Outside the Loop

A Newsletter for Geothermal Heat Pump Designers and Installers

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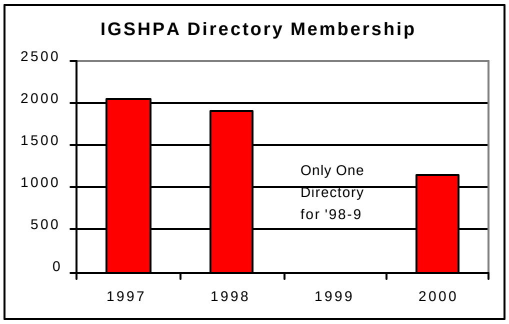
GSHPs Growing, IGSHPA Shrinking: Why?

This issue of *Outside the Loop* may appear to be a little more pointed than usual since it might be the last issue. **Ground source heat pumps (GSHPs) are outstanding HVAC systems that need to be used more frequently.** We owe it to the public and our environment to do an outstanding job of designing, installing, and yes, even marketing them. When the industry was small and needed direction, the International Ground Source Heat Pump Association (IGSHPA) was created. Training was set up, information was shared, standard practices were developed, research was organized, and the wagons were circled. A great debt is owed to Oklahoma State University for their leadership and vision.

This technology is on the threshold of being considered a common and premier HVAC system. We have a big challenge before us. Unfortunately, the folks in the wagon circle are shooting at each other at a time when our industry needs unity. The central organizations and players are not focusing enough attention on meeting the needs of the GSHP professionals in the trenches. Look at the numbers. **When their needs don't get met, people walk.** In spite of industry growth, IGSHPA membership has sharply declined.



The competition has a lot more resources. So it's time to circle the wagons. **It's time for reform and merger** with the Geothermal Heat Pump Consortium. While the GHPC has filled a void for a few of us who left IGSHPA in disgust, many GSHP professionals do not feel represented by either organization. Having the top dogs meet in DC, Stillwater, or at a meeting with a $425 registration will not work. This will only result in continued posturing for control and a bigger slice of the pie rather than meeting the needs of the industry.

So here's a suggestion: **Survey the industry** to evaluate the current programs, literature, training, meetings, technical assistance, research/development, overall effectiveness, and solicit suggestions. Then set up a broad, representative committee to analyze the results, make recommendations and initiate the necessary changes. **Contact us regarding if and how we should proceed. (geocool@bama.ua.edu)**

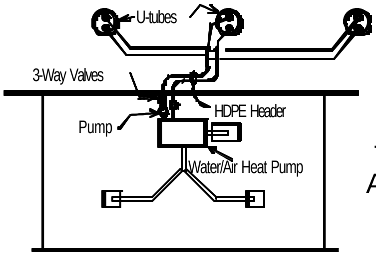
Harry Braud was Right: A Call for Simplicity

There are two graphics that are etched more deeply in my mind than all others in this GSHP business. One is Kevin Rafferty's high school drawing of a open loop system. It's not impressive but I've seen it so many times it is burned in my memory. Thus, it must be effective.

The other is Harry Braud's classic slide showing residential GSHPs as the tip of an iceberg and the larger commercial system potential being what's below the water. We've tried to expand Harry's prophesy with this newsletter and the research that we've gathered. We agree that residential GSHPs are the greatest thing since sliced bread. Yet commercial GSHPs are even better since they can be installed by experienced personnel at lower costs than many competing technologies.

This writer has been fiddling with GSHPs for 23 years and started living in a house with one 38 years ago. I've seen and heard about a lot of good ones and I know of mistakes (some were mine or my idea). My overwhelming conclusion is:

> The best **commercial** HVAC system currently possible is a simple one-heat pump, one-loop, one-pump GSHP (that looks very much like a residential system). While some may argue that you can't always do this in a big building. My philosophy is that **good engineers** will strive to make his/her design look as much like this as possible. **Lack luster engineers** will turn their jobs over to salespeople or consultants and they will look like a piping spaghetti bowl with controls and redundant equipment that will compromise the many benefits of GSHPs.



The Simple GSHP
As Good As It Gets

Well Completion Reports: A Great Info Source

One of the best sources of sub-surface geology and hydrology information on a given site is a copy of well completion reports for nearby water wells. These reports, submitted by the driller upon completion of a well, and are generally available from the state water regulatory agency. Although, filed for water wells, the data they contain is useful for both open and closed loop systems. Using these reports it is possible to determine the presence or absence of aquifers at the site, their

Continued on Page 2

Well Completion Reports (Continued from Page 1)

ability to produce water, water levels, subsurface geology, drilling conditions, water (soil) undisturbed temperature and well design details. The level of information included on and availability of the reports varies from state to state however in several states this information is available on the Internet.

