Outside the Loop

A Newsletter for Geothermal Heat Pump Designers and Installers

Fall 1999/Winter 2000 - Volume 2, Number 4 - Published Quarterly

Grout Pumps

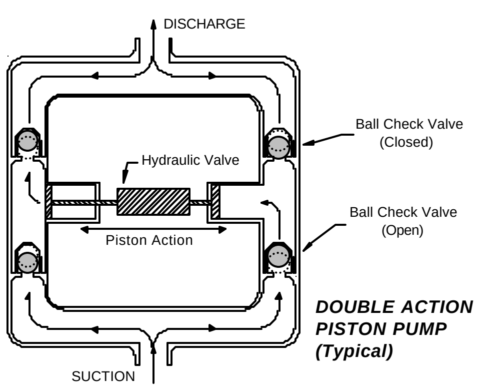
Allan Skouby, Geothermal Resource Technologies Inc.

This discussion will begin with the assumption that all "grouting" (either bentonite-based or cement based) materials will be placed in the annular space between the U-tubes and bore wall using a pressure grouting system through a tremie pipe. This method requires that the material be pumped, using a grout pump, down a tremie pipe to the bottom of the bore or at least below the grouted surface and up the bore annulus to the surface grade. In doing so, all air, drilling fluids or residual water in the bore, which is of lower specific weight, will be displaced from the bore annulus.

Grout pumps come in almost as many varieties as does the grouting materials. However, the selection should be based on the type of grout being installed, the diameter and length of the tremie pipe being used, the rate at which the grout needs to be pumped and the time required to mix and pump the grout completely through the tremie. A grout pump should be a positive displacement type pump in order to help control the materials hydration rate. If the hydration rate is accelerated due to the use of non-positive displacement pumps, the result will be excessive pumping pressures.

There are basically five types of positive displacement pumps that may have application when grouting GHEX bore holes. They include piston pumps, gear pumps, progressive cavity pumps, air-diaphragm pumps and peristaltic pumps.

Piston pumps are constant-speed and constant capacity reciprocating machines whose pistons are driven by a crankshaft from an external power source. Most are double-acting designs in which flow is induced regardless of the direction of the piston travel. Piston pumps have good capability of handling materials with high concentrations of



DOUBLE ACTION PISTON PUMP (Typical)

Continued on Page 2

Thermal Diffusivity – What Is It Good For?

Somewhere in the archive of a typical mechanical engineer's mind resides the term "thermal diffusivity". Although it is not frequently used, design programs for ground source heat pumps may require it as input. Diffusivity is the ratio of a material's ability to conduct heat (k $\Rightarrow$ thermal conductivity) to its capacity to store heat ($\rho c_p \Rightarrow$ thermal capacity).

$$\alpha = k/\rho c_p \equiv \text{ft}^2/\text{hr or ft}^2/\text{day}$$

Since most thermal conductivity tests do not include diffusivity as a result, the designer must calculate it (or guess). Fortunately, diffusivity does not impact ground coil size as much as conductivity and the specific heats of most soils and rocks are near 0.2 Btu/lb-°F. So reasonable estimates of density (ρ) will provide acceptable information for determining diffusivity of rocks and **dry** soils.

Example 1: Estimate the diffusivity of a limestone formation when a thermal test yielded a conductivity of 1.6 Btu/hr-ft-°F.

The variation of limestone density is 150 to 175 lb/ft^3. Thus:
α = 1.6 Btu/hr-ft-°F/0.2 Btu/lb-°F $\times$ 150 lb/ft^3 = 0.053 ft^2/hr
= 1.6 Btu/hr-ft-°F/0.2 Btu/lb-°F $\times$ 175 lb/ft^3 = 0.046 ft^2/hr

Converting to more common units, the diffusivity range is:
a = 1.28 to 1.10 ft^2/day

While this method does yield a 15% variation, loop design software can be used to demonstrate how little this will impact required loop length (<2%). A test run (Guess which software was used) computed a required length of 30 bores @ 210 ft using a diffusivity of 1.1 ft^2/day. A length of 214 ft. per bore was obtained with a value of 1.28 ft^2/day for the 13,000 ft^2, office building system described in our book *Ground Source Heat Pumps*, p. 35.

