Outside the Loop

A Newsletter for Geothermal Heat Pump Designers and Installers

January 1998 - Volume 1, Number 1 - Published Quarterly

Another Geothermal Heat Pump Publication?

The ground-source (or geothermal) heat pump industry has not always welcomed HVAC design engineers with open arms. On more than one occasion, engineers have been blamed for the failure of a GSHP system to be bid at an affordable price. Some GSHP contractors have become frustrated when HVAC engineers question their plan of action and slow down the job.

The GSHP industry went through infancy and adolescence in the residential sector where engineers were not always necessary. As more non-residential building owners and developers recognize the benefits of GSHPs, well-informed designers are a must. GSHP professionals must approach the engineer as an important part of the team rather than as a barrier to project success.

A primary purpose of this publication is to assist engineers in finding the tools and information needed to design larger GSHP systems. The newsletter expands the amount of information beyond these eight pages by listing publications, meeting schedules, and other sources that are of interest to GSHP designers.

Another goal of this newsletter is to communicate with other GSHP professionals who play a major role in system design and installation. These include equipment manufacturers, contractors, vendors, electric utility personnel, trainers, and researchers. In addition to sharing technical knowledge, it is important that all the players understand each other's constraints and problems. Contractors must have steady and profitable work. Manufacturers and distributors must earn stockholders and themselves a profit in the very competitive HVAC industry. Engineers must design cost-effective and reliable systems in spite of increasing building code complexity and legal liability. Electric utility personnel must be concerned about their company's direction and their own employment status in the face of deregulation and mergers.

We invite you to contribute to future editions of this newsletter. This could be in the form of announcing meetings, sharing your experiences, raising questions, expressing opinions, or offering suggestions to the industry. We expect future editions of this publication will contain more information from a wider variety of experts.

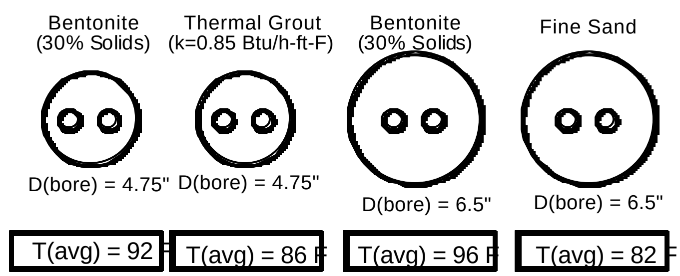
Steve Kavanaugh, University of Alabama, 205-348-6419 fax, skavanaugh@coe.eng.ua.edu
Kevin Rafferty, Geo-Heat Center, 541-885-1754 fax, raffertk@oit..edu

Omaha Tests Demonstrate Impact of Bore Hole Grout Thermal Conductivity

Engineers at Omaha Public Power District felt they were receiving conflicting information regarding soil and grout properties. The discrepancies had significant impact on the required lengths for vertical ground loops. So they built their own test rig for ground thermal conductivity testing.

Four ground heat exchangers were tested independently to determine the impact of various grouts. The U-tubes were installed in a sandy clay soil. A 4-3/4" and a 6-1/2" bore were grouted with high-solids bentonite. A thermally-enhanced grout was used on a second 4-3/4" bore and sand was used to back fill another 6-1/2" bore. Each loop was loaded for several days with an electric water heater.

The figure below shows the dramatic difference in temperature response. The sand backfilled borehole performed the best with an average loop temperature of 82°F after two days. The smaller diameter bore with the thermally enhanced grout was next at 86°F. The bentonite bores were warmer, especially the larger diameter bore.



CONDITIONS
250 ft. Bore, 3/4 in., SDR 11, HDPE U-Tube
48 Hour Test @ 4500 Watts (15.4 MBtu/h)
Ground Temperature = 55 F

OPPD has concluded the use of high conductivity grout or backfill is essential to minimize the required length (and cost) of vertical ground heat exchangers. OPPD is now using these same tests to determine ground thermal properties.

Other thermal tests have not demonstrated the dramatic performance differences among grouts. The OPPD test is significant because the tested loops did not share the heat source. Therefore, the load could not be shifted from the low-conductivity grout loops to loops that absorb (and have to store) more heat. (See related Hot Loops article, Page 3.)

