MASTER

DDE/ET/28443--T5

**GEOHERMAL
FIELD
TEST**

**HEAT
EXCHANGER
EVALUATION**

AC03-76 ET 28443

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APPENDICES

✓ SAN DIEGO GAS & ELECTRIC COMPANY

✓ ELECTRIC PRODUCTION DEPARTMENT

MECHANICAL ENGINEERING

GEOHERMAL FIELD TESTS: 44

HEAT EXCHANGER EVALUATION

D. E. Felsinger

July 6, 1973

This report gives the results of heat exchanger tests conducted June 17-21, 1973 at The Geothermal Test Facility Site in the Imperial Valley of California. Those persons directing and evaluating the testing were D. E. Felsinger and D. K. Mulliner. H. K. Bishop had responsibility for heat exchanger cleaning.

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TEST OBJECTIVES

Previous field testing conducted in March of 1973 had shown that heat exchangers in contact with geothermal brine would have their heat exchange surfaces coated with a very hard silica scale, but with the type of equipment available during those tests, reliable information on heat exchanger performance versus time could not be obtained.

The primary objective of these field tests was to determine heat exchange deterioration as a function of in-service time for heat exchangers in the proposed Geothermal Test Facility. It was particularly desired to determine the period of operation before heat transfer deteriorated to the "design" heat transfer rate. This was done by calculating the rate of heat transfer available with a clean (unscaled) heat exchanger and operating it at steady state design conditions until it was scaled to the extent that heat transfer had reached the "design" rate.

Secondary objectives of these field tests were to determine if thermal shocking of the heat exchangers would cause the silica scale to break loose and also to investigate various methods of cleaning heat exchangers once they had been fouled below "design" heat transferring capability.

"Design" heat transfer rate referred to in the above paragraph is that point at which the Geothermal Test Facility would have to be derated because of excessive fouling of the heat exchangers.

SUMMARY OF RESULTS

Results of the heat exchanger tests conducted on a scale model of a heat exchanger that has been designed and fabricated for the Geothermal Test Facility show that this exchanger will lose 60% of its heat transfer capability and fall below "design" requirements after 92 hours of operation. When the test exchanger was clean and operating as close as possible to design conditions, its overall heat transfer coefficient was $426 \text{ BTU/hr-ft}^2 - \text{f}$. when calculating in the fouling factor of .0035 this gave a "design" coefficient of $171 \text{ BTU/hr-ft}^2 - \text{f}$ which was reached after less than four days of steady state operation.

As can be seen on the heat transfer coefficient versus time graph on page 8, loss of heat transfer was almost a straight line function and at no time did it decline and taper off at some value above the design limit as anticipated by the C. F. Braun Company

Thermal shocking of the test heat exchanger once each hour while the exchanger was operating at design conditions had no effect on scale removal or heat transfer. Although this test was only carried out for 80 hours before it was discontinued because of equipment failure, extension of the graph plotted up to this time showed that the exchanger would have fallen below design conditions after approximately 95 hours of operation.

Results of tube cleaning showed that chemical treatment with 30% hydrochloric acid followed by a high pressure water jet (6,000 psig), was effective in removing scale from tubes contacted with geothermal brine. After cleaning, the tubes were examined and some pitting was observed throughout the length of one tube. It may be possible that the use of a more effective corrosion inhibitor would eliminate attack by acid cleaning.

CONCLUSIONS

The brine heat exchangers in the Geothermal Test Facility will not perform at design conditions after the first 100 hours of operation and at this time the Test Facility would have to be taken off the line for cleaning of the brine heat exchangers. Some concern was expressed by engineers at the C. F. Braun Co. that the distilled water pressure on the shell side of the test exchanger may have been too low, causing the distilled water to flash during the test runs and in turn give erroneous heat transfer data. For this reason and because of the importance placed on the results of these tests, this test will be repeated with a higher shell side pressure to verify the 100 hours of exchanger operation.

