OIT GEOTHERMAL SYSTEM IMPROVEMENTS

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INTRODUCTION

Three geothermal wells drilled during the original campus construction vary from 396 m (1,300 ft) to 550 m (1,800 ft). These wells supply all of the heating and part of the cooling needs of the 11-building, 62,200 m^2 (670,000 ft^2) campus (Figure 1). The combined capacity of the well pumps is 62 L/s (980 gpm) of 89°C (192°F) geothermal fluids. Swimming pool and domestic hot water heating impose a small but nearly constant year-round flow requirement.

In addition to heating, a portion of the campus is also cooled using the geothermal resource. This is accomplished through the use of an absorption chiller. The chiller, which operates on the same principle as a gas refrigerator, requires a flow of 38 L/s (600 gpm) of geothermal fluid and produces 541 kW (154 tons) of cooling capacity (Rafferty, 1989).

The annual operating cost for the system is about $35,000 including maintenance salary, equipment replacement and cost of pumping. This amounts to about $0.05 per square foot per year.

PRODUCTION

Three geothermal wells produce the fluid for the campus geothermal system. These wells, OIT-2, OIT-5 and OIT-6 (Figure 1), are capable of producing an estimated 8 L/s (130 gpm), 32 L/s (500 gpm) and 22 L/s (350 gpm) respectively.

The three original pumps were basically irrigation well water pumps with direct-coupled motors, open lineshaft with rubber bearings and standard lateral (which is the axial movement of the impellers within the bowls) pumps with bronze bearings and impellers (Culver, 1994). The wellhead and motors were in pits or cellars below ground level. The wells are within about 122 m (400 ft) of each other and produce from the same aquifer. Water temperature is the same in all three--89°C (192°F).

Problems experienced were broken lineshafts, motors overheated, pump impellers loosened on the shaft due to differential expansion and bronze bearings corroded. Because there was a lack of lateral in the bowls, pumps that had been shut-off required preheating by pumping water from another well to thermally equilibrate the entire column and shaft.

In 1970, a program of upgrading the pumping system was initiated. The wellheads were raised above ground level and enclosed in well-ventilated well houses. Variable-speed fluid couplings were installed. New pumps with oil-lubricated enclosed lineshaft and bronze bearings with extra lateral bowls, and keyed colleted impellers were installed. This design has proven very successful, for example OIT-5 was overhauled in 1989, after 19 years 5 months of service, by replacing the impellers and bowl bearings. This pump was replaced in 1995 with the addition of a flow meter and water level air-line for monitoring.

For well OIT-2, a new pump was installed in 1974. This 35-stage pump is rated at 8 L/s (130 gpm). The pump has not been pulled since its installation in 1974, and is still running apparently smoothly. The pump in OIT-6 well was installed in March 1971. This pump has 26 stages and is rated at 22 L/s (350 gpm) at 650 TDH, 1720 rpm and has 107 mm (4.2 in.) of lateral. In June 1988, the pump was pulled and refurbished with new pump bearings and impellers. Actual run time of these two pumps is unknown since run times are not logged; but, it is estimated to be between 7-8 years with speed and flow rate varying with campus heating load (Culver, 1994).

The three wells deliver geothermal fluid through short underground pipelines to a tank located in the "heat exchange" building above the campus. In 1995, a backup oil-fired boiler was removed after it had never been used in 32 years. A diagram of the control scheme for the production facility appears in Figure 2.

