Outside the Loop

A Newsletter for Geothermal Heat Pump Designers and Installers

Summer 1998 - Volume 1, Number 3 - Published Quarterly

Loop Contractors – Unsung Heroes Reach 11,000 GSHP Bores in Austin

In 1984 the Austin Independent School District (AISD) installed a ground source heat pump system consisting of 40 vertical bores in Menchaca Elementary School. Sixty-eight schools are now heated and cooled with GSHPs. GSHPs are also in ten schools in the nearby Leander ISD, three Austin Community College campuses, and two recreation centers. The total number of bores has reached 11,000, which represents about the same number of tons.

Austin, Texas – 11,000 GSHP Bores and Counting

Austin is not an ideal location for GSHPs. The ground is warm and dry, so required bores can exceed 250 ft. per ton. Hard rock, caverns, and unstable formations have been encountered. The electric utility did little to promote GSHPs.

Bob Lawson of the AISD was the GSHP crusader, but much of the credit also goes to a trio of loop contractors (Loop Tech International, Ball Drilling, and Johnson Drilling) that have installed the bulk of the loops. Ralph Cadwallader of Loop Tech did over half the jobs during the first 10 years and laid down a formula of success. Ball and Johnson followed around 1990. (Johnson has recently moved operations to Dallas.) **They have learned how to install successful systems with or without the assistance of a design engineer.** Some of the most satisfactory systems are very simple (a single loop connected to a console unit with a timer and thermostat).

One reason AISD has continued to use GSHPs is because of the low maintenance. However, Cadwallader and competitor Lonnie Ball, have expended their own resources to maintain quality. When hot loop problems arose with some larger systems, they had things investigated. They were able to point out that 10 ft. bore spacing in a grid pattern and low

See GSHPs and Austin Schools, Page 4

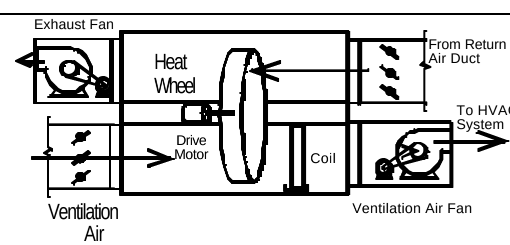
GSHPs and Outdoor Air

The current state of affairs with regard to dealing with outdoor ventilation air may cause design engineers to avoid using ground source heat pumps. We have heard engineers express concerns about outdoor air system complications introduced by having a large number of heat pumps located throughout a large building. The implication is that it is much easier to introduce a fixed amount of ventilation air at one location of a central air distribution system.

An article appearing in the June 1996 ASHRAE Journal (Indoor Air Quality: A Design Parameter by William J. Coad), suggests the use of a separate ventilation air distribution system. Although this system requires additional ductwork, the author feels it is a better alternative to the complex control system necessary to maintain constant ventilation airflow in a variable air volume (VAV) system. The author compares the current control "fixes" to the mythological monster, Hydra. As Hercules would cut off one of the heads of the 9-headed serpent, two would replace it. He suggests that a control "fix" may create two problems that also need a " fix". For a GSHP, his alternative would be no more complicated, costly, or problematic than the outdoor air system for a VAV.

The debate continues to rage over the proper amounts of ventilation air and the ability of outdoor air to "insure" good indoor air quality. It does not appear that resolution is near. Many designers will likely deliver higher amounts of outdoor air to protect occupants from health risks and themselves from litigation. These high outdoor airflow rates make minimization of energy consumption very important.

The Geothermal Heat Pump Consortium has recognized the magnitude of the problem and has provided funding to study outdoor air handling methods to the University of Alabama. A survey of engineers is being conducted and results will be presented in the next Outside the Loop. Demand and energy use of pre-heating and cooling equipment is being evaluated.



Heat Recovery Unit (Wheel Type)

You may want to check annual fan energy use and part load performance before specifying one of these. See page 3.

