

North City Family & Fitness Centre, Manchester
Thermal Response Test - Report
12th July 2021



Ground Loop Design

Thermal Conductivity Report – 12/07/2021

Project Name: North City Family Fitness Centre

Project Address: Upper Conran Street

City: Manchester **Postcode:** M9 4DA

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Drill Date: 09/06/21

TC Test Dates: 07/07/21 – 09/07/21

Client Name: Ameresco Ltd

Address line 1: Wesley House

Address line 2: Wesley Street

City: Castleford

Phone:

County: West Yorkshire

Fax:

Postcode: WF10 1JG

Email:

Calculation Results

Thermal Conductivity (W/m*K):	2.90
Thermal Diffusivity (est.) (m ² /day)	0.187
Average Heat Flux (W/m)	42.3
BH Thermal Resist (BTR) (m*K/W)	0.05
Average Flow Rate (L/s)	0.95
Test Duration (hr)	28
Calculation Interval	12-40

Borehole Input Parameters

Undisturbed Ground Temperature (C):	12
Depth (m):	175
Borehole Diameter (mm):	150
Pipe Size:	1 ½ in. 40mm
Grout Thermal Conductivity:	2
Drilling Method:	Standard
Drilling Time (hr):	5.0

Diffusivity Parameters

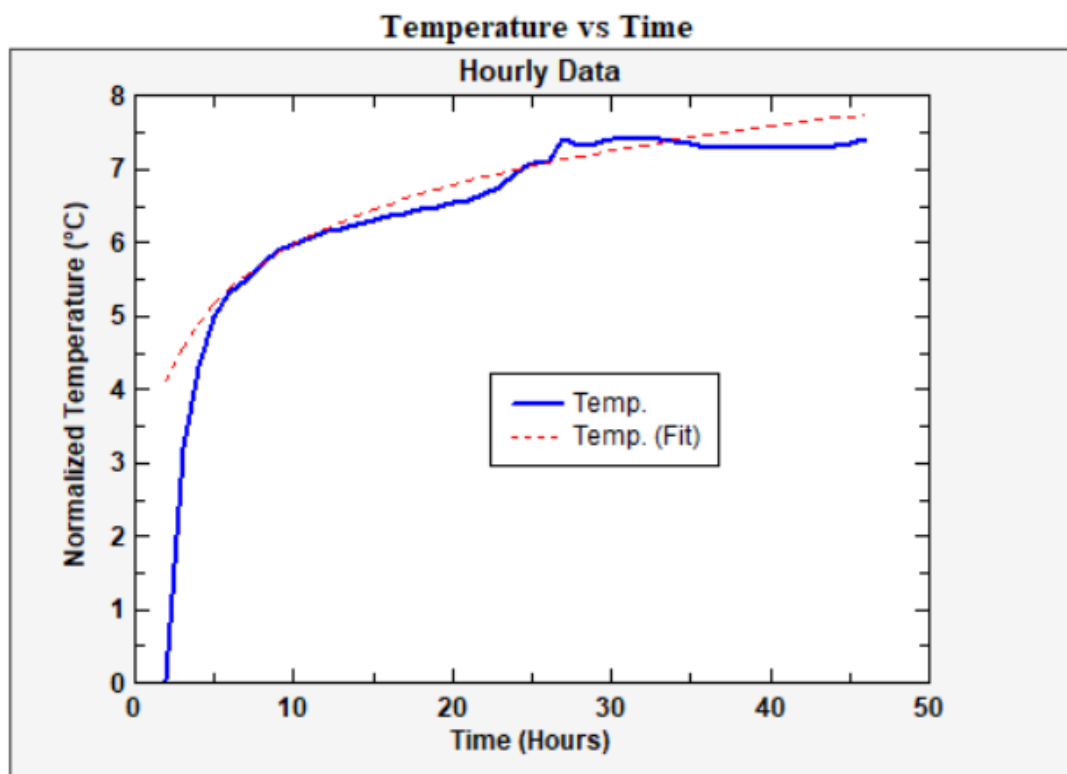
Soil/Rock Specific Heat – Dry (Kj/K*kg):	0.837
Soil/Rock Density – Dry (kg/m ³):	1601.8
Moisture (0-100) (%)	0.0