The two control valves respond to a signal from the tank level control modulating toward the closed position as the tank level rises (decrease in campus heating demand). As the valves close, the pressure in the lines from the production wells increases. This increase in pressure signals the variable-speed drive units to begin slowing the production pumps, thus reducing their output. The opposite sequence would result in the event of a decrease in the tank water level. From the

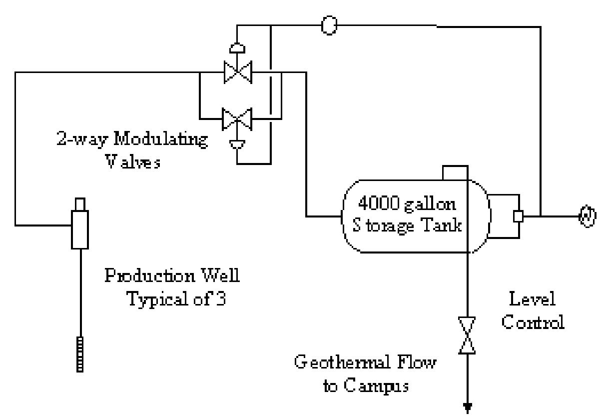
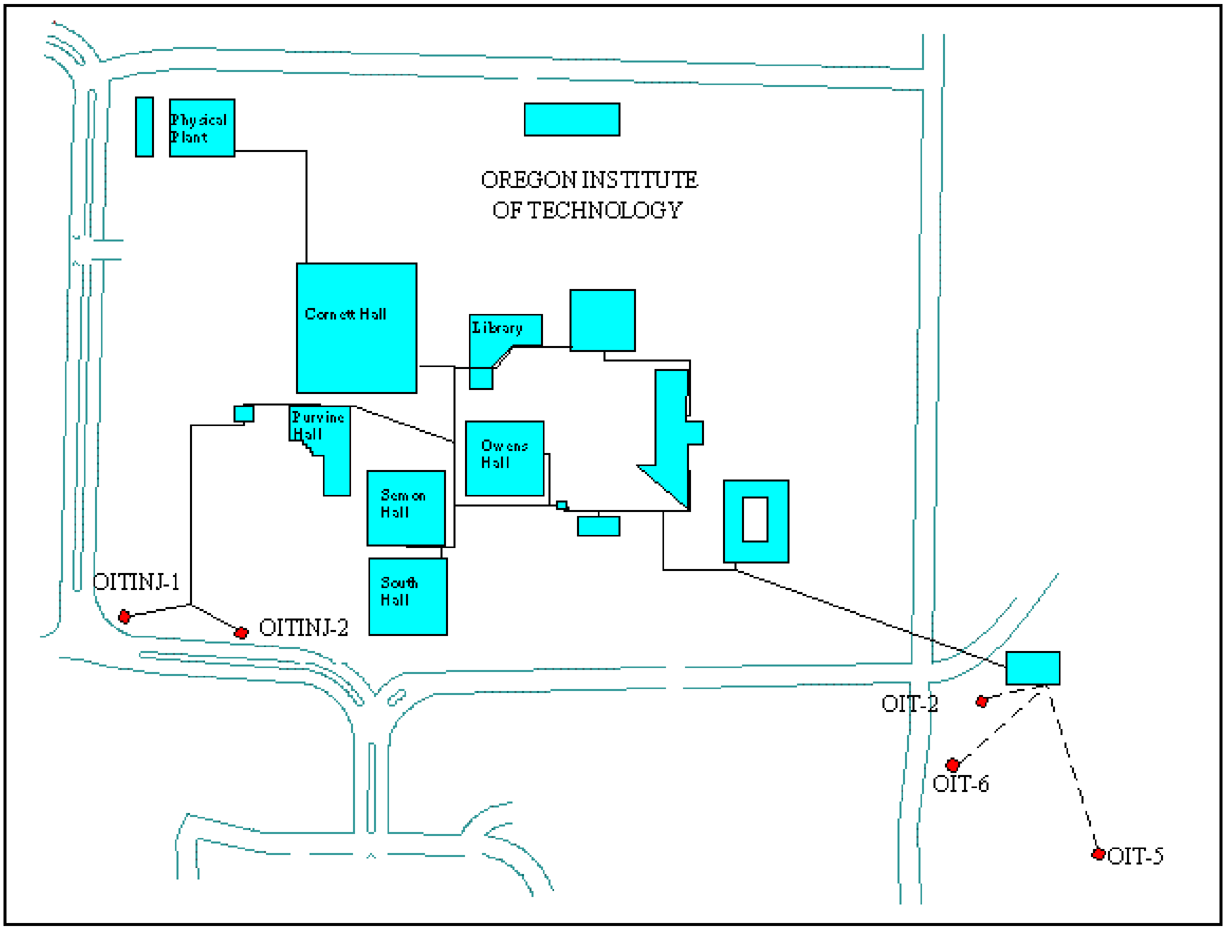


