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RAFT RIVER GEOTHERMAL FACILITY

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Introduction The Raft River Geothermal Facility is operated by EG&G Idaho, Inc., for the Department of Energy. The major feature of this facility is a binary pilot plant with a nominal gross rating of 5MW(e)(1), when supplied by a geothermal resource of 143°C (290°F) or greater. Isobutane is used as the working fluid in a two stage boiling cycle which provides high and low temperature streams to a double impeller radial inflow turbine. The turbine-generator, heat exchangers and feed pumps were designed for "floating power"(2) operation, thereby enabling the plant to produce significantly more power in the winter months than at the summer design condition. Geothermal water is being used for heat rejection. Its use has caused scaling and corrosion problems and has required special treatment(3). Geothermal fluid is supplied by three production wells. There are two injection wells. Cement-asbestos pipe is used to transmit the geothermal fluid.

In addition to the 5MW(e) pilot plant, a 60kW(e) binary system and a water treatment laboratory is located at the Raft River Facility which is used for conversion system research.

This paper will provide an update on the power conversion activities at the Raft River Facility.

5MW(e) Pilot Plant Status The power plant, shown in Figures 1 and 2, is essentially complete. Plant startup has been delayed approximately one year (from October, 1980) due to delays in completing construction, modifications and uncertain funding for FY-82. Recent developments indicate some funding will be available in FY-82 to permit testing and operation to proceed on a limited basis. A new startup schedule is being prepared and means of operating with a reduced crew is being investigated.

Geothermal Supply Pumps The downhole pump experience at Raft River has been very poor. Original plans were to use submersible pumps; however, all that have been installed and tested have failed(3). During the past year a large horsepower submersible pump was installed and tested, and even though it was specifically designed for geothermal applications, it failed in about four hours. Smaller conventional submersible pumps were operated longer but eventually failed.

Current plans are to install new line shaft pumps (Peerless) in wells RRGE-1 and RRGE-2. These pumps will have lead bronze bearings lubricated by water in which a soluble oil has been added. Delivery of these units will be completed by mid-July. A line shaft pump (Peerless) with Teflon bearings and no lubricating fluid is currently installed in well RRGE-3. The installed depths, rated conditions and horsepower of these pumps is given in Table 1.

TABLE 1 GEOTHERMAL SUPPLY PUMP RATINGS - SHAFT DRIVEN

Well No.	Set Depth, m (ft)	Flow m/s (gpm)	TDH, m (ft)	Motor hp
RRGE-1	305 (1000)	.071 (1120)	408 (1340)	500
RRGE-2	305 (1000)	.043 (680)	408 (1340)	350
RRGE-3	304 (998)	.024 (375)	434 (1425)	250

Cooling water treatment test programs(4,5) to establish the best treatments for removal of silica and hardness from the makeup water, corrosion protection for the carbon steel condenser tubes, and scale control have been concluded. Although a chromate based treatment provided the best corrosion protection, a phosphate based inhibitor treatment has been adapted to eliminate potential environmental concerns. The condenser tubes were cleaned and passivated. The inhibitor treatment will consist of a combination of polyphosphate, orthophosphate, zinc and a copper inhibitor. The cooling tower will be operated at approximately eight cycles of concentration.

Testing has shown that scale formation cannot be controlled if silica levels greater than approximately 25-30 ppm are permitted in the cooling system. This low limit is due to the presence of dissolved iron in the cooling water. Thus, when operating the cooling water system at eight cycles of concentration, the silica in the makeup water must be reduced to about 3 ppm. Reduction of silica to such low levels is very costly.

The problem of silica removal from makeup water is not unique to Raft River. Ground waters in the Basin and Range regions in which many geothermal areas are located have silica levels up to approximately 60 ppm. Thus, silica removal will be required to prevent precipitation when the water is concentrated in the cooling system. Large reductions in the cost of silica removal can be achieved if cooling systems are designed to eliminate ions causing silica precipitation from entering the system. Concentrations approaching approximately 120 ppm should be achievable without the use of dispersants and perhaps double that level will be possible with dispersants. The water treatment testing program in progress at Raft River will establish the actual limits.

