VERTICAL THERMAL CONDUCTIVITY TESTING
SELECTION OF TEST BOREHOLE LOCATION, DEPTH & PIPE SIZE

We are often asked to provide a thermal conductivity (TC) test proposal for the design of a closed loop ground heat exchanger (GHX). Before we can provide a proposal and cost, we need to know the location, borehole depth, and pipe size. This is to be determined by the engineer or designer responsible for the design of the vertical closed loop ground heat exchanger.

Considerations

Before a TC test is considered, a preliminary GHX field layout should be completed, usually to a worst case or largest potential layout. The reasons for this are as follows:

1. A preliminary layout that is acceptable to the team is used by the GHX designer to select a test hole location that will allow the test bore to be later integrated into the operating field. Depth and circuit pipe size will be that used for the final design of the field.
2. The test bore location should be selected to account for flexibility for final borehole spacing, total number of bores and even headering variables. Preliminary GHX simulations allow for an early site plan and layout to aid in this decision making.
3. The test bore depth selection is important as TC values can vary at the same location due to differences in geology, effect of formation densities, and other variables.
4. Preliminary sizing provides a scale and scope of area required to fit the ground heat exchanger, and take into account geometry of the field, provide a perspective of installation range to the team, and permit preliminary soft costing for budget purposes.
5. A preliminary GHX site plan allows the design team, from architectural, civil and any other disciplines affected by the design of the GHX, to comment on other potential conflicts with utilities or other infrastructure.
6. The TC test parameters and GHX design should account for local or state regulations pertaining to ground loop installations, geologic conditions, and ability of local drilling assets.
7. A preliminary GHX layout should also consider peak flow rates required by the mechanical system. Even pumping strategies can influence the design of the field – ie, total peak flow of the heat pumps, or peak flow based on peak cooling or heating loads.

A TC test does not determine if a GHX or ground source heat pump system is viable. The test provides final hard data for completing the design of the GHX. The data provided by the test, primarily the determined thermal conductivity and undisturbed temperature over the average length of the borehole, and secondarily, the value of diffusivity, are integrated into the GHX simulation with the hourly loads and representative heat pump performance to finalize GHX installation parameters.

The objective of a ground heat exchanger is to provide an acceptable entering water temperature range at any time of the year that the intended heat pump equipment can reliably function with. Many variables go into the design of a closed loop GHX – load calculations, heat pump schedule, control schedule of the mechanical system impacting load durations, fluid flow rates, geologic values, capabilities of drilling assets, influence of site characteristics, conflicts with other infrastructure, regulatory considerations and other potential influences. A TC test is an important step in completing a competent design but needs to account for the variables that can affect the final configuration.

Scheduling

Not all drillers can drill, install a ground loop and grout the test bore, so depending on the region drilling assets may be limited. Availability is dependent on current backlog; one should never assume a borehole and TC test can be completed immediately without confirmation of available assets and schedule.

Keep in mind that after the test bore and loop are installed, the borehole needs to rest for 5 days to allow the geology to return to undisturbed conditions, particularly undisturbed temperature (one of the key recorded values of the test). Test duration is 48 hours minimum.

Most drillers or consulting firms that provide TC testing will either rent a data logger or have their own, with a stable power source, typically a diesel-powered generator. Turnaround time for completed results is usually within 2 to 3 business days but may be longer pending backlog.

Consequences of TC Testing without Pre-Design Due Diligence

The following are not potential problems for operating a thermal conductivity tests without pre-design considerations, but actual examples that wasted both money and time, often resulting in delayed construction. As TC testing can range from $8,000 to $15,000+ depending on timing, location, drilling conditions, bore depth, etc., appropriate care should be taken in selection of test parameters.

1. Selection of test hole location incompatible with later integration into the operating field. TC test data was judged useful, but test hole could not be integrated into operating field. Cost of test hole excluding data logging, $8,000.

2. Borehole depth incorrect for application and available area. A new, deeper TC test was required to accommodate design scope; the original shallow test hole was of no value. $13,000 wasted excluding project delay.

3. Test bore too shallow, wrong ground loop size and borehole was not drilled on project property. $10,000 and time wasted.

4. Test bore used a ground loop made of a plastic material not designed to withstand the installation into a borehole, and not recognized by presiding regulatory authority. Depth and location also incompatible with project. $18,000 and time wasted.

5. TC test depth incorrect, pipe size incorrect, and insufficient power to operate data logger to meet industry standards for test value fidelity. $9,000 wasted and time.

TC Testing Assets

The GHX, and therefore the TC test, are part of the mechanical system design, and **NOT** part of the construction effort related to geotechnical testing – this is an important distinction. Most geotech firms do not have the perspective, training, drilling capacity, or data logging and processing capabilities for vertical TC testing.

Experienced GHX design professionals can provide direction for identifying competent TC testing assets, typically with one cost inclusive of drilling, loop installation, data logging and final data processing.

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