PN-ABU-133
ISN 93311

TECHNICAL ASSESSMENT ON H_2S GAS ABATEMENT SYSTEMS AT CALIFORNIA ENERGY'S COSO GEOTHERMAL POWER PLANTS

Philippines
September 26 - October 6, 1994

Prepared for:

US - ASIA ENVIRONMENTAL PARTNERSHIP

WEC

WORLD ENVIRONMENT CENTER

DISCLAIMER

This project was sponsored by the U.S. Agency for International Development (USAID) through the World Environment Center's (WEC) Cooperative Agreement in support of the U.S.-Asia Environmental Partnership (US-AEP). The opinions expressed herein are the professional opinions of the author and do not represent the official position of the Government of the United States of America or the World Environment Center.

TABLE OF CONTENTS

I.	EXECUTIVE SUMMARY	1
II.	INTRODUCTION	2
III.	MEETINGS HELD AND FACILITIES VISITED	4
IV.	CONCLUSIONS AND RECOMMENDATIONS	12

APPENDICIES

A. PHOTOGRAPHS AND FIGURES

B. ITINERARY

C. PERSONS AND ORGANIZATIONS VISITED

D. BUSINESS CARDS OF PERSONS CONTACTED

E. LIST OF DOCUMENTS RECEIVED

F. CURRICULUM VITAES

I. EXECUTIVE SUMMARY

An Environmental Business Exchange (EBE) program with Philippine National Oil Company - Energy Development Corporation (PNOC-EDC) and California Energy Co., Inc., (CECI) was conducted from September 26 to October 6, 1994. Representing PNOC-EDC were Mr. Francis Dolor, Planning Manager, Mr. Hermes Ferrer, Geoscientific Manager, Mr. Herman Guillen, Engineering Design Manager, Mr. Romy Jabonillo, Process Instrumentation Coordinator and Mr. Dwight Maxino, Production Manager. The PNOC-EDC participants visited four geothermal power plant sites at CECI's Coso geothermal field in California between September 26 and October 1, 1994. Afterwards, they attended the Geothermal Resource Council's Geothermal Conference, held in Salt Lake City, Utah, on October 3-5.

This EBE's purpose was to expose the participants to hydrogen sulfide (H_2S) abatement technology -- the same technology applied in the Coso Geothermal Power Plants. Exchange participants assessed the existing H_2S abatement system facilities based on performance, operational difficulties and problems encountered.

Training provided the participants with a general overview of H_2S abatement technology system maintenance, operation and manpower requirements. The information gathered will assist PNOC-EDC in the technical evaluation, award, design and construction of the H_2S abatement systems for future geothermal power plants in the Philippines.

Funding for this project was provided through a Cooperative Agreement between the World Environment Center (WEC) and the United States-Asia Environmental Partership (US-AEP).

II. INTRODUCTION

Current Philippine environmental regulations mandate a significant reduction in hydrogen sulfide (H_2S) emissions from geothermal power plants. The development of the 640 MW geothermal power plants in Leyte, Philippines will emit substantial amounts of H_2S gas. Thus, H_2S abatement downstream of the geothermal turbine is included in the turn key contract of the Leyte A Power Plant.

This report focuses on the H_2S abatement facilities at the four power plant sites (BLM-East, BLM-West, Navy I and Navy II) at CECI's Coso geothermal field. Prior to the use of H_2S abatement, the Coso field utilized a gas injection method to reduce gas emissions. However, after nearly seven years of operation problems have arisen with the gas injection practice, including observed gas breakthroughs in the BLM field, vapor lock at the reinjection wells and corrosion in the gas lines and well casings. Therefore, gas injection is being phased out and industry practice is beginning to embrace and develop H_2S abatement technology.

CECI has installed an H_2S abatement plant at each power plant site. The BLM-East SulFerox unit has a capacity of 7.1 long tons of sulfur per day (LTPD) and the BLM-West unit has a capacity of 8.8 LTPD while the two LO-CAT II process plants at the Navy I and Navy II plants have capacities of 2.4 LTPD and 5.77 LTPD, respectively.

After three months of continuous operation, plant operators encountered problems such as line fouling and plugging as well as mechanical pump seal failures on both the SulFerox and LO-CAT II process plants. Excessive chemical losses due to leakages were observed in the SulFerox plant. At present, the Coso plant operators are not comfortable with the performance of the SulFerox system.

The SulFerox process was developed jointly by Shell and Dow while LO-CAT II was developed by the Wheelabrator Clean Air System Inc. Both have employed REDOX process using iron as catalyst to accelerate the reaction of H_2S to sulfur. The capital costs of SulFerox plant and LO-CAT II plants are very close. However, the relationship of capital cost to LTPD is not linear but has the benefit of economies of scale. The actual operating cost reported range from 200 USD to 500 USD per ton of sulfur for the SulFerox and the LO-CAT II process plants.

The sulfur recovered in the H_2S abatement plants was collected in the 7.5 long tons capacity bin and sold to a fertilizer manufacturer at a cost of $1 to $6 (US) per long ton.

In general, gas injection to reduce H_2S gas emissions in geothermal power plants is the appropriate method of abatement for short term plant operation. For long term plant operation, this method has economic disincentives stemming from possible gas breakthroughs in the geothermal field and likely corrosion of pipelines and well

casings. Vapor lock at the reinjection wells may also be encountered if the liquid brine in not sufficient to force the vapor phase down the hole.

On the other hand, the H_2S gas abatement system utilizing the REDOX process has been successfully operating at the geothermal power plants in Coso. Technical assessments have shown that improvement in the flexibility of the SulFerox and LO-CAT II H_2S abatement systems installed in Coso have room for improvement in their level of flexibility in dealing with the significant fluctuations in gas concentration occuring in normal plant operation to minimize the chemical consumption and save operating cost. Proper selection of the equipment and control instrumentation will also improve the downtime of the plant.

Other H_2S gas abatement methods like the RT2 process should be considered in the final selection of the abatement system in the geothermal power plants.

III. MEETINGS HELD AND FACILITIES VISITED

A. Meetings Held

Upon arriving at Ridgecrest, California on Tuesday, September 27, 1994, the PNOC-EDC participants were greeted by Andy Jones and Dave Maystrick of CECI. Initial presentations were given by CECI concerning its overall capabilities and experiences using the gas injection method of H_2S abatement at their geothermal power plants in Coso, California. Wednesday, September 28 was again spent by the PNOC-EDC participants listening to presentations concerning the two REDOX methods of H_2S gas abatement, SulFerox and LOCAT II, used at the Coso field. The presentations on the SulFerox process were given by representatives of Dow Chemical Co. and by representatives of CECI. Presentations on the LOCAT II process were given by representatives of Wheelabrator, Inc. and by representatives of CECI.

On Thursday, September 29, the EBE participants drove from Ridgecrest to Coso and spent the day touring the the facilities of the four power plant sites at the Coso geothermal field. Subjects and facilities of note were the gas ejector and vacuum pump systems, compressor systems, brine and condensate injection systems, metallurgy, and surface condensor and on-line cleaning.

Several more presentations were given by representatives of CECI on Friday, September 30, 1994. Presentation topics covered were CECI's experience with corrosion of well-casings and injectors utilitzed in the gas injection method of H_2S abatement, the design and maintenance of cooling towers, compliance and safety issues and CECI's training program.

The PNOC-EDC participants departed Ridgecrest, California on Saturday, October 1, 1994, and traveled to Salt Lake City, Utah to attend a geothermal conference.

1. Hydrogen Sulfide Control Technologies

The Coso Geothermal field, operated by California Energy Co., Inc., consists of four power plant sites (Navy I, Navy II, BLM-East, and BLM-West), with each site consisting of three power plants. The Navy I and Navy II power plants have three 30 megawatt rated, modular type turbines, producing a total of 90 megawatts for each plant site. The Bureau of Land Management (BLM) plants, BLM East and BLM West, also have a total combined capacity of 90 megawatts. BLM East and Blm West were intentionally separated in compliance with the California government regulation which allows only one 50 MW or greater capacity power plant in one area. The Navy I, Navy II, BLM-East, and BLM-West plants are all approximately 1.25 miles apart.

The average size of the production wells in Coso geothermal field is 3 to 5 MW with an estimated maximum reservoir temperature of 250 C (482 F) for Navy I and II, and 345 C (653 F) for the BLM fields. The gas concentration in the steam ranges from 10,000 ppmw to 30,000 ppmw with up to 3% H_2S in the gas.

Gas injection has been employed as Coso's method of H_2S abatement for nearly seven years. However, the gas injection method is being phased out due to the following problems:

a) Gas breakthrough observed in the BLM field.

b) Vapor lock at the reinjection wells primarily of Navy II and BLM, due to insufficient liquid for reinjection. This problem has become worse as some producing wells change to produce higher steam fraction and less liquid.

c) Corrosion of the gas lines and well casing

The injection of a portion of waste steam is continuing at Coso in order to prevent build-up of silica scale in injection wells. For purposes of overall gas disposal, it has been concluded that the gas injection method employed in the Coso geothermal power plants was unsuccessful. It is believed that this method will only work effectively for small facilities, for low NCG concentrations, and for lateral injection (not underneath).

The method of H_2S gas abatement at Coso has shifted from gas injection to liquid redox processes, which removes sulphur from the waste stream by converting it into solid, elemental sulphur. At BLM-East and BLM-West plants, CECI utilizes the Dow SulFerox process with two separate SulFerox units currently in operation. At the Navy I and Navy II plants, CECI utilizes Wheelabrator Clean Air System's (WCAS) "LO-CAT II" process at two separate LO-CAT units (one at each plant site).

These four abatement units have the following maximum design capacities in long tons of sulfur production per day (LTPD):

Navy I LO-CAT II Unit:	2.41 LTPD.
Navy II LO-CAT II Unit:	5.77 LTPD.
BLM-East SulFerox Unit:	7.10 LTPD.
BLM-West SulFerox Unit:	8.80 LTPD.

SulFerox Process

The SulFerox process technology was developed by Shell Oil Co. and Dow Chemical Co. It is a single process for removing H_2S from the gas streams and converting it to

elemental sulfur. The process operates best at a very low H_2S concentration with either high or low pressures. The process involves three basic steps: absorption, regeneration and sulfur recovery.

Absorption

The sour gas stream containing hydrogen sulfide comes in contact with a liquid containing soluble ferric iron chelate Fe(3+). The hydrogen sulfide is selectively oxidized to form elemental sulfur and the ferric chelate Fe(3+) is reduced to the corresponding ferrous chelate Fe(2+). The equation of the absorption process is:

$$2\ Fe(3+) + H_2S = 2\ Fe(2+) + 2\ H(+) + S\ (solid)$$

The equipment used in this process is either a pipeline contactor for a pressure of 5 to 6 psi or a sparge tower and spray tower when a very low pressure drop is required. Stainless steel material is used in the pipeline contactor.

Regeneration

In order to continually supply the absorption section with a fresh supply of iron in active Fe(3+) form, the operating solution is sent to a regeneration section where the Fe(2+) is reoxidized with air back into Fe(3+) and then sent back to the absorption section to be reused. 50% to 100% excess air is required in the actual operation. The equation of the regeneration process is:

$$2\ Fe(++) + 2\ H(+) + 1/2\ O_2 = 2\ Fe(+++) + H_2O$$

Sulfur Recovery

The elemental sulfur formed in the absorption reaction is concentrated and then filtered from the solution. The moist cake can then be reslurried and fed into a sulfur melter to produce a yellow, molten sulfur by using a settling vessel and a sulphur filter. The sulfur filter can be either a rotary vacuum drum filter, vacuum belt filter, or a pressure filter. At Coso, the sulfur is separated from the slurry by a Larox filter press. The sulfur recovered in this process may contain 20 to 40 % moisture. Coso initially utilized a Westec vacuum drum filter, but achieved unsatisfactory results.

