, the meter factor is 1.025.
For the 2.5 lateral log, the meter factor is 13.33.

Interpretation of Resistivity Values

In interpreting the resistivity values obtained, clays, and shale will be minorly resistive and sands, gravels, sandstone, and limestone, will be high resistive. Igneous and metamorphic rocks (such as granites and gneisses) will generally be extremely high resistive.

The exact range of numerical values will depend upon the:

- type of earth material making up the formation,
- degree of cementation of the formation,
- water quality of the formation water,
- porosity of the formation,
- diameter of the borehole, and
- resistivity of the fluid in the borehole.

In interpretation, the unknowns will generally be 1, 2, 3, and 4. Granular materials will be high resistive compared to fines such as silt and clay; crystalline materials (such as limestone or granite) will be high resistive compared to the granular materials.

The quality of the formation water will greatly affect the measured resistivity. In general, the resistivity of a formation will vary in an inverse proportion to the total dissolved solids. For example, all other conditions remaining the same, if the total solid content increases, the formation resistivity will decrease. Hence, clean sand filled with salty water may actually have extremely low resistivity.

Porosity of the formation also has an effect on the resistivity. It is not as pronounced as the effect from water quality. In the logging of chemical precipitates, such as limestone, changes in porosity may enable you to detect the water producing zones. Increased porosity will lower the formation resistivity and hence is a low resistive zone (where no shale is present) . This is then indicative of possible water production.

The exact range of values for clean sand, gravel, or sandstone is something which you learn by experience in your own particular area. In the Midwest United States, clean sand and gravel generally exhibit resistivity values in the range of 350 to 1000 ohm feet. The lower values apply to formations having water quality in the range of 300 to 400 ppm total solids and upper values apply for formation waters having 100 to 150 ppm total solids. The above remarks are very general and included for guidance only.

Selecting Formation Contacts

In “picking” the formation boundaries, the .25 feet curve should be used wherever possible. The inflection point (the point midway between changes in curvature of the resistivity curve) of the resistivity curve is used to mark the contact between different formations.

Correlation by Electric Logs

A useful application of the electric logs is in correlating formation thicknesses and depths from one well to another. For example, two wells within a few feet of each other invariably will give identical electric logs. When the wells are farther apart, the correlation will still be recognizable and the changes which occur. For example, thickening or thinning of beds are exactly the information needed to guide further exploration.

Correlation is commonly possible to considerable distances in the bedrock formation, in the order of thousands of feet. Because of the variable nature of unconsolidated glacial and alluvial deposits, we do not expect such distances except in special cases of a single widespread type of deposit.

The Effect of Metal on the Resistivity Log

Because metal is such a good conductor, its presence in the zone of measurement, as for example air lines which have dropped to the bottom of the well, will cause a major decrease in resistivity and make the log unusable, insofar as determining formation type. This effect, however, may be used to locate such steel in the well. In making the log, the bottom of the well casing will be detected when the probe enters it. The effect on the curves will be that both fall off to extremely low values. 5 to 20 ohm feet and then remain fairly constant. Where the casing is sealed into very low resistive shale it may be rather difficult to determine the exact position of the casing by this method.

The Spontaneous Potentials Curve

The SP measured in a borehole are of great value in deep oil wells where saline waters are encountered. For these situations the SP Curve exhibits a great deal of character and can be related to relative changes in formation permeability. Where logging in fresh water horizons, the SP Curve will usually be featureless and provide little or no useful information.

Section 4: System Maintenance

Protect the Borehole Resistivity System by giving it the proper care. Of primary importance is that all plugs, panel connections, etc., be kept dry. Moisture on the panel plugs or cable plug can cause current leakage and result in improper operation of the instrument.

The same is true of the cable and cable reel. Upon pulling the cable out of the well make sure it is wiped clean and do not let water accumulate in the cable reel.

Maintenance of Resistivity Instrument

The only required maintenance other than cleaning is changing the batteries. The test set will tell you when the 9 volt batteries need replacement. The 1.5 volt cell should be replaced every two months. See Section 5 for instructions on checking and replacing batteries.

In operating the instrument, care should be exercised so that the RESISTIVITY and SELF POTENTIAL dials are not slammed against their stops. When turned all the way counterclockwise, they both should read exactly zero. If they do not, loosen the set screws with a small Allen wrench and reset the knob to zero.

Maintenance of the Cable and Cable Reel

In handling the cable, care must be exercised so that damage to the insulation will not occur. The cable should always be wiped clean and the unit kept in a dry place.