From the information gained to date, it appears that heat exchanger cleaning can be accomplished by the use of a chemical acid solution followed by a high pressure water blast. Due to the frequency of cleaning required and the time involved in the cleaning operation, it does not appear that the present design of the Geothermal Test Facility will be acceptable for any type of continuous operation. If continuous operation of the Geothermal Test Facility is to be a criteria for a valid Geothermal Reservoir evaluation, then future field testing may indicate that a change from the present design to perhaps an all steam system or a parallel heat exchanger system may be required.

RESULTS

Design Exchanger

The design test exchanger was put into operation at 1400 hours on 6/17/73 with clean tubes and at this time its overall heat transfer coefficient was equal to 426 BTU/hr-ft²-°f. As can be seen from the graph on page 8 the heat transfer decreased almost linearly from the time the exchanger was put into operation until it reached its design value 92 hours later.

It had been anticipated that during the first few hours of operation, the heat transfer rate would decline rapidly as the scale built up inside the tubes and then level off to some undetermined value above design conditions. This was not the case.

Research Exchanger (Thermal Shocking)

The research test exchanger was put into operation at 1400 hours on 6/17/73 with clean tubes and at this time its overall heat transfer coefficient was 473 BTU/hr-ft²-°f. This exchanger was then thermal shocked once each hour for a five minute duration with 80°F water in hopes of removing the scale deposition by rapid expansion and contraction of the exchanger tubing. This test was carried out for over 80 hours before equipment failure led to cancellation of the test. The data collected up to this point showed that this exchanger

operating at near design conditions with periodic thermal shocking had lost 87% of its design heat transferring capability before the test was discontinued. As can be seen on the graph on page 8 a continuation of the graph of the points plotted up to this time show that this exchanger would have also failed after approximately 92 hours of operation.

The results of this test show that thermal shocking of the exchangers will have no effect on scale removal with a corresponding change in heat transfer.

DESCRIPTION

The heat exchanger used in these field tests consisted of a ten foot length of four-inch pipe for the exchanger shell and two tube sheets welded inside this shell a distance of 9'6" apart. Each tube sheet was then drilled and tapped with two 1" openings in which swagelok fittings were attached. (See detailed drawing of heat exchanger on page 14). Two lengths of 1" o.d. titanium tubing were then placed inside the exchanger and the ends were then held in place by the swagelok fittings. The swagelok fittings were then tightened down over teflon ferrules so that the tubing could expand and contract without buckling or bowing. Over the end of each exchanger was then placed a 4" flange with a 2" opening for allowing the fluids to pass through the exchanger tubing.

The inlet brine pressure and its corresponding temperature into the heat exchanger were controlled by an automatic control valve located upstream of the exchanger on the flash drum. (See flow diagram of geothermal test unit on page 13). The brine velocity through the exchanger tubes was controlled by an automatic flow control valve located down stream of the exchanger and the temperature of the distilled water into the shell side of the exchanger was controlled by an automatic

temperature control valve. The flow of the distilled water into the exchanger shell was set by a manually operated valve.

The temperatures, pressures and flow rates in and out of the test exchanger are listed in tabulated form and compared to the exchanger conditions for brine exchanger E-1A in the Geothermal Test Facility.

TUBESIDE

	<u>Fluid</u>	<u>Inlet °F</u>	<u>Inlet Press.</u>	<u>Outlet °F</u>	<u>Velocity</u>
Test Exchanger	Brine	375	150 psig	342	5 ft/sec
Geothermal Test Facility Exchanger E-1A	Brine	375	150 psig	283*	5 ft/sec

SHELLSIDE

	<u>Fluid</u>	<u>Inlet °F</u>	<u>Inlet Press.</u>	<u>Outlet °F</u>	<u>Velocity</u>
Test Exchanger	Distilled H ₂ O	208	25 psig	220	1.44 ft/sec
Geothermal Test Facility Exchanger E-1A	C ₄ H ₁₀	220	525	270	7 ft/sec

* The reason for the large difference in outlet temperatures is that exchanger E-1A contains eight passes with twenty feet long tubes, while the test exchanger is single pass with nine foot six inch long tubes.

