MASTER

TECHNICAL REPORT

FOR THE PERIOD

APRIL 1 THROUGH JUNE 30, 1977

**MULTIFLASH FEED-AND-BLEED COUPLING
FOR THE EVAPORATION AND
CRYSTALLIZATION INDUSTRY**

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BECHTEL CORPORATION

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CONTENTS

<u>Section</u>		<u>Page</u>
1	INTRODUCTION/SUMMARY	1-1
2	THIRD QUARTER WORK	2-1
	2.1 Candidate Industry Evaluation	2-1
	2.2 Economic Analysis	2-2
	2.3 Fuel Savings	2-6
	2.4 Environmental Impact	2-8
	2.5 Alternate Methods	2-8
	2.6 Final Report	2-10
3	REMAINING WORK	3-1
	REFERENCES	R-1
	APPENDIX A	
	APPENDIX B	

Section 1

INTRODUCTION/SUMMARY

In October of 1976, Bechtel Corporation was awarded a contract by ERDA (Division of Geothermal Energy) to determine the technical and economic feasibility of using low temperature geothermal brine in place of steam from conventional sources for industrial multi-effect evaporation and crystallization. A key aspect of the study is that Bechtel's multiflash feed-and-bleed concept will be incorporated in the evaporation and crystallization processes to use the geothermal energy most effectively.

This document is the third and last quarterly report. In it is a summary of the work performed on this contract during the period of April through June 1977. This work included the following:

- Candidate Industry Evaluation
  - Process flow diagrams, heat and material balances completed
  - Conceptual engineering completed
  - Visit to Leslie Salt plant
- Economic Analysis
  - Economic groundrules established
  - Capital and operating costs derived
  - Cost comparison of geothermal vs. fossil fuel plants nearly completed

- Economic Impact
  - Analysis of fuel savings by use of geothermal resources made
- Environmental Impact
  - Analysis of environmental impact of geothermal vs. fossil fueled plants completed
- Alternate Methods
  - Comparison made of feed-and-bleed process with other geothermal heat utilization processes
- Final Report
  - Final report started

Since the final report on this study is scheduled to be issued shortly (August, 1977), this quarterly will not contain the detailed discussion of results that will soon be presented in the final report. Instead, the work performed in the third quarter is reviewed in sufficient detail to show the progress made and the major areas of work effort. Where needed, examples of completed work are given.

To date, it has been concluded that the cost of applying non-electric geothermal brines to the evaporation and crystallization industry will be largely determined by the following factors:

- Characteristics of the resource (distance, temperature, well cost, and flow)
- The effectiveness of the process to utilize the brine
- The percent onstream factor of the process.

Section 2

THIRD QUARTER WORK

This section gives an account of the third quarter work summarized in Section 1.

2.1 Candidate Industry Evaluation

The required process flow diagrams along with the respective heat and material balances have been completed for the three candidate industries. The drawings for the tomato paste process are enclosed in the appendix. A complete list of these diagrams is given as follows:

<u>Drawing No.</u>	<u>Title</u>
T-1	Conventional - 200 ton/hr Tomato Paste Plant (Enclosed in Appendix A)
T-2	Retrofitted - 200 ton/hr Tomato Paste Plant (Enclosed in Appendix B)
S-1	Conventional - 4000 ton/day Beet Sugar Factory
S-2	Retrofitted - 4000 ton/day Beet Sugar Factory
N-1	Conventional - 500 ton/day Salt Plant
N-2	Retrofitted -500 ton/day Salt Plant

In addition, flow diagrams have been completed for a typical Geothermal Brine Supply and Reinjection System (Drawing No. R-1), and a conceptual

Portable Test Loop (Drawing No. SK-5).

Conceptual engineering work on the three candidate industries has been completed. Equipment required for new and retrofitted geothermal plant cases have been sized. This equipment includes the necessary new flash tanks, piping, geothermal systems (wells, pipelines, pumps, etc.), as well as the modified units (evaporators/crystallizers, condensers, pumps) in retrofitted plants. Equipment lists have been prepared (see Table 1 for an example). This work formed the basis for the economic analysis of the candidate industries.

In May, the Leslie Salt Crystallization Facility at Newark, California was visited. This was done in order to get a first hand look at the process operations of one of the candidate industries. A meeting with the plant manager was held so that the potential use of geothermal heat in the salt manufacturing process could be discussed.

