

Economic Analysis of Vertical Ground-Coupled Heat Pump Systems with Pipe Spacers

1. System parameters for simulation

- Gross floor area : 22604.21 ft²
- Annual Heating/cooling load : 88.9 MWh / 70.5 MWh
- HDPE pipes diameter: 32 mm
- Software: GAIA Ground Loop Design.
- Grout Conductivity: 0.75 Btu
- Mean thermal conduction of soil 1.56 Btu
- Mean heat volume 31.79 Btu/F*ft³
- Borehole depth 328 ft,
- Borehole distance 16.4 ft

Table 1:

Software Simulation comparing single, double, and single with pipe spacers U-tube GCHP system

Items	Single U-bend system	Single U-bend with Pipe Spacers
Number of boreholes	22	17
Total borehole length (feet)	7218	6065ft
Pipe length (feet)	14436	12 130 ft
Landscape area (ft ²)	4706	3631
Antifreeze volume (l)	4118	3461
Grout volume (l)	33974	28848
EZ-Snaps quantity	0	612

Benefits and drawbacks of single U-bend with Pipe Spacers

Benefits

- ✓ 15.97% less boreholes, pipes, grout
- ✓ 15.97% less landscape and antifreeze
- ✓ Less installation time and electricity

Drawbacks

- Pipe spacers cost

2. Price parameters for comparison

- Drilling: 11\$/ft
- Pipes and grout: 4.50\$/ft
- Landscape cost: 5\$/ft²
- Antifreeze cost 1.25\$/litre
- EZ-Snaps cost 4\$/ea.

Table 2:

Cost Analysis of Single, Double and Single with Spacers U-bend Systems

Items cost (Canadian dollar)	Single U-bend system	Single U-bend with Pipe Spacers
Boreholes drilling	79,398	66,715
Loop and grout	32,481	27,292.5
Landscape	20,380	18,155
NI	5147	4326.25
Pipe Spacers	N/A	2,448
Total cost	137,406	118,936.75

Conclusion

Compared to the double U-tube system, the single u-tube with Pipe Spacers system offers a 13,44% reduction in installation costs. In this project, it amounts to savings of almost 18,469.25\$. Even though it is not mentioned, it also reduces total installation time and pumping electricity consumption.

By Patrick Lambert, P. Eng, CGD , April 23rd, 2018

Note: See next pages for actual Ground Loop Design Software results

GAIA Ground Loop Design Software Results

Average pipe spacing Page 1

Ground Loop Design Borehole Design Project Report - 2018-09-24



Project Name: Typical simulation for Pipe Spacers Rev Geo-01	
Designer Name: Geo-Energie inc. - Patrick Lambert, P. Eng, CGD	
Date: 2018-04-10	Project Start Date: 2018-04-10
Client Name:	
Address Line 1:	
Address Line 2:	
City:	Phone:
State:	Fax:
Zip:	Email:

Calculation Results

	COOLING	HEATING
Total Length (ft):	7222,9	4686,6
Borehole Number:	22	22
Borehole Length (ft):	328,3	213,0
Ground Temperature Change (°F):	+1,0	+1,5
Unit Inlet (°F):	84,9	32,0
Unit Outlet (°F):	95,5	26,7
Total Unit Capacity (kBtu/Hr):	614,1	388,4
Peak Load (kBtu/Hr):	443,5	382,1
Peak Demand (kW):	41,8	37,9
Heat Pump EER/COP:	10,6	3,0
System EER/COP:	10,6	3,0
System Flow Rate (gpm):	110,9	95,5

Input Parameters

Fluid		Soil	
Flow Rate:	3,0 gpm/ton	Ground Temperature:	51,8 °F
Fluid:	25% Propylene Glycol	Thermal Conductivity:	1,56 Btu/(h*ft**F)
Specific Heat (Cp):	1,00 Btu/(°F*lbm)	Thermal Diffusivity:	1,09 ft^2/day
Density (rho):	62,4 lb/ft^3		
Piping			
Pipe Type:	1 1/4 in. (32 mm) - SDR11		
Flow Type:	Transition		
Pipe Resistance:	0,115 h*ft**F/Btu		
U-Tube Configuration:	Single		
Radial Pipe Placement:	Average		
Borehole Diameter:	6,00 in		
Grout Thermal Conductivity:	0,72 Btu/(h*ft**F)		
Borehole Thermal Resistance:	0,288 h*ft**F/Btu		

GAIA Ground Loop Design Software Results

Average pipe spacing Page 1

Input Parameters (Cont.)