Figure 1 is a copy of a well completion report used in Oregon. The first few sections of the report relate to the owner information, the type of work (new well or repair etc), the use of the well and drilling method. Of these, the most useful is the information on the drilling method. This, combined with the time to construct the well (section 12) indicates the success of the method in the local geological setting.

Sections 5, 6 and 7 provide details on the construction of the well. This information is most useful to open loop designers as it provides the description of the completion of the well in terms of casing size, screen (slot size, diameter, material), gravel size and sealing details. The performance of the existing well might support reuse of the design described or modifications to improve performance if problems have been encountered. This particular well was initially drilled to a depth of 252'. Due to the lack of water bearing intervals, the bottom was backfilled with gravel to 217' and a cement plug placed from 202' to 217'. Total depth, 8"casing is sealed with cement from surface to 152 ft and the interval from 167' to 182' is completed with 8"diameter, 0.50" slot (opening size), 304 stainless steel screen. The gravel pack consists of 6-9 sand from 148' to 182'.Section 8 contains valuable information for both open and closed loop systems. Generally ground water temperature (52 F in this case)is the same as undisturbed soil temperature and this value is a key design input for both system types. For open loop systems, the information regarding the pump test is also of great interest. Selection of the optimum ground water flow for a system is based on well pump power. Flow and drawdown are the primary variables in calculating pump power. As indicated, this well produced 200 gpm with an 85 ft drawdown after 1hr. This would correspond to a specific capacity (flow rate divided by drawdown) of about 2.4 gpm/ft. This information, combined knowledge about the type of aquifer (confined or unconfined), allows the determination of the drawdown at other flows.

Sections 10 and 11 provide information on the local static water level and aquifers present at the site. Again, the aquifer information is of most use in open loop design but depth to water and static level are of interest to contractors in evaluating drilling methods for closed loop boreholes as well.
In this case the well penetrated 4 different producing intervals between 42' and 246'. The 11' static water level indicates that the 167' to 182' producing interval is a confined aquifer since the static level is well above the depth at which the producing interval was encountered. Because the specific capacity of a well penetrating a confined aquifer is a constant value (in this case 2.4 gpm/ft), it is possible to quickly calculate the drawdown at any other flow for this well or a similar well producing from the same interval. At 100 gpm, the drawdown would be 100/2.4 = 41.7 ft for example.

Section 12 contains information valuable for closed loop systems since it details the materials the driller encountered in the course of construction. This information provides a preliminary idea as to the heat transfer characteristics (conductivity and diffusivity), which might be expected, provides a background against which to judge the results of an in-situ test and also provides potential contractors with an idea of the drilling conditions at the site. In this case there were two additional pages (not shown here), which detailed the materials from 92' to 252'.

At the end of section 12 are the dates on which construction was started and completed on the well. In some cases, this provides an idea of drilling difficulty at the site. In this case the approximately 7 weeks required is likely more a function of the rig type. Cable tool drilling is a very slow process.

In summary, well completion reports are a valuable source of information about the subsurface for both open and closed loop designers. Information about access to these reports and other public geological information in the 12 most active GSHP states is contained in a publication entitled “ A guide to Online Geological Information for Use in GSHP Site Characterization” available from the Geo-Heat Center.

OTL Pop Quiz #2:

A 500-ton chiller has a rating of 0.5 kW/ton and:

- a 70% efficient chilled water pump with 75 ft. @ 1200 gpm
- a 70% efficient cond. water pump with 75 ft. @ 1500 gpm
- a cooling tower with a 30 hp fan
- five 70% efficient AHU fans with 4.0 in. TSP @ 40,000 cfm
- five 70% efficient RA fans with 1.0 in. TSP @ 40,000 cfm
- and 167 - 1200 cfm series fan-powered VAV terminals with 8.1 a, 115 VAC fan motors.

Assuming 93% efficiency for all motors (except the VAV fans), find the resulting capacity, EER and kW/ton based on net capacity.
See p. 52 of the June 2000 *ASHRAE Journal* for answer.

Note and hint: Due to fan heat this 500 (gross)-ton chilled water system (CWS) has a net capacity of 410 tons.

Extra Credit Problem
Compare the resulting system EER and kW/Ton of the CWS with 82 five-ton, 14 EER water-to-air heat pumps (which are rated in net capacity with the fan heat penalty included). However, a 70% efficient ground loop pump with 75 ft. @ 1200 gpm with a 93% efficient motor should be considered.

Ground Source Heat Pump Design and Costs

Loop Cost Survey Results – June 23, 2000

The table below is a summary of the responses we received from the commercial/institutional loop cost survey. We mailed out over 70 surveys to contractors but only received six usable responses. The responses bordered by heavy lines indicate they are from the same contractor. It was our hope to get a more detailed breakdown of costs so that engineers could adjust designs to address the often-repeated statement, “You have to get the loop cost down”. Since only one respondent broke down the cost, our goal was not necessarily achieved. However, this respondent from Kentucky indicates a lot of money is being spent on something beside the vertical loop. Note the school (where costs were $3.27 for the vertical loop) ended up costing $9.22 per/ft when all loop costs where included. What could it be?