The fly in ointment is the fact that although moisture in the formation is a good thing with regard to heat transfer, it complicates matters when computing diffusivity. The specific heat of water (1.0 Btu/lb-°F) is **f**ve times that of soil but density (62.4 lb/ft^3) is about one-half.

The procedure is the same but the specific heat and density must be adjusted to account for moisture.

$c_p = [\%H_2O \times 1.0\ \text{Btu/lb-°F} + (100 - \%\ H_2O) \times c_{p\ Dry}] / 100\%$
$\rho = [\%H_2O \times 62.4\ \text{lb/ft}^3 + (100 - \%\ H_2O) \times \rho_{Dry}] / 100\%$

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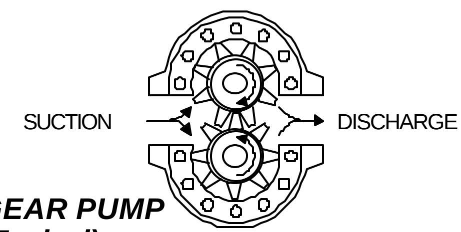
Design Issues and Tools

Grout Pumps (Continued from Page 1)

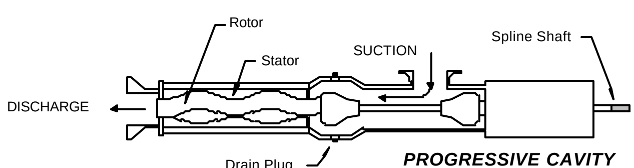
suspended solids with very little wear. Piston pumps can produce very high pressures that may be required when pumping most thermally enhanced grouting materials.

Gear pumps (also referred to as “Bowie Pumps”) are rotary pumps in which two or more gears mesh together to provide the pumping action. The mechanical contacts between the gears form a part of the fluid seal, while the outer radial tips of the gears and the gear body form the remainder of the moving fluid seal between the inlet and outlet ports. Typically the gears are manufactured from a rubberized synthetic material. Therefore, this style of pump would not be recommended for use with highly abrasive materials as is typically found in the new thermally enhanced grouting materials.



GEAR PUMP (Typical)

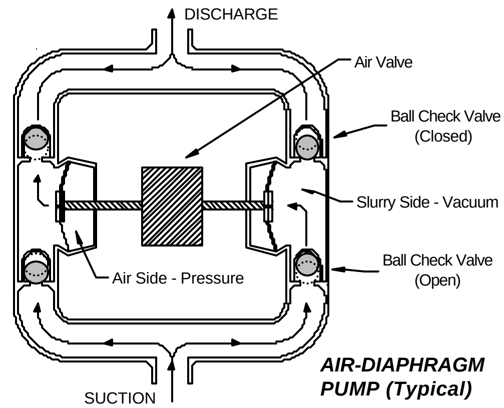
Progressive cavity pumps (also referred to as “Monyo Pumps”) are a type of rotary positive displacement pump in which flow through the pumping elements is an axial design. The material flow is forced by the rotating rotor through the volume between the rotor and stator. Progressive cavity pumps can handle liquids with a wide range of viscosity, although performance in sensitive to the viscosity. They are self-priming and have a delivery flow characteristic which is essentially independent of pressure. However, progressive cavity pumps do tend to show signs of wear when handling highly abrasive materials at sustained high RPM’s.