It is estimated that the chemical consumption for the whole process is 400 pounds for every ton of sulfur recovered as quoted by DOW. Actual experience at Coso has not achieved this low level.

LO-CAT II Process

Similar to SulFerox process, Wheelabrator Clean Air System's LO-CAT II process uses iron as a catalyst to accelerate oxidation reaction of H_2S into elemental sulfur. Oxygen is furnished by the injection of air, and also acts as a floatation agent for the sulfur. A chelating agent is maintained in the system to keep iron in the solution. Thiosulfate is added to prevent chelating agent from degradation. Fluid pH is maintained between 7.5 to 9.0.

The overall reaction of the LO-CAT II process is:

$$H_2S\ (gas) + 1/2\ O_2\ (gas) \xrightarrow{(Fe)} H_2O + S\ (solid)$$

2. Findings Concerning Hydrogen Sulfide Control Technologies

Chemical Losses

Chemical carryover has only occurred at the SulFerox units. The SulFerox plants initially had demisters installed in the vent stacks, but these quickly fouled with sulfur after start-up and had to be removed. Carry-over has not been a major problem with the LO-CAT II units.

Fouling/Plugging

Plugging has not been observed in the water lines, nor has it been a problem to date with LO-CAT II units. In the SulFerox units, within a month of operation, plugging due to fouling has been frequently observed in heat exchanger tubes, water lines and pipe contractors.

Pump Failure

Mechanical seal failures have occurred at SulFerox plants because of the significant amount of solid sulphur contained in the liquid.

Air Compressor Oil Losses

Oil consumption has been excessive in the regeneration system of the SulFerox plants due to losses in the system.

Sulfur Disposal

The sulfur recovery rates in the H_2S abatement process plants are as follows:

Navy I LO-CAT II Unit:	1.92 LTPD.
Navy II LO-CAT II Unit:	5.16 LTPD.
BLM-East SulFerox Unit:	1.04 LTPD.
BLM-West SulFerox Unit:	3.38 LTPD.

The sale price of sulfur sold to fertilizer manufacturers is $1.00 to $6.00 (US) per long ton.

3. Power Plant Cooling Tower Operation and Maintenance

The cooling system in geothermal power plants play an important role in the performance of the turbines. An atmospheric or evaporative type of cooling system is employed in most of the geothermal power plant industry. Evaporative cooling is a process of dissipating waste heat to the atmosphere by evaporating a small portion of cooling water. The output of a geothermal power plant using the atmospheric cooling system will be dependent on the design ofits wet bulb and the prevailing ambient wet bulb temperature. Selection depends upon cooling requirements, climate and economic considerations.

Mechanical Draft Cooling Towers

Mechanical draft cooling towers are recommended for cooling systems requiring a low approach (10 degrees F or less) that need relatively small amounts of water as a coolant. They can be designed to accomodate a broad range of water flows by boosting water cell size and/or numbers of water cells. In fact, multiple-cell towers are highly attractive to engineers because they can be adjusted easily to varied cooling system parameters. A mechanical draft cooling tower uses one or more fans to move large quantities of air through the tower. The induced type mechanical draft cooling tower uses fans to suck the air out of the unit, while the forced type mechnical draft cooling tower uses fans to pump the air through the unit.

Natural Draft Cooling Towers

The natural draft cooling tower doesn't have fans, being designed to allow air to flow through the unit. Cooler, heavier air enters around the base, displacing the warmer, lighter air in the tower and forcing it out of the top. Generally, natural draft cooling towers have not been found to be economically feasible. Studies have shown that a hyperbolic natural draft cooling tower is costly for small size power plants. For large power plants, however, such towers become more economically attractive.

Cooling Tower Technical Data at the Navy 1 Power Plant

Unit 1	Units 2 - 9
Brand: Marley	Brand: Hamon Company
Type: Counter Flow Force Draft	Type: Counter Flow Force Draft
Number of Water Cells: 4	Number of Water Cells: 4
Pump Horsepower: 200	Pump Horsepower: 200

Cooling Tower Maintenance at the Navy 1 Power Plant

Routine maintenance of the cooling towers is scheduled for every six months. Services include manual oil changes and visual inspections inside and out. Basin cleaning occurs every 3 to 4 years. The water circulating through the cooling tower is treated with sodium bicarbonate to maintain a neutral pH.

The gear box in the Hamon Company cooling tower failed after about one year of operation due to moisture pulled into it and was further compounded by the lack of an oil filtration system. The Marley cooling tower performance is satisfactory except for a minor vibration observed in the fan.

B. Geothermal Resource Council's "Restructuring the Geothermal Industry" Conference

The PNOC-EDC participants also attended the Geothermal Resource Council's Geothermal Conference held at the Little America Hotel, Salt Lake City, Utah, from October 3-5, 1994. The theme of the conference, "Restructuring the Geothermal Industry," defines the strategic role the geothermal industry will play at the turn of the century. The conference drew interest not only from the geothermal industry, but also from the power industry. There were approximately 30 contributors and approximately 50 exhibitors from different countries including Italy, Japan, Mexico, Iceland, New Zealand, Australia, Indonesia and others. Among the companies participating in the conference were California Energy Inc., Ben Holt Co., Magma Power Co., Fuji Electric Corporation of America, Unocal Corpration, Pacific Gas and Electric Co. and Peramina Indonesia Oil and Gas Mining Enterprises.

At the conference, various technical papers covering a broad spectrum of topics were presented and discussed briefly during the technical sessions. The spectrum of topics included new trends in the geothermal industry, ongoing studies undertaken by different entities and individuals, innovations, improvements and solutions to problems in such fields as power generation, geothermal reservoirs, engineering, drilling and environmental pollution mitigation. Some of the sessions attended by PNOC-EDC participants were as follows:

a) Second Law Analysis of Flash-Binary and Multilevel Binary Geothermal Power Plants,

b) Advances in Binary Organic Rankine Cycle Technology,

c) Applying Kalina Cycle Technology to High Enthalpy Geothermal Resources,

d) Reaction Type Hot Water Turbines,

e) Turbine-Driven Compressors for Non-Condensible Gas Removal at Geothermal Steam Power Plants,

f) An Interpretation on the Silica Scaling Phenomenon in Geothermal Plants,

g) Operating Experience and Future Development of the Los Azufres and Los Humeros 5 MW Geothermal Power Plants,

h) Geothermal Applications with GRAPE Plants,

i) An Analysis on the Efficiency of Vane Type Demisters,

j) Heat Pumps in the Western U.S. and Fort Polk Projects,

k) Slinky Pipe System Installation Procedure for Geothermal Heat Pump Systems.

The PNOC-EDC participants also visited various exhibits where each company participating in the conference displayed its products. Among the company exhibits visited by the volunteer experts were those of Dow Chemical Co., Chemco Water Technology Inc., Fuji Electric Corporation Ltd., NASH Engineering Co., Douglas Energy Co. and Mitsubishi Heavy Industries America Inc.

Regarding environmental issues, the participants had a follow-up technical discussion on the application of Sulferox process plants in H_2S gas abatement. A similar discussion was arranged with Pnuema Filter Press for the handling of silica slurry waste from existing and future geothermal power plants.

Overall, the Geothermal Conference was a success. The PNOC-EDC participants believe that the new discoveries and advances in geothermal technology contribute to a positive outlook in the power industry. PNOC-EDC is looking forward to being among the vanguard in harnessing geothermal energy, applying technological breakthroughs and in pursuit of opening other fields where geothermal energy is

applicable.

The PNOC-EDC participants gathered technical brochures from several companies participating in the Geothermal Conference and hope to continue to receive those companies latest publications. Brochures received at the Conference were:

1. Mitsubishi Portable Geothermal Turbine Generators,
2. List of Mitsubishi Geothermal Power Plants,
3. Econ-Abator Catalytic Oxidations Systems,
4. Solution to H_2S Removal,
5. AMCEC Engineered Absorption Systems,
6. LAROX Inc. Pressure Filter,
7. Biphase Turbine,
8. Sulferox Process Brochures.

Personal contacts made by the PNOC-EDC participants at the conference were with the Technical Sales Representatives of Dow Chemicals Inc. and the President of Pnuema Press Filters Company.

IV. CONCLUSIONS AND RECOMMENDATIONS

The purpose of PNOC-EDC's visit was to evaluate H_2S abatement technologies. Two methods of reducing the H_2S gas emissions of CECI's Coso geothermal power plants were described in this report. The first described is the gas injection method. The gas injection method employed in the Coso geothermal power plants was unsuccessful and it is believed that it will only work effectively for small facilities, for situations with a low NCG concentration and when using lateral injection (not underneath). In spite of the potential problems identified and experienced in Coso power plants, this method should not be discarded. Rather, it should remain as an option for consideration, especially for new geothermal fields in which the reservoir behavior and fluid chemistry have not yet been established.

The second method detailed in this report is H_2S abatement downstream of the turbine using a REDOX process. The H_2S abatement system installed in Coso, particularly in the SulFerox plants, needs system design improvements to increase its level of flexibility during changes in H_2S gas concentration, a common occurrence in geothermal fields. Chemical waste due to losses in the system should be minimized by installing more reliable equipment and effective control instrumentation. Overall though, this method of H_2S abatement is very effective.

Chemical operating costs for the REDOX H_2S abatement process range from $200 to $500 (US) per ton of sulfur. Careful planning and economic study should be carried out by plant officials before proceeding with this method. Economic studies should consider the availability and supply of the needed chemicals as well as appropriate disposal methods of the recovered sulfur.

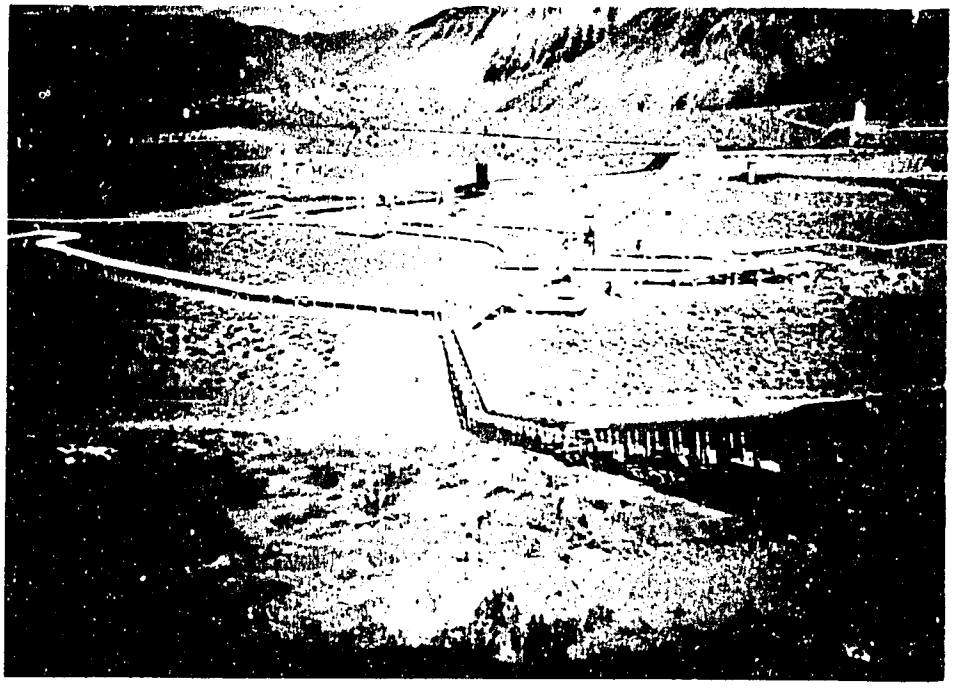
Other H_2S abatement methods like the RT2 technology wherein the aqueous sulfur can be easily reinjected back to the reservoir should be considered. This technology might prove to be inexpensive and its chemical consumption minimal. Technical engineering support from the supplier should be emphasized and must be considered in the turnkey contract. Chemical supplies should also be guaranteed by the supplier for at least five years of plant operation.