Next Issue - Impact of Grout Conductivity on Loop Length and Cost

Design Issues and Tools

Excessive Pump Power Can Ruin GHP Efficiency

Auxiliary power consumption can also ruin the performance of GHP systems. Pumping too much water at too high a head follows the rule of thumb: For every 100 ft. of head required of the pumps, add 0.1 kW/ton. For fractional horsepower circulator pumps, up to 0.25 kW/ton can be required for every 100 ft. of head.

When the fan energy is considered, the EER for GCHPs is in the 12 to 15 Btu/Whr range. This converts to 1.0 to 0.8 kW/ton. Excessive pump power could add up to 0.2 kW/ton if smaller, less efficient pumps and motors are used. Thus EER could fall into the 10 to 12 range. EER could go to as low as 8, when low efficiency heat pumps are also used.

Adding Up the Auxiliary Power Consumption

(How 0.5 kW/Ton Chillers become 1.4 kW/Ton Systems)

Centrifugal chillers are extremely efficient devices capable of 0.5 kW/ton with 45°F leaving water temperatures and 85°F entering condenser water. So how could GHPs compete? Easy! Designers don't fully appreciate the amount of auxiliary power required for a CWS. Some rules of thumb are given below for auxiliary additions.

For every 1.0" water required of fans – Add 0.09 kW/ton
[for small fans (1/2hp and less)] – Add 0.25 kW/ton
For every 100' water required of pumps – Add 0.1 kW/ton
[for small pumps (1/2hp and less)] – Add 0.25 kW/ton
For centrifugal cooling tower fan – Add 0.14 kW/ton
For axial cooling tower fan – Add 0.06 kW/ton

Example

A chilled water, VAV system has a 0.5 kW/ton chiller. Filter losses are 1" of water (0.09 kW/ton). The air handler unit coils have a 1.5" loss (0.13 kW/ton). The required supply duct static pressure is 2" (0.18 kW/ton). The fans in the FPVAV boxes deliver 0.5" (0.12 kW/ton). The return duct requires 1" of water (0.09 kW/ton). The chilled water pumps deliver 100 ft. of water (0.1 kW/ton) and the condenser pumps 50 ft. (0.05 kW/ton). The cooling tower has a centrifugal fan (0.14 kW/ton).

Adding these up for the system = 1.4 kW/ton (EER = 8.6)

Groundwater - How Much Do You Need?{PRIVATE }

Probably less than you think. One of the most frequent errors in the design of groundwater system is the use of excessive groundwater flow. This condition compromises efficiency and drives up first cost.

For most large commercial applications, the groundwater flow requirement is governed by the size of the cooling load. In addition, it is a function of the groundwater temperature, well

pump head, heat exchanger approach temperature difference (between the leaving groundwater and building loop return temperature) and heat pump performance. The fundamental consideration is: the higher the groundwater flow, the better the performance of the heat pumps (due to more favorable operating temperature). At the same time, however, increasing groundwater flow results in higher well pump power consumption. The bottom line is that at some point, decreasing heat pump power is overtaken by increasing well pump power, and design for groundwater flows in excess of this value is wasteful of both capital and energy.

Table 1 presents data from a recently evaluated system with a 150-ton peak block load, which will operate on 60°F groundwater.

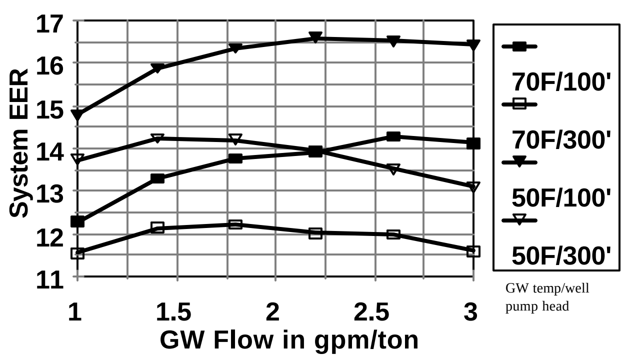
Table 1 - 150-Ton System, 60°F Groundwater