LAYOUT OF GEOTHERMAL TEST FACILITY

FLOW DIAGRAM OF GEOTHERMAL TEST UNIT - TWO STAGE STEAM FLASH

DETAIL OF HEAT EXCHANGER

TEST CONDITIONS

The following assumptions and test parameters were imposed on the system in order to simulate if not duplicate the design conditions proposed by C. F. Braun.

Test Assumptions

1. The specific heat for geothermal brine is equal to 1.0.
2. All exchanger tubes are perfectly clean or new at the initiation of a test.

Test Conditions

1. The geothermal brine enters the heat exchangers at 375°F and 150 psig.
2. The velocity and mass flow rate of the geothermal brine is 5 feet per second and 9265 pounds per hour respectively.
3. The distilled water enters the heat exchangers at 208°F and 25 psig.
4. The velocity and mass flow rate of the distilled water is 1.44 feet per second and 24,107 pounds per hour respectively.

In tabulated form:

	Inlet Temp. °F	Pressure psig	Velocity ft./sec.	Mass Flow Rate lbs/hr
Geothermal Brine	375	150	5	9265
Distilled H ₂ O	208	25	1.44	24,107

TEST PROCEDURES

Brine Pressure Control Valve

Hot brine at 450°F and 360 psig is taken directly from the well head and throttled twice before the design conditions are reached. The most throttling is done through an in line plug-valve, afterwhich, an automatic pressure control valve brings the geothermal fluid to the control conditions of the 375°F and 150 psig. The automatic pressure control valve is a model 72P315 Moore Products valve. It is controlled pneumatically by a Masoneilan International Controller, model number 2715. This pressure valve simultaneously controls the temperature of brine into the system. The brine temperature is then recorded on a Barton Temperature Recorder, model number 879.

Distilled Water Flow

The distilled water is stored in a 9,000 gallon tanker truck and the flow through the exchanger is measured by a Worthington Gammon Turbine Meter, which was calibrated against a Neture Trident Meter, model 426705.

Brine Velocity

The velocity of the brine on the design exchanger is controlled by a control valve made by A. W. Cash Company with a model number of 3286. This valve is controlled

by a Foxboro model 43A pneumatic flow controller, model number C128AC, serial number 2240204.

The velocity of the brine on the research exchanger is controlled by a 2-inch Fisher Governor valve, model number 2758AFF and serial number 2447687. This valve is controlled by a Barton Pneumatic Flow Controller.

Distilled Water and Brine Temperature Measurements

All temperature measurements were made with three calibrated Van Waters & Rogers mercury filled, glass thermometers, (0-400°F). Special care was taken to insure that the same thermometer was used to measure the same fluid each time readings were taken.

Pressure Measurements

All pressure measurements such as the well head pressure, the flash drum pressure, and the shell side of both the heat exchangers were made with Victor (0-400 psig) gauges,

Thermal Shock Treatment

A thermal shock treatment was performed on the research exchanger for five minutes of every hour throughout the test. This was accomplished by an injection of irrigation water through a three-way valve arrangement upstream of the exchanger. The irrigation water was pumped through the tube side of the exchanger at 80°F and 25 psig.

