RESIDENTIAL DOWNHOLE HEAT EXCHANGER KLAMATH FALLS, OREGON

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Well with three DHEs, a single 2-in. (5-cm) pipe used for space heating and two 3/4-in. (2-cm) pipes used for domestic hot water.

LOCATION

Klamath Falls, Oregon is located on the western edge of the Basin and Range physiographic province on the east flank of the Cascades approximately 30 miles north of the California border. It is located in a graben structure about 10 miles wide flanked by horst blocks rising over a 1,500 feet with steeply dipping normal faults trending in a northwest-southeast direction. Upper Klamath Lake, a shallow body of water about 35 miles long, dominates the graben.

RESOURCE

Geothermal wells and springs are widespread in the Klamath Falls area. The springs were prevalent over 100 years ago and were used by the Indians and early European settlers. However, due to pumping from wells, all of the springs no longer flow on the surface. Today more than 500 hot water wells have been drilled in the area, most of which are located along the eastern edge of the graben taping into the upflow zones along the fault system. Hot water, heated at depth, migrates up along these fracture zones and then flows southwesterly in permeable zones of volcanic cinders and fractured lava flows. Wells were drilled in the area, starting around 1930, to provide space heating for local residences using downhole heat exchangers (DHE). These DHEs consist of a closed loop of pipe in the well with city water in them extracting heat from the well water. The DHE conserve the resource by extracting only heat from the well water, and can provide space heating and domestic hot water to individual homes, several homes or even schools and businesses in the area. A typical residential well can provide up to about 250,000 Btu/hr (0.1 MWt) of energy, and installations with multiple DHE, such as for schools, provide about 10 times this amount of energy. Well depths in the city vary from 100 to 1,800 feet, with 300 feet being the average. Temperatures vary from 120 to 220ºF, with 140ºF and above considered desirable for providing sufficient energy using a DHE.

UTILIZATION

The DHE example selected from Klamath Falls serves two residences from a single well. The system design is fairly simple, but typical of others in the city that provides both space and domestic hot water heating. The well is 200 feet deep, with a temperature of 196ºF at the top, and 204ºF at the bottom (when drilled). The static water level is 75 below the casing top. The well was drilled in 1954 and cased to the bottom with a 10-inch diameter casing, which is perforated just below the water surface and at the bottom of the well in the live water area. The perforations are about 0.5 inches wide and 6 inches long for a total distance of about 15 feet at each location. The casing is sealed with cement from the surface down to 21 feet, and then the annulus is open below this point providing about a 1-inch clearance. The perforations and opening between the casing and wellbore allows a vertical convection cell to develop, bringing the hotter water from the aquifer (live water zone) at the bottom to the top.

Originally there were four DHEs in the well, two 2-inch diameter closed-loop pipes for the space heating and two 3/4-inch diameter open loop pipes for the domestic hot water heating–one set for each home. After 19 years of service (1974), the black iron pipes were replaced due to corrosion at the water line. The two 2-inch diameter heating loops were replaced with a single 2-inch diameter heating loop which is now shared by both homes. Since the domestic hot water is a consumptive system, the two loops for this system were retained.

The space heating system consists of baseboard hot water radiators on a two-pipe system with flow control valves on each heating unit. A motorized valve on the return leg of the heating loop controls the flow via a thermostat. Recently, a solid state controller hooked to a storage battery was installed in case of a power failure. A 10-gallon expansion tank is connected to the high point in the heating system, and pressure reducing and relief valves are part of the cold water supply line used to initially fill the heating loop. City water is also provided to the domestic hot water loops in an open system. There is no storage tank for the domestic hot water, and there is also no circulation pump on the space heating loop, as the circulation is produced by normal thermal syphoning.

The estimated utilization of the system for both houses is about 164 million Btu/yr (48,000 kWh). The maximum capacity of the well is probably 10 times this utilization, but obviously it has not been plumbed or tested to this amount, which depends upon the aquifer flow and efficiency of the vertical convection cell.

OPERATING COST

The original cost of the well was $2,400 and $800 for the DHE for each house. Thus, each homeowner paid about $2,000 for the system. At today's prices, the well would cost around $10,000 and $3,000 for the three DHEs. The annual O & M cost are only for the electricity to run the motorized valve and the equivalent annual cost of replace parts of the DHE on about a 25-year intervals, amounting to probably less than $100 per year. The estimated annual heating and domestic hot water cost for the two homes at about 4,500 sq ft total of heated space using natural gas would be about $1,800 per year or $2,900 per year for electricity, plus $5,000 for the capital cost of two furnaces and hot water heaters. This would give a simple payback of five and three years, respectively.

ENVIRONMENTAL IMPACT

Initially, to prevent corrosion of the DHEs at the water-air interface, several pounds of paraffin were placed in the well. This was considered a pollutant to the groundwater; thus in 1974, after the DHEs were replaced, a steel plate was welded to the top of the water to limit air (oxygen) entering the wellbore. This is the recommended procedure today.