Location & Building	Loop Description	Drilling Conditions	Header Description	Vert. Loop Cost	Total Loop Cost
N. Carolina, (East) School	122 – 4”×200’ bores, 1” u-tubes, 20 grout cap	Mud rotary	2” reverse return S/R to building		$5.76/ft
Virginia Middle School	192 - 4”×225’ bores, 1”u-tubes	Mud rotary	12 – 4” S/R rev. return to building		$6.40/ft
Delaware HS, East Shore	180 – 4”×305’ bores, 1” u-tubes, 20’grout cap	Mud rotary, sandy clay	1 large vault, 3” laterals, 900’ - 12” S/R to bldg		$7.50/ft
Virginia Elem. School	66–5½”×350’ bores, 1” u-tubes, gravel fill, 50’grout	90’ temp. casing (ov’brdn), granite	12 sets of 3” reverse return S/R to building		$12/ft
Kentucky, Office	20– 4”× 200’, ¾” u-tubes, cuttings backfill, 20’ grout	Limestone, air hammer	Individual loops, 1¼” S/R to building		$5.50/ft
Kentucky Elem. School	220 - 6¼”×300’ bores, 1”u-tubes, cuttings	40’ steel casing, rock to 300’	10-3” S/R to manhole, 8” to bldg.	$3.65/ft	$6.22/ft
Kentucky Elem. School	126 - 6¼”×300’ bores, 1”u-tubes, cuttings	18’ steel casing, rock to 300’	3 manholes w., 9-3” rev. ret. each, 3 sets of 6” S/Rs to bldg.	**$3.27/ft**	**$9.22/ft**
Texas, Elem. School	117 – 4¾” × 290’ bores, 1” u-tubes, grout	Shale, air rotary	Indiv.loops, rev.-ret. hdrs.		$4.10/ft
Texas, High Sch. Addition	155 – 4¾” × 290’ bores, 1” u-tubes, sand fill	Hard limestone, air rotary	Indiv.loops		$4.23/ft
Texas, Elem. School	107 – 4¾” × 278’ bores, 1” u-tubes, sand fill	Hard limestone, air rotary	Ind.loops, close hdrs. Rock saw for trenches		$6.00/ft
NJ, Middle School	359-7”×350’ bore, 1¼” u-tubes, HS ben. grout	Mud rotary			$4.74/ft
NJ, Middle School	84-6”×300’, 1” bores, HS ben. grout	Rock			$5.86/ft
NJ, College Science Bldg.	50-6½”×250’bore, 1¼” u-tubes, HS ben. grout	Mud rotary			$6.48/ft
PA, Prison	136-6”×240’bore, 1¼” u-tubes, HS ben. grout	Rock			$6.64/ft
NJ, Safety Ed. Facility	12-6½”×300’bore, 1¼” u-tubes, HS ben. grout	Mud rotary			$6.88/ft
PA, Motel	30-5”×300’bore, 1¼” u-tubes, HS ben. grout	Rock			$6.88/ft
17 Others - Mostly schools	1¼” u-tubes, 200 to 400 ft. bores, 5–7” bores,	Rock and Mud rotary			$7.50 to $12 per ft.
NJ, Primary School	160-5½”×300’, 1” bores, Ther. Enh. ben. grout	Rock			$12.97ft
CT, Hdq. Software Firm	30-6”×335’bore, 1¼” u-tubes, HS ben. grout	Rock			$13.90/ft
NJ, Police Bldg.	12-8”×200’bore, 1¼” u-tubes, HS ben. grout	Mud rotary			$14.08/ft
NJ, Elem. School	36-7”×395’bore, 1¼” u-tubes, HS ben. grout	Mud rotary			$16.60/ft

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Design Issues and Tools

Note from OTL: OTL previously published an article by Dr. Marita Allan (Berndt) of Brookhaven Lab on thermally enhanced-cementitious grout. The following article was written by Dr. Chuck Remund, of South Dakota State University and GeoPro, a developer and supplier of thermally-enhanced bentonite grout. OTL welcomes the development of both of these products, but cautions users about misuse and overstated claims of similar products that do not adhere to Drs. Remund's and Allan's specifications for components and handling procedures. **We encourage users of these and other bore fill materials to verify the claims and quality of installation with periodic sampling and testing.** See article *Outside the Loop*, Vol. 2, No. 3, 1999.