PROGRESSIVE CAVITY PUMP (Typical)

Diaphragm pumps utilize mechanical or hydraulic power to impart a reciprocating action on the diaphragm. Mechanically actuated pumps are commonly used for low-pressure service where leakage cannot be tolerated. These are relatively low cost, require medium maintenance and are capable of pumping slurries and corrosive chemicals. There disadvantages include low pressure capabilities and limited pumping capacities of 12 to 15 gallons per hour. Hydraulically actuated pumps have additional advantages of a much higher pressure capability (up to 100 psi) and can pump to 20 gallons per minute. However, these pumps are more expensive.

See Related Geo-Loop Article, Page 6



AIR-DIAPHRAGM PUMP (Typical)

Peristaltic pumps have recently been used in the mining industry to transfer sludge and slurries. The basic peristaltic principle consists of a smooth wall flexible tube or hose element to which a rolling or squeezing motion is imparted along a predetermined length. The liquid or powder contained in the tube is positively displaced by each roll squeeze cycle. The pumped material passes straight through the tube from suction to delivery without valves, vanes, gears or other obstructions. This eliminates incidence of blockage within the pump, and enables viscous, high-solids content sludge and slurries to be transferred with minimal moisture.

The typical portable grouting units today consists of one of the above listed pumps, a paddle mixing tank, a grout holding tank and a portable power unit. In many cases, the mixing tank and the grout holding tank are incorporated as combined unit. In some cases, the mixing section and the pumping section are separate “stand-alone” components.

Many of the grout manufacturers (primarily bentonite-based grouts) will recommend the pump that is most efficient for their particular products. However, it has been determined through trial and error as well as limited research that the piston style pumps tends to offer the best overall performance while helping to control maintenance cost for geothermal heat pump applications, especially when considering the use of the new thermally-enhanced grouting materials.

Thermal Diffusivity (Continued from Page 1)

Example 2 Calculate the thermal diffusivity of clay with a dry density of 110 lb/ft^3, a dry specific heat of 0.22 Btu/lb-°F, a moisture content of 10%, and a thermal conductivity of 0.7 Btu/hr-ft-°F.

c_p = [10%×1.0 Btu/lb°F + (100 - 10%)×0.22 Btu/lb-°F] /100%
= 0.298 Btu/lb-°F

ρ = [10% × 62.4 lb/ft^3 + (100 - %10) × 110 lb/ft^3] / 100%
= 105.2 lb/ft^3

α = 0.7 Btu/hr-ft-°F / (0.298 Btu/lb-°F × 105.2 lb/ft^3)
= 0.0223 ft^2/hr = 0.54 ft^2/day

Sand Control in Water Wells

The number one problem encountered with water wells in the US is sand production. This is difficult to understand given the fact that the tools are available to control sand production with the well completion design or as a somewhat less attractive second choice, surface separators. It is important to remember that in order for sand to reach a surface separator, it must first pass through the well pump. Pumps don't like to eat sand any more that you do.

The issue of sand is more critical in applications in which injection is the disposal method. This is because any sand that is produced from the production well and not removed in the system, ends up in the injection well. For systems disposing on the surface, it is likely that no operational problems might be encountered even at sand contents of 10 to 15 ppm. It is important to remember that a well producing 200 gpm, operating for 2000 hrs per year at a sand content of 10 ppm would produce 2000 lbs of sand - a ton of sand! That's enough to make any injection well choke.

Minimizing sand production begins with the production well. Screen and possibly gravel packing are the components that provide the "filtering" of the water entering from the aquifer. Gravel pack construction is expensive and not necessary for all high capacity wells. It is used only under specific conditions (fine , uniform sand formations; thin, alternating sand/clay sequences and some partially consolidated sandstone formations) Development is the process of removing some of the aquifer particulate materials from the near well vicinity. It is in the development specification that the designer specifies the acceptable sand content. Accurate specification of these aspects of well construction is the means by which sand production is controlled. Details of these issues along with other water well specification issues are available in the water well specification publication available from the Geo-Heat Center (see publications section of this newsletter).