PNOC-EDC will be evaluating the applicability of the H_2S abatement technologies observed at CECI's Coso geothermal field for use in their current and planned geothermal power plants.

APPENDIX A

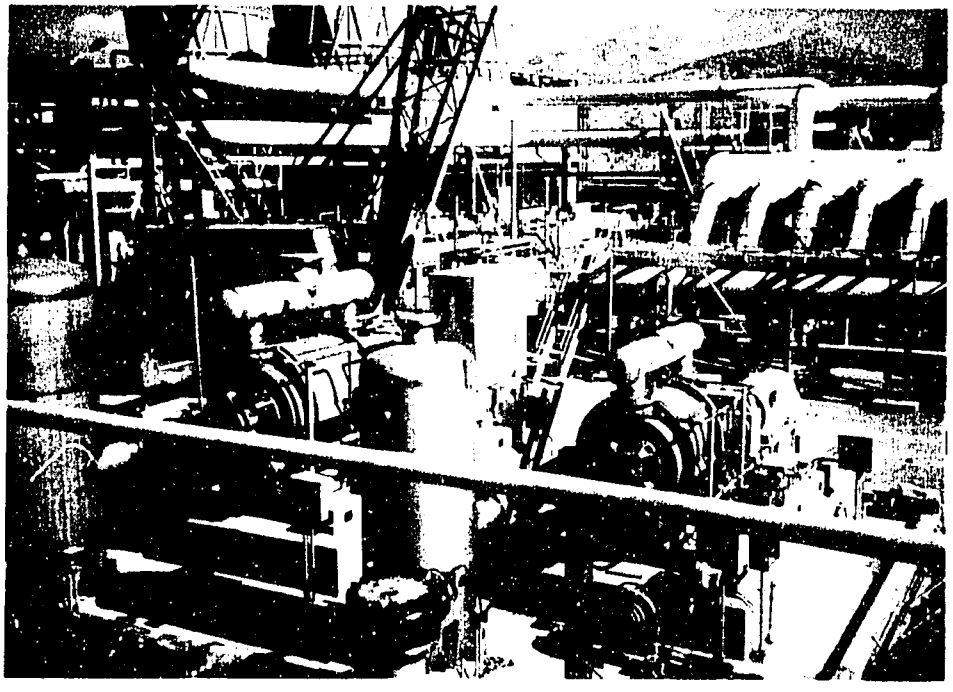
PHOTOGRAPHS AND FIGURES

COSO GEOTHERMAL FIELD

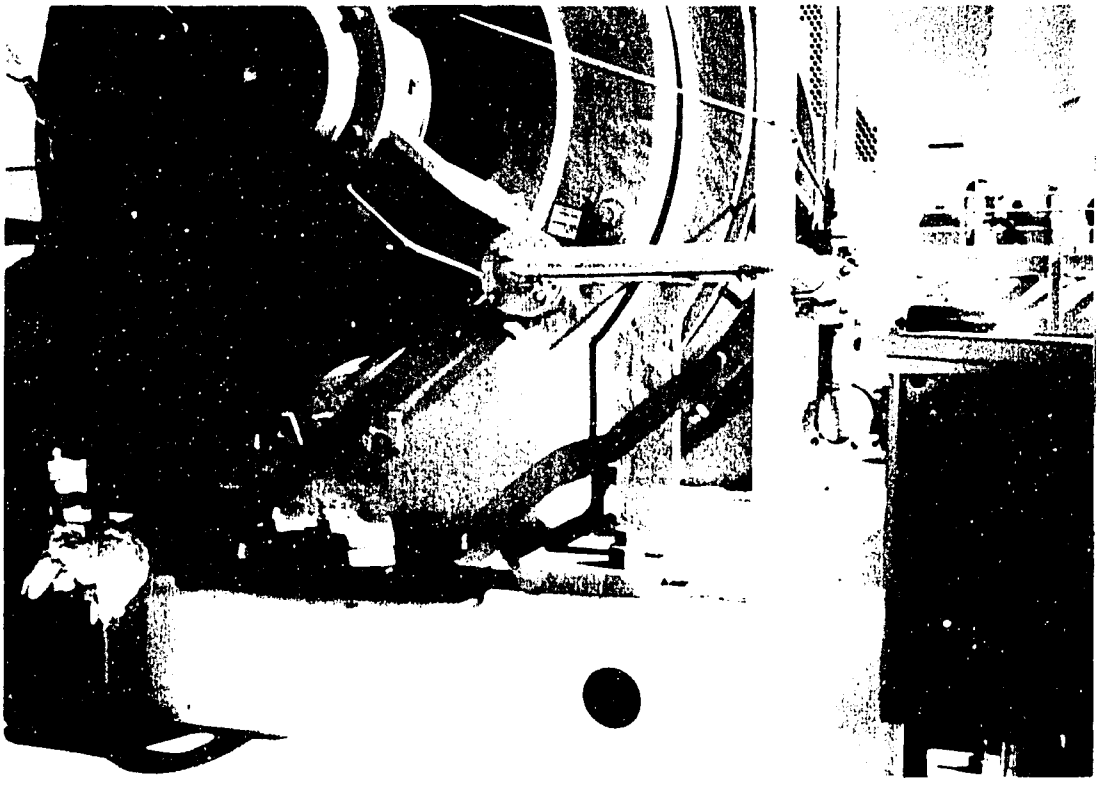


SEPARATOR STATION

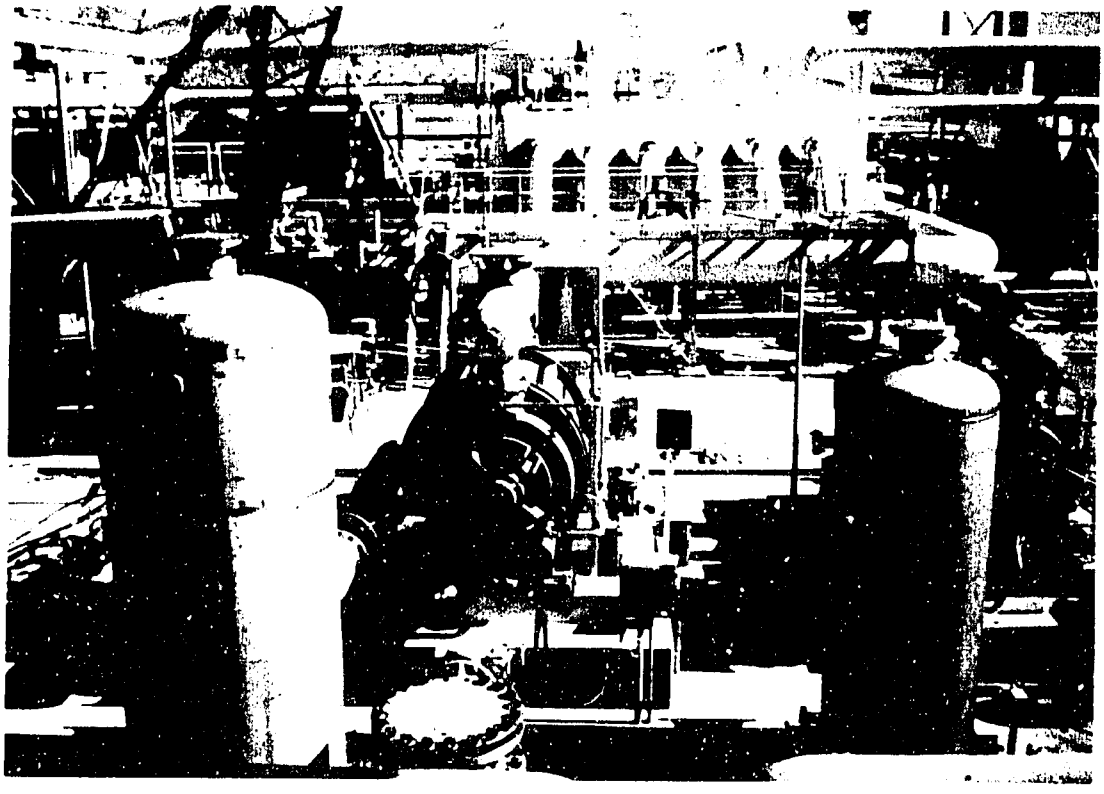
PRODUCTION WELLHEAD



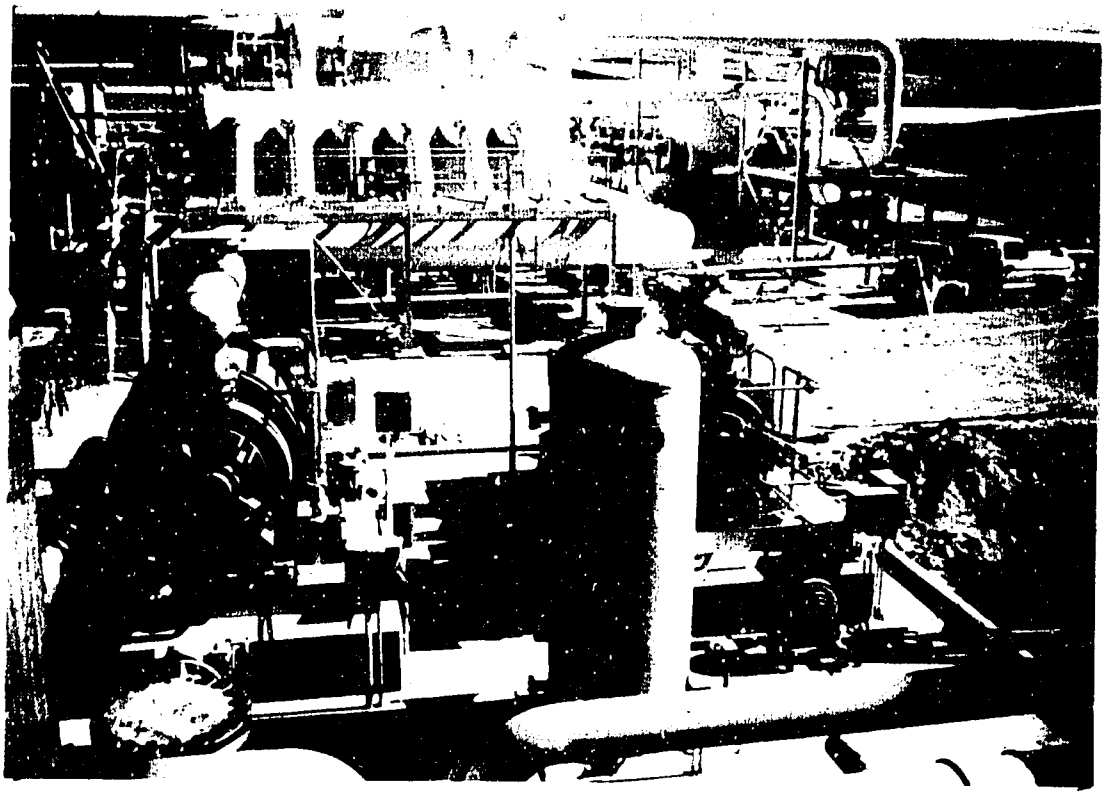
POWER PLANT FACILITIES