Grout Thermal Conductivity – Bigger is Not Always Better

Since 1991 there have been several research efforts considering both bentonite and cement grouts from a heat transfer perspective. The objectives have generally been to find practical methods to thermally-enhance both bentonite and cement mixtures. That research has led to a slow movement by the industry toward thermally-enhanced grouting materials, guided by careful consideration of actual performance (Kavanaugh, Outside the Loop, Vol. 1, No. 1, 1998), effects on bore design length (Kavanaugh, Outside the Loop, Vol. 1, No. 2, 1998), and economics (Skouby, The Source, Vol. 11, No. 6, 1998). But, as grout thermal conductivity has become a popular topic, I believe that there has been an overreaction toward a "bigger is better" attitude relative to grout thermal conductivity. Relative to the economics of the loop-field installation, two questions need to be addressed: 1) Does higher grout thermal conductivity necessarily translate into a more cost-effective loop-field? and 2) Is the new thermally-enhanced cementitious grout (Allan, Outside the Loop, Vol. 2, No. 2, 1999) a cost-effective grouting material?

To determine the effect of grout thermal conductiviy on borehole design length, GchpCalc v3.1 was used to design a ground loop for a 100-Ton (1200 MBH) cooling load in a building occupied 5 days per week. Important design parameters included:

EWT_{max} = 90 F
T_{soil} = 62 F
Heat Pump EER = 13.0
Flow Rate = 2.75 gpm/Ton
D_{bore} = 5.0 inches
Heat Pump COP = 3.2
k_{soil} = 1.30 Btu/hr ft F
D_{pipe} = 1.0 inch
Transition flow in a 10 x 10 loopfield @ 20 foot center-to-center spacing (1 bore per ton)

The analysis considered grout thermal conductivities of 0.40, 0.85, 1.07, 1.20 and 1.40 Btu/hr ft F, resulting design lengths were 323, 262, 246, 232, 226 and 219 feet of borehole per ton, respectively. As a design engineer, you are now faced with balancing the physics against the economics. According to the calculated design lengths, utilizing the highest grout thermal conductivity does result in the shortest design lengths, but does the cost of using that grout result in the lowest installed cost for the loopfield system? There is no comprehensive data for the entire range of grout thermal conductivities that document the savings to a job based on loop-length reduction due to grout thermal conductivity. Skouby (The Source, Vol. 11, No. 6, 1998) identifies three projects where increasing grout thermal conductivity from 0.40 to 0.85 resulted in significant savings in the installed cost of the job (actual savings of $200 per installed ton on one job in the Midwest). But, when grout thermal conductivity is specified higher than the 0.85 level, there is no data that reflects actual savings to a job. Achieving high grout thermal conductivity does not come without cost. The cost of materials for the grout along with the cost of transporting those materials to the job site increases with increasing grout thermal conductivity. Additional costs, often over-looked by the specifying engineer, are the increased labor requirements to handle and install the higher thermal conductivity grouts. One measure of the increased labor requirements is to consider the weight of dry material that must be handled at the job site to produce the grout mixture (Table 1).

Table 1. Dry Weights of Various Grout Components per 100 Gallons of Grout Slurry

Grout TC Btu / hr ft F	Water (Gal)	Bentonite (lbs)	Sand (lbs)	Yield (Gal)	Dry solids per 100 Gal
0.40	24.0	50	0	27.5	182
0.69	15.2	50	100	23.4	641
0.85	17.8	50	200	30.6	817
1.07	20.3	50	300	37.5	933
1.20	22.2	54	400	44.1	1029
1.40	25.2	54	600	56.1	1166
1.40 (cement)^1	6.2	94 (cement)^1	200^2	19.1	1539

1. Laboratory value. Field value of 1.2 is advised.
2. Very specific sand gradation required.

Loopfield installers that I have worked with report higher labor and installation equipment costs to deal with the highest grout thermal conductivity products, in some cases as much as $0.20 per borehole foot for every grout thermal conductivity increase of 0.2 Btu/hr ft F above the 0.85 level. One loop installer in the Northeast reports that, even when purchasing the components individually, the cost of the cementitious thermally-enhanced grout is 40 to 50 percent higher than a bentonite-based thermally-enhanced grout mixed to 1.20 Btu/hr ft F. In addition, the cost of installation with the cement-based product increases by an additional 20 percent due to the need to completely clean the grouting equipment after each use. One case has been documented in the Northeast of a pre-packaged version of the cement-based grout costing an equivalent of $1.82 per gallon of slurry as delivered to the job site. That compares to actual cost to the contractor for a 1.40 Btu/hr ft F bentonite-based grout of between $0.90 and $1.10 per delivered gallon, depending on location.

Without extensive cost studies, one can estimate the costs and savings to a job relative to drilling cost, pipe costs and grout costs. This will be done without considering the additional equipment and labor costs of using a thermally-enhanced grout, although those costs can be extensive as the amount of product handled at the job site increases. The analysis is based on a "Best Case" and "Worst Case" scenario. The "Best Case" reflects drilling costs of $2.50 per foot, documented transportation costs in the Midwest, contractor pricing on the bentonite-based grouting products, and direct purchase of the components of the cement-based grout by the contractor. The "Worst Case" reflects drilling cost of $6.00 per foot, documented transportation costs in both the Northeast and Southeast, contractor pricing on the bentonite-based products, and documented costs for a pre-packaged version of the cement-based grout delivered to the job site. Pipe costs are assumed the same in both cases at $0.60 per foot of borehole. Results for the cooling load design are presented in Tables 2 and 3 and graphed in Figure 1.