Design Issues and Tools

Expansion Tanks for Polyethylene Piping Loops

Tried and true expansion tank sizing methods must be adjusted to account for the higher coefficient of expansion of high-density polyethylene (HDPE). Phillips Driscopipe lists the coefficient of expansion for ASTM-PE3408 as 1.2×10^{-4} in/in-°F. The coefficient for steel is 6.5×10^{-6} in/in-°F according to the ASHRAE Systems Handbook (1996, p. 12.4). The recommended diaphragm tank volume (V_t) is,

$$V_t = V_s \frac{[(\upsilon_2/\upsilon_1)-1]-3\alpha\,(t_2-t_1)}{1-(P_1/P_2)}$$

where
- t_1 - minimum loop temperature (°F)
- t_2 - maximum loop temperature (°F)
- υ_1 - specific volume of water @ t_1 (ft^3/lb)
- υ_2 - specific volume of water @ t_2 (ft^3/lb)
- P_1 - pressure @ t_1 (psia)
- P_2 - pressure @ t_2 (psia)
- α - coefficient of linear expansion (in./in.-°F)
- V_s - Volume of piping loop (gal.)

The $[\nu_2/\nu_1 - 1]$ term represents the relative change of volume of water and the $3\alpha(t_2 - t_1)$ term is the change in volume of the pipe itself. The $[1-(P_2/P_1)]$ term represents a correction for the allowable pressure changes in the tank. The high expansion coefficient for HDPE results in the volume change in the pipe being greater than the volume change of the water. Thus the equation would produce to a negative tank volume.

This actually means the tank pressure drops when the loop gets warmer (the water expands but not as much as the pipe). If a HDPE piping loop has been adequately purged of air, maximum pressure will occur at minimum temperature. If there is air in the piping loop, it will counteract this effect since it will expand with rising temperature.

Our opinion is that the above equation is valid. P_1 is indeed the pressure at the minimum temperature. However, it is now the maximum desired pressure rather than the minimum. The minimum pressure would occur at t_2. The denominator in the equation is also negative for HDPE pipe networks, so the required tank size is positive.

Check it out based on a 1130 gallon HDPE loop set to have minimum pressure of 10 psig (24.7 psia) and a maximum of 50 psig (64.7 psia). The ground loop temperature swings from 45° to 95°F. The ASHRAE Fundamentals Handbook (1997, pp. 6.8-6.9) gives υ_1 as 0.01602 and υ_1 0.01612 ft^3/lb.

$$V_t = \frac{1130\left[\frac{0.01612}{0.01602}-1\right]-3\times1.2\times10^{-4}\times(95-45°F)}{1-(64.7\ psia/24.7\ psia)}$$