Section 5: System Troubleshooting

A “test set” is provided so that you can check the instrument’s operation independent of the cable assembly and the well probe. If the instrument reads the correct value for the test set, then the instrument is functioning properly and the trouble is somewhere other than the electronics of the instrument.

To use the test set, plug the test set into the instrument as described under “Test Set” in Section 1, and then follow the operating instructions outlined in Section 2. The electrode selector switch must be in one of the normal logging positions.

Checking the Batteries

With the test set plugged into the instrument, turn the function switch to the CAL position and try to calibrate the instrument:

1. If the instrument can be calibrated, then turn the function switch to CUR and check the current by holding in the CURRENT switch; if the current flowing is less than 8 mA (full scale on the meter is 25 mA) then the complete set of six 9 volt batteries should be replaced.

2. If the instrument cannot be calibrated, the complete set of six 9 volt batteries should be replaced.

Unable to Calibrate the Instrument

Most often caused by insufficient or no current flowing in the ground circuit.

3. Check all lines and plugs for bad connections.

4. Sometimes insufficient current is the result of high resistance at the steel surface current electrode. If the meter shows less then 8 mA and it cannot be increased by rotating the CAL ADJ knob, then the contact resistance at the steel stake is too high. Reduce the resistance by driving the stake deeper, or pour water around the stake, or double stake until an excess of 8 mA can be obtained.

If at least 8 mA cannot be obtained, the ground circuit is too highly resistive (a situation encountered in areas having a thick cover of dry sand or where there is frost on the ground) and obtaining a log in these situations requires the use of the lateral arrangement of electrodes with the CUR wire connected to the well casing.

Fluctuating SP

Meter fluctuates uncontrollably when function switch is in the log position.

A. Check the surface potential stake to make sure it is buried in moist soil and that the wire from it is not frayed or broken.

B. If the SP fluctuates badly, stray ground potentials may be the cause; a situation encountered in highly industrialized areas. To remedy this situation, use the lateral arrangement of electrodes.

Unable to Zero the Meter with Self-Potential Dial

A. Be sure you have tried reversing the SP polarity switch. To zero the meter the injected voltage must be of proper polarity. Note that the polarity of the SP may change during logging.

B. Check the voltage of the 1.5 volt “C” battery. Replace it if necessary.

C. Check the condition of 9 volt batteries (6 total), and replace if necessary.

D. Check all lines and plugs for bad connections.

No Meter Response to Self-Potential Dial

Check all plug-in connections and surface lines, in particular, the potential surface line where it is connected to the surface stake.

Meter Deflection with No Connections to Instrument

This condition will be present when water has entered the CURRENT switch thereby maintaining an electrical connection within the switch without switch activation. When this happens, use heat to dry the switch.

Although this condition is not normal, if proper calibration and operation of the unit can be affected with the test set, then the instrument will operate properly when the CURRENT switch is activated.

Battery Voltage Check – Using a Voltmeter

9 Volt Batteries

Remove each 9 volt battery by pulling the battery tray out toward the side of the Control Panel Box. Then slide it out of the battery pocket. With the voltmeter function switch at +DC volts and the range switch at full scale reading closest to, but not lower than 10 volts, connect the red (+) lead to the positive terminal (male) and the black (-) lead to the opposite (female) terminal of the battery. Record this open circuit voltage. If battery reads below 8 volts then it should be replaced. Follow these steps to check all six (6) 9 volt batteries.

1.5 Volt (C-Cell) Battery

Remove the battery by unscrewing the C-Cell battery pocket cap. With the function switch of the volt meter at +DC volts and the range switch at the full scale reading closest to, but not lower than 2 volts, connect the red (+) lead to the exposed positive terminal (male) and the black (-) lead to the exposed negative terminal (female) of battery. Record this open voltage. If the battery reads below 1 volt, then it should be replaced.

Even though battery voltage readings may seem adequate, they are open circuit readings. Once they are installed in the control box and the current switch is activated, the voltages may drop rapidly if the batteries are weak or defective. If instrument is still not functioning properly after checking voltages, then replace all batteries.