OBSERVED DATA (DESIGN EXCHANGER)

GEOTHERMAL FIELD TESTS

Item	Name	Units	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
	Day/Time		6-17-73/1400	6-18-73/1400	6-19-73/1700	6-20-73/1100	6-20-73/2100	6-21-73/1400
Th ₁	Brine In. Temp.	°F	375	375	375	375	375	375
Th ₂	Brine Out. Temp.	°F	342	344	350	352	358	361
BFLOW	Brine Flow Rate	lb./hr.	9265	9265	9265	9265	9265	9265
Tc ₂	Distilled H ₂ O Temp. In.	°F	208	208	208	208	208	208
Tc ₁	Distilled H ₂ O Temp. Out.	°F	220	216.7	214	213.4	212	211
DWFLOW	Distilled H ₂ O Flow Rate	lb./hr.	24,107	24,107	24,107	24,107	24,107	24,107
PDW	Distilled H ₂ O Pressure	psig	25	25	25	25	25	25

CALCULATED DATA (DESIGN EXCHANGER)

LMTD	*LMTD	°F	144.24	146.87	151.35	152.67	156.37	158.35
U	*U	$\frac{\text{BTU}}{\text{hr-ft}^2\text{-}^\circ\text{F}}$	426.50	393.48	307.93	280.84	202.67	164.82
U _d	U _{design}	$\frac{\text{BTU}}{\text{hr-ft}^2\text{-}^\circ\text{F}}$	171.10					

Each test was held at these conditions for 20 minutes before data was taken.

*U_{clean} = U on Run No. 1.

*LMTD = Log-Mean Temperature Difference.

OBSERVED DATA (RESEARCH EXCHANGER)

GEOTHERMAL FIELD TESTS

Item	Name	Units	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
	Day/Time		6-17-73/1400	6-18-73/1400	6-20-73/2200			
Th ₁	Brine In. Temp.	°F	375	375	375			
Th ₂	Brine Out. Temp.	°F	339	344	357			
BFLOW	Brine Flow Rate	lbs./hr.	9265	9265	9265			
Tc ₁	Distilled H ₂ O Temp. In.	°F	208	208	208			
Tc ₂	Distilled H ₂ O Temp. Out.	°F	222	217	215			
DWFLOW	Distilled H ₂ O Flow Rate	lbs./hr.	24.107	24.107	24.107			
PDW	Distilled H ₂ O Pressure	psig	25	25	25			

Run 4 - 6 Data Lost
Due to Equipment
Failure

CALCULATED DATA (RESEARCH EXCHANGER)

LMTD	*LMTD	°F	141.75	146.75	154.37			
U	*U	$\frac{\text{BTU}}{\text{hr-ft}^2\text{-}^\circ\text{F}}$	473.44	393.80	217.37			
U _d	U _{design}	$\frac{\text{BTU}}{\text{hr-ft}^2\text{-}^\circ\text{F}}$	178.18					

Each test was held at these conditions for 20 minutes before data was taken.

*U_{clean} = U on Run No. 1.

*LMTD = Log-Mean Temperature Difference.

METHOD OF HEAT EXCHANGER CALCULATION

Sample Calculation- (Using Run No. 1 on Design Exchanger)

The object of the following method of calculation is to obtain the overall heat-transfer coefficient (U). Since the following calculations will be for Run No. 1, the overall heat-transfer coefficient (U) will also equal the overall heat-transfer coefficient of a clean tube (U_{clean}). Knowing U_{clean} we can then calculate U_{design} , which is another number unique to Run No. 1. The calculations begin with the assumption that the specific heat of geothermal brine is equal to one. We can then propose that the heat lost in the system (Q) is equal to the change of enthalpy in the system (ΔH). Therefore, the heat lost is equal to the mass flow rate of the brine multiplied by the temperature difference of the brine through the exchanger. The surface area of the exchanger tubes is then found by finding the accumulated product of the length, circumference, and the number of tubes. The log-mean temperature difference (LMTD) is to be solved for next. A verbal description of the LMTD is the temperature difference at one end of the exchanger, less the temperature difference at the other end of the exchanger, divided by the natural logarithm of the ratio of these two temperature differences. Once the LMTD has been found, the overall heat-transfer coefficient U (in this case U_{clean}) can be computed by dividing the heat lost (Q)

by the product of the surface area of the tubes and the LMTD. Knowing U_{clean} we can calculate U_{design} by taking the inverse of the quantity of the fouling factor plus the inverse of U_{clean} .