Table 2. Grout Thermal Conductivity Effects of Loopfield Cost per Borehole (Best Case)

k_{grout}	Drilling	Pipe	Grout	Total	Savings
0.40	808	194	90	1092	---
0.69	655	157	182	994	98
0.85	615	148	160	923	169
1.07	580	139	160	879	213
1.20	565	136	167	868	224
1.40	548	131	174	853	239
Cement	548	131	234	913	179

Table 3. Grout Thermal Conductivity Effects of Loopfield Cost per Borehole (Best Case)

k_{grout}	Drilling	Pipe	Grout	Total	Savings
0.40	1938	194	117	2249	---
0.69	1572	157	224	1953	296
0.85	1476	148	190	1814	435
1.07	1392	139	193	1724	525
1.20	1356	136	202	1694	555
1.40	1314	131	212	1657	592
Cement	1314	131	350	1795	454

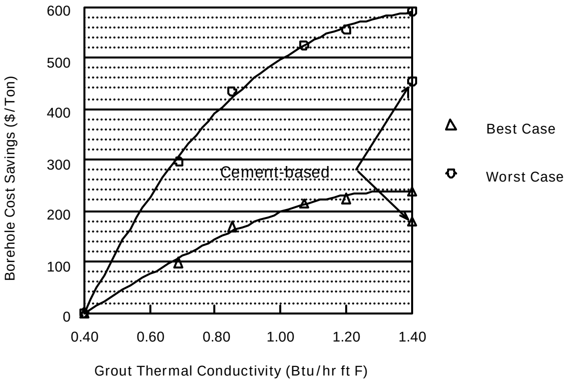

Figure 1. Borehole Cost Savings for "Best" and "Worst" Case Scenarios.

The data in Tables 2 and 3 show relatively large cost savings for small to moderate (0.69 and 0.85) increases in grout thermal conductivity. But, to increase the grout thermal conductivity to the higher levels results in very small additional savings, as shown more clearly in Figure 1, which will likely be consumed by the added equipment and labor costs to handle the increased weight of dry materials. Use of the cement-based grout, in both cases, shows extreme savings reductions due to the higher cost of mixture components along with the excessive weight of material that must be shipped to the job site. Again, no allowance has been included for labor, which will increase with the weight of material that must be handled on the job site. Also, the difficulty of pumping the grouting materials has mot been addressed, which generally becomes much more difficult with the highest grout thermal conductivity mixtures.

The goal of a loop-field design is to achieve the desired heating and cooling capacity at a justifiable cost. An important component in that design is the grout thermal conductivity that is specified. Based on the results of the analysis, the following conclusions can be made:

1. Higher grout thermal conductivity will not necessarily equate to a more cost-effective loop-field, and a complete analysis should be made including the cost of handling the grouting materials at the job site.

2. The thermally-enhanced cementitious grout has not been proved a cost-effective grouting material due to its high component, material transport and labor costs.