Figure 2. Diagram of the control scheme for the production facility.



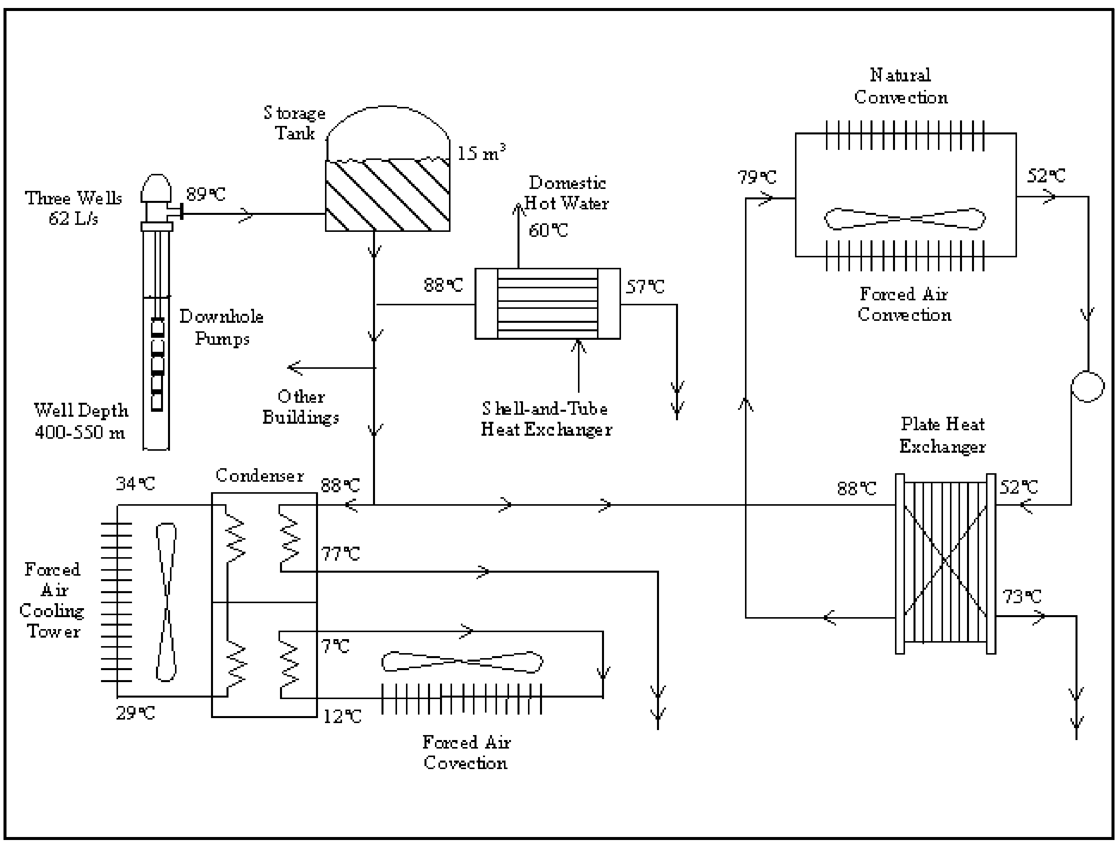


Figure 1. Oregon Institute of Technology geothermal heating system layout and flow diagram.

storage tank, the entire distribution system operates by gravity due to the elevation difference between the tank and the campus (Rafferty, 1989).