Pattern		Modeling Time Period	
Vertical Grid Arrangement:	11 x 2	Prediction Time:	10,0 years
Borehole Number:	22	Long Term Soil Temperatures:	
Borehole Separation:	16,4 ft		Cooling: 52,8 °F
Boreholes per Parallel Circuit:	1		Heating: 53,3 °F
Fixed Length Mode	Off		
Grid File	None		
File:			
Heat Pumps		Optional Boiler/Cooling Tower	
Manufacturer:	ClimateMaster	Tower	Boiler
Series:	GR Vertical	Load Balance	0 % 0 %
Design Heat Pump Inlet Load Temperatures:		Capacity (kBtu/Hr)	0,0 0,0
	Cooling (WB) Heating (DB)	Cooling Tower Flow Rate (gpm):	0,0
Water to Air:	67 °F 70 °F	Cooling Range (°F):	10,6
Water to Water:	55 °F 100 °F	Annual Operating Hours (hr/yr):	0
Extra kW		Loads File	
Pump Power:	0,0 kW	<i>for China1.zon</i>	
Cooling Tower Pump:	0,0 kW		
Cooling Tower Fan:	0,0 kW		
Additional Power:	0,0 kW		

GAIA Ground Loop Design Software Results

Pipes Along the Outer Wall Page 1

Ground Loop Design Borehole Design Project Report - 2018-09-24



Project Name: Typical simulation for Pipe Spacers Rev Geo-01	
Designer Name: Geo-Energie inc. - Patrick Lambert, P. Eng, CGD	
Date: 2018-04-10	Project Start Date: 2018-04-10
Client Name:	
Address Line 1:	
Address Line 2:	
City:	Phone:
State:	Fax:
Zip:	Email:

Calculation Results

	COOLING	HEATING
Total Length (ft):	6065,9	4048,8
Borehole Number:	17	17
Borehole Length (ft):	356,8	238,2
Ground Temperature Change (°F):	+0,6	+0,9
Unit Inlet (°F):	84,9	32,0
Unit Outlet (°F):	95,5	26,7
Total Unit Capacity (kBtu/Hr):	614,1	388,4
Peak Load (kBtu/Hr):	443,5	382,1
Peak Demand (kW):	41,8	37,9
Heat Pump EER/COP:	10,6	3,0
System EER/COP:	10,6	3,0
System Flow Rate (gpm):	110,9	95,5

Input Parameters

Fluid		Soil	
Flow Rate:	3,0 gpm/ton	Ground Temperature:	51,8 °F
Fluid:	25% Propylene Glycol	Thermal Conductivity:	1,56 Btu/(h*ft**°F)
Specific Heat (Cp):	1,00 Btu/(°F*lbm)	Thermal Diffusivity:	1,09 ft^2/day
Density (rho):	62,4 lb/ft^3		
Piping			
Pipe Type:	1 1/4 in. (32 mm) - SDR11		
Flow Type:	Transition		
Pipe Resistance:	0,115 h*ft**°F/Btu		
U-Tube Configuration:	Single		
Radial Pipe Placement:	Along Outer Wall		
Borehole Diameter:	6,00 in		
Grout Thermal Conductivity:	0,72 Btu/(h*ft**°F)		
Borehole Thermal Resistance:	0,218 h*ft**°F/Btu		

GAIA Ground Loop Design Software Results

Pipes Along the Outer Wall Page 2

Input Parameters (Cont.)

Pattern		Modeling Time Period		
Vertical Grid Arrangement:	17 x 1	Prediction Time:	10,0 years	
Borehole Number:	17	Long Term Soil Temperatures:		
Borehole Separation:	16,4 ft		Cooling: 52,4 °F	
Boreholes per Parallel Circuit:	1		Heating: 52,7 °F	
Fixed Length Mode	Off			
Grid File	None			
File:				
Heat Pumps		Optional Boiler/Cooling Tower		
Manufacturer:	ClimateMaster		Tower	Boiler
Series:	GR Vertical	Load Balance	0 %	0 %
Design Heat Pump Inlet Load Temperatures:		Capacity (kBtu/Hr)	0,0	0,0
	Cooling (WB) Heating (DB)	Cooling Tower Flow Rate (gpm):	0,0	
Water to Air:	67 °F 70 °F	Cooling Range (°F):	10,6	
Water to Water:	55 °F 100 °F	Annual Operating Hours (hr/yr):	0	
Extra kW		Loads File		
Pump Power:	0,0 kW	<i>for China1.zon</i>		
Cooling Tower Pump:	0,0 kW			
Cooling Tower Fan:	0,0 kW			
Additional Power:	0,0 kW			