The calculated overall heat-transfer coefficient (U) for each run is then plotted against its corresponding accumulated test time to produce a curve like the one shown in the results section of this report.

CALCULATIONS

Symbols

Q	= Heat lost by geothermal brine.
A	= Total surface area of heat exchanger tubes.
LMTD	= Log-mean temperature difference.
U	= Overall heat transfer coefficient
U _{clean}	= Overall heat transfer coefficient (clean tube).
U _{design}	= Minimum overall heat-transfer coefficient.
Th ₁	= Brine in temperature.
Th ₂	= Brine out temperature.
Tc ₁	= Distilled water out temperature.
Tc ₂	= Distilled water in temperature.
BFLOW	= Brine mass flow rate.
DWFLOW	= Distilled water mass flow rate.
D	= Diameter of heat exchanger tube.
L	= Length of heat exchanger tube.
PDW	= Pressure distilled water.
ff	= Fouling factor built into brine exchangers for the Geothermal Test Facility = .0035.

CALCULATIONS

Sample Overall Heat-Transfer Coefficient Calculations

Test Conditions (Run No.1)

$$Th_1 = 375^{\circ}F$$

$$Tc_2 = 208^{\circ}F$$

$$BFLOW = 9265 \text{ lbs./hr.}$$

$$DWFLOW = 24,107 \text{ lbs./hr.}$$

Measured Conditions (Run No. 1)

$$Th_2 = 342^{\circ}F$$

$$Tc_1 = 220^{\circ}F$$

CALCULATIONS

Calculations

Calculation of heat lost by the brine:

$$\begin{aligned} Q &= \Delta H = \text{BFLOW} (Th_1 - Th_2) \\ &= 9265 (375 - 342) \\ &= 305,745 \text{ BTU/HR} \end{aligned}$$

Calculation of surface area (heat exchanger tubes)

$$\begin{aligned} A &= 2(\pi DL/144) \\ &= \frac{2(\pi(114))}{144} = 4.97 \text{ FT}^2 \end{aligned}$$

Calculation of log-mean temperature difference

$$\begin{aligned} \text{LMTD} &= \frac{(Th_1 - Tc_1) - (Th_2 - Tc_2)}{\ln \left[\frac{(Th_1 - Tc_1)}{(Th_2 - Tc_2)} \right]} \\ &= \frac{(375 - 220) - (342 - 208)}{\ln \left[\frac{(375 - 220)}{(342 - 208)} \right]} \\ &= \frac{21}{.14558} = 144.24^\circ\text{F} \end{aligned}$$

CALCULATIONS

Calculations

Calculation of overall heat transfer coefficient

$$Q = (U)(A)(LMTD)$$

$$U = \frac{Q}{(A)(LMTD)} = \frac{305,745}{(4.97)(144.24)} \\ = 426.498 \frac{\text{BTU}}{\text{hr-ft}^2\text{-of}}$$

$$U_{\text{clean}} = U (\text{Run No. 1.})$$

Therefore;

$$U_{\text{clean}} = 426.498 \frac{\text{BTU}}{\text{hr-ft}^2\text{-of}}$$

U_{design} is then calculated from U_{clean}

$$U_{\text{design}} = \frac{1}{\left[\frac{1}{U_{\text{clean}}} + ff \right]} = \frac{1}{[2.344 \times 10^{-3} + .0035]} \\ = \frac{1}{5.844 \times 10^{-3}} = 171.095 \frac{\text{BTU}}{\text{hr-ft}^2\text{-of}}$$

U_{clean} = 426

3 x 10⁻³ + .0035

EXCHANGER CLEANING

by H. K. Bishop

Summary

Chemical treatment with 30% hydrochloric acid followed by a high pressure water jet, is effective in removing scale from tubes contacted with geothermal brine. After cleaning, the tubes were examined and some pitting was observed. At this time it is not certain that this was caused by the chemical cleaning.