Key to the accurate completion of a well is the analysis of samples from the aquifer taken during drilling. These samples are passed through a series of sieves to arrive at the aquifer particle size distribution. This data is used to select the screen opening (called slots) size and gravel size distribution if gravel is to be used. In screened wells, a slot size that retains 40 to 50% of the aquifer materials is normally selected. In gravel packed wells, the size distribution of the gravel is selected based on the results of the drill cutting sieve analysis. The screen slot size is then selected to retain the gravel pack. As an alternative, if there are other wells in the area, completed in the same materials, these parameters can be based upon the design of the existing wells.

One problem with specifying sand free (<1ppm) performance lies in verification. The standard sand testing device used in the water well industry (Imhoff cone) is only accurate down to approximately 10 ppm. For testing of lower values a more sophisticated device, the Rossum Sand Tester, is capable of measurements to 0.5 ppm though the availability of this later device is spotty.

In cases where it is not possible to fully control sand production with well construction techniques, a surface device of some sort can be used. In broad terms there are 3 approaches available here, settling tank, centrifugal separator and screen/strainer. The settling tank is the least desirable of the three. Tanks require substantial space, allow oxygen to enter the system, CO_2 to escape, and increase system complexity. Centrifugal separators are not designed to achieve the low levels of sand content (1ppm) necessary for this application. In addition, they pass sand for a brief time at each start up before the adequate separation conditions are established in the unit. For applications in which the pump may be starting at 5 to 15 min intervals(in the worst case) this is not acceptable. The centrifugal approach is also compromised by the use of variable speed operation of the well pump. Because the centrifugal approach is dependant upon water velocity to achieve separation, variable water flow can compromise the effectiveness of the device.

As a result, the most desirable type of surface device is the strainer. This provides certainty as to the particle size and effectiveness of the separation operation and is unaffected by variable water flow. As in the case of the well screen, a screen opening size for a surface strainer cannot be properly selected without an idea of the particle size. As a result, the sieve analysis data from drilling samples or from sand samples collected from flow testing after development is complete, are necessary for this process as well. It is important to realize that an additional head loss will result from the use of a surface separator as well. For strainers incorporating automatic blowdown (advisable) a pressure drop of approximately 7 psi is common. For centrifugal separators, 4 to 10 psi, depending upon flow.

The relative cost of these sand control strategies is also a consideration. For wells the cost is difficult to characterize since the costs for screen and gravel pack depend on the aquifer thickness, drilling conditions and other issues. Stainless steel screen in an 8" diameter costs approximately $100 per ft. In water table aquifers, generally the lower third of the aquifer is screened. A plain basket type strainer for 6" pipe would have a cost of $1250. A 6" strainer equipped with automatic blowdown $3500 and a 6" duplex strainer $6000. These are material only costs for these items. In the case of the strainers, costs would also be incurred in ongoing maintenance for screen cleaning and potentially pump maintenance.

Sand is a common problem in water wells but sand itself is not the culprit, lack of adequate design is.

Ground Source Heat Pump Design and Costs

The KIS Philosophy of Austin's Mike Green, P.E.

OTL: Mike, when did you get started in GSHPs and would you summarize your first project?
MG: Bruce Evans, the local Command-aire rep had been working with Bob Lawson, of Austin Independent School District. Bob really liked what he had experienced in that smaller scale project at an elementary school. In 1985 or '86 we had a lot of reservations, but AISD was willing to pay an extra fee for us to design this system and observe construction. We faced a of lot hurdles, but we learned a lot.

OTL: Did you have any experience to help you with GSHPs?
MG: We had designed several water source heat pump projects with towers and boilers.

OTL: Were you able to find contractors?
MG: A drilling contractor worked with a mechanical contractor, who put the pipe in the hole and hooked the loops up to the units. Of course, the mechanicals hated it because it was new and the GSHPs cut out a lot of their work. A lot of them still don't like GSHPs. We learned a lot on this project. The driller bored the hole, the mechanical put the pipe in the hole, and, against our suggestion, waited until the next day to backfill. When we came back out the next day there was a big bundle of black spaghetti on the ground since the poly-pipe had floated out of the hole. I'm not sure how they fixed it but they backfilled with sand and capped it with 10 ft. of concrete. We went back the next day and the concrete was gone. Apparently, the hole had bridged and the concrete dropped.