Installation Equipment and Loop Contractors

Commercial Building GCHP Loop Contractors

A&E Drilling Services, Greenville, SC 864-288-1986
Alabama Closed Loop, Opp, AL, 334-493-4671
Alabama Geothermal, Trussville, AL 205-661-9143
Ash Drilling, Lebanon, TN, 615-444-0276
Ball Drilling, Austin TX, 512-345-5870
Michael Barlow Drilling, Joppa, MD 410-838-6910
Bergerson-Caswell, Maple Plain, MN 612-479-3121
Bertram Drilling, Billings, MT (and PA), 406-259-2532
Harvey Cain Drilling, Atlanta, TX 903-796-6339
C&W Drilling, Columbiana, AL 205-669-0228
Can-America Drilling, Simla, CO 80835, 719-541-2967
Caster Well Drilling , Jamestown, NY 716-484-7436
Closed Loop Systems, Tallahassee, FL, 850-942-7668
Craig Test Boring, Mays Landing, NJ, 609-625-4862
Douglas Exploration, Douglas, WY, 307-358-3125
Donamarc Geothermal, Union Town, OH, 330-896-4949
Earth Energy Engineering, Big Stone Gap, VA 540-523-2283
Energy Systems, Pensacola, FL, 850-456-5612
Enviro-Tec, Cresco, IA, 800-728-6187
Ewbank & Associates, Enid, OK, 405-272-0798
Falk Brothers, Hankinson, ND 701-242-7252
Gedney-Moore, King of Prussia, PA, 610-354-9843
Geo-Energy, Vermillion, SD, 605-624-6745
Geo-Therm Heating-Cooling, Alexandria, KY, 606-635-7442
Geo-Systems Inc., Wallingford, KY, 606-876-4621
GeoMasters, Newton, TX 409-379-8537
Georgia Geothermal, Columbus, GA, 800-213-9508
Geothermal Drilling, Huntsville, TX, 409-293-8787
Geothermal Drilling, Louisville, KY 502-499-1500
Geothermal Loop Services, Bel Air, MD, 410-515-6191
Geothermal Services, Mays Landing, NJ 877-394-4689
Geothermal Energy Management, Savannah, GA,912-964-7486
Ground Source Systems, Buffalo, MO, 417-345-6751
Frame Drilling, Elkins, WV, 304-636-6025
Hammett & Hammett, Andalusia, AL, 334-222-3562
Henry Drilling, Franklin, TN, 615-794-1784
Jedi Drilling, Cibilo, TX, 210-658-7063
Jensen Well Company, Blair, NE, 402-426-2585
Johnson Drilling Co., Dallas, TX 972-924-2560
K & M Shillingford, Tulsa, OK, 918-834-7000
Layne-Atlantic, Suffolk, VA 757-934-8971
Loop Master, Indianapolis, IN, 317-872-3766
Loop Tech International, Huntsville, TX, 800-356-6703
Mid-America Drilling, Oakland, IA 712-482-6911
Mid-State Drilling, Livingston, TN, 931-823-7345
Middleton Geothermal, Akron, OH 330-620-0639
Mineral Services Plus, LLC, Cologne, MN 612-446-5503
Morrison Inc., Duncannon, PA 717-834-5667
Moses Drilling Co., Gray, KY, 606-523-1215
Murray Drilling Corp., Princeton, KY, 502-365-3522
Neese Jones Heating-Cooling, Alpharetta, GA, 770-751-1850
Larry Pinkston, Virginia Beach, VA, 804-426-2018
Pruitt Drilling, Moab, UT, 435-259-6290
Reith Brothers Well-Drilling, Emmaus, PA 610-965-5692
Richard Simmons Drilling, Buchanan, VA 540-254-2289
Rock Drillers, Inc., Bardstown, KY, 502-348-6436
Saathoff Enterprises, Bruce, SD, 605-627-5440
Somerset Well Drilling, Westover, MD, 410-651-3721
Thermal Loop, Joppa, MD 410-879-3588
Venture Drilling, Inc. Tahlequah, OK 918-456-8119
Van and Company, Duncan, OK, 580-252-2205
Virginia Energy Services, Richmond, VA, 804-358-2000
Virginia Service Co., Virginia Beach, VA, 757-468-1038
Warren Builders, Albertville, AL 256-878-1847
Winslow Pump & Well, Hollywood, MD, 301-373-3700
Yates & Yates, Columbia, KY 502-384-3656
Jesse Yoakum Well Drilling, Cleveland, MO, 816-899-2561

Loop Cost Survey Results – June 23, 2000 (Continued)

Location & Building	Loop Description	Drilling Conditions	Header Description	Vert. Loop Cost	Total Loop Cost
New York High School	320 – 6”×410’ bores, 1¼” u-tubes, bentonite w. clips	Shale	Contractor only did vertical loops	$5.25/ft	NA
Pennsylvania Museum	276 - 6”×285’ bores, 1¼” U-tubes, bentonite grout	Bedrock	Contractor only did vertical loops	$4.35/ft + Piping	NA
Pennsylvania College	40 – 6”×350’ bores, 1¼” U-tubes, bentonite grout	Rock	Contractor only did vertical loops	$5.00/ft	NA

Thanks to the six loop contractors who took the time to share this information with us.

Letters, Comments, Questions, & Suggestions

Two Pumps in One Well? No Problem

We are in the process of designing a 500-ton open loop system for an office building. A single production well in this area will easily produce the required flow rate for the system. We would like to design in some well pump redundancy without incurring the cost of a second production well. Is there a way to install two pumps in a single well?

Needing back up in Batavia

Dear Needing back up:

There are at least two potential approaches to the development of redundancy in a system such as this. If injection is the chosen method of disposal for the ground water, it is possible to equip the injection well with a pump though pump and column sizing, injection tube placement and pump housing casing issues must be carefully coordinated to assure that all the components will fit in the well.

If the system has no injection well, it is possible to install two pumps in the production well. One device which accommodates this type of installation is known as a "Wesley Tool" and is manufactured by Orbit Industries, Inc of Washougal WA. Basically it is a manifold to which separate pumps can be attached, with one pump located above the other. This greatly reduces the pump housing casing size required relative to a side-by-side pump placement. The manifold itself, fabricated from 304 stainless-steel is shaped in such a way as to conform to the well casing. One pump is attached at the bottom of the assembly and pumps, through a check valve, to a "header". Water flows from the header into a crescent shaped bypass section connected to an upper header. The concave shape of the bypass section forms a cavity in which the upper pump is housed. The upper pump is connected, through a second check valve to the upper header. The upper header also serves as the point at which the entire assembly is connected, through a third check valve, to discharge column. This configuration allows either of the pumps to operate independently or together in parallel. The length of the assembly is custom fabricated to accommodate any upper pump length. In addition, the device can be configured to permit a 3-pump installation.