DISTRIBUTION SYSTEM

The original campus distribution system consisted of direct buried steel piping. This piping, which delivered the geothermal fluid to each building, was field insulated and covered with a bituminous mastic coating.

In the early-to-mid 1970s, it was discovered that the coating material was no longer intact in many locations. As a result, groundwater from the soil was able to penetrate the insulation and cause serious corrosion of the steel piping. This occurrence was most pronounced at the elbows in the piping system. Evidently, repeated expansion and contraction of the lines caused numerous cracks in the coating in those areas. A program of distribution system replacement and modification was initiated in the mid-to-late 1970s. The new hot water supply piping consisted of factory pre-insulated fiberglass piping. This piping, as shown in Figure 3, was installed in underground concrete tunnels which were located largely under the campus sidewalks. As such, the tunnels also provide snow melting system for the walkways.

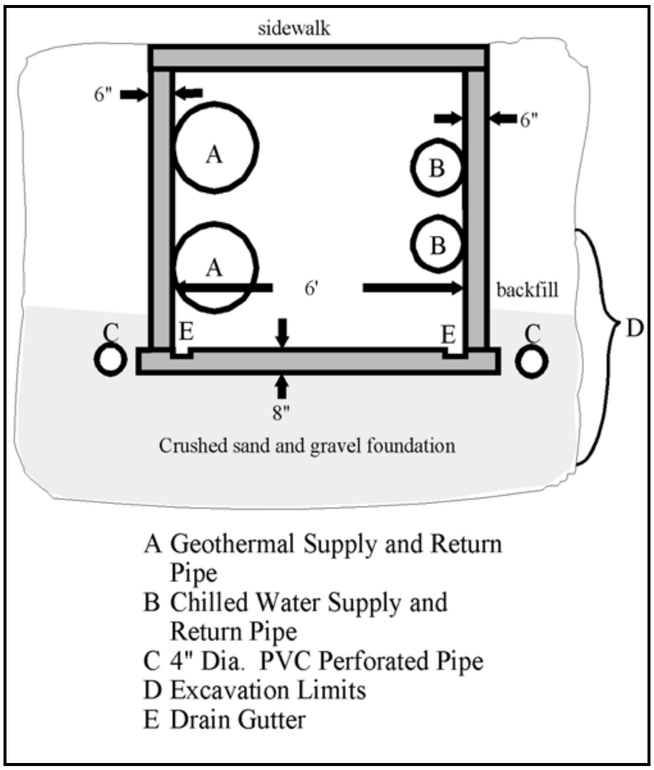


Figure 3. Tunnel construction detail.

The tunnel installation is expensive; however, it offers the opportunity to accommodate other utilities and affords much better piping access than direct burial. Completion of the tunnel system to all buildings occurred in 1992. Cost for the 1.8 m x 1.8 m (6 ft x 6 ft) tunnels was approximately $984 per m ($300 per linear ft) without piping. In most cases, the piping is hung from the walls of the tunnel. Epoxy adhesive joining is used on all fiberglass piping on the campus. This has been quite successful with no leaks reported.

In addition to changes in the hot water supply lines, the disposal side of the system has been completely redesigned. As originally constructed, each building discharged the "waste" geothermal fluid to the storm sewer. The storm sewer system then delivered this water along with roof and surface drainage to a ditch at the west side of the campus.

As a result of a Klamath Falls City ordinance, all geothermal systems had to employ injection for disposal of effluent by 1990. In response to this ordinance, the campus installed a dedicated geothermal-fluid collection network. This piping of 76 mm (3 in.) through 203 mm (8 in.), pre-insulated fiberglass material was installed in the campus tunnels along side the supply piping.

Completion of the collection system resulted in an innovative design of a new classroom building constructed in 1988. The building heating system was designed to use the "waste" water from the collection system rather than the primary geothermal supply water This design eliminated the need to increase total geothermal pumpage for the campus.

