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Treatment of Geothermal Condensate to Reduce Iron Chelate Consumption

Geothermal Power Initiative

Final Report for the Period September 30, 1997 to March 31, 1998

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Tasks completed during the project:

1. Assembled a portable oxygen generator system consisting of a Pressure Swing Absorption (PSA) oxygen generator, surge tanks, and two mixing eductors. The typical process flow diagram is shown in Figure 1. PSA capacity was 2,000 LB/day of oxygen at 92% purity. This flow was split between the two eductors. Eductor motive water flow was 100 GPM per eductor.
2. Conducted Emission Test No. 1 at Unit 5. The point of oxygen injection is shown in Figure 2.
3. Conducted Emission Tests Nos. 2, 3, and 4 at Unit 11. Two different eductor configurations on the combined Inter and After Condenser tailpipe and one eductor configuration on the condensate pump discharge were tried. (Figure 3).
4. Disassembled the portable oxygen generator system.

Emission Test Procedure:

In general, the emission test procedure for each unit consists of three parts:

Part A: Measure initial H₂S emission response when injecting oxygenated water.

This is a simple before and after check at the cooling tower stacks. All other plant parameters (such as iron chelate concentration and air oxidation operation) are normal. H₂S concentrations in the main steam line are checked before and after the stack readings. Part A is a "go / no go" check. If the observed decrease in stack H₂S emissions is so small as to preclude any hope of justifying a permanent oxygen system, then Parts B and C are canceled.

Part B: Determine optimum iron concentration with oxygen and air oxidation systems in service.

Iron concentration is reduced over the course of several days until stack emissions are equal to "as found" values in Part A. The reduced iron concentration indicates the economic benefit of oxygen injection. Measure the H₂S concentration in the condensate just upstream of the oxygen injection point.

Part C: Determine optimum iron concentration with oxygen in service and air oxidation out of service.

This test determines if Oxygen injection can be operated in lieu of the existing air oxidation system. With the oxygen system on, iron concentration is first raised (to ensure that there is no excess emissions during the transition). Then air oxidation is turned off. Iron concentration is slowly reduced over the course of several days until stack emissions are equal to "as found" values in Part A.

Test Results:

No emission reductions were detected at Units 5 or 11 for any of the eductor configurations. Any observed response was so small that it could be construed to be below measurement tolerance. Consequently, Parts B and C of the test procedure were not done. The table below summarizes the results. Testing at Unit 10 was canceled due to Unit 10's similarity to Unit 5 and the poor Part A response at Unit 5. Oxygen purity was verified at the end of each test to ensure that the oxygen generator was operating properly. All logical eductor configurations have been tested. Therefore, no additional tests are planned.

<u>Test No.</u>	<u>Unit</u>	<u>Eductor Discharge Configuration</u>	<u>Test Procedure</u>	<u>Results</u>
1	5	Into Condensate Pump Discharge	Part A	No Emission Reduction
2	11	Into tailpipe: one eductor at Inter and After Condenser mix point, the other 100' downstream.	Part A	No Emission Reduction
3	11	Same as No. 2 but both eductors at Inter and After Condenser mix point	Part A	No Emission Reduction
4	11	Into Condensate Pump Discharge	Part A	No Emission Reduction

Conclusions:

The lack of an emissions response at either site or in any configuration is probably due to a combination of the following factors:

1. Poor mixing between the oxygen rich water from the eductors and the circulating water flow in the target pipeline.
2. Inadequate residence time between the point of oxygen injection and cooling tower stacks.
3. An inadequate amount of oxygen relative to the flow in the target pipeline.

Without performing actual H₂S and iron chelate valence measurements at various points it is difficult to determine which factor dominates. However, the following comments can be made:

At Unit 5 all three factors probably contributed. Unit 5 was selected because a static mixer was already in place on the top of the cooling tower, just upstream of the first cell. However, there is very little residence time between the mixer and the point downstream where the circulating water is first exposed to the atmosphere. To compensate, the eductor injection point was located as far upstream of the mixer as possible, near the condensate pump discharge and adjacent to the air oxidation injection point. Approximately 200 GPM of oxygen rich water was injected into the center (4 foot diameter pipe) of the 50,000 GPM condensate flow. Either this new oxygen rich stream did not adequately mix with the condensate flow or there was not enough residence time downstream of the static mixer. The eductor flow increased the oxygen content of the condensate by approximately 35% over what it would be with only air oxidation in service.

Injection into the Unit 11 Inter and After Condenser tailpipe (Test 2 and 3) was considered the best chance for success. The tailpipe flow (1,500 GPM) was relatively low compared to the mixing eductor outlet flow (200 GPM). That, plus the long residence time to the tower should have facilitated good chelate regeneration once oxygen was introduced to the tailpipe flow. The condenser packing modifications completed at Unit 11 in 1997 were expected to shift most of the absorbed H₂S from the main condenser to the inter and after condenser tailpipes. This shift was not verified directly, measurement attempts utilizing liquid chromatography resulted in too many interference's to be of use. However, the resultant reduction in iron chelate use after the packing installation indicated a positive change in overall plant adsorption. The lack of any oxygen injection response might suggest that the total liquid side H₂S load may not be as concentrated in the tailpipes as previously thought. Another possibility may be that any positive iron chelate regeneration effect in the tail pipes is overshadowed by regeneration or other chemical effects in the cooling tower basin.

FIG. 1 O₂ INJECTION PROCESS FLOW DIAGRAM

FIG. 2 UNIT 5 INJECTION LOCATION

FIG. 3 UNIT 11 INJECTION LOCATIONS
Page 5