During the past year Permutit Company conducted tests on silica removal using reverse osmosis and rusting iron in a sidestream system(6). The rusting iron shows significant promise as an inexpensive means for removing silica.

Condenser Tube Materials Corrosion testing to determine a preferred tube material for the 5MW plant condenser is in progress. Two types of tests are being performed: spinner tests which are used to screen materials and pilot cooling tower tests which expose actual tubing to conditions more representative of an actual system. Figure 3 shows the spinner apparatus in which small coupons are moved through the aerated brine. Figure 4 shows the pilot cooling tower set up. To date approximately 35 materials have been tested in the spinner apparatus and four materials are presently being tested in the pilot towers. Preliminary results based upon weight loss and inspection for pitting indicate that the better materials are: Sea Cure (A-268-79A), AL 6X (A-268), 70/30 Copper/Nickel (B-359-B111) and AL 29-4-C (A-268).

These materials cost about 2 to 3.5 times as much as carbon steel but are much less expensive than Inconel, Hastelloy and other very corrosion resistant materials.

Although these tests are being performed to establish an alternative material for the 5MW plant condenser, the results, we believe, have a great generic value and should benefit anyone selecting materials for a binary system condenser when relatively poor quality cooling water is available.

Performance Predictions The geothermal fluid temperature at the pilot plant is expected to be about 138°C (208°F) rather than the 143°C (290°F) design value. Parameter studies(7) have been conducted to investigate the effect on performance of a lower geothermal fluid temperature and to establish equipment operating limits encountered when changing geothermal flow to compensate for the lower temperature. The results of this investigation may be summarized as follows:

1. A decrease of 5.5°C (10°F) in the geothermal fluid temperature will result in a reduction in power output of about 8%.
2. Power lost by reduced geothermal fluid temperature can be partially made up by increasing the geothermal flow.
3. The feed pump (head) appears to be the most restrictive component to achieve maximum possible performance for the large variations encountered with floating power and heat exchanger fouling. The performance study suggests that a variable speed, or a two speed pump might be valuable and permit increased performance (several percent gain).
4. The dual boiling system appears to be self compensating with respect to the flow split as resource temperature decreases. No changes in turbine nozzle areas appear to be required.
5. Power output was estimated to be 33% greater in the winter than in the summer.

60kW Prototype Power Plant The Prototype Power Plant (PPP) is a small 60kW binary plant (Figure 5) which is part of the DOE Conversion Technology Program. The system configuration is modified as required to conduct test programs. The first part of the program was to conduct a series of performance tests, to gain operation experience and to operate the plant in an automatic mode. A detailed report of the experience with this plant during this phase is given in Reference 8. Operational problems encountered were:

1. Isobutane contamination with nitrogen which drastically reduced condenser performance.
2. Considerable leakage of isobutane even though retorquing of flanges, tightening of packing, etc., was conducted on a regular basis.
3. Winter operation caused several problems: power outages occurred frequently causing plant shutdown which leads to a potential vacuum hazard, difficulties were encountered with plant fill and drain back to storage, and the usual problems of tower icing and freezing of water and instrument lines existed.

The plant was operated about 87% of the time that geothermal water was available. Variation in power due to variations in ambient conditions were determined. Daily power variations were found to be 25-30% during the summer and 10-15% during the winter. Often when considering power variation, only the first order change between summer and winter is considered. These data show that very substantial variations in the daily power output must be considered as well (in the cooler climates).