		Well	Loop	Heat			
Groundwater	**Gpm/**	**Pump**	**Pump**	**Pump**	**HP**	**Total**	**System**
Flow (gpm)	**Ton**	**kW**	**kW**	**EWT**	**kW**	**kW**	**EER**
150	1.0	10.2	11.2	82.0	128.6	150	12.0
175	1.2	12.1	11.2	77.9	124.1	147.4	12.2
200	1.3	14.1	11.2	74.8	120.8	146.1	12.3
225	1.5	16.4	11.2	72.3	117.7	145.3	12.4
250	1.7	18.9	11.2	70.4	115.4	145.5	12.4
275	1.8	21.6	11.2	68.8	113.9	145.3	12.4
300	2.0	23.9	11.2	67.5	112.5	147.6	12.2
350	2.3	28.8	11.2	65.4	109.8	149.8	12.0

It is apparent that, for this application, pumping any more than 225 gpm (1.5 gpm/ton) is unnecessary. In fact, at just 150 gpm (1.0 gpm/ton), the result is only about 3% loss in system performance (EER). The original specification for this system called for 375 gpm.

The attached figure provides some general guidelines for groundwater flow in commercial systems. Curves are shown for 100' and 300' total well pump head for 50, 60 and 70°F groundwater temperatures. These curves are based on the use of moderate-efficiency heat pumps, 3°F heat exchanger approach and a 65% wire-to-water well pump efficiency.

Groundwater Flow
for Maximum System EER



Fundamentals: Mother Nature Can Be a Wonderful Partner

(But she can also be a real B#!% if you ignore her.)*

Hot Loops I

Hot loops and the resulting system performance degradation have been an issue on more than one ground source job. While in some cases hot loops may be the result of gross loop undersizing, poor installation or naturally warm ground, the problem may be a result of ignoring basic laws of heat transfer and thermodynamics.

One common cause of hot loops is due to thermal storage effects of the ground. This is more likely to occur in large loop fields when a high percentage of the bore holes are surrounded by three or four adjacent loops. The problem is magnified when there is insufficient bore separation and the surrounding soil (or rock) does not readily transmit water.

The fundamental equation to be considered in this case is:

$$Heat = Density \times Spec.Heat \times Volume \times Temp.Change$$

$$Q = r\, c_p\, V\, \Delta t$$

The equation can be transformed into the heat rise on an annual basis by finding the difference between the amount of heat rejected (equivalent full-load cooling hours ´ heat rejection rate) and the heat removed (equivalent full-load heating hours ´ heat absorbtion rate). This difference is divided by the thermal capacity of the ground surrounding the loop to find the temperature rise.

$$Temp.Rise\,(°F) = \frac{1.26 q_c\, EFLH_c - 0.77\, q_h\, EFLH_h}{r\, c_p \times Volume}$$

The coefficients in the equation convert the heat pump capacity to heat rejection (1.26) in cooling and heat absorption (0.77) in heating. They are representative of a heat pump with an average EER of 13 and a COP of 3.5.

Now consider the annual average ground temperature rise in limestone (c_p = 0.22 Btu/lb-°F, r = 165 lb/ft^3) surrounding a U-tube that has adjacent U-tubes on all four sides that are separated by 10 feet. Assume the U-tubes are sized at 175 ft. per nominal ton (q_c = q_h = 12,000 Btu/h), so that heat is rejected to a 10 ft. x 10 ft. x 175 volume. In an office building with normal internal loads, it would not be uncommon for the heat pump to operate 1200 hours in cooling and 500 hours in heating even in colder climates.

$$Temp.Rise = \frac{1.26(12{,}000)(1200) - 0.77(12{,}000)(500)}{(160)(0.22)(10 \times 10 \times 175)}$$

$$Temp.Rise = 22.0°F$$

This rise is mitigated somewhat by the fact that some bores are not surrounded on all four sides. However, this is the rise after one year and the situation may get worse in subsequent years.