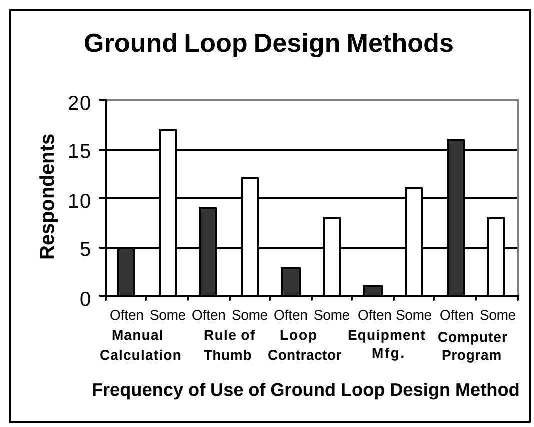
V_t = 8.2 gallons

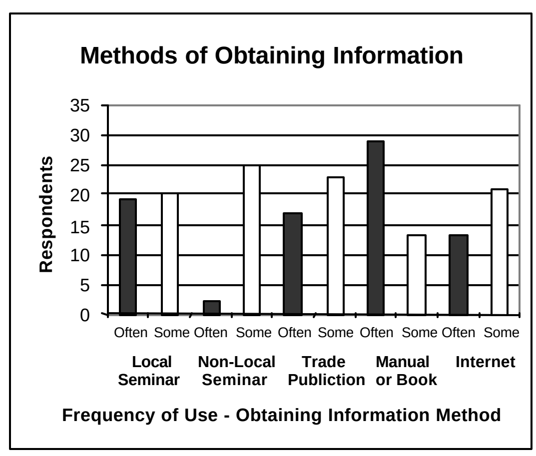
If the ground loop is HDPE and the interior pipe is steel, it appears they would counteract each other to reduce the tank size compared to a loop with only one type of pipe. Three terms would appear in the numerator of the equation. A $[-3\alpha(t_2 - t_1)]$ term for HDPE is multiplied by the volume of liquid in the HDPE piping, a similar term would appear for the steel piping, and the $[(\upsilon_2/\upsilon_1) - 1]$ term would be multiplied by the total volume.

The impact of U-tube grouting materials may also play a role in reducing required tank size. Loose, unsaturated backfill materials will not limit pipe expansion like a cement-based grout. **Please send us your thoughts or experience on the matter, so the expansion tank with HDPE piping issue can be resolved with simple and field-tested procedures.**

Design Methods Survey

As part of the GHPC sponsored program to improve design tools and GSHP education, a survey was conducted to determine needs, current design methods, and preferences for continuing education. Some results are shown in the figures below. Engineers favor computer programs or rules of thumb for ground loop design, while preferring to gather new information from books, manuals, or local seminars.





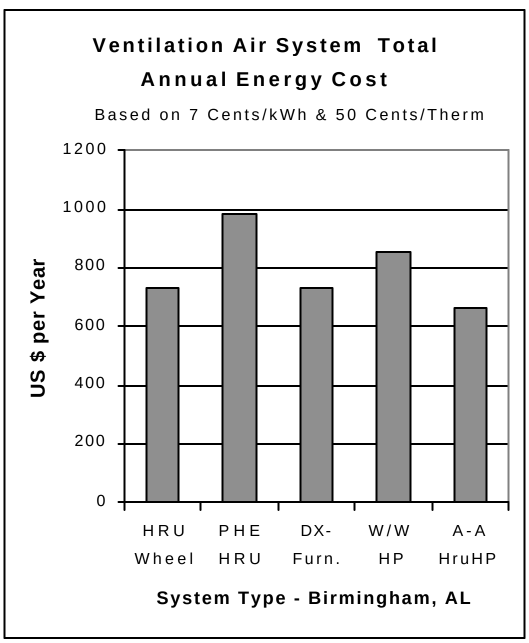
Fundamentals: Mother Nature Can Be a Wonderful Partner

(But she can also be a real hard to live with if you ignore her.)

Heating and Cooling Outdoor Air

Proper handling of large amounts of outdoor ventilation air can be costly. Improper handling of large amounts of outdoor ventilation air can be even more costly. There are a variety of equipment options available to condition (heat, cool, humidify, or dehumidify) ventilation air. Decisions are often based on the performance at extreme or design conditions. However, part-load or seasonal performance is equally important since so many hours of operation occur when the outdoor conditions are mild.

The figure below demonstrates the results of an energy analysis of outdoor air treatment systems. Bin weather data is available in a format that permits psychrometric analysis of cooling and heating coils and energy (or heat) recovery equipment. The bin method was used to compare five outdoor air equipment options for a 4-story office building in Birmingham, AL with a 40 hour per week occupancy and a 4000-cfm outdoor air rate. The lowest seasonal energy consumption was with an air-to-air heat recovery heat pump followed by a conventional DX cooling/furnace unit, a heat recovery wheel, a water-to-water heat pump, and a plate heat exchanger heat recovery unit. A "free cooling" economizer was a valuable addition with all five systems.



The heat recovery units saved energy during extreme outdoor conditions. However, these savings were offset by much higher fan energy use compared to conventional equipment. Since HRU performance is dependent upon outdoor-exhaust air temperature and humidity difference, they are ineffective during the many hours when outdoor air temperature and humidity levels are near indoor conditions. It is recommended that this type of analysis be conducted before specifying outdoor pre-conditioning equipment.