Conclusion The foregoing discussions show that much is being learned about the use of geothermal power systems. Plants such as those at Raft River and elsewhere demand that activities focus on the real problems and their solution. This experience can be gained in no other way. The Raft River facilities have features that are being applied for the first time, some are developmental, others will yield new experiences to be added to the data base, and all will ultimately be factored into the design of commercial plants. The following summarizes areas in which the 5MW(e) Raft River Facility is unique or will add significantly to our understanding of geothermal power production:

- Staged (dual) boiling cycle performance
- System designed for floating power
- Radial inflow turbine performance
- Geothermal water used for heat rejection
- Fault controlled hydrothermal system behavior
- Submersible geothermal supply pumps
- Stimulated wells
- Environmental baseline

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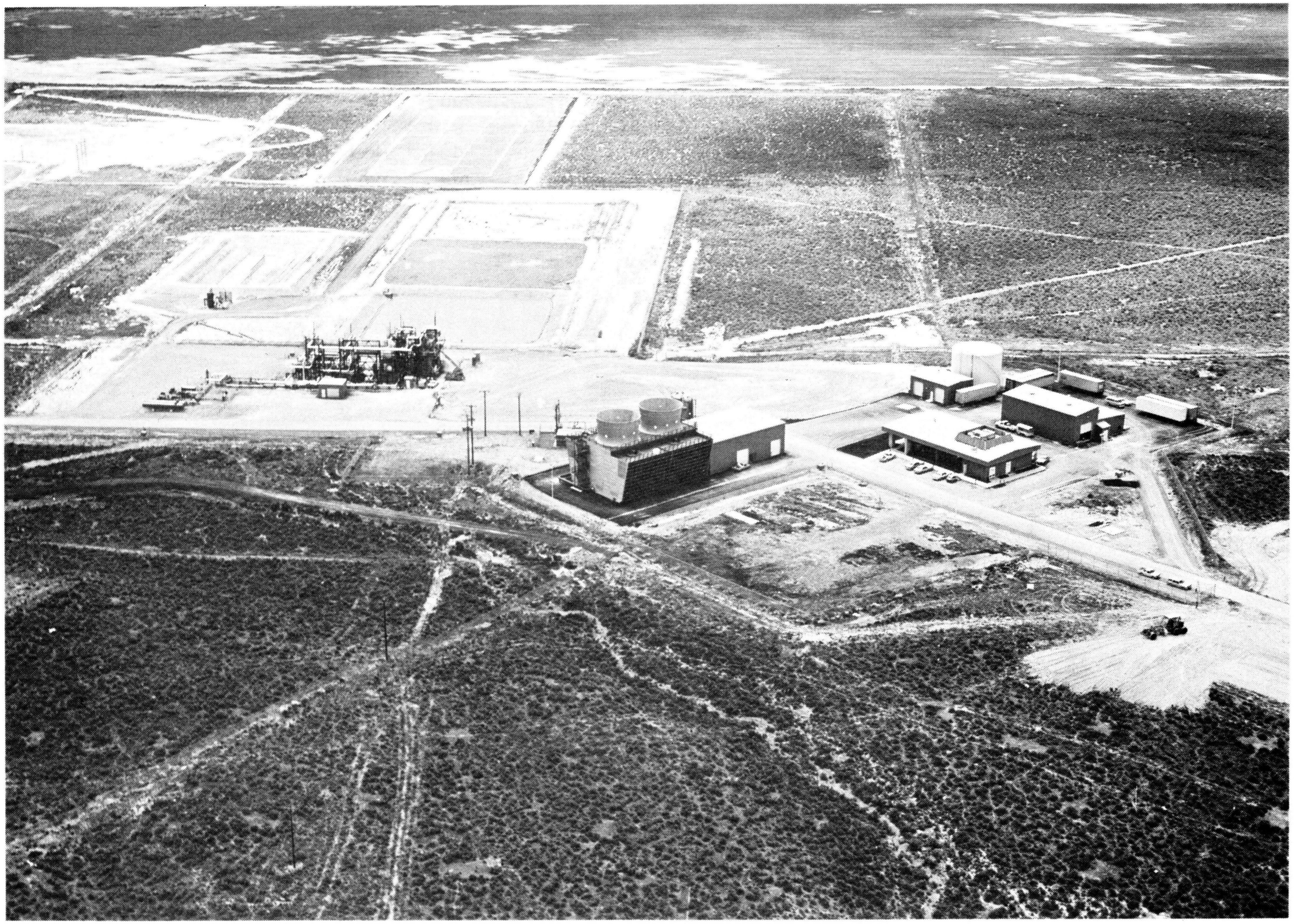

