QUARTERLY PROJECT REPORT
GEOTHERMAL LOOP EXPERIMENTAL FACILITY
FOR
ENERGY RESEARCH & DEVELOPMENT ADMINISTRATION
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1. **Summary**

Operations with the Geothermal Loop Experimental Facility were ended on June 16 for a major plant inspection of the separators, scrubbers, pumps, valves and controls. The total operating time for the unit up to this shutdown was 404 hours since brine from Magmamax No. 1 was admitted to the plant.

A capability to operate for the long-term was demonstrated from the unit's performance during runs in June which totaled 240 hours. The one major problem encountered during this term of operation was the erosion of the brine pipe elbow down stream of the pressure control valve at the first stage separator inlet. Moving the control valve to a new location did eliminate the erosion of the elbow. The eroded condition of the downstream valve surface and connecting flange remains to be resolved.

Maintenance was conducted in the plant during the shutdown period on valves, condensate pumps and injection pump. The brine system drains and high stack drain was installed and routed to discharge into the fourth stage separator. Painting and other miscellaneous grounds maintenance was completed.
The major bulk of activity was inspections performed on pumps, valves, vessels, heat exchangers and instrumentation. The findings will be described in detail in a separate report by July 30.

Lawrence Livermore Laboratory's personnel were actively engaged in obtaining scale samples, radiographic and ultrasonic inspections at various predetermined points in the Test Facility equipment. Their results should become available by July 30.

Following this shutdown the unit will be operated with geothermal brine from Woolsey No. 1 well. This test run should be completed by August 31. At this time a second major inspection will be performed.

2. **Problems and Corrective Action**

The erosion of the brine pipe elbow immediately downstream of the first stage separator pressure control valve and the erosion of the valve exit surface, as well as the connecting flange, became evident after about 200 hours total operating time. The fluid state conditions were 120 psig and 350°F.

The six inch, schedule 80 elbow and flange, as well as the valve body and trim, were sent to the Lawrence Livermore Laboratory for metallurgical examination. An applications engineer from Control Specialists, the vendor for the valve (a 6 inch Fisher Vee-Ball), examined the
piping arrangement and the valve. One of his findings was that the pressure control valve should be an 8 inch rather than the existing 6 inch size. The 6 inch valve's coefficient was too low. The proper valve of the coefficient should be about 1100.

On the basis of the valve engineer and SDG&E's evaluations, the valve was placed in the pipeline such that it discharged the two-phase brine flow into a 6 inch to 16 inch diameter pipe enlargement and into a straight run of 16 inch diameter pipe. The 6 inch elbow was replaced with new material and exposed to the two-phase, geothermal fluid in operating conditions for 102 hours.

Erosion of the piping appears to have been eliminated, however, some erosion was repeated in the valve. The immediate plan is to replace the 6 inch Fisher Vee-Ball with an 8 inch valve. The larger valve should reduce the excessive flashing which will result in lower fluid velocity and eliminate the valve erosion. The correct valve size has been purchased.

Level control of the plant's stages was improved with the installation of electrical capacitance in the ultrasonic level control circuit. This capacitance increases the time response of the electric signal actuating an electrical-to-pneumatic converter and thus the pneumatic signal which drives the level control valve. Resulting pressure fluctuations in the separators was reduced from
30 psi to about 10 psi in the second stage and from 10 psi to 3 psi in the fourth stage. The third stage was out of service for foundation repairs, however, when it was operating, pressure fluctuations were about 20 psi.

The ultrasonic level control scheme has been modified to a proportional control from simply an off-on one. This was accomplished by increasing the number of control probes from one to six and installing a simple electric circuit which adds the electric signal of each ultrasonic probe in succession as the probes are covered by liquid.

A second type of proportional control investigated was differential pressure. An adjustable range of 0-100 inches of water to 0-750 inches of water controller is manufactured by Fisher Controls and appears to be a viable method for proportional control of the level control valves. We have the electric-to-pneumatic converter and Fisher multi-trol installed.

During the start-up operations the third stage separator foundation structure was damaged from shocks in the separator. The shocks were the result of very rapid steam condensation and explosive steam formation when the incoming, hot, two-phase geothermal fluid mixture contacted cold brine in the vessel. To preclude this problem, subsequent start ups were performed with drained
separators and scrubbers. A drain system and sump was installed to drain the brine system. A vertical centrifugal pump drains the sump to the fourth stage separator.

Traps at each scrubber wash water drain were by-passed after flooding was observed in the scrubbers. The flooding condition is determined by an alarm when the high level point in the scrubber is attained by the wash water. Each by-pass installed is nominal 1 inch, schedule 40 pipe.