REGULATORY ISSUES

Drilling a geothermal well with less than 250ºF temperature is under the jurisdiction of the Oregon Department of Water Resources (DWR). Wells that exceed this value are under the jurisdiction of the Department of Geology and Mineral Industries (DOGAMI). A drilling log must be filed by the driller to the state (DWR) once the well is completed. The well casing must also be sealed from the surface down to competent formation or to 21 feet below the surface. The city of Klamath Falls passed an ordinance in 1990 to prevent the dumping of geothermal water in the storm sewer or waterways–-all water must be reinjected into the same aquifer. Since only heat is removed from a well using DHE, this ordinance does not apply.

PROBLEMS AND SOLUTIONS

The only major problem was the corrosion of the DHEs at the air-water interface. These were replaced in 1974 at a cost of about $500. The homeowners were able to save on purchasing new pipe, as the two space heating DHEs, were replaced with a single DHE. There has been no corrosion problems since this date. Typical life of DHE in Klamath Falls wells average 14 years. Recently, the pressure reducing and pressure relief valves on the city water supply side connected to the closed loop DHE had to be replaced; as, they were causing high pressure in the system, producing leaks.

CONCLUSIONS

This system has been operating with few maintenance problems and low annual costs. This is an ideal configuration providing the resource temperature is at least 140ºF. It also conserves the resource as only heat is removed from the water. The design of these system is extremely simple; however, more complex systems can be found in the city and are documented in the reference below.

REFERENCES

Geo-Heat Center Quarterly Bulletin, Vol. 20, No. 3 (September 1999). "Downhole Heat Exchangers," Klamath Falls, OR, 28 p. (available on the GHC website: http://geoheat.oit.edu/bulletin/bull20-3/bull20-3.pdf).

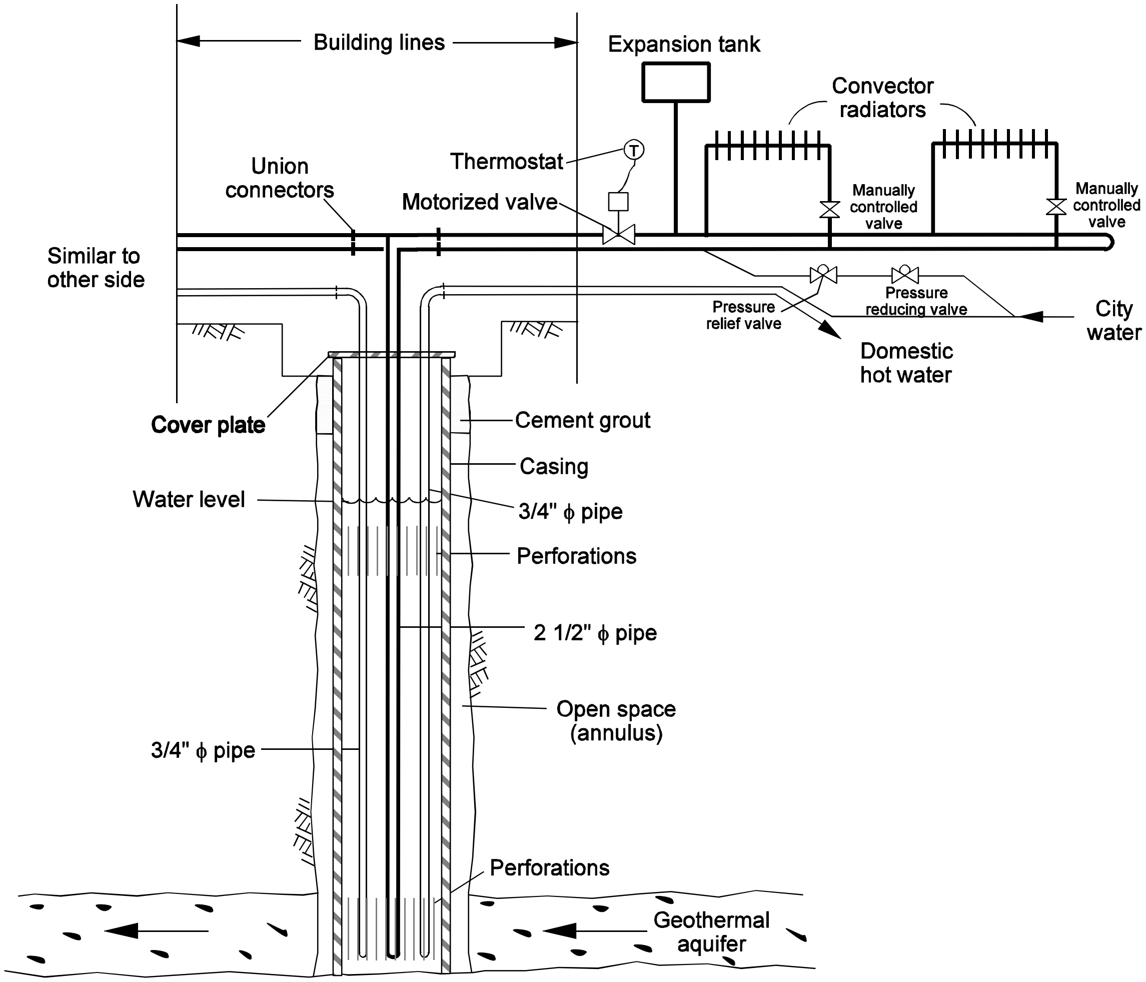

Diagram of the entire system for the basic installation.