FIGURE 1 AERIAL VIEW 5MW PILOT PLANT FACILITY

Right - Control, Office and Lab Building, Maintenance Building
Center - Cooling Tower and Adjoining Water Treatment Building
Left - Process Area, Flare Pit, Holding Ponds

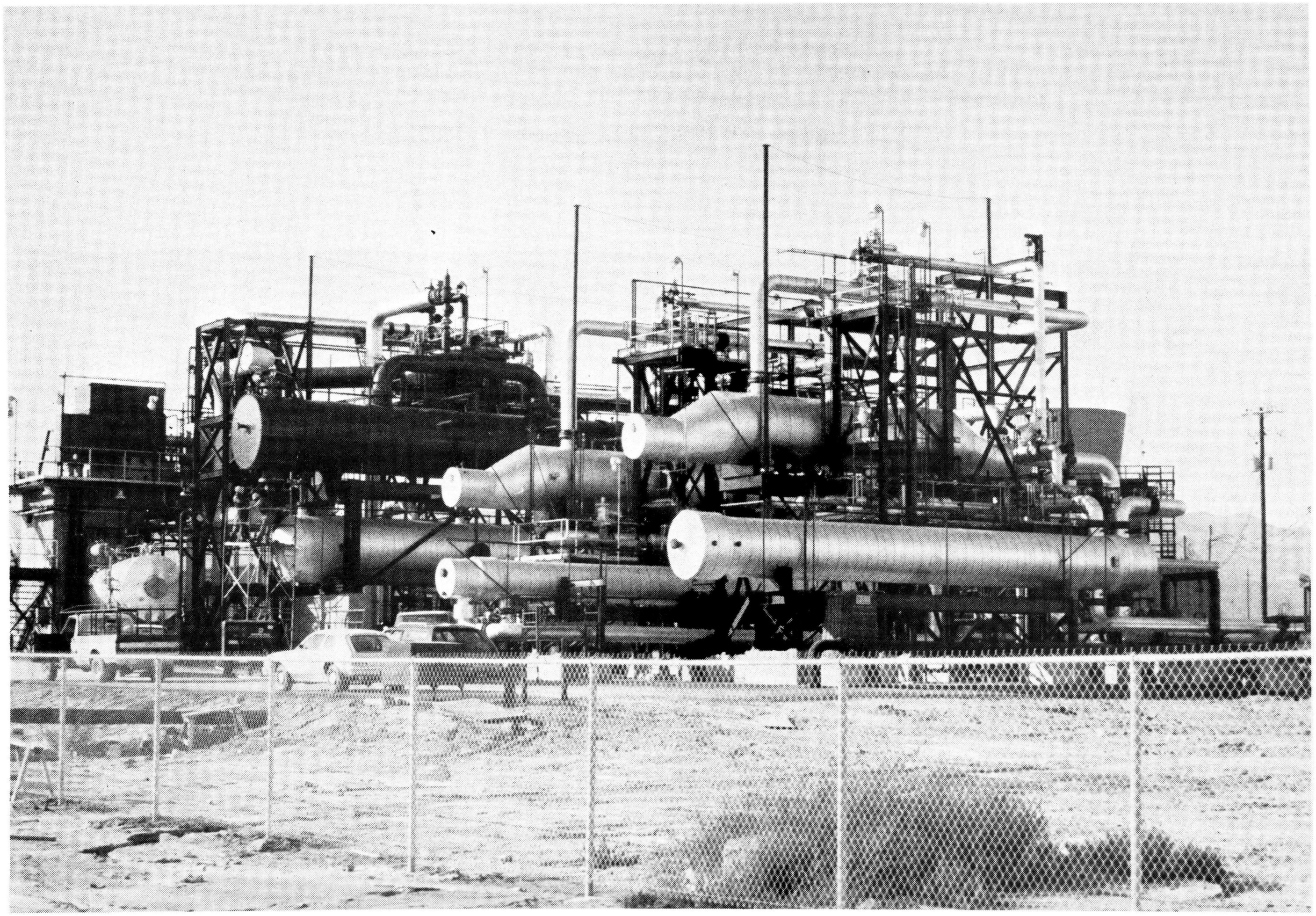

FIGURE 2 RAFT RIVER 5MW(e) PILOT PLANT PROCESS AREA

Right - L.P. Preheater (lower), L.P. Boiler (upper)
Center - H.P. Preheater (lower), H.P. Boiler (upper)