OTL: After all of this, why did you do another one?
MG: **With all other types of systems it seems the job is never finished, we get a lot of call-backs. Something really strange happened. With this GSHP no one called, so I knew the owner was happy and I was sold.**

With chilled water systems, VAVs, fan coil units and conventional water source heat pumps, we have control problems, noise complaints, balancing problems, and coordination problems.

OTL: Why were they different than the water source heat pumps systems you mentioned.
***MG*:** In WSHP systems there are boilers, cooling towers, and steel pipe. Units quit, coils get plugged, you can never get the mechanical to flush the piping sufficiently, strainers plug, cooling towers freeze or get plugged, and boilers don't fire or they leak. With GSHPs we don't have any of these things.

OTL: How many GSHP jobs have you done?
MG: Let's see, we've done five for the Leander school district, with two more coming, at least 10, maybe more, for AISD, and two for Austin Community College.

Mike Green, a graduate of Texas A&M University, is vice president of MEP Engineering, Inc., 1000 Westbank Dr., Austin, TX, 78746. (mgreen@mepaus.com)

OTL: Do you have a GSHP design philosophy?
MG: **I talk to the people in our office and encourage them to design systems that keep in mind what our local work force is capable of doing. The number of quality people is going down. They are still out there but there is a greater chance that the contractor that is low bid on the project is not going to have people with a high level of skill. So we need to "keep it simple" --- KIS.**

OTL: You mentioned some mechanical contractors don't like GSHPs. Why?
MG: The way we design them, especially if we use console units in the classroom, there is not much work for them. The loop contractor handles the piping to the unit and there is no ductwork except for maybe a small amount of duct for the outside air.

OTL: So how do you handle the outside air with a console?
MG: We are concerned with the air deliver humidity and temperature of the air delivered, so we often use a dual wheel heat recovery unit. It is a total energy wheel, a cooling coil and a sensible wheel. Outside air is delivered direct to the room at a neutral temperature. It costs about $6 to $8/cfm but we can downsize the console units to 2-tons in a typical 900 ft^2 classroom.

OTL: What about when you use a ducted package heat pump?
MG: When we can mix the outside air with the return air, we use a single wheel heat recovery unit with a DX coil. They cost about $4 to $6 per cfm but there is more cost for duct.

OTL: So let's talk cost, Mike. What can you tell us?
MG: Even though the console unit is more expensive, these systems are the lowest cost alternative. We use these rules of thumbs for duct on a normal job:

- 1 lb. of sheet metal per square foot of floor area, and
- $4 per lb to fabricate and install

So we save about $3600 per classrooms with consoles.

OTL: I can see why the mechanical contractors aren't high on your designs. What about the rest of the system?
MG: We have been installing loops that are about 290 ft. per ton and we get them put in for about $1100 including headers. I think the console units cost us about $3000. The outdoor air unit is a big-ticket item but we have been able to average about $11,000 per classroom for everything. So for a 900-ft^2 classroom, this is $12 to $14 per ft^2, including the outside air. The average for the entire building runs $11 to $12/ ft^2.

OLT: What about the controls?
MG: We use the simple mechanical thermostat provided by the manufacturer. A central time clock is used to lock out the units during unoccupied periods. However, a 3-hour by-pass override can be activated by a teacher, if someone is using the space after hours. There are two levels of freeze protection, we override the lockout when outdoor air falls below 40°F so control defaults back to the thermostat on the unit. The manufacturer also has an internal freeze protection.