BUILDING HEATING SYSTEMS

The original design for the campus involved the use of the geothermal fluid directly in the individual building heating systems. After a few years of operation, it was apparent that use of the fluid directly would not be acceptable over the long term. Serious corrosion problems occurred, particularly in copper and copper alloys. Copper tubing, due to attack by hydrogen sulphide (H_2S), failed in as little as 5 years. In addition, various solders used for joining the copper piping were completely removed from fittings in as little as 2 years.

In response to this situation, plate heat exchangers have been installed in all buildings to isolate the building heating systems from exposure to the geothermal fluid. Most of the heat exchangers are constructed of Type 316 stainless steel and nitrile rubber gaskets.

COOLING

In addition to providing for the heating needs of the campus, the geothermal resource, in conjunction with an absorption chiller installed in 1980, supplies a portion of the cooling needs as well.

The chiller, which works on the same principle as a gas-fired refrigerator supplies the base-load cooling needs of approximately 26,000 m^2 (280,000 ft^2) of buildings area. To accomplish this task, it requires 38 L/s (600 gpm) of 88ºC (190ºF) geothermal fluid. In comparison to a standard application, this machine produces only about 50% of its cooling capacity. This is due to the fact that absorption chillers are designed to operate on a 116ºC (240ºF) heat input. The OIT resource only produces 89ºC (192ºF) fluid and as a result, the machine capacity is reduced. Figure 4 gives a flow scheme for a typical lithium-bromide/water absorption cycle.

Due to the absorption chiller inefficiency, cost to operate the well pumps and concern about corrosion on the copper