COOLING TOWER AND VACUUM PUMP

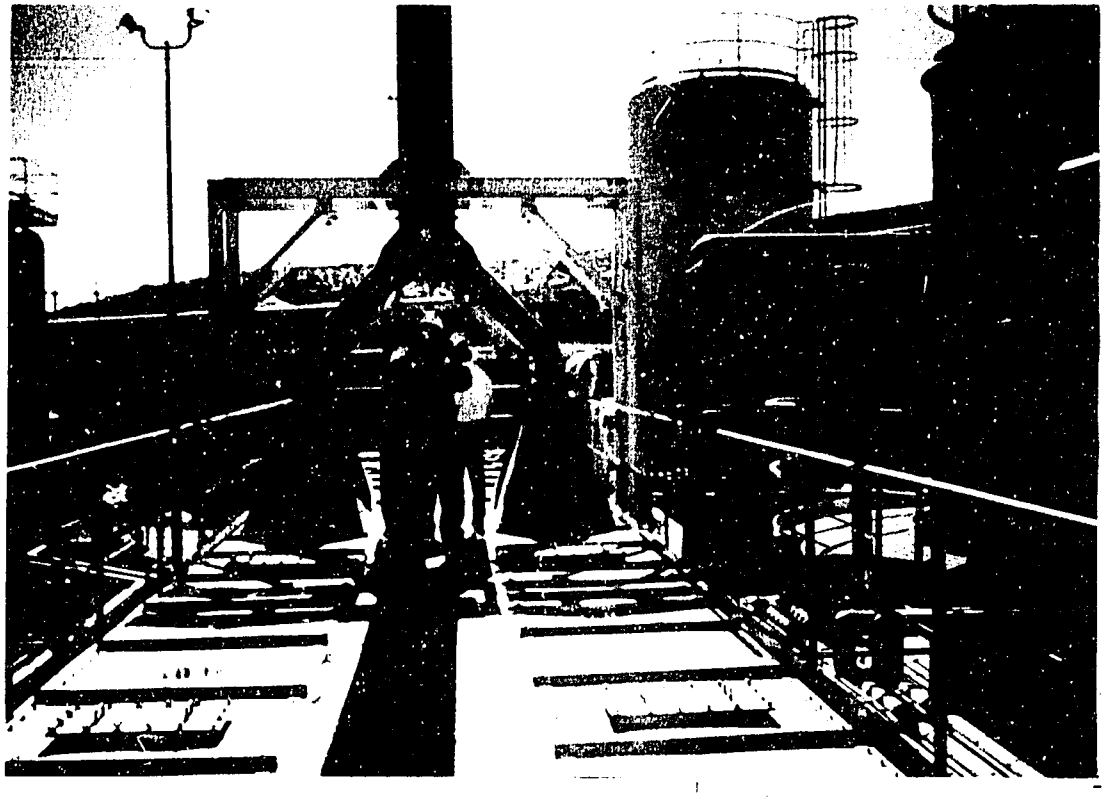


POWER PLANT FACILITIES



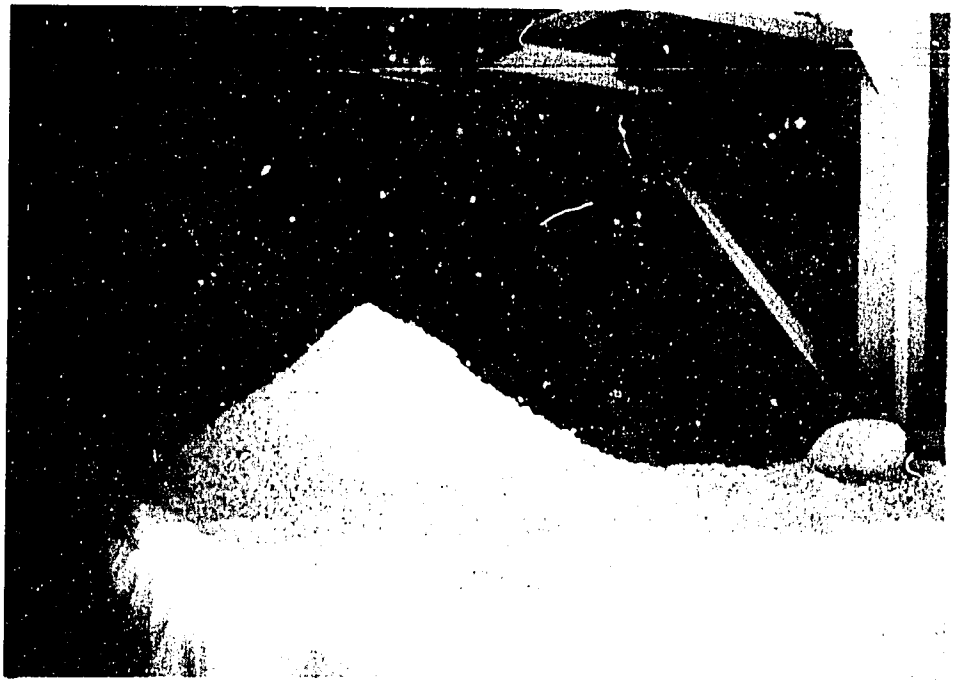
GAS EJECTION SYSTEM - VACUUM PUMP

ARI LO-CAT PLANT

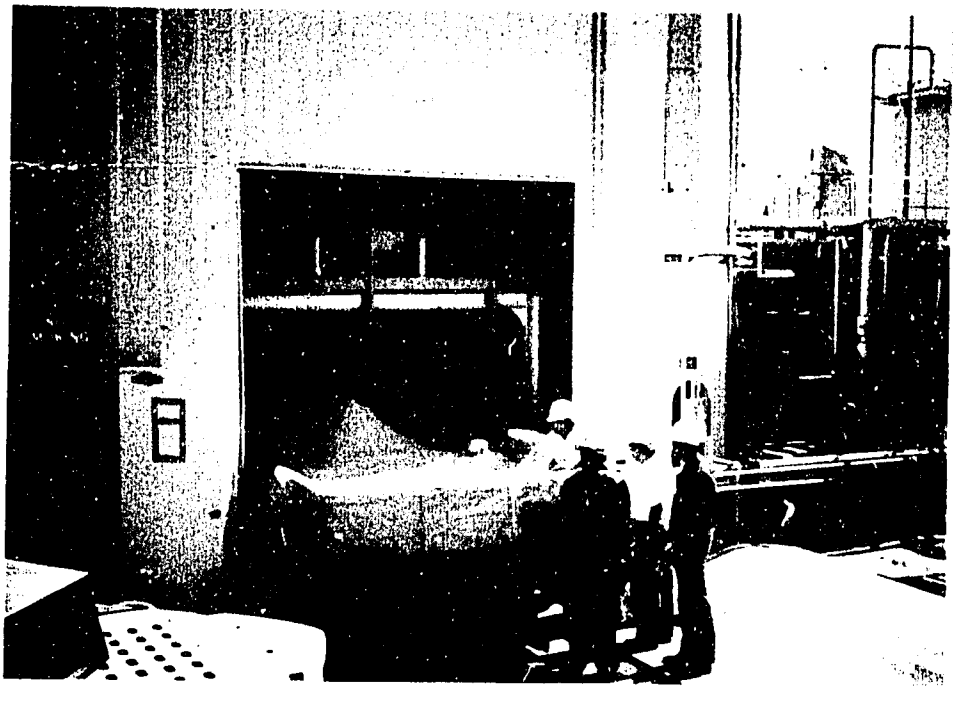


H_2S VENT STACK

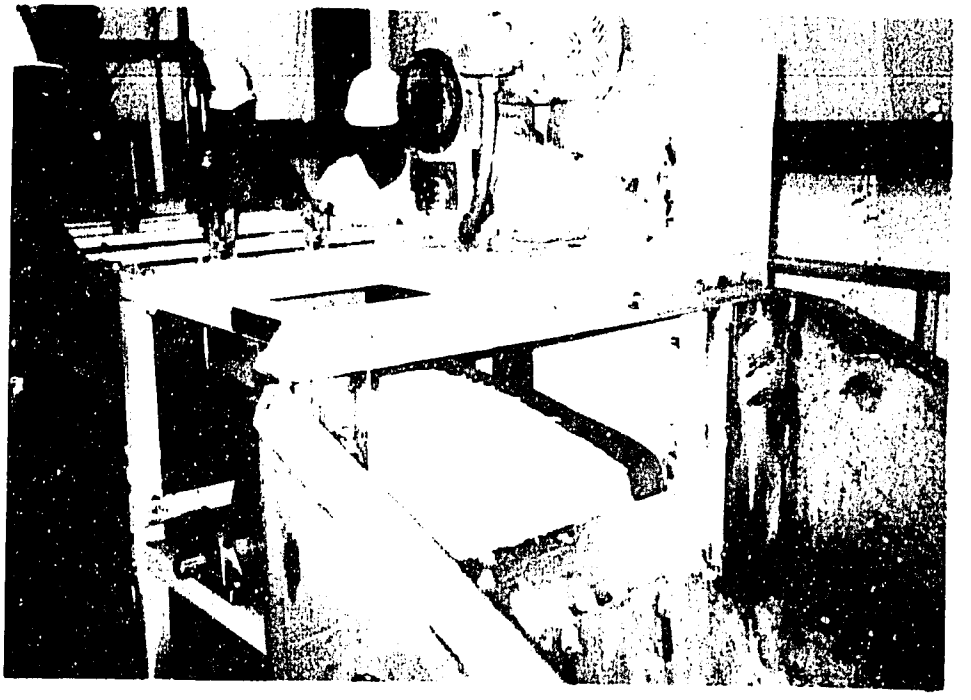
OXIDIZER AIR BLOWER SYSTEM



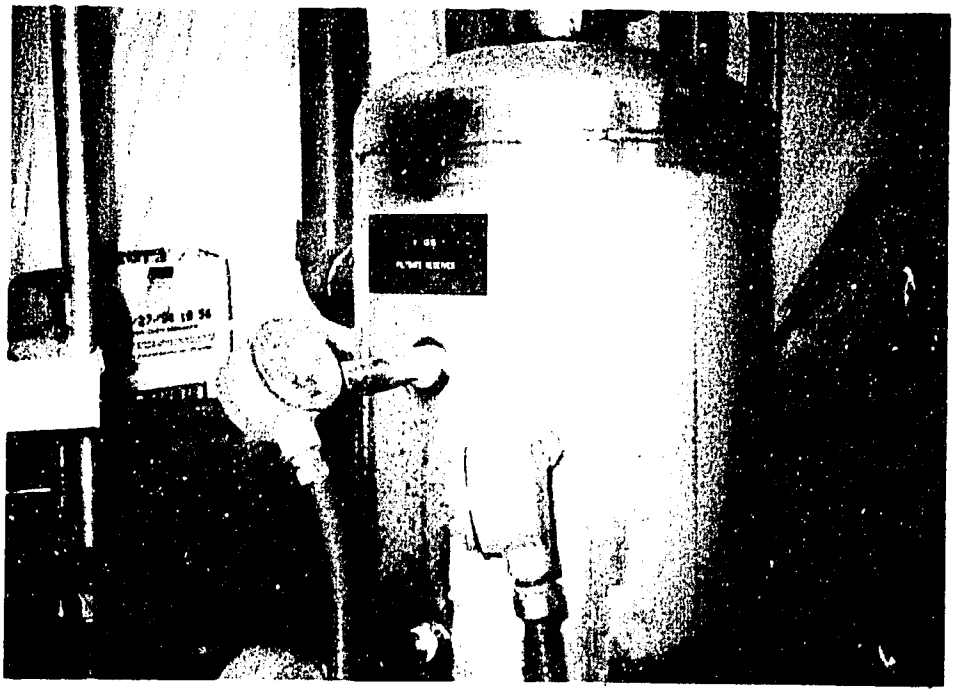
ARI LO-CAT



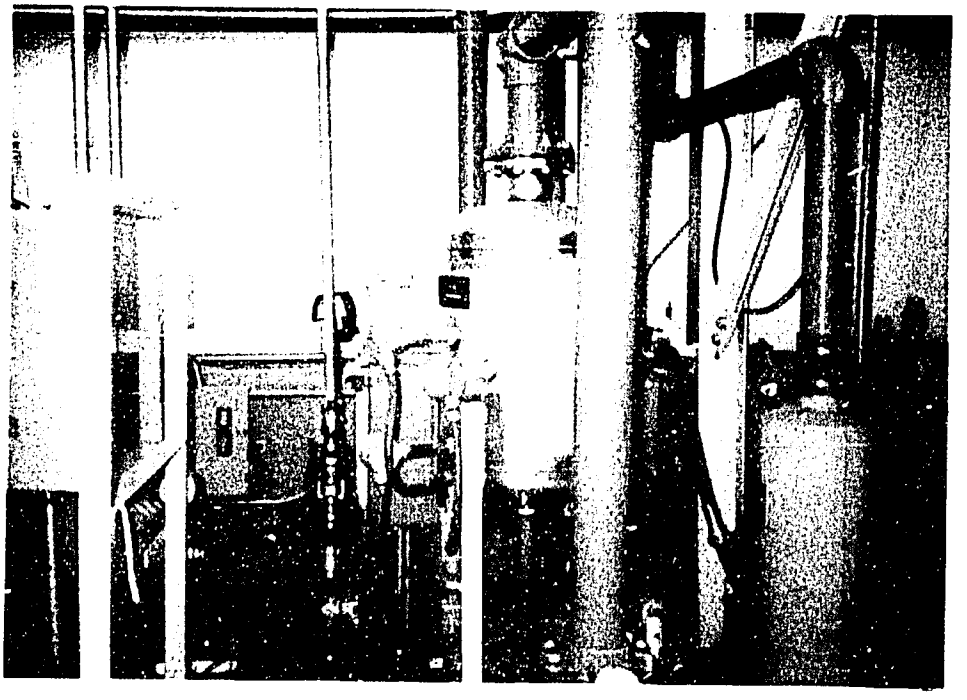
SULFUR RECOVERY SYSTEM



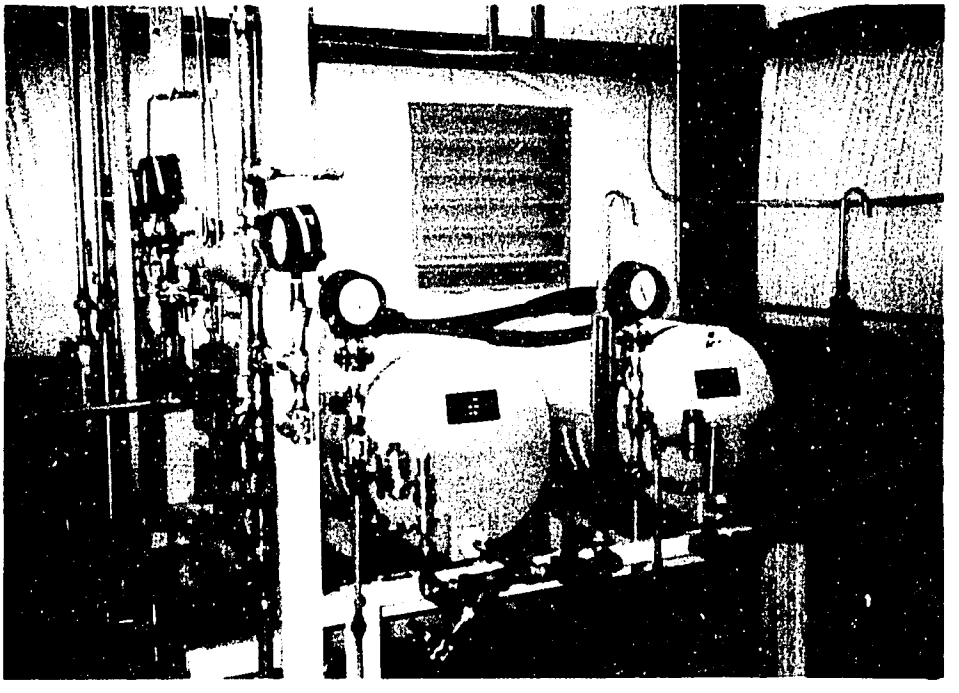