Designers using bore separation distances of less than 15 ft. for buildings with significant cooling hours are asking for trouble. A minimum of twenty feet bore separation is recommended for buildings with 12-month operation and high internal loads.

If you have hot loops in a commercial system, a hybrid GSHP system is often the most economical fix. For a reference, see the Publications section (page 7) under Geothermal Heat Pump Consortium.

Hot Loops II

The second fundamental equation that impacts loop temperature comes from any introductory heat transfer textbook. It's the same equation we use for determining required pipe insulation thickness or heat loss. A common form of Fourier's Law for heat transfer through a hollow cylinder is,

$$q = \frac{2p\, k\, L\,(t_i - t_o)}{\ln\left(r_o / r_i \right)}.$$

Now consider a 1 inch U-tube placed in the center of a 6 inch borehole, that is backfilled with a high solids bentonite grout, a common practice in the GSHP industry. This grout is a clay with a thermal conductivity (k) of 0.43 Btu/hr-°F-ft. For the previous example, the 175 ft. U-tube is rejecting one ton of heat in the cooling mode (q_r=1.26 ´ 12,000 = 15,120 Btu/h). So the temperature of the liquid inside the U-tube must increase by (t_i – t_o) in order to dissipate the heat. The widest dimension of a 1 inch U-tube is about 3 inches. So it could be assumed that a hollow cylinder of grout with inner diameter of 3 inches (r=1.5") and an outer diameter of 6 inches (r=3") surrounds the U-tube. The above Fourier equation could be rearranged to find the temperature rise due to the grout.

$$Temp.Rise = \frac{q_r \ln(r_o / r_i)}{2p\, k\, L} = \frac{15{,}120 \ln(3''/1.5'')}{2p(0.43)(175')}$$

$$Temp.Rise = 22.6°F$$

Summary

Some in the GSHP industry may discount the impact of these two fundamental principles upon loop temperature. You are encouraged to carefully review the above concepts before approving a specification that calls for less than 20 ft. bore separation or pure bentonite grout. There are alternatives.

Products, Services, and Installation Innovations

In-Situ Ground Conductivity Testing May Improve Loop Design Accuracy

Several firms are now offering a service that has the potential to dramatically reduce the uncertainty of finding the thermal conductivity of soil or rock formations. The process involves installing a vertical ground heat exchanger, imposing a thermal load, measuring loop temperatures, and then deducing conductivity.

Continued development is necessary for this very promising innovation. However, some limitations exist at this time:

1. ***Installing a U-tube will alter the thermal properties of the soil around the bore hole. (Air drilling will dry the formation out and mud drilling will add clay and moisture to the formation). Investigation of the amount of time the near ground needs to recover is warranted.***
2. ***If the bore hole thermal resistance is high (large bores and/or low conductivity grouts), results may be more inaccurate since the systems are normally measuring the combined bore and ground resistance and then computing soil conductivity.***
3. ***More work is needed to verify accuracy.***
4. ***Calibration is difficult.***
5. ***The required run time of test is a hotly debated topic among "experts".***
6. ***Since most tests depend on pure conduction models, the impact of natural or induced water movement on the results is not well documented.***

In spite of these current limitations, proper in-situ thermal conductivity can improve ground loop design accuracy.

Contacts:

Ewbanks & Associates, P.O. Box 148, Fairview, OK 73737
405-227-3352

Oklahoma State University, GHP Research
490 Cordell South, Stillwater, OK 74078-8018
800-626-4747

Northern Geothermal Support Center
South Dakota State University, ME Department,
Brookings, SD 57007
605-688-6400

Omaha Public Power District (Brian Langel)
444 South 16th Street Mall, Omaha, NE 68102-2000
402-636-2000

Ted Wynn & Associates
417 Welshwood Drive, #114, Nashville, TN 37211-4225
615-331-7660

Please notify us if we have omitted any other firms that provide this service.

Commercial Building GCHP Loop Contractors

(Talk to these people before you design something that's hard to install.)

