

GEOHERMAL HEAT PUMPS IN PIERRE

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There are two municipal connected heat pumps in Pierre, South Dakota. They are South Dakota Discovery Center and Pierre City Hall (Figures 1 and 2). Both systems now utilize plate heat exchanger between the city water loop and the building loop. In-coming water is pumped to a pressure of

110 to 120 psi (760 to 830 kPa) in order to reenter into the city water main. The water then passes through a plate-type of heat exchanger, 1 to 3°F (1 to 2°C), is removed or injected into the water (Figures 3 and 4). This heat removal or injection is due to if the building is in a heating or cooling mode.

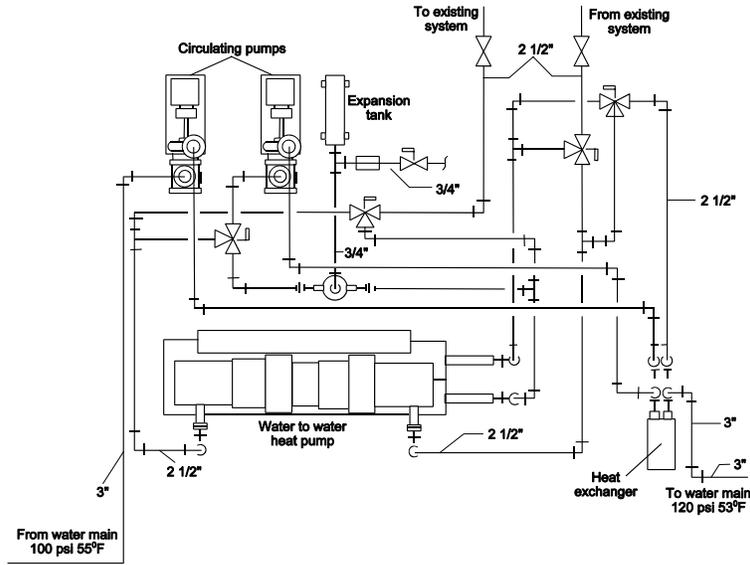


Figure 1. Schematic of City Hall heat pump system.

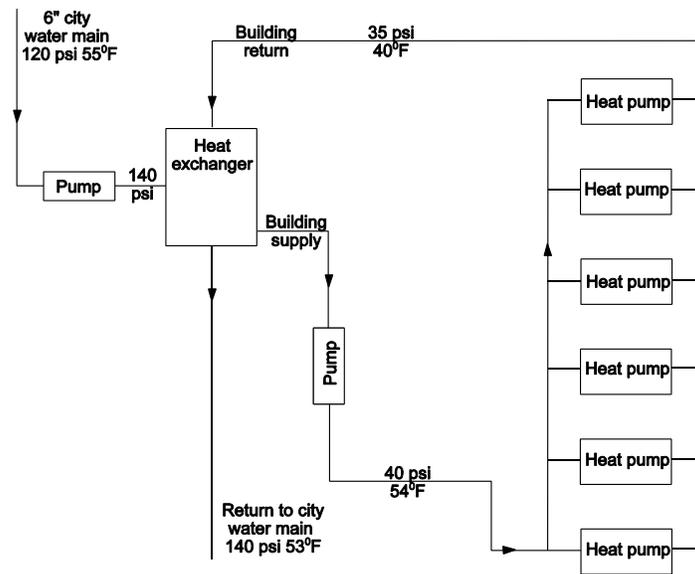


Figure 2. Schematic of Discovery Center heat pump system.

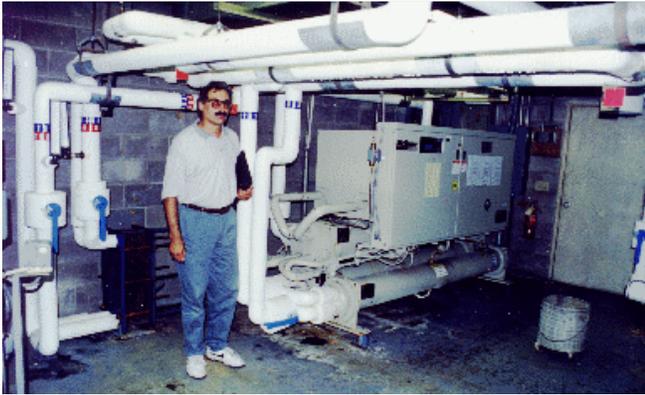


Figure 3. City Hall geothermal heat pump.



Figure 4. Plate heat exchanger in basement of Discovery Center.

The building water loop is operated at a much lower pressure typically 20 to 30 psi (140 to 210 kPa). This water flows through the heat exchanger and then to the heat pumps where conditioned room is heated or cooled. The building water loop temperature leaving the heat exchange is typically 53 to 57°F (12 to 14°C). As the heat pump removes or rejects heat, the building water loop temperature will decrease or increase by 10°F (5.6°C) before it returns to the heat exchanger.

The South Dakota Discovery Center and Aquarium is located adjacent to the Missouri River in Pierre. Built in 1932 as a WPA project, the building was first used for electric power generation. Because of the 6 diesel-powered electric generators housed in the building, it was designed to lose heat.

The facility is made up three levels with a total building volume of 360,000 ft³ (10,200 m³). The basement, approximately 9000 ft² (836 m²), is currently used for storage and classrooms. Exhibit space occupies the second level of the building, also covering approximately 9000 ft² (836 m²). A mezzanine makes up the third level covering 2000 ft² (186 m²).

Built of masonry construction, the facility has no insulation in the sidewalls. The roof is built to an R-21 value. New double-glazed windows make up 30% of the building surface area. Pierre has a design temperature of -15°F (-26°C), and the building has a design heat loss of 1.5 million Btu (1.6 GJ) per hour.

In the spring of 1989, officials from the city of Pierre decided to utilize the building as a science and technology

center. At that time, the building was being used as a city shop and garage. Heated with a hot water boiler fired by Number 2 fuel oil, annual heating costs were in excess of \$20,000 based on 50 cents per gallon (13cents/L) fuel oil. City officials wanted to improve the energy efficiency of the building without changing the historical features. These restrictions would not allow for removing any glass from the walls nor changing the appearance of the building. Adding insulation to the side walls was not possible.



Figure 5. Discovery Center building.

After reviewing the various options available, a system was selected using the city municipal water supply as a heating and cooling source. The water-to-air heat pump system selected has the following characteristics:

- Five 25-ton (87.5 kW) water-to-air heat pumps connected by a parallel piping system.
- Water is delivered to the building by a 6-in. (15-cm) water main at 100 pounds per square inch (689 kPa). Two 100-gallon (6.3 L/s) pumps then increase the water pressure up to 150 pounds per square inch (1034 kPa). This increase in pressure is needed to overcome piping and heat exchanger resistance. Higher pressure also insures that the water cannot be contaminated by the lower pressure refrigerant.
- Water is piped around the building in 2-in. (5-cm) copper pipes with a mechanical balance valve maintaining proper flow through the heat pump and heat exchanger. The water is supplied at a constant flow and consistent temperature of 58°F (14°C).
- When heating or cooling, a compressor starts and the air circulation fan moves the air around the building.
- The water changes only 1°F (0.6°C), plus or minus, as it moves through the system.
- The water is now returned to the city water main for reuse.

Total annual energy usage for the building has been approximately 66,000 Btu per ft² (975 MPa/m²) or \$0.88 per ft² (\$9.47/m²). This demonstrated that water-to-air heat pumps can provide a viable heating/cooling source for buildings where traditional energy conservation techniques cannot be used.