Heat Pump Ratings – Be Advised

An Air Source Heat Pump with a SEER of 18.
A Ground Source Heat Pump with an EER of 22.
A 2.3 liter, 4-cylinder, '89 Ford Ranger that can go 130 mph.

What do they have in common? The conditions under which they achieved the stated level of performance are not necessarily the conditions under which they would normally operate. The Ford Ranger can achieve 130 mph while going down a 15° incline with a large tail wind.

The conditions used to achieve SEER and EER are not as advantageous, but they can be used to inflate the performance of ordinary machines. The procedures for calculating SEER are far more complex than necessary (in this author's opinion). This complexity presents many opportunities for loopholes, which include:

Air entering the indoor cooling coil is 80°F. The bin weather data used to generate two-speed heat pump SEER is mild with 2/3rds of the hours at temperatures below 80°F (ARI Standard 210/240, Table A6.1.2). So the outdoor coil is in cooler air than the indoor coil for a majority of the time.

The external static pressure (ESP) of the unit (with clean filters) must only be 0.1" of water (0 to 28 MBtuh units), 0.15" (29 to 42 MBtuh units), or 0.20" (43 to 70 MBtuh). See Table 6, ARI 210/240. Fan motors that unload under low static (like brushless DC motors) typically draw 40 to 50% less power than they would under more realistic ESP.

Two-speed units can be rated with the compressor in low speed and the fan in high. The indoor coil might operate at a high temperature (60°F+), since it is sized for the high-speed compressor capacity. The result will be high efficiency but no dehumidification. The SEER will decline if the fan speed were lowered enough for the coil to remove moisture.

The 22 EER GSHP uses some of the same loopholes (low ESP, coil-to-compressor mismatch). However, the ARI Directory of Certified Applied AC Products does list both the low and high-speed EERs for GSHPs.

Suggestions:

1. Check EER or SEER of the equipment when the airflow is 400 cfm per ton or less or the SHR is 0.75 or less.
2. Check the EER of the equipment at design conditions (~400 cfm/ton and 95 to 100°F outdoor air for air source or 85 to 90°F entering water for ground source).
3. If a brushless DC fan motor is used, about 200 watts per 1000 cfm above the rated value will be required for an ESP of 0.5" of water (350 watts/1000 cfm for 1.0" ESP).
4. Compare the high and low-speed EERs for 2-speed GSHPs.
5. Don't drive a little truck down a steep hill in a tornado.

Products, Services, and Installation Innovations

GSHPs & Austin Schools (Continued)

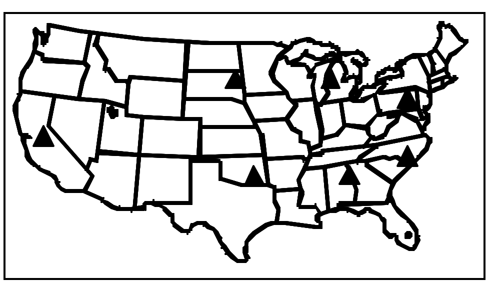
efficiency heat pumps were likely culprits. Larger bore spacing is now required. When experts suggested the hot loops could be solved with a cement-bentonite grout and better conductivity testing. Ball participated in a test to insure the AISD did not invest in an unnecessary expense.

Loop contractors are often blamed for high system cost. You can be the judge if the loop contractors are the problem in Austin. GSHPs with classroom console units (no ductwork or ventilation air) were averaging $3000 per ton ($9000 for a three-ton system). The contractors were charging about $5 per ft. or $3600 for a complete three-ton ground loop connected to the unit. A three-ton water-to-air heat pump, a 1/6 hp circulator pump, a thermostat, 3-way valves, setting the unit, and wiring cost $5400. It looks like there might be more room for profit above the ground than below it.