Ball Drilling, Austin TX, 512-345-5870
Bertram Drilling, MT and PA, 406-259-2532
Craig Test Boring, Mays Landing, NJ, 609-625-4862
Ewbank & Associates, Enid, OK, 405-272-0798
Falk Brothers, Hankinson, ND 701-242-7252
Georgia Geothermal, 800-213-9508
Geothermal Services, KY 502-499-1500
Ground Source Systems, Buffalo, MO, 417-345-6751
K & M Shillingford, Tulsa, OK, 918-834-7000
Loop Tech International, Huntsville, TX, 800-356-6703
Larry Pinkston, Virginia Beach, VA, 804-426-2018
Thermal Loop, Joppa, MD 410-538-7722
Yates & Yates, Columbia, KY 502-384-3656
Winslow Pump & Well, Hollywood, MD, 301-373-3700

Please inform of us of other contractors who specialize in large buildings.

A Sample of GHP Specialty Firms

Harry Braud, P.E., Ph.D. (504-673-6816) in Geismar, LA has been involved with GHP development for 20 years. He can assist novice designers and is well known for his informative and entertaining presentations. He has also served as an expert witness. Harry's approach is a welcome change from the typical GHP presentation.

Peterson's (502-773-4353) in Cave City, KY. "Pete" Peterson is an old hand a GHP systems. He sells pipe, will hold your hand if you're a novice designer, and politely tell you when he thinks something is not a real good idea. He is a true southern gentleman, although he resides in an area with a 55°F deep earth temperature.

Water & Energy Systems (603-3624666) in Atkinson, NH. Carl Orio is another old hand in this business. He will do conventional GHPs. However, his specialty is "standing column wells", a semi-open loop system that requires a lot less bore length. Give him a call if you have a minute (or more).

Geothermal Design and Engineering (405-272-0780) in Oklahoma City is a full service MEP firm that provides engineering service and "dirt to data" project management. GD&E specializes in ground-coupled systems and hybrid applications. In addition to the normal design functions, they can provide economic feasibility analysis, monitoring and controls, loop inspection and testing, installer pre-qualification, and in-situ conductivity measurement. This firm features two partners with the most opposite personality types in this industry.

Cost and Performance of Ground Source Heat Pump Buildings

Hot Demand for Maintenance Cost Report

Caneta Research of Mississauga, Ontario has recently completed the study, "Survey and Analysis of Maintenance and Service Costs in Commercial Building Geothermal Systems". The survey indicates significant savings, compared to currently published data for conventional equipment. The authors suggest that the results should be compared to data for this conventional equipment that is currently being updated. The full report is available from the project's sponsor, the Geothermal Heat Pump Consortium (888-255-4436).

GHPs Use Less Energy Than Chilled Water System Auxiliaries in Lincoln Nebraska Schools

Many engineers have a hard time believing GHPs could use less energy than the newest chilled water systems with 0.5 kW/ton chillers. Monitoring of seven new schools in Lincoln, Nebraska has shown that GHPs use less energy than the auxiliary equipment of the CWS (fans, pump, cooling towers, etc.). Although the newer CWSs were heated with natural gas, the systems winter electric use was greater than the GHPs.

The total energy costs for the four GHPs were 40¢/ft^2-year for a two-year period. A water-cooled CWS required 75¢/ft^2-year for the same period. Two air-cooled CWSs required 90¢/ft^2-year.

A summary report is available from Scott Benson at Lincoln Electric Systems (sbenson@les.lincoln.ne.us).

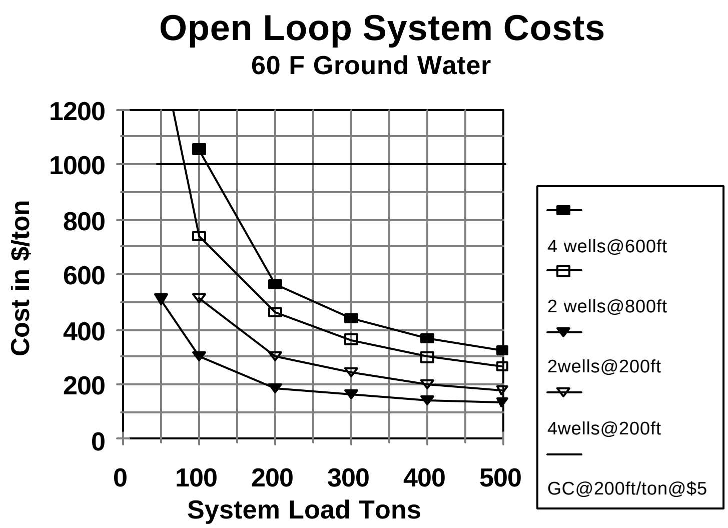
See also, "Adding Up Auxiliary Power Consumption", p. 2.