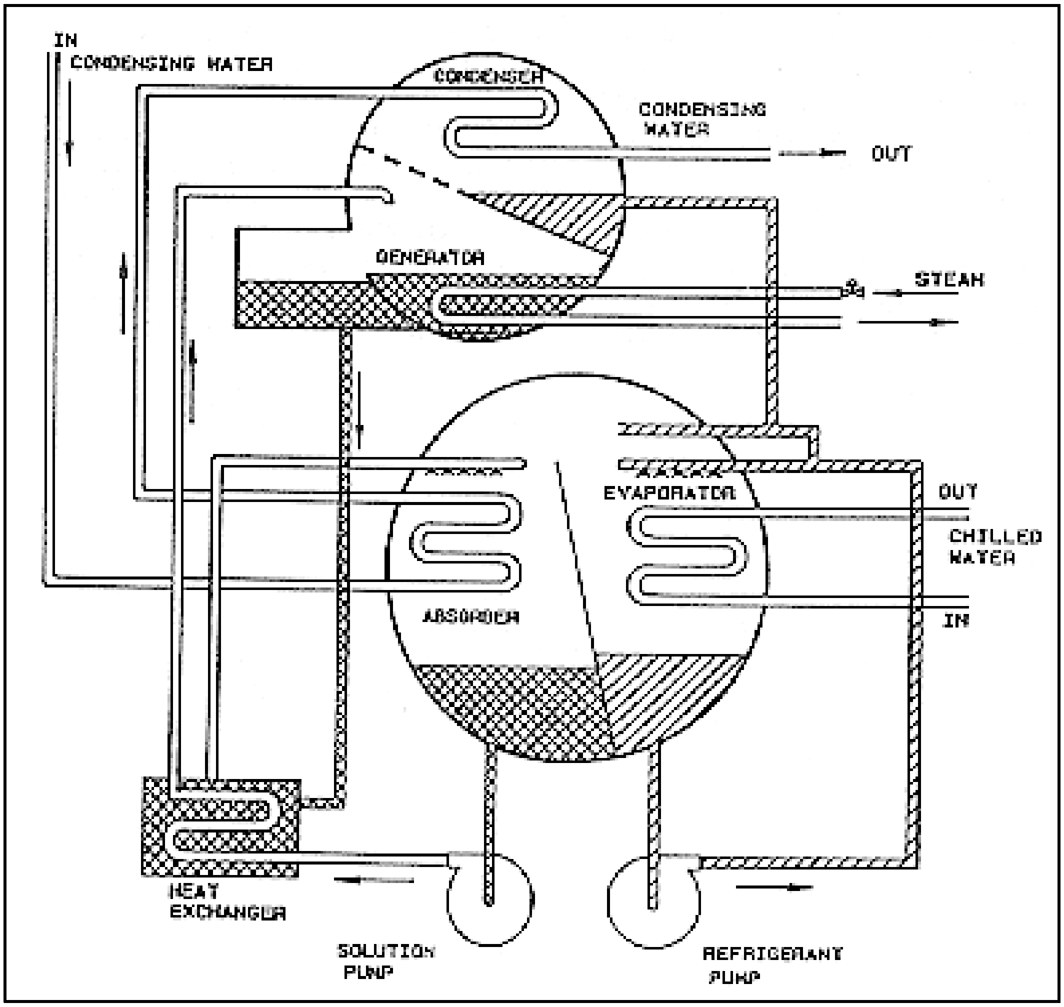


Figure 4. Typical absorption chiller components.

tubes in the generator section, this machine may be replaced in the next two years (Colahan, 1996). New electric chillers have had a huge increase in efficiency, approximately 50%, in recent years. It is estimated the cost to operate the new electric chillers will be slightly more than the geothermal absorption chiller; however, the capital cost for the electric chiller is much less (the electric chiller is less than half the cost of an absorption chiller for a 150-ton service). The absorption chiller and the 33-year-old backup centrifugal electric chiller will be replaced with two modern electric chillers--if funds are appropriated by the legislature.

DISPOSAL

Since its original construction, the OIT system has employed surface disposal. Geothermal waste water had historically been collected, either through the storm drains or more recently via dedicated collection network, and delivered to a drainage ditch on the west side of the campus.

Since 1990, all geothermal effluent has been injected. A new collection tank was installed just west of Purvine Hall (Figure 1). All waste flow is delivered from the collection system to the tank. From here, booster pumps delivered the flow through a 457-m (1,500-ft) pipeline to the injection well located at the southwest corner of the campus.

The first injection well was completed to a depth of 610 m (2,000 ft) in late-1988 at a cost of approximately $300,000. Testing of this well revealed that it was capable of accepting only about 22 L/s (350 gpm) on a long-term basis due to drilling mud invasion into rock fractures. As a result, a second well was air-drilled in 1992, about 82 m (270 ft) east of the first injection well, to a depth of 510 m (1,675 ft). This well is capable of accepting approximately 57 L/s (900 gpm) and it was possible to bypass the injection booster pumps.

CONCLUSIONS

The OIT campus has successfully used geothermal fluids for heating since 1964. A number of improvements to the system that have occurred over 32 years of operation could benefit potential developers of geothermal resources for similar applications. These include using lineshaft well pumps that use bronze bearings, oil-lubricated enclosed lineshaft, keyed-colleted impellers, and extra lateral. A distribution system employing utility tunnels proved desirable for the installation of additional utilities (i.e., return piping, chilled water supply and return pipelines, computer cables, electric power cables, cold-water supply lines, etc.) and maintenance; however, the installation cost of these systems is high. Fiberglass piping with epoxy adhesive joining has been successful. Isolation heat exchangers are necessary when a direct distribution system is used (i.e., geothermal fluids delivered to each building) to protect the heating units, which are primarily constructed of copper materials. Cooling of buildings is possible with geothermal fluids using absorption chillers; however, resource temperatures should be greater than 116^{o}C (240^{o}F). Due to inefficiency and operating costs, the OIT geothermal absorption chiller will eventually be replaced with electric chillers. Disposal of geothermal fluids by means of injection wells may be required to meet state or local regulations.

REFERENCES

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