Left - Condenser (upper), Condensate Receiver (lower)
Extreme Right - Generator (upper), Oil System (lower)

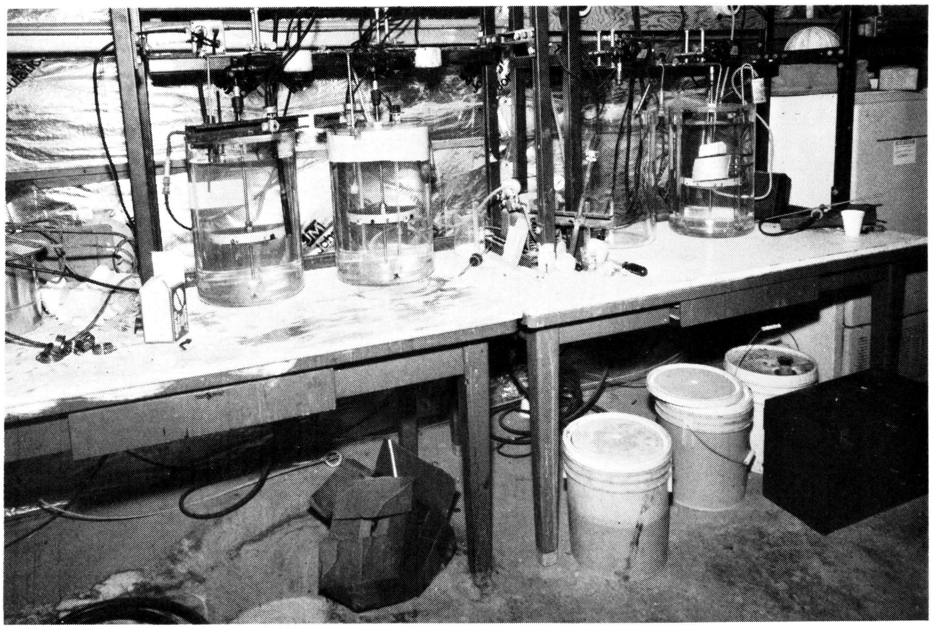

FIGURE 3 WATER CHEMISTRY LABORATORY
Spinner Apparatus used for Screening Corrosion Tests

FIGURE 4 WATER CHEMISTRY LABORATORY
Pilot Cooling Towers used for Establishing Water Treatment and Corrosion Tests (tubes in heat exchangers on the wall)