2.2 Economic Analysis

During the third quarter, assumptions used in the economic analysis of the candidate industries were set. Some of the more significant assumptions are:

- Production well parameters
  - depth, cost/ft
  - flow rates
  - well life
  - exploration costs

Table 1
Tomato Paste Plant
Mechanical Equipment List

<u>Equipment</u>	<u>Description</u>	
Flash Tanks	Quantity Type Size Design Pressure Design Temperature Material Remarks	2 Horizontal 5 ft. dia. x 20 ft. length 67 psia 300°F Carbon Steel Include three flash stages, product trays, and mist eliminator.
Supply Wells	Quantity Depth	17 1000 feet
Reinjection Well	Quantity Depth Miscellaneous	9 1000 feet Surge Tank 75,000 gallons steel
Supply Pump	Quantity Capacity Type Efficiency Driver	17 250 gpm at 750 feet Deep Submersible 80% Induction motor, 60 HP
Transfer Pump	Quantity Capacity Type Efficiency Driver	2 1800 gpm at 45 feet Centrifugal 80% Induction Motor 30 HP
Reinjection Pumps	Quantity Capacity Type	2 1800 gpm at 740 ft head Centrifugal

Table 1 (Continued)

<u>Equipment</u>	<u>Description</u>	
Reinjection Pumps	Efficiency Driver	80% Induction Motor, 450 HP
	Material	Cast Iron case, SS impeller
Recirculation Pump	Quantity	9
Electric Motor	Type	Induction Motor weatherproof Type II
Conversions	Size	(6) 250 HP (3) 400 HP
Third Effect Heat Exchanger	Quantity Size	3 3600 square feet of area
	Material	SS Tubes
Hot Breaks	Quantity	10
Exchanger Surface	Size Material	1800 square feet SS
Packaged Boiler	Quantity Size	1 150 pounds @ 15,000 lbs per hour

Major Piping List

<u>Description</u>	<u>Diameter (in.)</u>	<u>Schedule or Thickness (in.)</u>	<u>Length (ft.)</u>	<u>Material</u>
<u>Brine System Piping</u>				
Brine Inlet	16	40	5280	CS
Brine Reinjection	16	40	5280	CS
<u>Steam Lines</u>				
Effect 1 and 3 and Hot Breaks	20	40	400	CS
Effect 2	12	40	200	CS

- Reinjection well parameters

- number
- well life
- depth

- Pipeline parameters

- length, cost/mile
- material
- pressure drop

- Equipment parameters

- material
- operating costs

- Fossil fueled plant parameters

- fuel costs
- capital costs associated with steam generation

These assumptions were used to make conceptual cost estimates so that the cost of energy (\$/MMBTU) for the various cases (geothermal vs. fossil fueled plants) could be determined. Energy costs are shown as a function of such variables as pipeline length and plant operating factors for a retrofitted and new plant. In this manner, the influence of these major parameters on the cost of energy is shown.

The preliminary conclusion is that the cost of using the brine will be primarily determined by the cost of the resource. The cost for retrofitting the plant will normally be small in comparison to obtaining the resource. In addition, the resource cost on a dollars per million Btu basis will be least when the onstream factor is highest.

2.3 Fuel Savings

An estimate of potential fossil fuel savings was made by assuming only those multi-effect evaporation/crystallization users who are within a reasonable proximity of the geothermal resource will convert from fossil fuel to geothermal derived steam. Fuel savings were estimated for two cases:

Case 1: This estimate takes into account all multi-effect evaporation/crystallization users within 25 miles of a "Probable Geothermal Resource Area" (as defined by Geological Survey No. 647, 1971).

Case 2: This is a more conservative estimate which considers only those multi-effect evaporation/crystallization users within the "Probable Geothermal Resource Areas".

An industry by industry breakdown was developed giving potential fuel savings for each case. The results are shown in Table 2.

Table 2
Estimated Fossil Fuel Savings

INDUSTRY	U. S. TOTALS		ZONE I ⁽⁴⁾		ZONE II ⁽⁵⁾		ZONE I & II Energy Savings 10 ⁶ <u>BBL OIL</u> ⁽⁶⁾ YR
	Plants	Energy Use, 10 ¹² BTU/Yr	Plants	Potential Energy Savings 10 ¹² BTU/Yr	Plants	Potential Energy Savings 10 ¹² BTU/Yr	
Food ⁽¹⁾	480	142	8	8.7	44	17.8	4.6
Paper ⁽²⁾	220	1595	1	0.6	9	13.5	2.4
Chemical ⁽³⁾	100	270	0	—	12	<u>15.0</u>	<u>2.6</u>
TOTALS				9.3		46.3	9.6

NOTES:

- (1) Includes Beet Sugar, Tomato Paste, Frozen Juice, and Dry Milk segments.
- (2) Includes Pulp Mill, and Integrated Pulp/Paper Mill segments.
- (3) Includes Caustic (from diaphragm cells), Salt (Vacuum pan NaCl), Other Inorganic Salts (by evaporation): Soda Ash, Salt Cake, Sodium Phosphates, Calcium Chloride, Potassium Chloride, Borax, Sodium Chloride.
- (4) Within "Probable Geothermal Resource Areas".
- (5) Within 25 miles of "Probable Geothermal Resource Areas", but outside Zone I.
- (6) 5.8×10^6 BTU/BBL Fuel Oil.
- (7) Energy Figures are, for the most part, based on 1972 data.
- (8) References: 3, 10, 11, 31, 34, 46, 53, 55.