Installation Equipment and Loop Contractors

Geo-Loop Grout Pro Pumps Just Right for Geo

Jeff Bowen of Aurelia, Iowa has been involved with geothermal heat pumps since 1979 and has a habit of doing what needs to be done to make things work. The electric cooperative in his area had difficulty in the early days of finding a contractor to coordinate the entire loop. Jeff's experience was in the excavating and plumbing. Drilling was left to other contractors. So to make things more effective for customers, Jeff went into the drilling business in a rather unique way. He designed and built a drill rig that could be mounted to the bucket of his back-hoe loader. The mud rotary drill rig used 10 ft. × 2-3/8 in. rods and normally drilled a 4-1/4 inch bore. Jeff's company installed a large number of loops in the upper mid-west with this very portable rig.

Jeff's experience in the field made him aware of the fact that loop installation rates were limited by the grout pumps, which are optimized for non-GHP applications. At the same time, the industry was becoming aware of the need to thermally enhance conventional bentonite grouts with abrasive materials that accelerated wear rates of conventional pumps. After trying a variety of options on the market, Jeff decided to design and build a better mousetrap (sound familiar).

Geo-Loop products are hydraulically-activated, double-acting piston grout pumps (see article, page 1). The **Model 50-500** delivers 50 gpm @ 500 psig and is driven by an oil-cooled, electric-start 18-hp Onan engine. Large 5-in. × 8-in. pistons are used to reduce pumping frequency and wear rates compared to pumps with smaller pistons. However, the pump can be easily rebuilt in the field, since the unit is assembled with hammer unions (no wrenches necessary) and parts are standard. Geo-Loop also has a **Model 30-500** that delivers 30 gpm at 500 psig with a 13-hp Kohler or 12-hp Honda engine.

To make loop grouting smoother, Jeff provides the pumps in a skid-mounted (powder-coat paint) with stainless tank mixers (60 or 80 gal.) and optional 350'×1¼" (or 500'×1") tremie-tube reels. The pumps handle both standard and thermally-enhanced bentonite and cement grouts. A **Model 150-250** mud pump is also available as a lower cost (and weight) alternative to gear pumps for circulating drilling mud. Geo-Loop has pumps in 30 states and training is available on the job site. Jeff has tried other pumps but he built this one just for geo-junkies.

Þ Þ Þ Visit www.geo-loop.com for details. Ü Ü Ü

Commercial Building GCHP Loop Contractors

Please send names of other commercial GHP contractors.

A&E Drilling Services, Greenville, SC 864-288-1986
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
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,
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

See page 7 for more contractors!

Letters, Comments, Questions, & Suggestions

Open Loop Fix-up for Closed Loop Screw-up?

We are involved in a school project in which a closed loop system was installed a few years ago. Heat pump entering water temperatures last summer were as high as 110 F. The district is interested in modifying the system to assure efficient operation and more reasonable operating cost. The options which are under consideration include a cooling tower (undesirable due to aesthetics), additional ground loop (undesirable due to cost) and adding a plate heat exchanger to the loop served by a water well. What are your thoughts?

Perplexed in the Pan Handle

Dear Perplexed

First off, everyone involved should approach a situation of this type with the preferred goal of identifying the problem with the existing system and correcting it. Too often a “Well, this kind of system didn’t work - Let’s try something else” mentality sets in. In most cases, the owner will be best served if the basic system layout (closed loop, open loop etc.) is preserved rather than grafting another system type on to it. Simplicity is one of the key advantages of GSHP systems.

Any closed loop system operating at temperature levels you describe is either being used under conditions grossly different from those assumed by the designer or design of the system contains serious flaws. Of these, the later is more common.

The engineer of record is responsible for providing a design that conforms to accepted industry practices. Peer-reviewed, accepted practices for the design of both closed and open loop systems have been widely published by ASHRAE. In addition, design software that addresses the issue of borehole interference and long term temperature buildup (often the cause of high loop temperature) is available for closed loop systems. If the system fails because the designer chose not to conform to these accepted practices, he can and should be held responsible. In the past some engineers have used loop designs prepared by others (pipe suppliers, contractors, etc.). This does not absolve the engineer of responsibility for the design however. If his stamp appears on the construction documents containing the loop design, he is responsible. If the system doesn’t work, the owner does have recourse. As a result, unless the owner chooses not to pursue satisfaction from the original designer, cost should not be the principal criteria in the selection of a solution.