FILTRATION SYSTEM



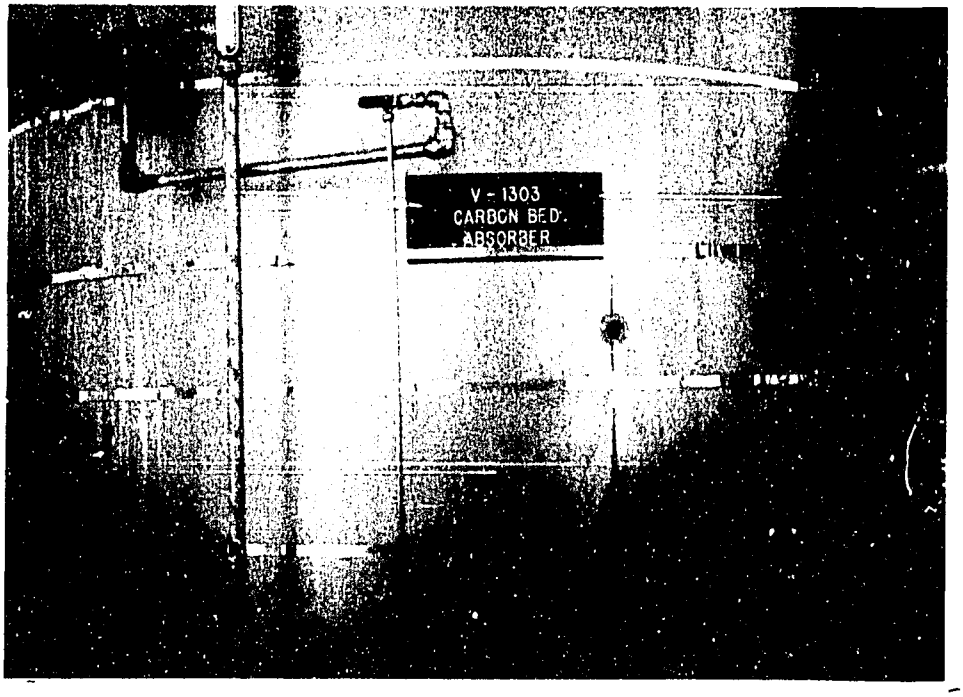
FILTRATE RECEIVER SYSTEM



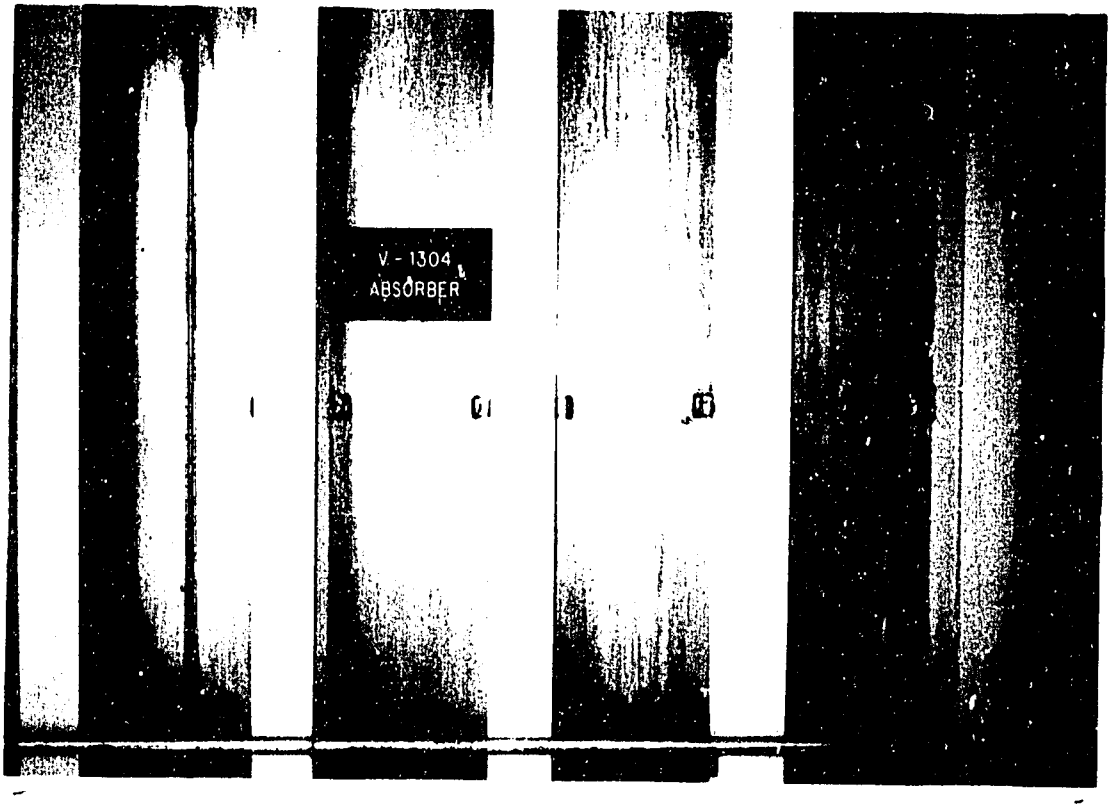
ARI LO-CAT



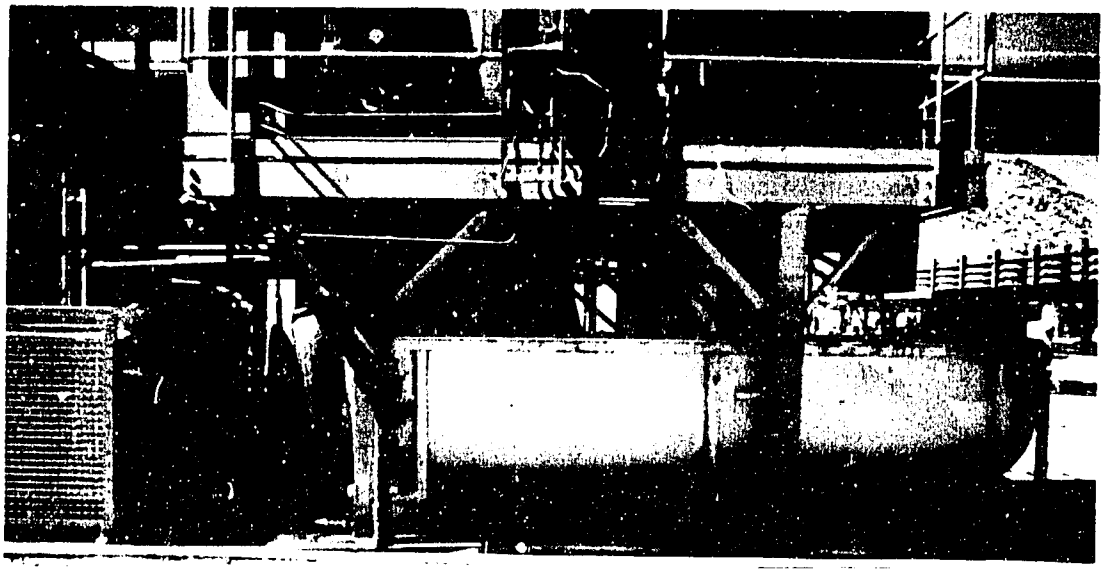
CHEMICAL FEED SYSTEM



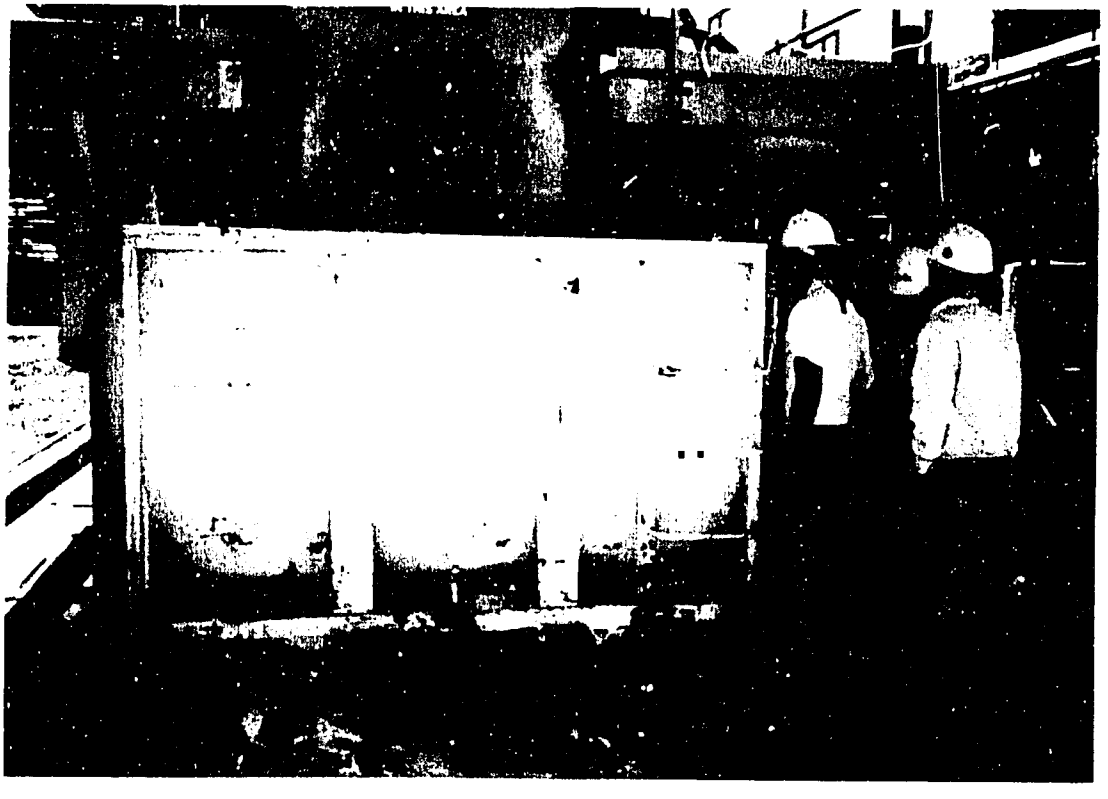
ARI LO-CAT PLANT



ABSORPTION SYSTEM



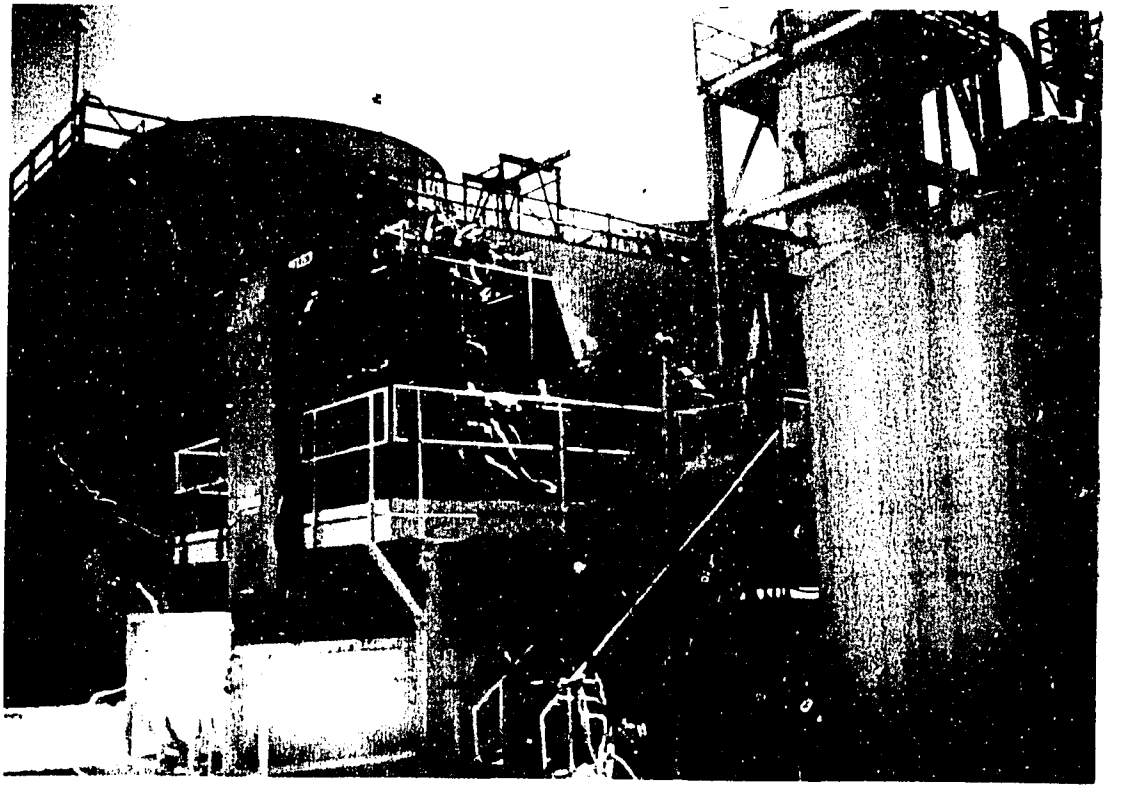
SULFEROX PLANT



SULFUR COLLECTION BIN

SULFEROX PLANT

GAS ABSORBER SYSTEM



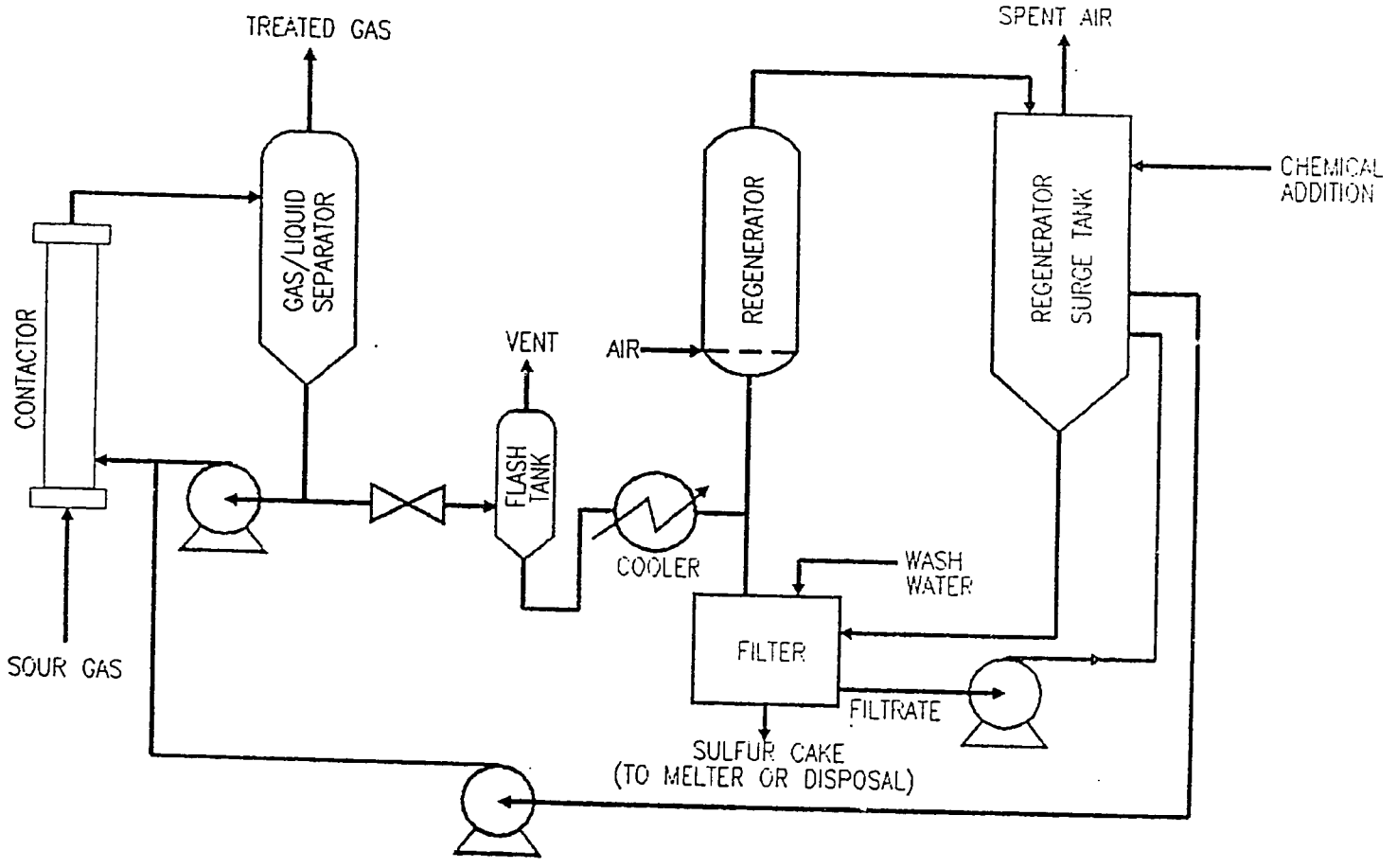
FILTRATION SYSTEM

SULFEROX PLANT DIAGRAM

TYPICAL PROCESS FLOW SYSTEM

SULFEROX PLANT

(TYPICAL PROCESS FLOW SYSTEM)



Absorption

$2Fe(III) + H_2S \rightarrow 2Fe(II) + 2H^+ + S\downarrow$

Regeneration

$2Fe(II) + 2H^+ + \frac{1}{2} O_2 \rightarrow 2Fe(III) + H_2O$

SULFEROX

APPENDIX B

ITINERARY

ITINERARY

PNOC VISIT TO RIDGECREST AND COSO

Monday, September 26, 1994

PNOC-EDC EBE participants arrive in Los Angeles; Andy Jones and Dave Maystrick arrive at Inyokern (INY).

