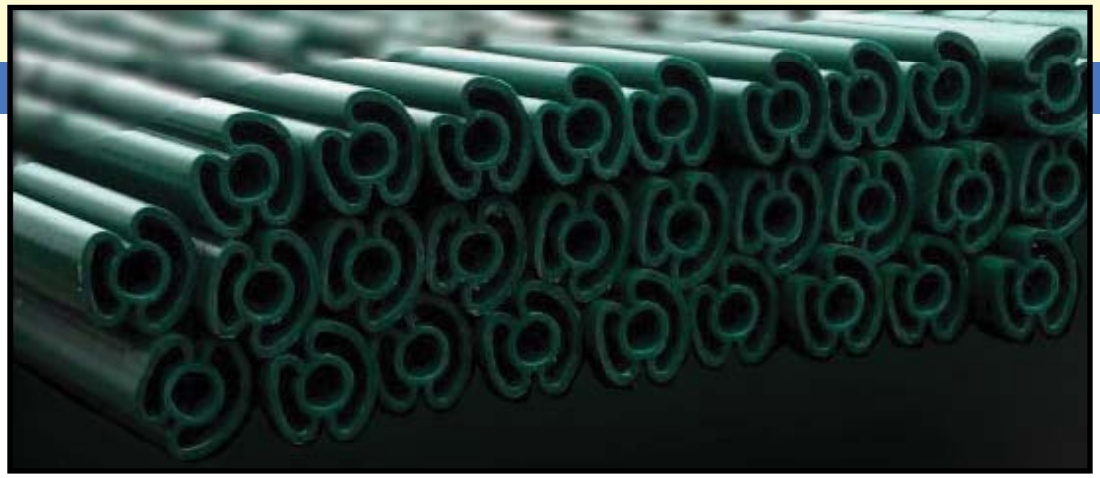
Gi-4

Advanced Ground Heat Exchanger

Engineering Overview



Geothermal Innovations LLC

Introducing Gi-4
- Engineered Ground Heat Exchanger

Gi-4 is a revolutionary engineered heat exchanger designed to improve the performance of vertical geothermal well fields. Engineered by a group of Geothermal experts, it is designed to maximize heat exchange with the ground formation and minimize the thermal pollution between the fluid supply and return ports.

The thermal resistance is significantly lower than any other vertical heat exchanger available. CFD modeling by the University of Tennessee reveals that Gi-4's design optimizes heat transfer performance, which occurs by conduction into the ground formation through the surrounding grout and pipe walls, convectively transferring heat with the conduit fluid. The design includes improved thermal performance of the material, grout thickness and most significantly maximizes the surface area over which convective heat transfer occurs.

Advantages of Gi-4 vs. 1¼" U-Bend

- **SUPERIOR CONDUCTIVITY**
  Up to **400%** Better
- **FEWER BOREHOLES**
  Total Active Linear Feet field size reduction of **60-70%**
- **GROUT REDUCTION**
  Quantity reduction greater than **60%** with equivalent bore diameters
- **ANTIFREEZE SOLUTION REDUCED**
  Reduction of **40%** compared to an equivalent system
- **IMPROVED ROI**

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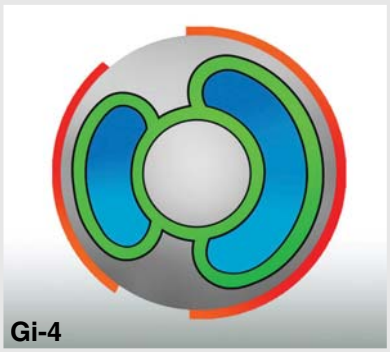
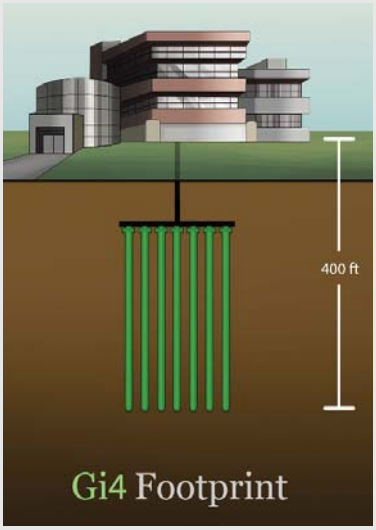
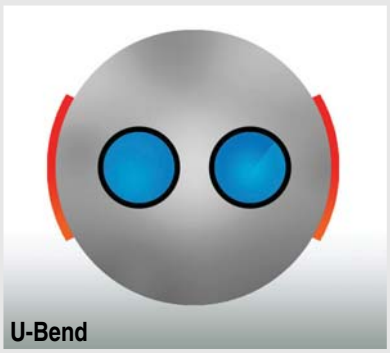
6" Borehole Comparison
Gi-4 vs. 1¼" U-Bend