Regional Heat Pump Training Centers

There are six regional geothermal heat pump training centers located throughout the USA to complement the training facilities at International Ground Source Heat Pump Association (IGSHPA). While these centers have concentrated on residential installation skills and sizing methods, several of them are branching out into engineer training, marketing training, and other forms of assistance and support. Contact:

Advanced Energy Corp., Raleigh, NC, 919-857-9000
Alabama Power HPTC, Verbena, AL, 800-634-1054
IGSHPA, Stillwater, OK, 800-626-4747
Keystone Training Center, Johnstown, PA 814-269-3874
Midwest Resource Center, Big Rapids, MI, 616-592-3051
Northern Support Center, Brookings, SD, 605-688-6400
Western HP Training Center, Davis, CA, 916-750-0135



IGSPHA & Regional Training Center Locations

EnLink Geoenergy Developing Novel Rig

Most vertical loop contractors use conventional drilling rigs adapted to GSHP installation. However, the possibility of developing a novel rig for easing the rigor of vertical ground exchanger installation has attracted driller Tom Amerman of Houston. He has developed, field tested, and is making final modifications to a prototype rig to reduce GSHP costs. The rig is track-mounted and uses a continuous reel drill, unlike conventional rigs with drill stem sections. The operator is able to drill for the full depth of the bore without having to stop to insert (or remove) each joint. The rig also bores a 3-inch hole, which requires less grout and reduces associated thermal penalty. The machine can drill at a 30° angle and has a system for recirculating drilling fluids and recovering cuttings. Contact Tom @ 281-398-6715 for information.

Commercial Building GCHP Loop Contractors

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

A&E Drilling Services, Greenville, SC 864-288-1986
Ball Drilling, Austin TX, 512-345-5870
Bergerson-Caswell, Maple Plain, MN 612-479-3121
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
Hammett & Hammett, Andalusia, AL, 334-222-3562
Johnson Drilling Co., Dallas, TX 972-924-2560
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 GSHP Firms & Organizations

Central Texas College, Air-Conditioning & Refrigeration
John Brewer, Department Chair, is not afraid to emphasize geothermal heat pump installation and service. His thorough coverage of loops and equipment includes a heavy dose of "hands on" learning. The placement rate for his graduates is 100%. John has built his program with generous assistance from Ralph Cadwallader (Loop Tech Int'l.) and Charles Davis. Phillips Driscopipe, Trane, WaterFurnace, FHP, and Vanguard Plastics have (and continue to) provide equipment and supplies. John has also been involved with Sandia Labs in a research project at nearby Fort Hood.

Virginia Energy Services (804-358-2000) is an energy services company (ESCO) with a Geothermal Division. VES designs and installs GHPs for residential and commercial applications. The Geothermal Division has invested in GHP installation equipment and has worked jobs ranging from 3 to 400 tons. David Ames, Vice-President, is the guy at VES to talk to about GHPs.

A Few Thoughts on Plate Heat Exchangers

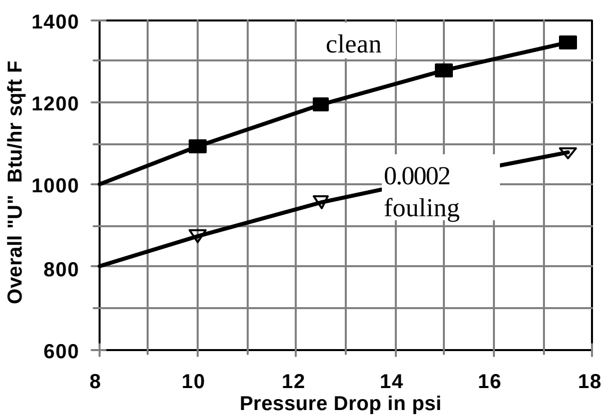
Plate heat exchangers (PHEs) are often used in large commercial ground water heat pump (GWHP) systems to isolate the building loop from the ground water. Although final selection is made by the vendors using proprietary software, it is useful to review some general rules for materials, design and cost.