Future Work

Halliburton Services has been contacted and arrangements made to submit tubes scaled by geothermal brine for hydro jet cleaning using a specially designed nozzle. These tubes will be taken to Los Angeles to witness the cleaning procedures. In this way we can decide if they would be suitable for power plant operations.

Discussion

The Cal-Chem Cleaning Company of El Monte visited the geothermal site for the second time to demonstrate their cleaning techniques. During their previous visit it was determined that the use of their high pressure water jet for removing scale formed during scale testing of the geothermal brine was not effective. However, the

use of a high pressure water jet following chemical treatment of the tubes with hydrochloric acid appeared promising as a method for scale removal.

During their second visit two treatment methods were used. The first utilized a hot dilute (14%) hydrochloric acid solution for treating the tubes. This solution, at a temperature of 150°F to 180°F, was pumped through the tubes for a period of one hour. One tube was then removed and washed with a high pressure (6,000 psig) water jet in one pass. Only partial removal of the scale was observed. In the second method the concentration of the circulating acid was increased to approximately 30%. This acid was circulated at a temperature of approximately 132°F for a period of one hour. The tubes were again washed with a high pressure water jet and the interior examined with a borescope. Scale removal appeared to be complete. Pitting of the titanium tube surface was observed. However, a second titanium tube which was exposed to both the hot dilute acid and the concentrated acid and finally washed with a high pressure water jet did not show evidence of pitting.

It is not certain at this time whether the pitting was caused by the acid although it was observed for the first time following acid cleaning. During the previous cleaning test a borescope was not available for examination

of the interior of the tubes. It is possible that use of a more effective corrosion inhibitor with the acid would eliminate the pitting.

PROBLEM SECTION

This section will be devoted to some of the problems that have arisen while trying to work with geothermal fluids in the hopes that others may benefit from our experiences. This section will be updated with each report.

1. Valves, whether automatic or manual, in contact with geothermal fluids should not have close tolerances between valve skirts and guides. If they do, it is just a matter of hours before silica deposition will freeze the valves solid in position. One type of valve that has been found to outlast all others is the plug valve, where the only time there is surface contact is when the valve is closed.

2. Pressure taps are normally drilled to 1/16" diameter but in geothermal circuits taps as large as 1/4" plug solid after one week of operation and have to be drilled or cleaned out. No remedy has been arrived at for this problem but when pressure instrumentation or controllers start to go bad, one of the first places to look is the pressure tap.

3. Thermometer wells in contact with geothermal fluids are coated with a thick deposit of mineral solids after just a few days of operation. This deposit acts as an

insulation around the thermometer well and makes it slow to respond to temperature changes. This could definitely prove to be a problem in an operating system where a temperature controller is used to change process variables, such as isobutane flow through a system as a function of the temperature of geothermal fluids into that system.

4. Mechanical seals on pump shafts pumping geothermal fluids have not been found to be acceptable. Due to the abrasiveness of the geothermal fluids these seals are only good for several hundred hours of operation before they start leaking. Pumps with packing around the shafts are more convenient to work with because when leaks begin to appear, it is no problem to either tighten down or replace the packing.

APPENDIX I

Analysis of Geothermal Brine and Scale

GHT LABORATORIES OF IMPERIAL VALLEY, INC.
106 SOUTH 8th STREET • BRAWLEY, CALIFORNIA
344-2532

LABORATORY NO.	C 10031-1	REPORTED	6-21-73
FOR	SAN DIEGO GAS & ELECTRIC	SAMPLED	
SAMPLE	BRINE (2) SCALE (1)	RECEIVED	6-18-73
IDENTIFICATION	1. BRINE FROM SEPRATOR 6-18 2. BRINE INLET 6-18 3. SCALE FROM BRINE EXCHANGER TUBS		

Based on sample ... drawn by this laboratory (1)

delivered to us ☒

RESULTS OF ANALYSIS

SEE ATTACHED SHEET

GHT LABORATORIES OF IMPERIAL VALLEY

ROBERT A. REYNOLDS

As a mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of clients, and authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved, pending our written approval.