Section 6: System Specifications

INSTRUMENT

Current:	9 milliamps
Resistivity:	DC, null-reading meter; 0-10,000 ohm feet readable within ±0.10% full scale.
Self-Potential:	Range, 0-1,000 millivolts, positive or negative
Batteries:	Six 9-volt transistor batteries; one C-cell battery
Dimensions:	7” x 16” x 12” (18 cm x 41 cm x 30 cm)
Weight:	13 lbs. (6 kg)

CABLE

Surface Type:	Two single conductor insulated wires with connectors on cable storage reel
Dimensions:	50 feet (15 m) long (each)
Net Weight:	2.5 lbs. (1 kg)
Downhole type:	4-conductor, 1/4” (6.3 mm) diameter, 500 feet (152 m) long
Reel:	Powder coated steel
Dimensions:	13” x 12” x 15” (33 cm x 30 cm x 38 cm)
Weight:	30 lbs. (13.6 kg)

PROBE ASSEMBLY

Type:	One 1” (2.5 cm) diameter current electrode and three potential electrodes mounted on 15 feet (4.5 m) of cable with waterproof in-line connector for attaching to logging cable
Weight:	1.5 lbs. (.68 kg)
System weight:	47 lbs. (21 kg)

Section 7: System Schematic

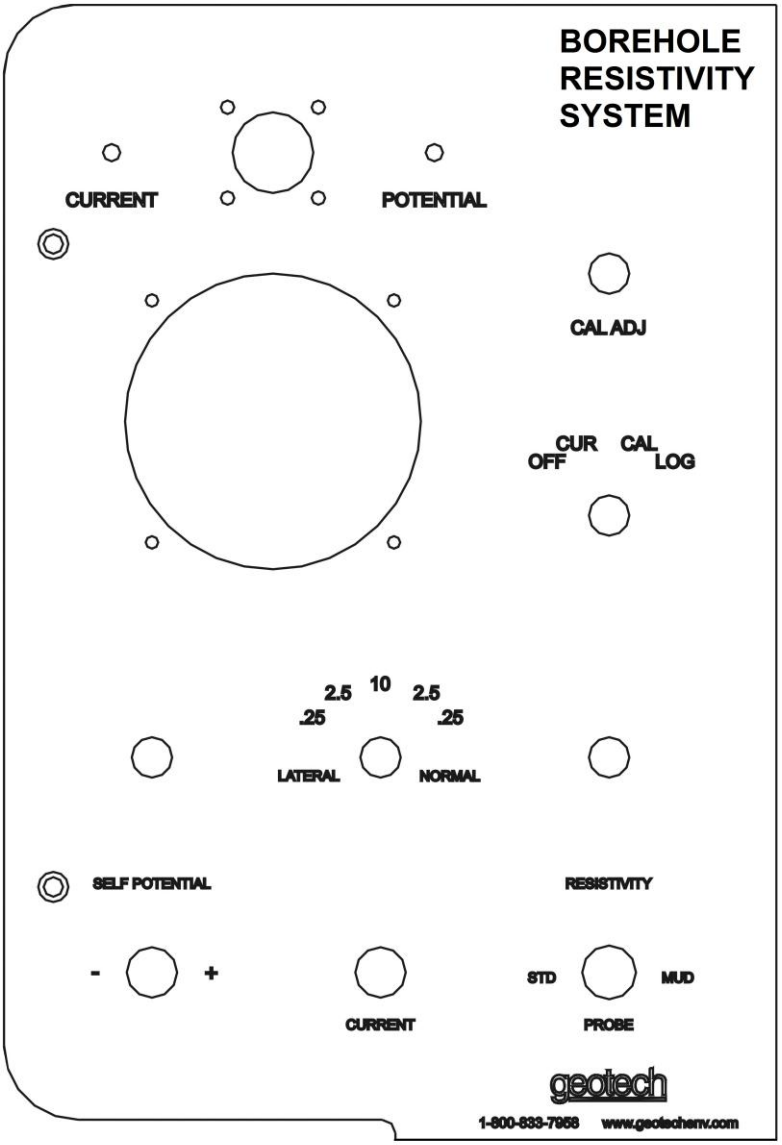


Figure 7-1 – Control Panel Label

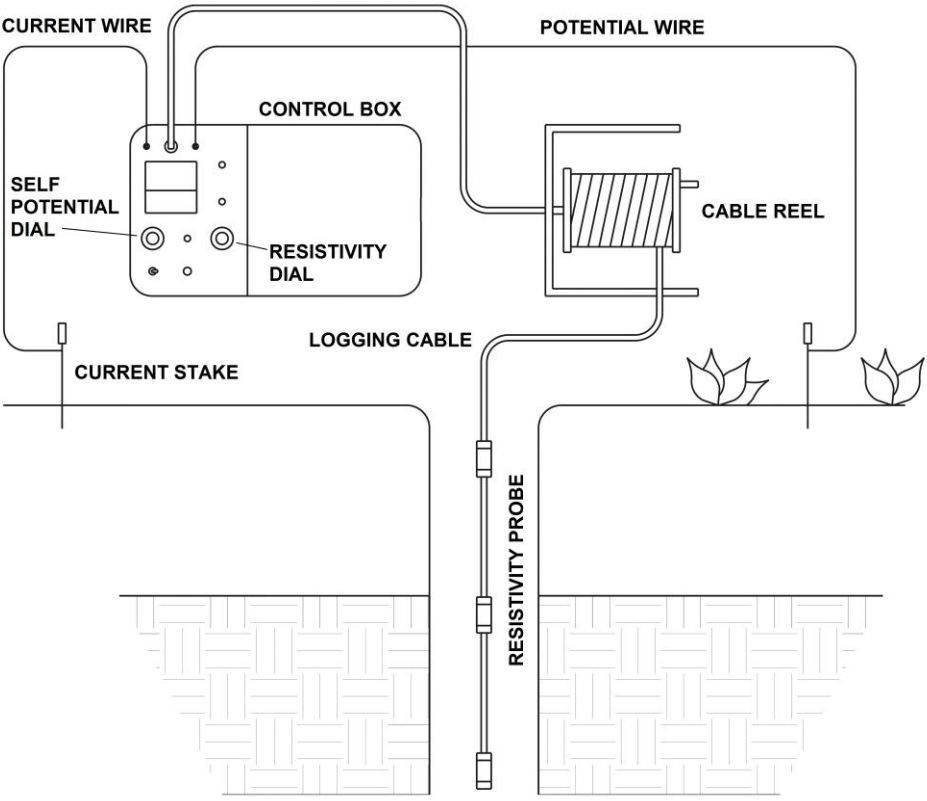


Figure 7-2 – Borehole Resistivity System

Section 8: Replacement Parts List

Parts Description	Parts List
CABLE,4-COND,500FT W/FEM CONN CR	12250019
CABLE,4-COND,500FT W/M-F CONN CR EXTENDER	12250021
MARKER,CABLE,130-255FT CR	12250024
MARKER,CABLE,260-385FT CR	12250025
MARKER,CABLE,390-515FT CR	12250026
WELL SHEAVE,UNIVERSAL FOR 2" OR 4" WELLS	21400007
STAKE,SURFACE,DR	22250011
ASSY,TEST SET,DR	52250003
ASSY,PROBE,DR	52250004
ASSY,REEL,CR	52250005
ASSY,REEL,CR EXTENDER,500FT INCLUDES 500FT CABLE	52250009

The Warranty