Suitable materials for most GWHP applications include 304 SS plates and medium nitrile (NBR or Buna N) gaskets. For waters with elevated chloride (Cl) content 316 SS plates should be used above 200 ppm Cl and Titanium above 400 ppm Cl.

Two often misunderstood issues regarding PHEs are fouling and the connection between pressure drop and performance. Fouling is treated much differently in PHEs than in other types of exchangers. PHEs are somewhat self-cleaning due to the turbulence induced by the plate patterns. More importantly they are easily disassembled for cleaning. For these reasons, it is not necessary to design a PHE to operate in a heavily fouled condition. Due to the very high performance of PHEs, the use of fouling factors intended for shell and tube units can result in 100% or more excess surface area in a PHE application. Total fouling for a PHE should not exceed 0.0001 to 0.0002 hr-ft^2-^{o}F/Btu in most GWHP applications. For a nominal clean U-value of 1000 Btu/hr-ft^2-^{o}F, this results in a 10 to 20% excess surface area.

PHE pressure drop is directly related to the overall U-value as indicated in Figure 1. Specifying a lower pressure drop results in a lower U-value and the need for greater surface area to accomplish the same heat transfer duty. This results in a trade-off between operating cost (lower pressure drop, lower pumping energy) and capital cost (lower U value, greater surface area, higher cost). For GWHP systems it is advisable to keep the pressure drop on the building side (normally the higher flow side) to 10 psi or less. This will typically result in an overall U value in the range of 900 to 1000 Btu/hr ft^{2o}F

Figure 1
Plate Heat Exchanger Performance



As discussed in Vol. 1, No. 1 of this newsletter, the nature of GWHP systems is such that optimum design often occurs at ground water flow rates which are far less than the building loop flow rate. This situation results in the approach (or minimum temperature difference) between the ground water and building loop flows occurring at the building loop entering/ground water leaving end of the exchanger. The question is how close this approach can be for an economical selection. The answer is that it should certainly be <5^{o}F and probably closer to 3^{o}F. An example is an effective way to demonstrate this. Consider a 300-ton block load system with 62^{o}F ground water and a building loop flow at 3 gpm/ton (900 gpm). Table 1 provides several selections for heat exchangers, which could meet this application. All selections were based on the ground water entering at 62^{o}F and leaving at 86^{o}F which was a result of the performance of the production well (375 gpm).

TABLE 1

HEX EWT ^{o}F	HEX LWT ^{o}F	Bldg. ΔP psi	U-value Btu/h-ft^2-F	Area ft^2	Cost $	Sys. EER Btu/whr
95	85	12.2	1029	264	4800	15.7
91	81	15.1	1151	369	5660	16.2
89	79	12.0	1096	503	7100	16.7
95	85	7.1	729	410	6000	15.9
91	81	7.0	909	468	6700	16.6
89	79	7.0	923	598	7670	17.0

In the first selection the loop return temperature is 95^{o}F. Since the ground water leaving temperature is 86^{o}F this results in an approach of 9^{o}F. The third selection reduces the approach to 3^{o}F and this results in a cost increase of $2300. The system EER increase of a full point (15.7 to 16.7) however would result in a simple payback on the additional cost of <2 yrs at 1500 hrs per year and 0.08 $/kWh. Similarly the second three selections demonstrate the cost effectiveness of a lower pressure drop selection. To achieve the same 3^{o}F approach at the 7.0 psi drop a larger exchanger is required. This adds $570 to the cost. Reduced pumping in this application would repay this added cost in approximately 1.5 years.

In summary selection of PHEs for GWHP systems should be based upon <10 psi pressure drop, <0.0002 hr ft^2 ^{o}F/Btu total fouling, approximately 3^{o}F approach. In most applications the manufacturer's base materials of 304 SS plates and medium nitrile gaskets will provide acceptable performance.