In terms of practicality, any of the three options could successfully address the problem. A closed loop solution to a closed system would be the first choice. In the interest of eliminating outside equipment, the ground water/plate heat exchanger would be second choice. This is a solution that has been used in the past. The cooling tower, particularly for a school, should be considered a distant third choice.

Separation of Ground Loop Headers

I am a contractor that is installing a loop field consisting of 108 bores, 300 ft. deep, 1 inch HDPE U-tubes, with bentonite grout. The design called for the ground portion of the supply and return headers to be separated by 10 ft. There is a run of 100 feet where this is almost impossible. The engineer says I have to guarantee the loop field temperature if I want to put them closer. I have never had to do this before, so what will happen if I bury these lines in clay 5 feet below grade with a 6 inch separation?

Ticked-Off In Texas

Dear Ticked Off,

Heat transfer estimates can be found using shape factors, for this type of problem. Steel pipe and turbulent flow will be assumed to simplify the calculation. If HDPE pipe is used, the negative impact will be even less.

The heat loss will be, $q = k \times S \times (t_s - t_r)$, where S is the shape factor for two buried cylinders of radius r_1 and r_2 (6.625”/2) with a center-to-center distance D (6” + 6.625”).

$$S = \frac{2\pi L}{\cosh^{-1}\left(\frac{D^2 - r_1^2 - r_2^2}{2\, r_1\, r_2}\right)} = \frac{2\pi\ 100\ ft.}{\cosh^{-1}\left(\frac{12.625^2 - 3.313^2 - 3.313^2}{2 \times 3.313 \times 3.313}\right)} = 249\ ft.$$

Heavy damp clay will have a thermal conductivity between 0.6 and 0.8 Btu/h-ft-°F and the design (t_s - t_r) for ground loop supply-return headers should be around 10°F. Thus,

q = 0.7 Btu/hr-ft-°F × 249 ft. × 10°F = 1743 Btu/h

Six-inch pipe will typically handle around 500 gpm. To get the temperature rise, the following equation applies,

q(Btu/h) = 500 × gpm × Δt (°F).

It must be rearranged to determine the temperature rise in the water returning to the building.

Δt = q ÷ (500×gpm) = 1743 ÷ (500×500) = **0.007 °F**

There is little chance of any noticeable impact on performance because the headers are only 6 inches apart. However, a loop temperature guarantee should be avoided the since the U-tubes are grouted with conventional bentonite. If the loops are in Texas, they will probably get hot because of the choice of grout rather than the header separation. Refer the designer to earlier editions of *Outside the Loop* (Vol. 1, Nos. 1 & 2).

Contractors, Meetings, Publications, and Information Sources

More Loop Contractors

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
Winslow Pump & Well, Hollywood, MD, 301-373-3700
Yates & Yates, Columbia, KY 502-384-3656
Jesse Yoakum Well Drilling, Cleveland, MO, 816-899-2561

Meetings & Seminars – 2000

Jan. 24-25, "Drilling Contractors Can Make a Profit Installing Geo Systems", NGWA, Westerville, OH 800-551-7379

Feb. 5-9, 2000 ASHRAE Annual Meeting, Adams Mark Hotel, Dallas, TX. 404-636-8400 or ***www.ashrae.org***

Feb. 16-19, Air-Conditioning Contractors of America (ACCA) 2000 Annual Conference, Albuquerque, NM, 202-483-9370

Mar. 8-9, Big GHPC Meeting, Goethermal Heat Pump Consortium, 888-255-4436, ***www.ghpc.org***

Apr. 6-7, Two-Day Seminar for Engineers, Sacramento, CA, Assoc. for Efficient Enviro. Energy Systems, 530-750-0135