For a period of one (1) year from date of first sale, product is warranted to be free from defects in materials and workmanship. Geotech agrees to repair or replace, at Geotech's option, the portion proving defective, or at our option to refund the purchase price thereof. Geotech will have no warranty obligation if the product is subjected to abnormal operating conditions, accident, abuse, misuse, unauthorized modification, alteration, repair, or replacement of wear parts. User assumes all other risk, if any, including the risk of injury, loss, or damage, direct or consequential, arising out of the use, misuse, or inability to use this product. User agrees to use, maintain and install product in accordance with recommendations and instructions. User is responsible for transportation charges connected to the repair or replacement of product under this warranty.

Equipment Return Policy

A Return Material Authorization number (RMA #) is required prior to return of any equipment to our facilities, please call our 800 number for appropriate location. An RMA # will be issued upon receipt of your request to return equipment, which should include reasons for the return. Your return shipment to us must have this RMA # clearly marked on the outside of the package. Proof of date of purchase is required for processing of all warranty requests.

This policy applies to both equipment sales and repair orders.

FOR A RETURN MATERIAL AUTHORIZATION, PLEASE CALL OUR SERVICE DEPARTMENT AT 1-800-833-7958.

Model Number: _____

Serial Number: _____

Date of Purchase: _____

Equipment Decontamination

Prior to return, all equipment must be thoroughly cleaned and decontaminated. Please make note on RMA form, the use of equipment, contaminants equipment was exposed to, and decontamination solutions/methods used. Geotech reserves the right to refuse any equipment not properly decontaminated. Geotech may also choose to decontaminate the equipment for a fee, which will be applied to the repair order invoice.

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