Drilling for Energy on the North Dakota Capitol Grounds

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This spring construction began on the well field for the 200-ton ground source heat pump (GSHP) system* that will heat and cool the 100,000-square-foot Heritage Center addition in Bismarck. Anyone using the east entrance to the capitol complex or passing by on State Street during April and the early part of May will probably have noticed the three truck-mounted drill rigs brought in for this purpose (fig. 1).

Located just southeast of the new building, the system's well field occupies an area about the size of 1.5 football fields (minus the end zones). It consists of a rectangular array of 170 vertical boreholes spaced at 20-foot intervals and drilled to a depth of 250 feet. The field is divided into five discrete closed circuits of thirty-four ground loops, each (circuit) with its own supply and return lines that connect it to headers inside the building (figs. 2 and 3). This is a much more practical and cost-effective arrangement for large well fields than a single, closed path. The headers will eventually be hooked up to a bank of ten heat pumps that will serve the entire new addition, providing all the heating, cooling, and humidity control it needs with an efficiency unmatched by any of its fuel-based HVAC contemporaries.

There is a lot more to constructing a well field for a GSHP system than drilling holes. Once that part of the operation is out of the way, there is the business of connecting the ground loops to the fluid supply and return lines (a process called "headering up"), which involves the excavation of some large trenches and the laying out of several hundred feet of header pipe (fig. 4). All the pipe joints – header to header, header to ground loop – are thermally fused. There are various ways to do this (fig. 5) but the end result is always the same: a joint that is corrosion resistant (it's all plastic) and stronger than the pipe itself.

Figure 1. Three truck-mounted drill rigs were used to construct the well field for the 100,000-square-foot addition to the Heritage Center. The truck in the foreground has its drill mast lowered while the crew maneuvers a loop reel into place. The reel holds a ground loop assembly, consisting of a prefabricated U-bend fused to two lengths of HDPE piping. After it is inserted into the borehole, the loop will be grouted in-place with a specially formulated thermally-enhanced grout. Later on, the individual ground loops will be connected into five separate closed circuits via headers buried about 6 feet below the ground surface (see figs. 4-7). Each circuit will have its own supply and return lines to and from the interior part of the geothermal system. The gray mounds to the right of the truck are drill cuttings piles. (Photo by Brian Austin, SHSND)

* This is the term favored by the International Ground Source Heat Pump Association (IGSHPA).

Figure 2. Header arrangement inside the building. This is where the supply and return lines to and from the well field come together. Although it is difficult to see in this picture, there are two separate headers (the large horizontal pipes) – one for supply, the other for return. Each pair of lines is connected to the headers by shut-off valves (the blue-and-red objects) that will allow isolation of the individual well field circuits for finer control of the building's climate and for maintenance. (Photo by Brian Austin, SHSND)

Figure 3. The same headers viewed from below. The supply and return lines for the well field are clearly visible where they cross the ceiling and extend down the wall on the right. They run the full height of the building and exit through the ground-level floor. This rather lengthy up-and-over pathway is a consequence of the building's interior layout. It is not a requisite of the of the GSHP system. (Photo by Brian Austin, SHSND)

Figure 4. The two pipes running parallel to the trench wall are the supply and return headers. Fluid from the heat pumps travels along one and is delivered to every ground loop in the circuit (the pairs of small-diameter pipe sticking out of the ground) then returns to the heat pumps via the second header. Note that all the ground loops are connected to both. And your eyes are not playing tricks on you: the header pipes really are different sizes. It is a way of ensuring that the required fluid flow rates are maintained throughout the closed circuit without compromising the overall efficiency of the GSHP system. The building in the background is the State Water Commission.

Before the trenches are backfilled, each closed loop circuit is flushed with water to wash out any debris and purge it of air. Then it is checked for leaks, blocked lines, and other errors; and finally pressure tested. To prevent their collapse during backfilling, the circuits are pressurized with water or air. The location of the buried piping is marked with detectable warning tape, which is placed about a foot below the surface (18 inches below grade) as the trenches are backfilled (fig. 6).

When it is finished (fig. 7), the well field will be covered by a parking lot and to many, simply vanish out of sight and out of mind. When the Heritage Center addition opens to the public, visitors will park their cars oblivious to what is going on underfoot. They may remark on the building's visual appeal but fail to notice the complete absence of exhaust vents, ductwork, refrigeration lines, coils, condensers, wiring, steam, noise, and all the other manifestations of a conventional space conditioning system. Which is as it should be, because GSHP systems are designed to be neither seen nor heard.

Figure 5. In the field, all plastic pipe joints are thermally fused. Originally developed for connecting HDPE gas lines, heat fusion is a process in which two melted pipe surfaces are brought together and held in-place under gentle pressure until resolidification is complete. As it cools, the molten plastic from each surface fuses into a homogeneous mass, effectively creating a seamless joint whose thicker walls make it not only stronger than the rest of the pipe, but virtually leak-free as well. Two methods of heat fusion commonly used for headering up are butt fusion and socket fusion. Butt fusion is a form of plastic welding: the technology responsible for much of that seemingly ubiquitous and infuriatingly hard-to-open plastic packaging we all know so well. Butt-fused joints are formed between two pipe ends and are commonly used on main header lines (a). A variation of this procedure called saddle (or sidewall) fusion is used to join concave and convex surfaces, such as an adapter fitting to the side of a pipe (b). Most header pipes arrive from the manufacturer with the saddle fusion joints already in-place. Socket fusion is used to connect small-diameter pipe (ground loops, for example) to socket fittings (c).

← **Figure 6.** Backfilling a header trench. Bright blue detectable warning tape installed 18 inches below grade marks the location of the buried pipe.

↓ **Figure 7.** The completed well field, smoothed and leveled, against a backdrop of the Heritage Center addition's main entrance (behind the dumpster) and Governors Gallery (right). The surface will eventually be paved and made into a parking lot and loading area.