Data Quality

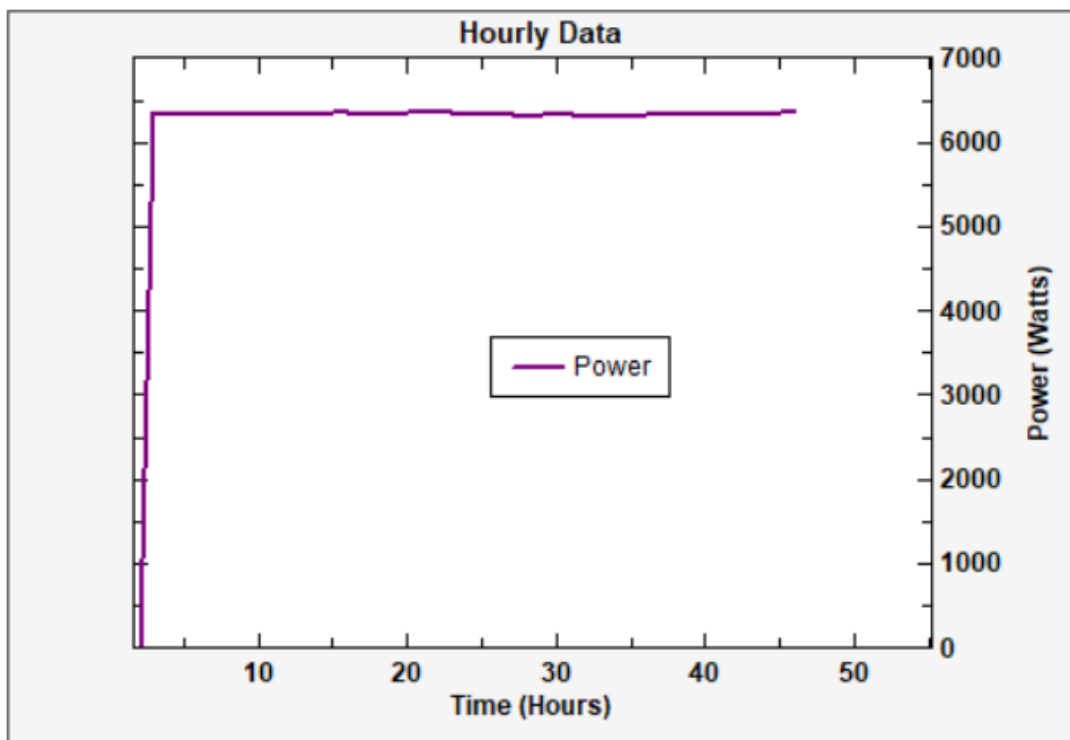
	Threshold		Threshold
Power Standard Deviation: Pass	1.50%	Flow Rate: Pass	5.00%
Power Variation: Pass	10.00%	Slope Stability: Pass	25.00%
Temperature: Pass	5.00%	Water Flow Test: Pass	20.00%

Flow Rate Input Parameters

TC Unit Model Name.	GeoCube
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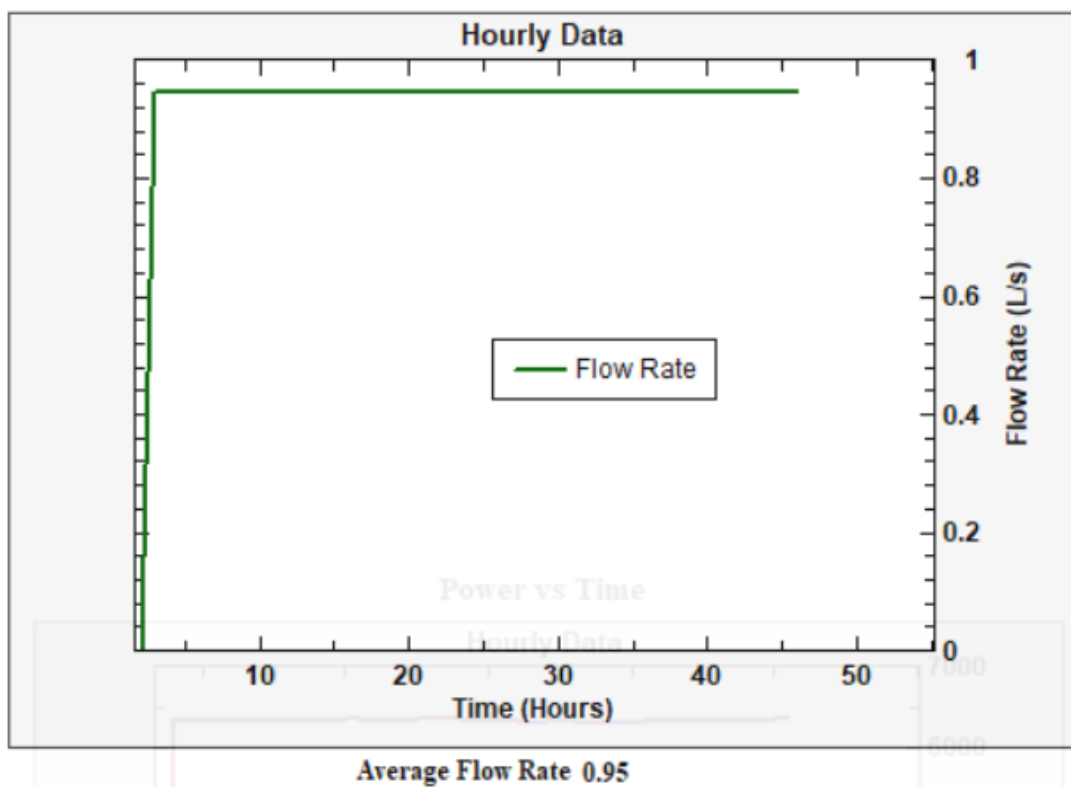