Open Loop System Capital Costs

The ground-source heat pump industry has expended a great deal of time, effort and attention to the issue of reducing system capital cost. Virtually all of this effort has been directed at closed loop systems. Unfortunately, this strategy overlooks an option that can offer substantial cost savings: the use of open loop design.

Due to the nature of ground loop sizing, closed loop systems do not offer much in the way of economy of scale. Because a fixed amount of bore length is required per ton, the cost of closed loop systems tends to be relatively flat, in terms of cost per ton above 50 tons or so. Open loop systems, on the other hand, do offer economy of scale since the cost of drilling and constructing water wells is not linear with capacity. A well producing 500 gpm may only cost twice that of a 100-gpm well.

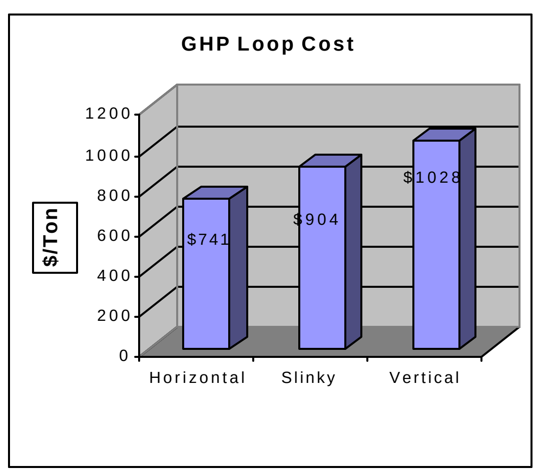
Figure 1 presents a comparison of the cost of the ground-source portion (outside the building) of systems from 50 to 500 tons for a variety of well depths and configurations. For comparison, a plot of ground-coupled system at 200 ft/ton and $5/ft (including bore holes, loops, and headers) is shown for comparison. The costs included for the open loop system are production and injection wells, well tests, pumps, piping to building, heat exchangers, controls, and 15% contingency.



It is apparent that even with relatively deep (600 to 800 ft) wells and the use of two production and two injection wells per system, that open loop design can be quite competitive with closed loop down to approximately 100 tons. With shallow (£ 200 ft) groundwater, open loop offers substantially lower capital costs down to 50 tons.

Cost Containment For GSHPs Report

A report of a cost survey and analysis that was sponsored by TVA and conducted by the University of Alabama is available from the Geo-Heat Center (541-885-1750). The report is base on a national survey with almost 300 responses. Although the focus was residential, the survey provides some information on loop and equipment costs.



Letters, Comments, Questions, & Suggestions

Pea Gravel Backfill in Caverns & Fractures

I am interested in knowing your opinion about the strengths and weaknesses of using 3/8-inch pea gravel as a filler around ground loops. The strengths I have heard are that it does not bridge, will not disappear into fractures, and is inexpensive. The weaknesses I can think of are: that it does not make good contact with the loop for heat exchange and that it may eventually cut a thermally expanding loop.

If water levels are currently high, the heat exchange issue is not as important, but who can guarantee the water will remain high? The strengths appear to be short term for the driller, not necessarily long-term strengths for the building owners.