May 14-17, GeoExchange Technical Conference, IGSHPA, Stillwater, OK, 800-626-4747 or ***www.igshpa.okstate.edu***

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 Design and Maintenance Issues
(Symposium DA-00-01 Papers from 2000 Winter Meeting)
- Update on Maintenance & Service Costs of Comm. GSHPs
- Comparing Maintenance Costs of GHPs in Lincoln Schools
- Importance of Grouting to Enhance Performance

Toward Optimum Sizing of Heat Exchangers for GSHPs
(Symposium DA-00-13 Papers from 2000 Winter Meeting)
- Comparison of Ground Heat Exchanger Design Software
- In-Situ System & Analysis for Measuring Ground Properties
- Test of New Method for Soil Conductivity/Bore Resistance
- Field Tests for Ground Thermal Properties/Impact on Design
- Effect of Groundwater Flow on Closed-Loop GSHP Systems

Air-Conditioning,Heating, and Refrigeration News 1999 GHP Articles (www.bnp.com/thenews)

"Adapting to geothermal: Contractor changes direction" 7/19.
"GeoExchange money in pockets…of customers", 3/15.
"Geothermal: unique niche in a crowded market", 7/19.
"Geothermal home promotes healthier air, 7/5.
"Geothermal homes in historic Williamsburg", 4/5.
"Military bases to install ground-source heat pumps, 9/13.
"Largest GHP taking chunk out of plant's HVAC budget",4/5.

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

"Ground Water Scaling Potential Maps", 1999.

"Outline Specifications for Water Wells and Pumps", 1998.

"An Information Survival Kit for the Prospective Geothermal Heat Pump Owner", 1997 - RESIDENTIAL

Geothermal Heat Pump Consortium (888-255-4436) www.ghpc.org

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)

GeoExchange Material and Publications – A list of materials and publication available through the GHPC (RP-015)

"Maintenance and Service Costs in Commercial Building Geothermal Systems", 1997 (RP-024)

Icemakers, Coolers & Freezers, and GX – A survey of water requirements for refrigeration equipment. (RP-030)

International Energy Agency Heat Pump Centre

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

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

Specifications: Geo. Heat Pumps & Associated Equipment
15512a/b: Ground Heat Exchangers/Grouting Vertical Loops
15540: Circulating Pump Systems
15786: Geothermal Heat Pumps
15901: Space Temperature Control Systems

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)

Outside the Loop

A Newsletter for Geothermal Heat Pump Designers and Installers

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

GEOEXCHANGE

Fall 1999/Winter 2000 – Volume 2, Number 4 - 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 & 7).**
- **You have verifiable cost data you want to share.**

Send information and requests to:

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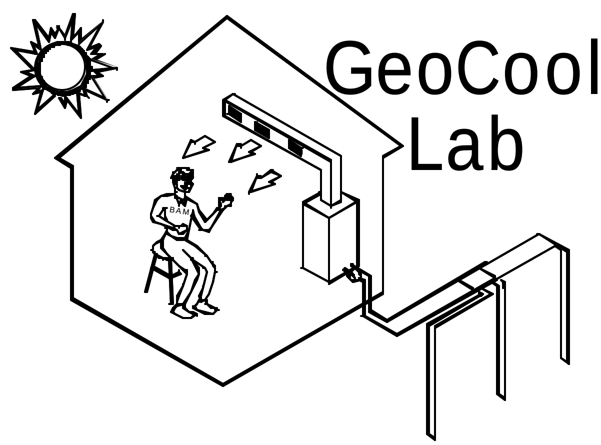

New Website: www.bama.ua.edu/~geocool

The University of Alabama is hosting a new ground source heat pump and HVAC website. This newsletter and a variety of related information is available. Check It Out.

Back issues of *Outside the Loop* can also be accessed on the web site of the Geo-Heat Center. http://www.oit.edu/~geoheat/otl/index.htm