Tuesday, September 27, 1994

EBE participants fly to INY; tour of Resource Department and Facilities; introduction to H_2S gas abatement experience at Coso.

Wednesday, September 28, 1994

Presentations on Sulferox H_2S Abatement Process (DOW), LOCAT II H_2S Abatement Process (Wheelabrator), and the operation, maintenance and economics of both systems (CECI).

Thursday, September 29, 1994

Tour of Coso Thermal Power Plant facilities.

Friday, September 30, 1994

Presentations on corrosion prevention and cooling towers.

Saturday, October 1, 1994

EBE participants fly to Salt Lake City, Utah for the Geothermal Conference.

Sunday, October 2, 1994

Pre-conference preparations.

Monday, October 3, 1994

Geothermal Conference begins.

Tuesday, October 4, 1994

Geothermal Conference continued.

Wednesday, October 5, 1994

Geothermal Conference wrap-up.

Thursday, October 6, 1994

EBE participants return to India.

GEOTHERMAL CONFERENCE AGENDA

1994 Annual Meeting

Program Summary

Thursday, September 29

12:00 noon to 5:00 p.m. — GRC Office Open ..... **Casper Room**
9:00 a.m. to 5:00 p.m. — WGC - 1995 Organizing Committee Meeting ..... **Foyer A**

Friday, September 30

8:00 a.m. to 5:00 p.m. — GRC Office Open ..... **Casper Room**
9:00 a.m. to 5:00 p.m. — WGC - 1995 Organizing Committee Meeting ..... **Arizona Room**

Saturday, October 1

8:00 a.m. to 5:00 p.m. — GRC Office Open ..... **Casper Room**
9:00 a.m. to 4:00 p.m. — IGA Board of Directors' Meeting ..... **Arizona Room**
4:00 p.m. to 6:00 p.m. — International Geothermal Association General Meeting ..... **Wyoming Room**

Sunday, October 2

8:00 a.m. to 5:00 p.m. — GRC Office Open ..... **Casper Room**
2:00 p.m. to 4:00 p.m. — Geothermal Resources Council Board of Directors' Meeting ..... **Wyoming Room**
4:00 p.m. to 7:00 p.m. — American Exposition Set-Up ..... **Grand Ballroom**
4:00 p.m. to 8:00 p.m. — Annual Meeting Registration and Check-in ..... **Coat Room**
4:00 p.m. to 8:00 p.m. — **HOSTED RECEPTION** ..... **Poolside Area**
6:00 p.m. to 9:00 p.m. — Geothermal Energy Association Board of Directors' Meeting ..... **Wyoming Room**
7:00 p.m. to 10:00 p.m. — Exhibit Companies Set-Up ..... **Grand Ballroom**

Monday, October 3

6:30 a.m. to 5:00 p.m. — GRC Office Open ..... **Casper Room**
6:30 a.m. to 5:00 p.m. — Annual Meeting Registration and Check-in ..... **Coat Room**

7:00 a.m. to 12:00 noon — Exhibit Companies Final Set-Up ..... Grand Ballroom

7:00 a.m. to 5:00 p.m. — Speakers' Continental Breakfast (7:00 a.m. to 8:00 a.m.) and Slide Testing ..... Sinclair Room

8:00 a.m. to 12:00 noon — Opening Session and Awards ..... Tent Area

8:00 a.m. to 10:00 a.m. — Guest Lounge Open ..... Cheyenne Room

10:00 a.m. to 5:00 p.m. — Paper Review 1995 WGC ..... Cheyenne Room

1:30 p.m. to 6:00 p.m. — Exhibits Open ..... Grand Ballroom

12:00 noon to 1:30 p.m. — **LUNCH** *(Everyone on own)* ..... Hotel Restaurants

1:30 p.m. to 4:40 p.m. — Federal Regulation and Legislation ..... Flagstaff Room

1:30 p.m. to 4:40 p.m. — Basin and Range ..... Wyoming Room

1:30 p.m. to 4:40 p.m. — Power Generation 1 ..... Idaho Room

1:30 p.m. to 4:40 p.m. — Public Information ..... Arizona Room

5:00 p.m. to 11:00 p.m. — Dinner, Show and Dancing at Snowbird Lodge *(Optional Event)* ..... Off Property

Tuesday, October 4

6:30 a.m. to 5:00 p.m. — GRC Office Open ..... Casper Room

6:30 a.m. to 7:45 a.m. — Fun Run ..... Off Property

7:00 a.m. to 5:00 p.m. — Speakers' Continental Breakfast (7:00 a.m. to 8:00 a.m.) and Slide Testing ..... Sinclair Room

7:00 a.m. to 5:00 p.m. — Annual Meeting Registration and Check-in ..... Coat Room

8:00 a.m. to 10:00 a.m. — Guest Lounge Open ..... Cheyenne Room

8:00 a.m. to 11:35 a.m. — Business Development ..... Flagstaff Room

8:00 a.m. to 11:35 a.m. — The Geysers Field ..... Wyoming Room

8:00 a.m. to 11:10 a.m. — Power Generation 2 ..... Idaho Room

8:00 a.m. to 9:40 a.m. — Hot Dry Rock — Reservoir Development and Operations ..... Arizona Room

8:00 a.m. to 9:00 p.m. — Exhibits Open ..... Grand Ballroom

10:00 a.m. to 5:00 p.m. — Paper Review 1995 WGC ..... Cheyenne Room

10:20 a.m. to 11:35 a.m. — Hot Dry Rock — Modeling ..... Arizona Room

11:35 a.m. to 2:00 p.m. — **EXHIBITOR LUNCHEON** ..... Grand Ballroom

12:00 noon to 4:30 p.m. — Poster Presentation Set-Up ..... Poolside Area

2:00 p.m. to 5:05 p.m. — State Regulation ..... Flagstaff Room

2:00 p.m. to 5:05 p.m. — Reservoir Studies ..... Wyoming Room

2:00 p.m. to 5:05 p.m. — Drilling and Completion ..... Idaho Room

2:00 p.m. to 4:45 p.m. — Hot Dry Rock — Reservoir Analysis ..... Arizona Room

2:00 p.m. to 4:45 p.m. — Fourth Annual Teachers' Workshop on Geothermal Energy ..... Sun Valley Room

3:55 p.m. to 4:45 p.m. — Hot Dry Rock — Resource Identification and Verification ..... Arizona Room

5:00 p.m. to 7:00 p.m. — Poster Presentation *(Hosted Reception)* ..... Poolside Area

5:30 p.m. to 6:30 p.m. — USGIC Meeting ..... Sawtooth Room

6:30 p.m. to 7:30 p.m. — Geothermal Power Organization (GPO) Meeting ..... Sawtooth Room

7:30 p.m. to 9:00 p.m. — Poster Presentation Teardown ..... Poolside Area

Wednesday, October 5

6:30 a.m. to 5:00 p.m. — Annual Meeting Registration and Check-in ..... Coat Room

6:30 a.m. to 5:00 p.m. — GRC Office Open ..... Casper Room

7:00 a.m. to 5:00 p.m. — Speakers' Continental Breakfast (7:00 a.m. to 8:00 a.m.) and Slide Testing ..... Sinclair Room

8:00 a.m. to 12:00 noon — Federal Programs for Domestic and Export Assistance ..... Flagstaff Room

8:00 a.m. to 11:35 a.m. — Mexican Geothermal Development ..... Wyoming Room

8:00 a.m. to 11:35 a.m. — Geothermal Heat Pumps ..... Idaho Room

8:00 a.m. to 10:05 a.m. — Sustainability of Geothermal Production ..... Arizona Room

8:00 a.m. to 2:00 p.m. — Exhibits Open ..... Grand Ballroom

8:00 a.m. to 5:00 p.m. — Paper Review 1995 WGC ..... Cheyenne Room

10:20 a.m. to 12:00 noon — Direct-Uses ..... Arizona Room

12:00 noon to 2:00 p.m. — Business Meeting - Awards Luncheon *(Optional)* ..... Poolside Area

1:00 p.m. to 2:00 p.m. — Geothermal Drilling Organization (GDO), *Meeting (Open to the general public)* ..... Arizona Room

2:00 p.m. to 3:00 p.m. — Geothermal Technical Organization (GTO) Meeting ..... Arizona Room

2:00 p.m. to 4:45 p.m. — Environmental Studies ..... Idaho Room

2:00 p.m. to 5:10 p.m. — General Geosciences ..... Wyoming Room

3:00 p.m. to 5:00 p.m. — Geothermal Standards Committee - ASTM ..... Arizona Room

2:00 p.m. to 9:00 p.m. — Exhibit Teardown ..... Grand Ballroom

7:00 p.m. — Departure of the Yellowstone Field Trip to the Salt Lake City Airport, Transportation provided by Little America Hotel ..... Hotel Lobby

Saturday, October 8

2:30 p.m. — Yellowstone Park Field Trip returns to Salt Lake City Airport ..... Hotel Lobby

APPENDIX C

PERSONS AND ORGANIZATIONS VISITED

PERSONS AND ORGANIZATIONS VISITED *

Name and Position	Company	Location
Fred Manuel General Manager	California Energy Company	Coso Geothermal Project
Ben Holt Chairman Emeritus	The Ben Holt Company	South Lake Ave. Pasadena
David Maystrick Vice President Construction	California Energy Company	Omaha, Nebraska
Dale R. Schuster	California Energy Company	Omaha, Nebraska
Robert F. Eaton Director	Wheelabrator Clean Air Systems, Incorporated	Schaumburg
R.A. (Al) Lanning Senior Gas Conditioning Specialist Gas/Spec Technology Group	Dow Chemical Company	Houston Parkway
George Kast Vice-President	Psychrometric Systems, Incorporated	Lakewood, Co.
Steve C. Bepesi President	Pneumapress	Richmond, CA

*Business Cards in Appendix D

APPENDIX D

BUSINESS CARDS OF PERSONS CONTACTED

DALE R. SCHUSTER
VICE PRESIDENT

CALIFORNIA ENERGY COMPANY, INC
[illegible] OLD MILL ROAD, OMAHA, NEBRASKA 68154 (402) 330 8900 FAX (402) 330 9588

DAVID P. MAYSTRICK
VICE PRESIDENT
CONSTRUCTION

CALIFORNIA ENERGY COMPANY, INC
10831 OLD MILL ROAD, OMAHA, NEBRASKA 68154 (402) [illegible]

DENNIS KASPEREIT
MANAGER OF
RESERVOIR ENGINEERING

CALIFORNIA ENERGY COMPANY
[illegible] N. HERITAGE, BLDG D, RIDGECREST, CA 93555 (619) 499 2303 FAX (619) 499-[illegible]

FRED MANUEL
GENERAL MANAGER
COSO GEOTHERMAL PROJECT

CALIFORNIA ENERGY COMPANY
400 N. HERITAGE DR., BLDG D, RIDGECREST, CA 93555 (619) 499 [illegible] FAX [illegible]