2.4 Environmental Impact

The probable effect on the environment by geothermal facilities has been investigated, and compared to those effects produced by similar plants using fossil fueled derived steam. There will be varying degrees of environmental impact during construction and operation of both types of facilities. During operation, some of the following environmental effects can, potentially, be produced by either the geothermal or fossil fueled plant, or in some cases, both:

- Induced Seismicity
- Gaseous Emissions
- Liquid & Solid Emissions
- Land Surface Subsidence

The gaseous emissions may be the more serious of the problems since the liquids emissions and land surface subsidence can be controlled by rein-jection. The gaseous emissions will be influenced by the amount of non-condensable gases within the brine. These are primarily carbon dioxide and hydrogen sulfide. The assumed brines for this study are shown in Table 3. The values for the noncondensable gases have been modified from those shown in the First Quarterly Report, based upon a more comprehensive review of available data. The range shown is expected to be typical of the majority of geothermal brines.

*That's nice
BABS?*

2.5 Alternate Methods

During the last quarter, a study was begun of the advantages of the feed-and-bleed process over other conventional processes that utilize geothermal

Table 3

Ion Concentration (ppm by wt.)

Low Salinity Brine   Medium Salinity Brine

Na	1,500	8,560
Ca	25	2,820
Mg	1.0	5.0
Ba	0.30	—
Sr	2.2	—
K	85.	140.
Cl	1,970	18,000.
SO ₄	150.	80
HCO ₃	610.	650.
SiO ₂	150.	400.
Fe	1.0	90.
Mn	—	2.0
Sum of Ions	4,495.	30,792.
CO ₂	30	300
H ₂ S	2	20
pH	6.2	6.7

heat. As an example, the effects of brine temperature on brine flow for a feed-and-bleed system, and a conventional single-flash four-effect system are shown in Figure 1. The advantage of the feed-and-bleed system is the substantially lower brine flow requirement.

It can be concluded that when using geothermal brine, substantial modifications to the system can result in the lowest geothermal brine flows. These modifications include incorporation of the feed-and-bleed process and redistribution of the evaporator area to minimize the brine use.

2.6 Final Report

The final report was started. The major topics in the outline are shown below:

1. Introduction/Objective
2. Summary & Conclusions
3. Geothermal Resources
4. Multiple Effect Evaporation/Crystallization
5. Feed-and-Bleed Process Description
6. Basis for Economic Analysis
7. Candidate Industry Selection and Evaluation
8. Pressured Fruit and Vegetable Industry
9. Sugar and Confectionary Products Industry
10. Chemical Industry
11. Other Areas of Application

Figure 1

12. Environmental Impact

13. Economic Impact

14. Implementation Program

Sections 1, 3, 4, and 7-12 are essentially complete, while some work remains to be done on the others.

Section 3

REMAINING WORK

Bechtel's effort for the remainder of the contract (July 1977 until the draft of the final report is issued in August) will concentrate on completion of the required tasks. The major portion of remaining work is in the following areas:

- R&D, Implementation Program
  - Will point out problems of geothermal use
  - R&D program to solve or minimize these problems will be outlined
  - A plan of action to develop a cooperative geothermal demonstration program will be made, along with a suggested program schedule.
- Economic Analysis
  - Calculations for the cost of steam for conventional retrofit, and new geothermal plants will be completed.
- Economic Impact
  - An estimate will be made of the industry-wide economic impact due to the retrofitting of existing fossil fueled plants or the construction of new geothermal plants.
- Final Report
  - The draft of the final report will be completed.

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APPENDIX A
Drawing T-1

APPENDIX B

Drawing T-2

NOTES

1. * SATURATION TEMPERATURE
2. EVAPORATOR SYSTEM CONSISTS OF 3 PARALLEL TRAINS

△										
△										
△										
△	7/28/77							OB	1/2	
No.	DATE	REVISIONS			BY	CHKD	DESIGN SUPV	ENGR	PROJ ENGR	APPR
SCALE		DESIGNED		DRAWN		CHIEF ENGR				
BECHTEL SAN FRANCISCO										
ERDA NON-ELECTRIC USES OF GEOTHERMAL BRINE										
PROCESS FLOW DIAGRAM CONVENTIONAL - 200 TON/HR TOMATO PASTE PLANT										
	JOB No.			DRAWING No.			REV.			
	11940			T-1			O			

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NOTES

1. * SATURATION TEMPERATURE.
2. EVAPORATOR SYSTEM CONSISTS OF 3 PARALLEL TRAINS.

	7/20/77																	<i>B. J. H.</i>	
No.	DATE	REVISIONS				BY	CHKD	DESIGN SUPV	ENGR	PROJ ENGR	A								
SCALE		DESIGNED		DRAWN			CHIEF ENGR												
BECHTEL SAN FRANCISCO																			
ERDA NON-ELECTRIC USES OF GEOTHERMAL BRINE																			
PROCESS FLOW DIAGRAM RETROFITTED - 200TON/HR TOMATO PASTE PLANT																			
		JOB No.				DRAWING No.				REV									
		11940				T-2				C									