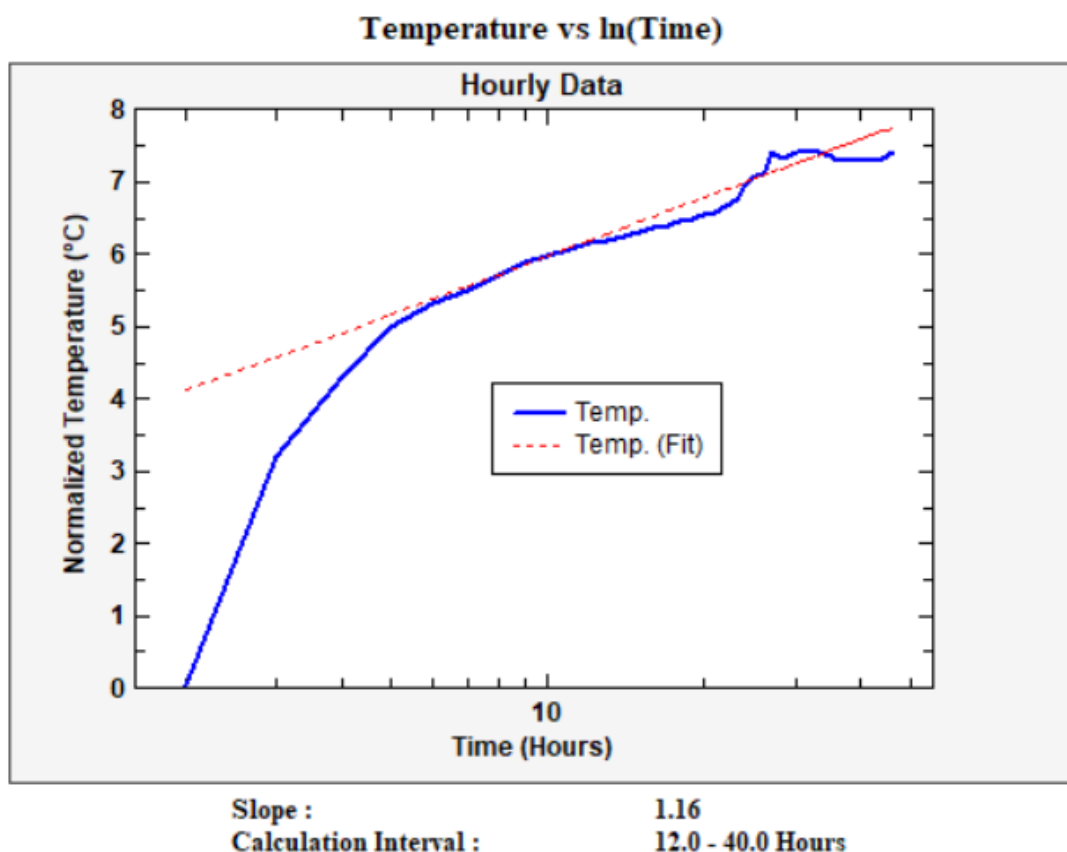
Power vs Time



Average Power 6338.9 Watts

Flow Rate vs Time





Data Quality

		Threshold			Threshold
Power Standard Deviation:	Pass	1.50%	Flow Rate:	Pass	5:00%
Power Variation:	Pass	10.00%	Slope Stability:	Pass	25.00%
Temperature:	Pass	5.00%	Water Flow Test:	Pass	20.00%

Comments

Thermal conductivity changed on numerical modelling software due to the change the original depth changed from 210m per borehole to 222m per borehole a difference of 12m.