Two other options for consideration are the provision of a second well pump assembly for the owner to store on site and the connection of the system to the domestic water supply for the building. The first option allows the spare pump assembly to be quickly installed in the event of a failure. In most cases a submersible well pump can be installed in a matter of hours. Connection of the system to the domestic water supply for the building permits some degree of operation in the event that the production well is out of service. Appropriate backflow prevention equipment will likely be required for the connection to the domestic supply.

Anti-Freeze Solutions – Should You Go with Marketing or Research?

What type of antifreeze solutions do should we use for closed loop geothermal heat pumps?

The American Society of Heating Ventilating, and Air-Conditioning Engineers (ASHRAE) commissioned a project to evaluate antifreeze solutions commonly used in closed loop ground source heat pump systems. The Geothermal Heat Pump Consortium supplemented funding for the project. A team from the University of New Mexico conducted the research and prepared a report, which is distributed by either organization (ASHRAE 908RP or GHPC #RP-010)). An excellent summary of the work appears in the 1999 ASHRAE Applications Handbook (p. 31.25).

Results suggest propylene glycol-water mixtures are the most appropriate fluids for these applications. However, it appears very few individuals have read or followed the report's recommendations. PG solutions are more viscous than most of the other mixtures, especially if 30% or more is used as often recommended by manufacturers for other applications. In terms of freeze protection, this percentage is much more than necessary in almost all **commercial** GCHP applications. Lower percentages would mitigate the higher viscosity problems and would give adequate freeze protection. Ten percent PG (by volume) will protect to 26ºF and 20% to 19ºF.

Unfortunately, many selections are made based on the influence of a good salesperson. One such product is an ethyl alcohol (ethanol)-water mixture with a very "green" name. Engineers should be aware of two issues the salesperson is unlikely to convey (or even be aware of).

1. When listing ethanol, the ASHRAE report and *Applications Handbook* have the statement: **"High black iron and cast iron, copper and copper alloy corrosion rates."** This would be pretty tough to defend if an engineer was drug into court because of a corrosion related problem. The note for methyl alcohol (methanol) is similar but does not include copper: **"High black iron and cast iron corrosion rates."**

2. There is some disagreement with regard to the viscosity of ethanol mixtures. Data from the Chemical Engineers Handbook indicate no advantage compared to propylene glycol mixtures. However, the ASHRAE Research project did not indicate "higher than average installation and energy costs" as it did for propylene glycol mixtures.

Another factor is the type of inhibitor package provided by the manufacturer. Some consideration should be given to their acceptability for in-ground piping service.

An easy way out of all this is: Use high density polyethylene piping for both the ground loop and interior piping (to minimize the need for inhibitors) and design the ground loop large enough to minimize the need for freeze protection.

Meetings, Publications, and Information Sources

Meetings & Seminars – 2000

Aug. 16-18, Heat Pumps in Cold Climates, Natural Resources Canada, For info: 905-542-2890 or ***caneta@compuserve.com***

Aug. 21-23, Energy 2000, Pittsburg, 800-396-8574 or ***www.energy2000.ee.doe.gov***

Aug. 30, Rocky Mountain Earth & Air Association Membership Meeting, Montrose, CO, 970-240-6018

Sept. 20 – One-Day Design Workshop for Engineers, Arkansas Energy Office, Little Rock, 800-558-2633

Sept. 20-22, IGSHPA Installation Workshop, Stillwater OK. 800-626-GSHP or ***www.igshpa.okstate.edu***

Oct. 25-27, Geothermal Heat Pump Consortium Annual 2000 Meeting, (in conjunction with the World Energy Engineering Conference), Atlanta, GA 888-255-4436 or 202-508-5500 [GHP Designer Workshop in conjunction with conference]

Dec. 3-6, IGSHPA Annual Conference & Expo, Norfolk (VA) Waterside Marriot, 800-626-GSHP - ***www.igshpa.okstate.edu*** [Installation Workshop in conjunction with conference]

Dec. 13-15, National Ground Water Association Convention & Expo, Las Vegas, NV, 800-551-7379 or ***www.ngwa.org***

Jan. 27-31, 2001, ASHRAE Winter Annual Meeting, Atlanta, GA, 404-636-8400 or ***www.ashrae.org***

Publications

ASHRAE (404-636-8400) web site: www.ashrae.org

"Operating Experiences with Commercial Ground-Source Heat Pumps", (Case Studies), 1998

Ground-Source Heat Pumps: Design of Geothermal Heat Pump Systems for Commercial/Institutional Buildings, 1997