Letters, Comments, Questions, & Suggestions

Backup Heat Exchanger for Redundant Standby

Our firm is in the process of designing an open loop system for an office building in Washington state. We will be using a plate heat exchanger to isolate the building from the ground water. We are concerned about the issue of heat exchanger maintenance. Specifically, should we specify a two heat exchanger arrangement to allow for service. How often does a heat exchanger need to be serviced and what is the time required to accomplish this task. Is it necessary to require the contractor to provide a complete set of gaskets for servicing the exchanger?

Way Worried in Washington

Dear Way Worried:

Much of the concern about maintenance requirements on open loop or ground water heat pump systems is an artifact of experience in the residential sector. With careful design and attention to water chemistry, maintenance of these systems will not be a burden to the owner.

It should not be necessary to go with a dual exchanger arrangement for an office building application. Unless a facility is a 24-hour/365-day operation which cannot tolerate any downtime, heat exchanger maintenance can be carried out without compromising the comfort of the occupants. Time requirements for cleaning the plates on a heat exchanger vary with the nature of the fouling, whether it is occurring on one or both sides and the size and number of plates in the exchanger. In most cases, the entire job can be accomplished by two workers in less than 8 hours.

There are certain precautions that must be observed in the process of cleaning a plate heat exchanger. Plastic brushes should be used on the plates. If wire brushes are necessary, they should be of the same alloy as the plates. Scratches produced by standard carbon steel brushes can lead to corrosion and failure of stainless plates. It is not necessary to replace the gaskets when reassembling the exchanger. Damage to the gaskets most often results from over-torquing of the tie bolts. The service technicians should be aware of the importance of observing the manufacturer's torque or plate pack dimension limits so as to avoid damage to the gaskets.

It is advisable to have at least one of each type of plate (most exchangers contain at least two types of plates) with the associated gaskets on hand. For plates that use glued gaskets, the spares should have the gaskets glued in place since many glues require an 18 to 24 hour curing time prior to being placed in service.

KR (OLG)

Central Loop vs. Multiple Loops

We have had good success with closed-loop geothermal heat pumps in new motels. The diversity factors and occupancy patterns result in relatively short vertical loops compared to other types of commercial building applications. However, we are having difficulty locating the larger piping headers in the building. What is the possibility of locating these headers in the ground outside the rooms on the first floor and running take-offs to units in the room on the upper floors through the exterior wall?

The "Big Guy" in Poughkeepsie

Dear Big Guy,

This arrangement would eliminate the large headers in the hallways but it raises several other potential pitfalls and does little to lower the piping cost. In addition to the multiple penetrations through the external walls, landscapers are now a potential enemy. Trees and bushes are usually installed after the GHP loop is completed. So greater care is required to protect this more extensive external piping loop near the building.

Let me suggest another alternative that is usually less expensive for buildings with diverse floor plans like motels or schools. This alternative is to take advantage of diversity and occupancy patterns by connecting several heat pumps in an area to a single loop. A small central in-line pump (or a circulator on each unit with a check valve) can be used to deliver flow to the units. The supply and return headers to the exterior loop can be made of 1-1/2" (for up to 8 tons) or 2" (for up to 15 tons) HDPE. This pipe is delivered in rolls and is usually easier to route through the building interior. The ground loop should be located near the area to be served, especially if low-head circulators are used.

Although the total required ground loop length for the motel will be longer compared to a single central loop, the savings resulting from the elimination of the large diameter headers running to remote wings will be significant in buildings with diverse floor plans. You can still take advantage of diversity if you are wise when grouping the heat pumps on a ground loop. For example, try to put an even mix of east- and west-facing rooms together rather than all west-facing rooms. You can also maintain a central loop in the core of motel where laundry, kitchen, conference rooms, pool, and restaurant may have good diversity **and** room for routing the larger headers.