Signed,
A Somber Cleveland Indian Fan

Dear Somber Fan,

A possible disadvantage of this approach is that it may not be permitted in some locations. Review your local and state codes. However, you have identified the advantages and disadvantages of pea gravel. You can mitigate the negatives by:

1. *Gather historical data on local groundwater static levels in the area. Your **state geological survey** is probably very concerned about water levels (for other reasons) and can be a big source of information.*
2. *Do not backfill above the lowest expected static water level with pea gravel.*
3. *Backfill above this point with conventional backfill or thermally-enhanced grout. Use grout at the top of the bore that complies with state and local codes. Access to a comprehensive state-by-state listing of codes is available to EPRI members and through the Geothermal Heat Pump Consortium (1-888-ALL-4GEO or www.ghpc.org).*
4. *Use smooth pea gravel and thick-wall pipe to minimize the possibility of damage. This should be 1-1/4" or 1-1/2" High Density PE, SDR 11 pipe or 1", SDR 9 for U-tubes. SDR 9 will have some thermal penalty, which must be accounted for in your design procedure.*
5. *You also need to have the loop contractor provide some means of verifying that the gravel does not bridge.*

Iron Bacteria

For the past 16 years, we have had a groundwater (open loop) heat pump system serving our home/office. The well, which also serves the domestic needs, has had some problems over the years with what the driller calls "iron bacteria." From time to time, the capacity of the well drops off. When this happens, we pour a gallon of bleach down the well and let it sit for a few hours. This usually solves the problem. Lately, we have had to do this more often. Is there a more effective way to address this problem?

Signed,
Plugged Up in Portland

Dear Plugged Up in Portland,

Actually, of the many ways to treat iron bacteria (biocides, heat, UV and disinfectant), the use of a disinfectant, usually chlorine, is the most common. For chlorine to be effective, however, it must be properly applied. The issues of importance are: dosage, residual concentration, pH, and contact time.

When adding chlorine to water, a portion of the chlorine is consumed in the oxidation of organic material. The chlorine left is referred to as "residual." Most references suggest a residual chlorine content of 200 - 500 ppm, for a contact time of 24 hours for iron bacteria treatment. (This is much higher than the 50 - 100 ppm recommended for general well disinfection.) For maximum effectiveness, the pH of the water should be 6.0 or less; however, chlorine can be effective at a pH up to 8.0. Adding acid to lower the pH will improve the effectiveness of the chlorine.

The form in which the chlorine is added influences the quantity required. Commonly available chlorine bleach (Purex, Chlorox) contains about 5% available chlorine in the form of sodium hypochlorite. Calcium hypochlorite powder (HTH) has about 65% available chlorine. A 6-in. well with 75 ft of standing water, assuming a dosage of twice the residual requirement (400 - 1000 ppm), would require 0.8 to 2.2 gallons of liquid bleach or 0.6 to 1.5 lbs of chlorine powder. Both the chlorine concentration and pH should be checked periodically during the treatment to verify that they are within recommended limits. This can be done by briefly operating the pump to gain a water sample.

The effectiveness of this treatment is improved if some surging or swabbing of the well is done. Drillers have tools to accomplish this in an open well. If a pump is installed, a limited amount of surging can be done by intermittently operating the pump and allowing the water in the column to flush back into the well. The surface check valve must be disabled or bypassed to accomplish this.

Additional information can be found in "Iron Bacteria: occurrence, Problems and Control Methods" by Hackett, G.; Lehr, J. H. National Ground Water Association, 1985.

Publications, Information Sources, and Meetings

Publications

ASHRAE (404-636-8400)

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

Commercial Ground-Source Heat Pump Systems, (Collection of Papers), 1996

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

Understanding Vertical Ground Heat Exchangers (Part 1) Symposium Papers (Boston-97-08) – 1997 Annual Meeting

Understanding Vertical Ground Heat Exchangers (Part 2) Symposium Papers (Boston-97-11) – 1997 Annual Meeting

Operating Experiences with Commercial Ground-Source Heat Pumps, 863RP (Research Project Report), 1995

Assessment of Anti-Freeze Solution for Ground-Source Heat Pump Systems, 908RP (Research Project Report), 1996

Geothermal Heat Pump Consortium (888-255-4436)

"Survey and Analysis of Maintenance and Service Costs in Commercial Building Geothermal Systems", 1997

"Investigations of Multiple Callback Situations with Residential GHPs", 1997.

