Ewbank and associates
GEO SYSTEMS PROFESSIONALS

Thermal Conductivity Testing
Specification and Procedures

The following specifications and procedures for thermal conductivity testing are designed to achieve the best possible test results with the current test equipment and methods. Ewbank and Associates may update and alter these specifications and procedures as new equipment or methods are developed.

Equipment

The portable test unit is connected to an installed loop with one side connected to the supply outlet and the other side connected to the return inlet. The test unit measures and records flow (gallons per minute), supply and return temperature (degrees F), voltage, amperage and time. Data is recorded every minute. All data is measured to three decimal places. The test unit should be kept dry and protected from dust. In extreme temperature conditions the test unit should be wrapped in additional insulation. **For accurate results, it is imperative that the test unit and above ground piping do not gain or lose heat.**

A portable computer is connected to the test unit with a serial cable. The data is recorded into a specified file on the hard drive every one minute. The computer may be plugged into the test unit receptacle for power supply.

Purging

The loop and test unit must be purged of air and pressured to at least 10 psi. If the air is not removed, or the loop pressurized, the circulating pump may stop pumping or pump at varying rates. For accurate results, it is imperative that the test unit and loop is purged of air and pressurized to achieve a constant flow rate during the test.

Test unit hook up

The loop ends should be attached to the unit with hose clamps and inspected to make sure the connections do not leak. The portion of the loop and hoses that are above ground and outside the test unit should be well insulated to ensure that heat is not gained or lost between the ground and test unit.

Power Supply

The test unit requires a stable power supply. If line power is utilized, (not recommended), the extension cord should be of adequate gauge to minimize voltage drop. A twelve gauge electric cord is recommended. If a generator is used, it should be have a capacity of at least twice the wattage that will be required for the heating elements. Approximately 15 to 25 watts per foot should be used to heat the loop (a 200 feet borehole would require 3,500 watts). The wattage should be observed periodically to ensure the power input is stable. After initial stabilization of power, if the wattage decreases or varies more than 1.5% from the average power, the test may not provide accurate results. Make certain that the circuit breakers are of sufficient amperage to carry the load.

The line source/slope method of interpreting data is the only method that has been proven reliable through research and verification. **When using this method it is imperative to have constant power (+/- 1.5% of the average power).** Put simply, this method measures the temperature rise over time with a constant heat input. Variations in the rate of heat input change the rate of temperature rise. When line power is the only source of power, longer test times are required to "average out" the power variations.

It is Ewbank and Associates experience that power supplied by a generator provides much more reliable results. With the line source/slope method of interpretation, the slope of the temperature curve on a log time scale is the variable in the equation. When the slope is consistent over a 4 to 6 hour period, the results are more reliable than when the slope is constantly changing and an average or "best fit" is used.

Data

Temperature and wattage readings should be monitored periodically to check for erratic or unusual data. The data is recorded to a file every minute. When the test is completed, the data is transferred to Ewbank for interpretation and reporting.

Test length

The undisturbed formation temperature should be measured by observing the temperature of the water as it returns from the loop to the test equipment at startup. The test should be at least 36 to 48 hours in length for best results. The recommended test duration is dependent on the borehole diameter, thermal conductivity of the grout or backfill, position of the loop in the borehole, and thermal conductivity of the formation. Generally, the less efficient the borehole is for transferring heat, the longer the test duration (large borehole diameter compared to the equivalent diameter of the loop).

Since the borehole is usually less conductive than the formation, the material in the borehole must be heated to a higher temperature so that it will transfer heat at the same rate that the formation is conducting the heat. When the borehole is conducting heat at the same rate as the formation, the test unit is measuring the temperature rise in the formation. More efficient boreholes require less time to reach this point. Typically, the end of the "borehole effect" can be observed on the graph of the temperature on a log time scale. A "dog leg" or flattening of the curve is usually evident.

It is the experience of Ewbank and Associates that longer duration tests, such as 48 hour tests, must be carefully analyzed so that results are not overstated. As the temperature rises near the borehole, heat moves away at an increased rate due to the higher temperature differential to drive the heat. Consequently, the temperature rise per unit of time during the last portion of test is much less than that of the first portion of the test. When the temperature raises only a small increment over a period of time, any environmental effects or power fluctuations can dramatically alter the calculated results.

Equipment damage

Shipping and handling of the test unit may cause damage. Equipment should be handled with care during transport. Equipment is designed for durability, but the unit may require repair from time to time.

Thermal Conductivity Testing Instructions

1. Place test unit near borehole and loop. If the area is wet or muddy, set unit on blocks or other means to keep unit dry and clean.

2. Check loop pipes to see if they are full of water. If they are not full, use water supply to fill them.

3. Connect the loop ends to the test unit using short lengths of hose, hose adapter fittings and hose clamps.

4. Make sure the purge valve is closed. Connect the water supply to the water fill inlet and open the valve. Open flow control valve to full flow. Open the water supply valve and fill the loop and test unit.

5. Connect power supply cords, the thermistor cords, and the flow meter cord between the pump box and the electronic box. Connect power supply from the power source to the electronic box. Power outlet should have adequate size ground-fault circuit breaker.

6. Connect computer to the test unit by connecting the serial computer cord from the electronic box to the computer serial port. Start the computer test program. At C> type name of execute program. Answer questions as prompted. You will be asked the path and filename to be used to store the data. Type **C:(and the filename for the test)** and press enter. After entering test information and choosing to continue, the test data screen will appear on the computer. On the left side of the screen will be the temperatures, voltage, amperage, flow, watts, and times saved read-outs. Check for proper temperatures and voltage.

7. With water supply on, the water supply valve open, and the flow control valve open to full flow, turn the circulating pump switch located on the electronic box to the "ON" position.

8. The system must be purged of any air. Open the purge valve enough to allow air to vent. Observe water in purge hose for air. When no air is observed with the purge valve open, the system is air free. Purging process should be conducted at least 15 minutes to ensure air is removed from system. Make sure purge valve is closed when finished.

9. After air is purged, close water supply valve. System should have at least 10 psi.

10. Turn on the primary heating element by putting the primary heat switch located on the electronic box to the "ON" position. Observe wattage and temperature readings. When using auxiliary (second) heating element, plug in second electric cord to auxiliary power supply with the auxiliary heat off, then turn the auxiliary power switch to the "ON" position.

11. Slowly close the flow control valve until the supply temperature is approximately 3 to 4 degrees higher than the return temperature.

12. Wattage and temperatures should be monitored periodically during test. Erratic readings indicate inadequate power supply or air in the system.

13. Recheck all loop connections and valves for any leaks. Make sure all piping, hoses, and the test unit are well insulated.

14. Test should be run for at least 36 to 48 hours. Computer should be kept clean and dry.

15. After completion of test, turn off computer and disconnect from test unit. Turn off and disconnect power supply. Disconnect loop and other hoses. Drain water from test unit.

16. Transfer test data to Ewbank for interpretation and reporting. The data is saved on the hard drive of the computer in the location designated by the operator when the test information was entered. To copy a file from the hard drive to a floppy disk using MSDOS, at C> type ***a:*** and press enter. At a> type ***copy C:(filename used for test)*** The file will be copied to the disc. The disc can then be taken to a computer with internet connection and the file emailed to gewbank@io2online.com or uploaded from the web site www.geotctest.com

A stable power supply must be available for accurate results
All air must be purge from the system for proper testing
Carefully insulate the piping from the unit to the ground. Armaflex ¾" thick is recommended, with foil lined bubble wrap insulation wrapped around armaflex.