C 10031-1

SAN DIEGO GAS & ELECTRIC

BRINE

1. BRINE FROM SEPRATOR 6-18
2. BRINE INLET 6/18

ANALYTICAL CHEMISTS
PESTICIDE ANALYSTS

108 South Street
Brawley, California

Phone 344-2532

	AS RECEIVED		AFTER PERCHLORIC DIGESTION	
	#1	#2	#1	#2
SODIUM (Na)	67,500 mg/l	50,000 mg/l	65,000 mg/l	= 50,000 mg/l
POTASSIUM (K)	1250 mg/l	900 mg/l	1000 mg/l	800 mg/l
MANGANESE (Mn)	745 mg/l	620 mg/l	800 mg/l	630 mg/l
ZINC (Zn)	285 mg/l	215 mg/l	290 mg/l	250 mg/l
IRON (Fe)	125 mg/l	100 mg/l	250 mg/l	170 mg/l
MAGNESIUM (Mg)	112 mg/l	95 mg/l	100 mg/l	70 mg/l
LEAD (Pb)	98 mg/l	23 mg/l	125 mg/l	95 mg/l
COPPER (Cu)	5.0 mg/l	3.8 mg/l	1.7 mg/l	0.9 mg/l
SULFATE (SO ₄)	0.07 mg/l	0.08 mg/l	N.A.	N.A.
SULFIDE	NONE DETECTED		N.A.	N.A.
SILICA (SiO ₂)	56 mg/l	107 mg/l	580 mg/l	666 mg/l

ROBERT A. REYNOLDS

ANALYSIS OF
TEST RESULTS

C 10031

SAN DIEGO GAS & ELECTRIC

100 West San Diego
San Diego, California

Phone 442-512

NOTES:

1. After sampling, the brines apparently almost immediately begin to flocculate and settle. The analysis "as received" is on the liquid portion separated from the floc. The "after perchloric digestion" are analyses on an aliquot of the whole sample (50 ml), shaken to float the floc, and digested with 10 ml of conc. HNO_3 and 8 ml of conc. HClO_4 .
2. The digestion does not seem to materially affect the amounts of the alkali metals, but strongly affects the iron, lead, and silica determinations.
3. The silica was done gravimetrically after the perchloric digestion and probably proves the hypothesis of the S.D.G.E. personnel that a large amount of the silica is present in colloidal or other forms that escape the molybdate reduction method. To check, silica was determined on the filtrate of the gravimetric-silica determination, and there was present 0.8 mg/l of SiO_2 in both 1 and 2.

ROBERT A. REYNOLDS

GHT LABORATORIES OF IMPERIAL VALLEY, INC.
106 SOUTH 8th STREET • BRAWLEY, CALIFORNIA
344-2532

LABORATORY NO. **C 10031-2**
FOR **SAN DIEGO GAS & ELECTRIC**
SAMPLE **SCALE**
IDENTIFICATION **SCALE FROM BRINE EXCHANGER TUBS**

REPORTED **6-21-73**

SAMPLED

RECEIVED **6-18-73**

Based on sample --- drawn by this laboratory ☐

delivered to us - - - ☒

RESULTS OF ANALYSIS

SILICA (SiO_2)	21.52%
MANGANESE (MnO_2)	1.60%
IRON (Fe_2O_3)	1.68%
COPPER (CuO)	0.45%
ZINC (Zn)	0.18%
MAGNESIUM (Mg)	0.15%
CALCIUM (Ca)	6.85%
SILVER (Ag)	0.0024%
CHROMIUM (Cr)	0.0025%
NICKEL	0.0030%
POTASSIUM (K)	4.50%

GHT LABORATORIES OF IMPERIAL VALLEY

ROBERT A. REYNOLDS

RECEIVED

JUN 28 1973

San Diego Gas & Electric Company
GAS MAINTENANCE

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