"Analysis and Development of a Design Method for Hybrid GHPs", 1997

"Development of Head Loss Data and Design Tools for GHP Piping", 1997

"Geothermal Heat Pump Systems in Two Pennsylvania Office Buildings", 1997

Geo-Heat Center (541-885-1750)

"A Capital Cost Comparison of Commercial Ground-Source Heat Pump Systems", 1994.

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

"Cost Containment for Ground-Source Heat Pumps", (TVA-Univ. of Alabama), 1995

IGSHPA (800-636-GSHP)

Closed-Loop/Ground Source Heat Pump Systems: Installation Guide, 1988.

Geothermal Heat Pump Systems: Design and Installation Standards, 1994.

National Ground Water Assoc. (614-337-1949)

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

Meetings

1998

Jan. 17-21 -- ASHRAE Winter Annual Meeting, San Francisco Marriot

Jan. 9 – One-Day GSHP Design Seminar for Engineers, Omaha Public Power District /Univ. of Alabama

Jan. 28 – One-Day GSHP Design Seminar for Engineers, Grand Forks, ND, Otter Tail Power /Univ. of Alabama, 800-492-4944, ext. 8389

Jan. 29 – One-Day GSHP Design Seminar for Engineers, Fergus Falls, MN, Otter Tail Power /Univ. of Alabama 800-492-4944, ext. 8389

Jan. 30 – One-Day GSHP Design Seminar for Engineers, Rockford, MN, Otter Tail Power /Univ. of Alabama 800-492-4944, ext. 8389

Feb. 6 -- One-Day GSHP Design Seminar for Engineers South Bend, IN, Ferris State/AEP/Univ. of Alabama 616-592-3051

February 22-24 – Southeastern GeoExchange Conference, Perdido Beach Resort, Orange Beach, AL, Southern Co., Georgia's EMCs, and GHPC, 1-800-634-0154

Mar. 6 -- One-Day GSHP Design Seminar for Engineers Detroit, Ferris State/Univ. of Alabama 616-592-3051

Mar. 20 -- One-Day GSHP Design Seminar for Engineers Davis, CA, Geothermal Energy Association, 916-758-2360

Apr. 1-3 – IGSHPA Architect & Engineer Workshop, Stillwater, OK (Oklahoma State) 800-636-GSHP

Apr. 22-24 – IGSHPA Architect & Engineer Workshop, Stillwater, OK (Oklahoma State) 800-636-GSHP

May 17-20 – IGSHPA Technical Conference & Expo, Stillwater, OK (Oklahoma State) 800-636-GSHP

January 1998 – Volume 1, Number 1 - Published Quarterly

"Outside the Loop" is supported by a grant from the Geothermal Heat Pump Consortium to the Southern Company, Alabama Power and the University of Alabama.

Please let us know if:

- ***There is a type of information you need.***
- ***We have omitted your firm's name from a list.***
- ***You would like to disagree with our information.***
- ***You would like to add to our information.***
- ***You have a pearl of GHP wisdom to share.***
- ***You would like us to mail this publication to you or someone else.***
- ***You would like to write an article.***
- ***You have an announcement, meeting or publication to share.***
- ***You have a humorous GHP story.***
- ***You have verifiable cost data you want to share.***
- ***You just want to complain and your wife, husband, or significant other won't listen.***

We hope to continue this publication and modify our approach to meet the needs of the GHP community. We are convinced this technology is good for building owners and the environment when properly designed and installed. However, we have a great challenge before us to be able to establish a GHP infrastructure in areas where none exists, so that installation costs are reasonable and quality is high.

Send information or requests to:

"Outside the Loop"
University of Alabama, ME Department
Box 870276
Tuscaloosa, AL 35487-0276
205-348-6419 (Fax) – Please limit to four pages
skavanaugh@coe.eng.ua.edu

Outside the Loop

A Newsletter for Geothermal Heat Pump Designers and Installers

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

- ***Do We Need Another GHP publication?***
- ***Field Test of Grout Conductivity***
- ***Can GHPs Compete with 0.5 kW/ton Chillers?***
- ***Ground Conductivity Testing***
- ***Pump Oversizing***
- ***Hot Loop Fundamentals***
- ***How much Ground Water?***
- ***Publications***
- ***Meetings***

GEOEXCHANGE™