Thermal Conductivity Test Overview

The Thermal conductivity, or thermal response, test is a way to determine ground thermal properties that are critical for ground source heat pump system design. The test is performed by injecting a known and constant amount of heat power into a borehole heat exchanger and then measuring the temperature response. A competent test can provide the undisturbed ground temperature, the calculated thermal conductivity, the calculated borehole thermal resistance and an estimate of the thermal diffusivity. These values critical for the optimal design of a geothermal system, can be used in a geothermal design program to design an optimised, cost effective system.

Undisturbed Ground Temperature Determination

The undisturbed ground temperature is the constant temperature of the formation. Typically, this temperature is measured before starting the active thermal conductivity test. The TC module automatically estimates this value from the first few temperature measurements collected via the TC test unit data logger. The organisation that performs the test also has the option of manually estimating this value with temperature probes or the like. If the TC test is initiated too soon after the installation of the test bore, the undisturbed ground temperature may be inaccurate. In general, it is recommended that the testing company waits a minimum of 3 – 5 days after installing the borehole before initiating the test so as to ensure that the ground has returned to its native and undisturbed ground temperature.

Thermal Conductivity Calculation

Because thermal conductivity cannot be measured directly, the Ground Loop Design Thermal Conductivity Module uses the line source heat transfer model to calculate the required results. The line source model, which assumes an infinitely thin heat source in a homogenous medium, is very broadly referenced in the published literature and is considered to be the standard analysis methodology. To analyse test data, the average temperature of the water entering and exiting the heat exchanger is plotted versus the natural log of time. Using regression analysis, a best fit line is plotted to match the empirical data and the slope of the line is used to calculate thermal conductivity of the formation. Typically, the data analysis procedure maybe repeated several times for several different time intervals to ensure the closest fit between the empirical data and the derived best fit line. In addition, approximately the first 10 hours of temperature data are not included in the analysis so as to ensure that the conductivity value is determined from a steady state rather than a transient heat conduction process.

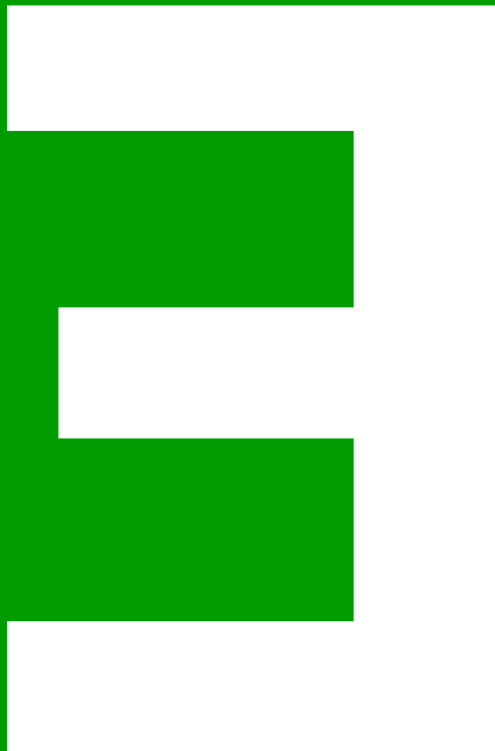
Thermal Diffusivity Estimation

Thermal Diffusivity may be estimated from a combination of the calculated thermal conductivity value (which is directly related to diffusivity) in conjunction with estimated of the specific heat, density and moisture content of the test bore. The thermal diffusivity reflects the rate of conductive heat transfer in the soil and helps determine the impact of neighbouring borehole interactions on the final geothermal loopfield design.

Test Procedure Recommendations

The American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) offers a set of procedural recommendations for in situ-thermal conductivity/response tests. These can be found in the ASHRAE 2007 HVAC Applications handbook. Several of the key recommended procedures are as follows:

- A) Time between test bore and installation and start of the TC test. A 5 day minimum wait time is recommended
- B) Undisturbed ground temperature measurements: The undisturbed ground temperature should be recorded prior to start up
- C) Test duration: Test duration typically should be 48 hours or longer
- D) Power Quality: The power standard deviation should be equal to or less than 1.5% of the average power and the maximum power variation should be less than 10% of the average power. The average heat flux should fall within the 15w/ft to 25w/ft range to best simulate the expected peak loads in the borehole.



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