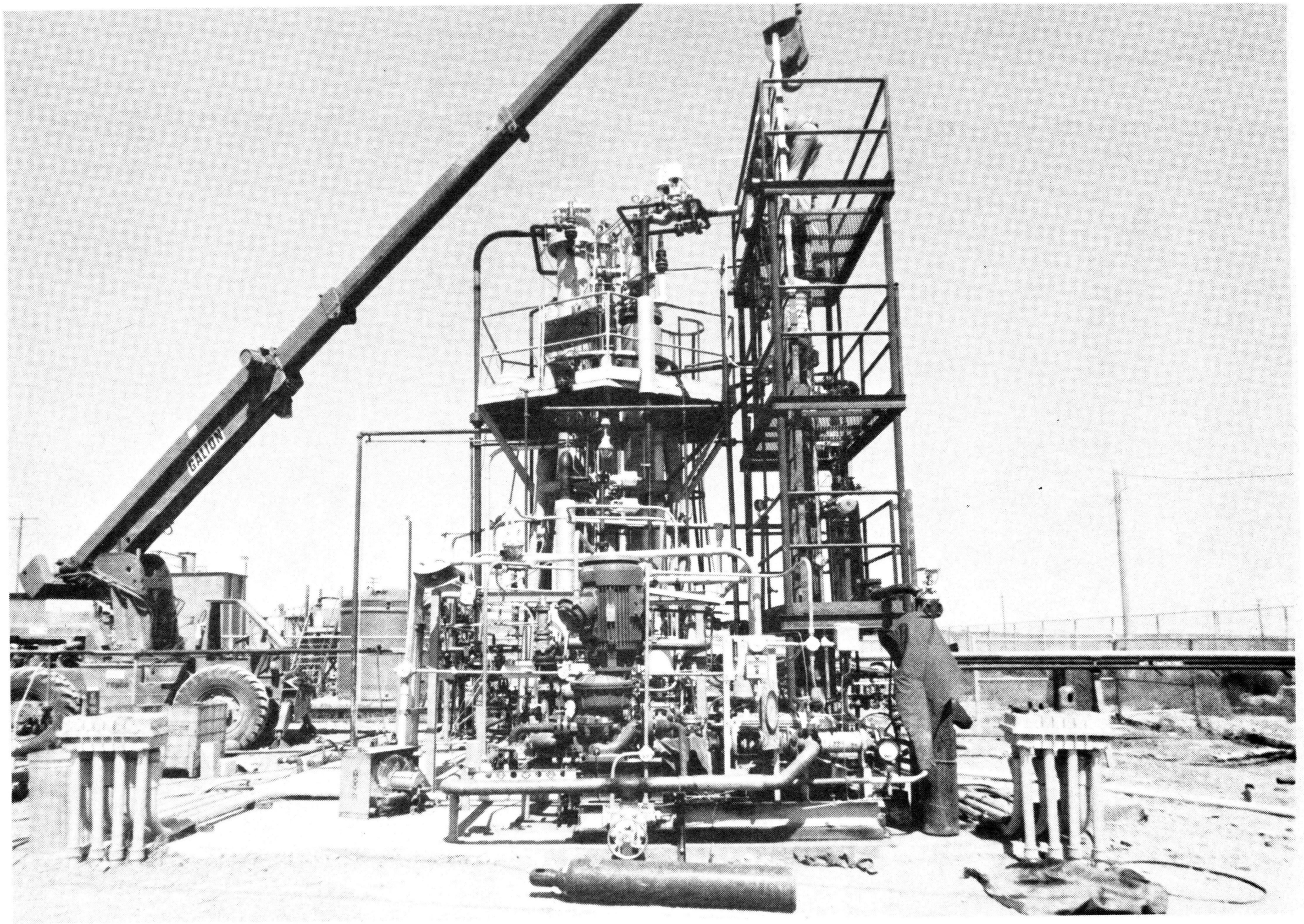

FIGURE 5 60kW(e) PROTOTYPE POWER PLANT FACILITY

Right - (within scaffold) Sieve Tray Preheater, Boiler Column
Center - Structure (right side) Shell and Tube Preheater Boiler
(left side) Vertical Fluted Tube Condenser (by ORNL)
Background - Water Treatment Facility