Commercial/Institutional Ground-Source Heat Pump Engineering Manual, 1995

Ground Source Heat Pump Bore Field Issues & Regulations
(Symposium MN-00-02 Papers from 2000 Annual Meeting)

- Geology & the Ground Heat Exchanger
- Measurement/Validation of Conductivity Fill Materials
- Bore Field Performance of Standard & Enhanced Grout
- Regulations on Grouting for Closed Loop GCHPs in the US

GSHP Systems: The Inside –the-Building Story
(Symposium MN-00-05 Papers from 2000 Annual Meeting)

- Measure Performance of VS Pumping in GHPs and WLHPs
- Energy Use of Ventilation Air Options for GSHPs
- Life Cycle Costs of GHPs & Conventional HVAC-Nebraska
- Operational Problems of Commercial GSHP and GWHPs

Geo-Heat Center (541-885-1750) www.oit.edu/~geoheat

"State Maps of Ground Water Scaling Potential", 1999 **(OL)**

"Guide to On-Line Geological and Ground Water Information", 2000 **(OL)**

"Design Issues in the Commercial Application of GSHP Systems in the U.S.", *Geo-Heat Center Quarterly Bulletin*, Vol. 21, No. 1. **(OL)**
"Scaling in Geothermal Heat Pump Systems", *Geo-Heat Center Quarterly Bulletin*, Vol. 21, No. 1. **(OL)**

"Ground-Source Heat Pump Systems: European Experience", *Geo-Heat Center Quarterly Bulletin*, V. 21, # 1. **(OL)**

"Geothermal Direct-Use in the United States", *Geo-Heat Center Quarterly Bulletin*, Vol. 21, No. 1. **(OL)**

"Specifications for Water Wells & Pumps", 1998. **(OL)**

"An Information Survival Kit for the Prospective Geothermal Heat Pump Owner", 1997 – RESIDENTIAL **(OL)**

Geothermal Heat Pump Consortium (888-255-4436)

www.ghpc.org

Earth Comfort Update, GeoExchange Resource Center Newsletter.

GeoExchange Heating and Cooling (Five minute how it works video) VT-900

GeoExchange Site List – A list of commercial and institutional GHP buildings in North America (RP-011)

International Energy Agency Heat Pump Centre

IEA Heat Pump Centre Newsletter
http://www.heatpumpcentre.org

IGSHPA (800-626-GSHP) www.igshpa.okstate.edu

Closed-Loop/GSHP Systems: Installation Guide, 1988.

Grouting for Vertical GHP Systems: Engineering and Field Procedures Manual, 1997 (a.k.a. EPRI Report # TR-109169)

National Ground Water Assoc. (800-551-7379)

www.ngwa.org

"Guidelines for the Construction of Vertical Bore Holes for Closed-Loop Heat Pump Systems", 1997

The **USGS** Ground Water Atlas of the US series. **(OL)** with text and figures. http://sr6capp.er.usgs.gov/gwa/gwa.html

(OL) = Available On-Line @ listed web site.

Outside the Loop
A Newsletter for Geothermal Heat Pump Designers and Installers

The University of Alabama
Box 870276
Tuscaloosa, AL 35487-0276

- **GSHPs Growing, IGSHPA Shrinking: Why?**
- **Harry Braud was Right: Call for Simplicity**
- **Well Completion Reports: Great Info Source**
- **OTL Quiz #2: Chiller System Efficiency**
- **Loop Costs Survey Results**
- **Dr. Remund on Thermally Enhanced Grout**
- **Letters – Two Pumps in One Well?**
- **Anti-Freeze, Go with Marketing or Research?**
- **GSHP Loop Contractors**
- **Publications and Meetings**

GEOEXCHANGE

Summer 2000 – Volume 3, Number 2 - Published Quarterly

Outside the Loop is supported by a grant from the Geothermal Heat Pump Consortium through the Strategic Outreach Program

Please let us know if:

- **There is a type of information you need.**
- **You would like to add to our information.**
- **We need to add someone to our mailing list.**
- **You would like to write an article.**
- **You have an announcement to share.**
- **You know a loop contractor we need to add to our list (see page 5).**
- **You have verifiable cost data you want to share.**

Send information and requests to:

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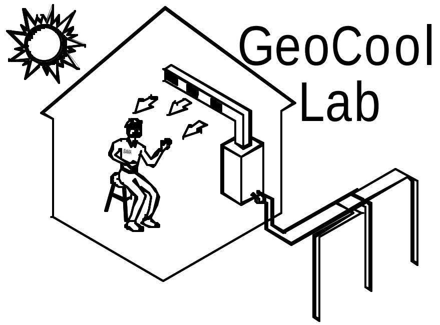
Back issues of _Outside the Loop_ can be accessed on the web sites of the GeoCool Lab at the University of Alabama or the Geo-Heat Center at Oregon Institute of Technology.



www.bama.ua.edu/~geocool

GHC

www.oit.edu/~geoheat