Gi-4

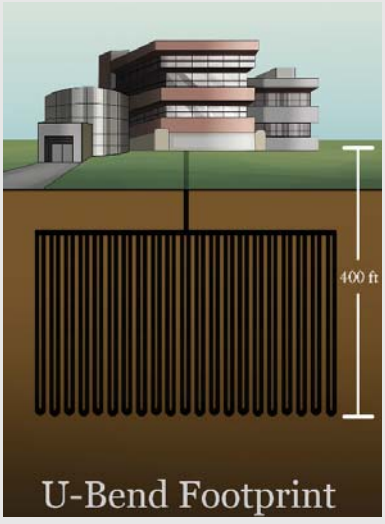
Material: HDPE - 100
Transfer Rate: 300-400% rate of U-Bend
Grout Volume per 100ft: (1.0 TC) 81 gal
Fluid Volume per 100ft = 30gal
Shipping: 20 or 50ft lengths





U-Bend

Material: HDPE - 80 (1.25")
Grout Volume per 100ft: (1.0 TC) 125gal
Fluid Volume per 100ft = 15gal
Shipping: 200-500ft coils



Gi-4 vs. U-Bend Performance Comparison

Type of Pipe	Ground Conductivity	Grout Thermal Conductivity	MAX AVG °F	MIN AVG °F	THR BTUh/ LF	THA BTUh/ LF	C LOAD BTUh/LF	H LOAD BTUh/LF	TTL LF RQRD	TTL LF PERCENT
U-bend 1.25"	FORMATION 1.4	1.0	85.4	47.0	58.8	28.8	48.0	38.4	25,000	272%
Gi-4			85.5	49.4	159.8	79.6	130.4	104.3	9,200	37%
U-bend 1.25"	FORMATION 1.8	1.2	85.5	46.7	69.2	34.4	56.5	45.2	21,250	287%
Gi-4			85.6	49.4	198.6	98.9	162.2	129.7	7,400	35%
U-bend 1.25"	FORMATION 2.2	1.4	85.3	46.5	79.5	38.9	64.9	51.9	18,500	294%
Gi-4			85.1	49.4	233.3	116.2	1090.5	152.4	6,300	34%

Above Design Criteria: BLOCK LOAD: 1200 MBH COOLING, 1500 EFLH; 960 MBH HEATING, 1200 EFLH; **6" BORE; FORMATION TEMP** 54°F; **Calculations run with GLD 2016 Professional Version**

2016 Test Data - Site 9430

CALCULATED FROM INSITU DATA

	1.25" U-BEND	Gi-4
Active Depth	350'	350'
Avg Heat (W) Input	10,526.26	10,528.10
Slope (Temp/Ln Elapsed Time)	6.6135	6.6345
k (Thermal Conductivity)	1.23	1.23
a (Thermal Diffusivity)	0.98	0.98
LWT Start	56.94°F	56.10°F
LWT Final	100°F	99.63°F
Hours to Final LWT	**39.93 @ 36,000 BTUh**	**157.0 @ 35,649 BTUh**

LWT = WATER TEMP RETURNING FROM BOREHOLE

Thermal conductivity testing completed using the GeoCube™.