SK (GGS)

Meetings, Publications, and Information Sources

Meetings & Seminars - 1998

Sept. 10-11, General GHP Seminar + One-Day Seminar for Engineers, Chattanooga, TN - TVA, 615-882-2802

Sept. 24-25, General GHP Seminar + One-Day Seminar for Engineers, Nashville, TN - TVA, 615-882-2802

Sept. 30-Oct. 2, Architects & Engineers Workshop, Stillwater, OK, IGSHPA, 800-626-4747

Oct. 2 -- One-Day GHP Design Seminar for Engineers, Sawyerville, NJ – GPU Energy, 732-528-4803

Oct. 9 -- One-Day GHP Design Seminar for Engineers, Reading, PA – GPU Energy, 732-528-4803

Oct. 16 -- One-Day GHP Design Seminar for Engineers, Johnstown, PA – GPU Energy, 732-528-4803

Oct. 30 -- One-Day GHP Design Seminar for Engineers, Colorado Springs – Col. Springs Utilities, 719-668-3738

Nov. 1-4, 1998 GHP Industry Conference, IGSHPA, Pheasant Run Resort, St. Charles, IL, 800-626-4747

Nov. 5-6, General GHP Seminar + One-Day Seminar for Engineers, Huntsville, AL - TVA, 615-882-2802

Nov. 11-12 – Western GeoExchange Heat Pump Conference, Sacramento, CA, Geothermal Energy Assoc., 530-750-0135

Nov. 12-13, General GHP Seminar + One-Day Seminar for Engineers, Knoxville, TN - TVA, 615-882-2802

Dec. 13-16, National Ground Water Association Convention & Expo, Las Vegas, NV, 614-337-1949

Publications

ASHRAE (404-636-8400)

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

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

Design, Operation, and Maintenance of GSHP Systems (Symposium Papers from 1998 Annual Meeting)
Operating Experiences with Commercial GSHP, Part 2
Ground Water Source Application for a Water Park
A Design Method for Hybrid GSHPs
Maintenance & Service Cost of Commercial GSHP Systems

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

Air-Conditioning & Refrigertion Institute (Fax 703-524-9011)

"Directory of Certified Applied Air-Conditioning Products" – Directory contains ratings for GSHP, GWHP, and WSHP products. ARI also publishes Standards 320 (WSHP), 325 (GWHP) & 330 (GSHP) that describe ratings test conditions.

Electric Power Research Institute (510-934-4212)

EPRI has recently released 17 new GSHP publications covering introductory topics, equipment directories, bore hole grout properties and installation guides, soil classification, anti-freeze solutions, and loop installation guides.

Geothermal Heat Pump Consortium (888-255-4436)

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)

Analysis of Existing GeoExchange Installation Data (RP-026)

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

Counting Geoexchange Systems: Issues & Estimates (RP-031)

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 - RESIDENTIAL

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

IGSHPA (800-626-GSHP)

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

GHP Systems: Design and Installation Standards, 1994.

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)

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

Summer 1998 – Volume 1, Number 3 - Published Quarterly

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

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- **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 4).**
- **You have verifiable cost data you want to share.**

Send information and requests to:

Outside the Loop
The University of Alabama, ME Dept.
Box 870276
Tuscaloosa, AL 35487-0276
Fax: 205-348-6419
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Outside the Loop

A Newsletter for Geothermal Heat Pump Designers and Installers

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

GEOEXCHANGE

Let Us Hear From You

We have only heard from a few of the 600 people to whom we send "Outside the Loop". We hope you are reading it and getting some benefits. We have tried to concentrate on important issues that may not be discussed in other publications. We appreciate the positive comments several (but not too many) people have expressed. We even added more pictures to this issue because of a comment made by an engineer-turned-salesman from Pennsylvania. (We also appreciate his humor but can't print it.)

However, more of your contributions and feedback would be helpful in better meeting the needs of the growing ground source (a.k.a. geothermal or GeoExchange) heat pump industry. Please look over the list of requests appearing in the column to the left to see if there is something you can share with us. Too often we hear about problems rather than successes and too often we learn about a good solution a little too late.

Let's hear from you.