One last major modification was to install the provision to flow all scrubber wash water drains, to flow all condensate (except purge water) from the condensate pumps, and the first stage steam condensate to the fourth stage separator. From there all of the above flows are injected.

3. Maintenance

Except for the cooling water pump and utility water pumps, the seals of all others were disassembled, cleaned and re-installed. Seals were replaced on the two purge water pumps, the fourth stage scrubber drain pump and the injection pump. High temperature, about 250°F, in the fourth stage is suspected as the cause of failure in the seals. The design temperature of these seals is 220°F.

During the major inspection of the facility in June, mill scale, iron oxide and scale obstruction in the
vessels, pipe connections, scrubber trays, pumps and pump suction barrels were removed.

General site clean up was performed as often as possible without interfering with the facility operation. Undercoat paint was applied to recent piping modifications.

Instrument calibration was in progress continuously during this reporting period, especially, pneumatic controls.

4. Inspections

The man-holes on the separators and scrubbers were opened following the shutdown of the Experimental Facility and a subsequent cool down period. The interior condition of all four separators was good and the buildup of scale was less than anticipated, especially, in the second and fourth stages. The second stage separator was especially clean. Scale in the first stage was as expected, in the order of one-sixteenth of an inch. Flakes of the thin scale were observed to be separating from the vessel surfaces. This condition was also observed during the 1974 field tests following a shutdown. Samples of this scale were removed for analyses by the Lawrence Livermore Laboratory and SDG&E.

The topmost tray and surfaces of the first stage scrubber had the appearance of rust stains and a slightly stippled surface. The central V-notch weirs did contain flakes of scale. All trays in the scrubber were inspected
with the greatest collection of loose scale chips being found in the bottom-most tray. This scale had the appearance of magnetite (iron oxide). A thorough analyses of this scale will be conducted to determine the constituents. The second stage scrubber was clean, similar to the second stage separator. The fourth stage scrubber had a thin but hard layer of scale, adhering to the surface in the bottom. An analysis of this scale is not available at this time.

The injection pump was removed and disassembled in the SDG&E shop. The carbon shaft bushings were extremely corroded and needed replacement. Type 316ss was selected as the new material for the bushings. The Hastelloy C impeller and bowls were in excellent condition and showed no signs of corrosion or erosion. Cracks and radial pits were observed in the K-Monel shaft material. The cracks appeared in the upper 8 foot long stub shaft, while the radial pits existed in the lower 12 foot long shaft. A new shaft will be made of a material which is similar to Hastelloy C. Both sections of the injection pump shaft were sent to Livermore Laboratory for metallurgical examination.

Scale about 3/8 inch thick coated the injection pump bowls and shaft. Approximately 1/16 inch of this layer was hard, very adhesive to the shaft, brittle and difficult to remove. The outer layer was soft and readily removed by scraping. Samples of this scale were collected for analyses.
The shafts of the injection pump contained scores at the shaft bearing locations. The intrusion of the highly saline brine and scale formation was the cause of this damage to the shaft. Purge water lubrication was provided to each of the shaft bearings by means of a small diameter piping arrangement which is fed by the purge water pump.

The fourth stage heat exchanger condensate drain pump, P-10, was removed and inspected. It was in good condition and clean. No maintenance repairs were performed on this pump.

P-9, the fourth stage scrubber drain pump was removed, disassembled and inspected. Purge water will be necessary to protect the pump's shaft bearings. This provision was accomplished in a manner identical to that for the injection pump. The cause of shaft damage was attributed to the high mineral content of the wash water draining from the scrubber, further concentrated by the drains from the other scrubbers. Directing the wash water drains from the first, second and third stage scrubbers to the fourth stage separator rather than the scrubber should help to minimize the contamination of the fourth stage scrubber drains.

5. Test Program

On June 21, representatives of Bechtel Corporation met with ERDA, SDG&E and Ben Holt Company personnel at
the facility site to discuss the final test program plan. A series of meetings lasted through June 23.

Bechtel stated the test program would be completed by the end of six weeks or about the first week of August. Another review of Bechtel's progress will be held near mid-July. A final review is expected to occur prior to issuance of the final draft.

6. Future Plans

The Geothermal Loop Experimental Facility should resume one-well operations by mid-July. A four to six week test run is scheduled to begin at this time with Woolsey No. 1 utilized as the producing well. Following this run, the Facility will be shut down for another major equipment inspection which is expected to last about three weeks.

Two-well operation, Magmamax No. 1 and Woolsey No. 1 as producing wells, will be attempted at this time. Distilled water will remain the working fluid until some experience is attained with the facility utilizing two wells in full production. This test operation should require two months.

Operation of the facility with isobutane could begin by mid-November if no serious problems are encountered during the previous tests.