"The elementary conclusion drawn from these directly comparative data is Gi-4 VHE installation performance is a factor of 4 x improvement over the directly comparable U-Bend VHE installation." - A.J. Baker, PhD

Gi-4 Composition and Installation

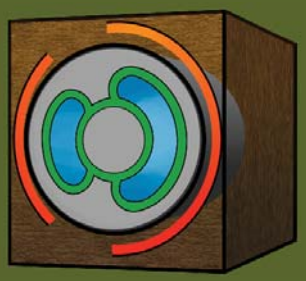
Gi-4 is extruded from PE100 (4710) by US Farathane, of Auburn Hills, MI and comes standard in 20' lengths; longer lengths available upon request.

The bottom section of the Gi-4 heat exchanger is capped with a proprietary butt fused HDPE100 Endcap using the heat fusion process approved by IGSHPA and meeting ASTM standards. Each additional section of Gi-4 is field fused and data logged with a McElroy Acrobat160 fusion machine by an IGSHPA and GI certified installer to the designed depth. The HDPE100 proprietary Header is field installed to the top section by a certified installer and 1-1/4" HDPE80 or HDPE100 pipe is socket fused to top of the Header. Traditionally, the 1-1/4" HDPE pipe is connected to a zone that is routed underground to a Valve Vault or Mechanical Room and connected to a manifold servicing the Geothermal Source Water for the equipment.

Once pressure tested, Gi-4 approved grout is installed by inserting a 3/4" tremie tube down the center port of the Gi-4 and running the tube to the bottom of the borehole. Grout is then pumped down through the tube grouting the borehole from the bottom up, per IGSPHA standards. Side slots in the Gi-4 allow the grout to flow into the annular space surrounding the heat exchanger. The total grout required per borehole is reduced by up to 30% compared to an equivalent borehole diameter with 1-1/4" U-bend installed.

Detailed Gi-4 Installation procedures are available upon request.

For more information visit:
www.gi-4.com



FAQ

What material is Gi-4 made from?
HDPE 100

What size hole should be specified?
Minimum 5 7/8" diameter main borehole. Casing used must have a minimum 6" ID.

What is the flow rate of Gi-4?
Minimum flow rate for turbulent flow is 7 GPM
Maximum flow rate is 15 GPM

What type of grout is recommended?
Grout must be approved and meet a density of 10.5 lbs/gal – 12.9 lbs/gal also must be a minimum of 1.0 TC.

What is the Gi-4 capacity per 100 LF?
30.38 gallons (sum of capacity of both Supply and Return ports)

Why does the reduction range between 60-70%?
It is dependent on the formation conductivity.
100 LF of Gi-4 is equivalent to +/- 300 LF of 1.25" U-Bend

What tools are required for installation of the Gi-4?
HDPE Fusion equipment currently used in the geothermal industry as well as inserts which can be purchased.

GI recommends using an equivalent to the McElroy Acrobat 160 unit with a Data logger.

How long does Gi-4 last?
Gi-4 is made of HDPE 100 raw material and is rated at 100 years at full pressure. Reality is that the system will never run at full pressure therefore extending the life of the Gi-4 field greater than 100 years.

With the reduction in bores and the increased transfer to the ground, how does GI mitigate overloading the field?
The field is designed with consideration of increased heat transfer by considering the load and incorporating optimal spacing between bores.

What design software would you use with Gi-4, if any?
GI is working with Ground Loop Design currently to include the calculation of the BTR of Gi-4 into their current selections within the design program. However, there is more to the adjustment in the calculation than confirming the BTR. And the adjustment in GLD will come with their next update, it will not be instantaneous.

At this point the adjustments that have to be made to GLD to get the program to return the correct design are the following:

- Multiply the actual (insitu) calculated Formation Thermal Conductivity by 1.8 (do not change the Diffusivity)
- Change the Pipe Resistance value to .003 and then the Borehole Thermal Resistance Value to .012.
- Note: No further changes on that page after you do this or the values will revert to the former values and you will not get the correct results. GI will assist with design until GLD effort is completed.

AUTHORIZED DISTRIBUTOR AND INSTALLER

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