SCOTT McKITRICK
PLANT ENGINEER

CALIFORNIA ENERGY COMPANY, INC
[illegible] HERITAGE DR., BLDG D, RIDGECREST, CA [illegible] 264 2551 FAX (619) 264 [illegible]

KENNETH L. ROBINSON
PLANT PRODUCTION ENGINEER

CALIFORNIA ENERGY COMPANY, INC
400 N. HERITAGE DR., BLDG D, RIDGECREST, CA 93555 (619) [illegible] FAX [illegible]

RICHARD G. CAMPBELL
President

THE BEN HOLT CO.
201 South Lake Avenue, Pasadena, CA 91101-3094

Engineers & Constructors

Tel. (818) 795-6866
Fax (818) 584-9210

BEN HOLT
Chairman Emeritus

THE BEN HOLT CO.
201 South Lake Avenue, Pasadena, California 91101

Engineers & Constructors

Tel. (818) 795-6866
Fax. (818) 584-9210

BEST AVAILABLE COPY

Unocal International Ventures
1201 West 5th Street, P.O. Box 7600
Los Angeles, California 90051
Telephone (213) 977-5180
Facsimile (213) 977-6438

UNOCAL 76

Philip H. Messer
Vice President

MAGMA POWER COMPANY

Jessie P. Reverente
Project Mechanical Engineer

551 W. MAIN STREET
BRAWLEY, CALIFORNIA 92227
619 351-3060 FAX 619 351-3039

ANSALDO
North America

Jose A. Gouvea
Business Development Analyst

375 Park Avenue
New York, NY 10152, U.S.A.

Tel (212) 355-0508
Fax (212) 644-5250

ANSALDO

Marco Zorzi
Market Development
Area Manager

20094 Corsico (MI) Italy
Via S. Caboto, 7a
Telephone 02.48343243
Telex 321388 Angiem I
Telefax 02.48343476

SHIGETO YAMADA
Assistant Manager – Plant Engineering
Engineering Dept. Thermal Power Div.

Fuji Electric Co.,Ltd.

1 - 1, Tanabeshinden, Kawasaki - ku, Kawasaki City 210 Japan
Phone : Kawasaki (044) 333 - 7111, (044) 366 - 1566
Facsimile : (044) 366 - 1672

MASAAKI OKABE
Assistant Manager
Electrical & Control Engineering Section
Thermal Power Plant Division

Fuji Electric Co.,Ltd.

No. 1, Fuji-machi, Hino-city, Tokyo 191, Japan
Phone : Hino (0425) 83-6111 (Representation)
: Hino (0425) 83-6624 (Direct in Line)
Fax : (0425) 83-1496

PRINTED ON RECYCLED PAPER

ROBERT F. EATON
Director

Wheelabrator Clean Air Systems Inc.

Sulfur Recovery/Odor Control
1501 E. Woodfield Rd., Suite 200 West
Schaumburg, Il. 60173
Tel. (708) 706-6970 (Direct)
Fax. (708) 706-6996
TWX. (910) 693-1591

A WHEELABRATOR TECHNOLOGIES COMPANY

DOW

R.A. (AL) LANNING
Senior Gas Conditioning Specialist
GAS/SPEC Technology Group

The Dow Chemical Company
400 West Sam Houston Parkway South
Houston, TX 77042-1299
Fax: 713/978-3701

713-978-3713

RECYCLED PAPER

BEST AVAILABLE COPY

Chemco
WATER TECHNOLOGY INC.

It All Boils Down To Service!

PROFESSIONAL WATER TREATMENT SERVICES

MARK STAPLETON

6014 N.E. 124th Court
Vancouver, WA 98682
Corporate Office. (206) 892-2418
Fax (206) 892-3518

P.O. Box 489
San Dimas, CA 91773
Fax (909) 592-0167
Office (909) 592-2649

PRINTED ON RECYCLED PAPER

ROBERT O. PETKUS
Sales Manager, USA

Wheelabrator Clean Air Systems Inc.

Sulfur Recovery/Odor Control
1501 E. Woodfield Rd., Suite 200 West
Schaumburg, IL 60173
Tel. (708) 706-6974 (Direct)
Fax. (708) 706-6996
TWX. (910) 693-1591

A WHEELABRATOR TECHNOLOGIES COMPANY

Psychrometric
Systems, Inc.

Wet • Hybrid • Dry
Cooling Towers

GEORGE KAST
Vice President

12600 West Colfax Ave.
Suite A550
Lakewood, CO 80215

MEMBER CTI COOLING TOWER INSTITUTE

Phone (303) 233-0400
FAX (303) 237-1877

Chemco
WATER TECHNOLOGY INC.

It All Boils Down To Service!

PROFESSIONAL WATER TREATMENT SERVICES

MIKE DUNHAM
Vice-President

6014 N.E. 124th Court
Vancouver, WA 98682
Fax (206) 892-3518

(206) 892-2418

GeothermEx, Inc.

GEOTHERMAL & PETROLEUM
EXPLORATION & DEVELOPMENT

ANTHONY J. MENZIES
SENIOR RESERVOIR ENGINEER

5221 CENTRAL AVE., SUITE 201
RICHMOND, CA 94804

(510) 527-9876
FAX (510) 527-8164
TELEX 709152 STEAM UD

Psychrometric
Systems, Inc.

Wet • Hybrid • Dry
Cooling Towers

TIM BOZIC
Manager of Business Development

12600 West Colfax Ave.
Suite A550
Lakewood, CO 80215

MEMBER CTI COOLING TOWER INSTITUTE

Phone (303) 233-0400
FAX (303) 237-1877

The World's Simplest & Most Effective Automatic Pressure Filters

PNEUMA PRESS®

Filtration Systems, Liquid/Solids Separation

Steve C. Benesi
President

Ph. (510) 232-2653
Fax (510) 232-5228

PNEUMAPRESS® Filter Corporation • 301 Ohio Ave. • Richmond, CA 94804

KOR Enterprises

WSA

JOHN A. KOZUB
President

2027 Finch Court • Simi Valley, CA 93063 • 805-583-4306

BEST AVAILABLE COPY

APPENDIX E

LIST OF DOCUMENTS RECEIVED

LIST OF DOCUMENTS RECEIVED

1. "Measurement of Velocity Profiles in Production Wells Using Wireline Spinner Surveys and Rhodamine WT Fluorescent Tracer; Coso Geothermal Field," W. L. Osborn & P. Spielman.

2. "Computer Program To Analyze Multipass Pressure Temperature Spinner Survey," P. Spielmans.

3. "Economics of Automatic On-Line Tube Cleaning Systems," J. Rosser.

4. "Automatic On Line Mechanical Cleaning System for Condensers and Heat Exchangers," M. Grande & K. Someah.

5. "Automatic On Line Debris Filters and Mechanical Cleaning Systems for Condensers and Heat Exchanger," K. Someah.

6. "Wheelabrator Clean Air System."

APPENDIX F

CURRICULUM VITAE

CONTACT INFORMATION FOR THE PNOC-EDC PARTICIPANTS

Mr. Francis Dolor, Planning Manager

Mr. Hermes Ferrer, Geoscientific Manager

Mr. Herman Guillen, Engineering Design Manager

Mr. Romy Jabonillo, Process Instrumentation Coordinator

Mr. Dwight Maximo, Production Manager

Pacific National Oil Company - Energy Development Corporation
Geothermal Division
Engineering and Construction Department
Merritt Road, Fort Bonifacio
Makati, Metro Manila
Philippines
Tel: 63-2-815-8961
Fax: 63-2-515-2747

PERSONAL DATA

Name	:	Dwight A. Maxino
Home Address	:	[redacted]
Date of Birth	:	
Place of Birth	:	
Sex	:	Male
Degree	:	Bachelors of Science in Mechanical Engineering
Employer	:	PNOC - Energy Development Corporation PNPC Complex, Meritt Road Fort Bonifacio, Makati Metro Manila, Philippines

EDUCATIONAL ATTAINMENT

SCHOOL YEAR	SCHOOL	DEGREE/COURSE
1964 - 1970	Foundation University Dumaguete City, Negros Oriental	Primary
1970 - 1974	Foundation University Dumaguete City, Negros Oriental	Secondary
1974 - 1977	Silliman University Dumaguete City, Negros Oriental	BSME III
1977 - 1979	Cebu Institute of Technology Cebu City	BSME
1981	University of Auckland New Zealand	Diploma Course in Geothermal Technology
1992 Jan - Mar	Asian Institute of Management Makati, Manila	Management Development Program

WORK EXPERIENCE

INCLUSIVE DATES	COMPANY/LOCATION	POSITION
Feb. 1980 - June 1980	PNOC-Energy Development Corp. Southern Neg. Geothermal Project Dumaguete City, Negros Oriental	Well Testing Aide
June 1980 - Nov. 1981	PNOC-Energy Development Corp. Southern Neg. Geothermal Project Dumaguete City, Negros Oriental	Reservoir Enginee
Nov. 1981 - Mar. 1983	PNOC-Energy Development Corp. Southern Neg. Geothermal Project Dumaguete City, Negros Oriental	Well Testing and Measurement Supervisor
Mar. 1983 - Nov. 1983	PNOC-Energy Development Corp. Bacon Manito Geothermal Project Sorsogon, Sorsogon	Acting Production Superintendent
Nov. 1983 - Feb. 1987	PNOC-Energy Development Corp. Southern Neg. Geothermal Project Dumaguete City, Negros Oriental	Steam Gathering System Maintenance Supervisor
Feb. 1987 - Sept. 1987	PNOC-Energy Development Corp. Bacon Manito Geothermal Project Sorsogon, Sorsogon	Field Production Superintendent
Sept. 1987 - Feb. 1989	PNOC-Energy Development Corp. Bacon Manito Geothermal Project Sorsogon, Sorsogon	Field Production Head
Mar. 1989	PNOC-Energy Development Corp. Leyte Geothermal Project Tongonan, Ormoc City, Leyte	Field Production Manager

PERSONAL DATA

Name	:	Francis M. Dolor
Home Address	:	[redacted]
Date of Birth	:	[redacted]
Place of Birth	:	[redacted]
Sex	:	Male [redacted]
Degree	:	Mechanical Engineer

EDUCATIONAL ATTAINMENT

SCHOOL YEAR	SCHOOL	DEGREE/COURSE
1959 - 1965	Sta. Maria Elem. School Sta. Maria, Ilocus Sur	Elementary
1965 - 1967	Ilocos Sur School of Arts and Trades	
1967 - 1969	Divine Word College-Vigan, Ilocos Sur	High School
1969 - 1974	University of the Philippines, Diliman	BSME

WORK EXPERIENCE

1981 - 1994 Business Development Manager
PNOC-EDC
PNPC Complex Merritt Road,
Fort Bonifacio, Makati, M. M.

PERSONAL DATA

Name	Romeo G. Jabonillo
Home Address	[redacted]
Nationality	Filipino
Date of Birth	[redacted]
Civil Status	Married; Children: 3
Profession	Registered Chemical Engineer
Language	Pilipino, English
Education	B. S. Chemical Engineering University of San Jose-R Graduated in 1980 Registered in the Philippines

PROFESSIONAL WORK EXPERIENCES

1980 - Present:

PNOC-Energy Development Corporation
PNPC Complex, Merritt Road
Fort Bonifacio, Makati
Metro Manila, Philippines

DESIGN COORDINATOR
July 1992 to present

Coordinate and supervise the process and instrumentation sections to develop a piping and instrumentation diagram (P & ID). Review the P & ID drawings before issuance to Mechanical Section. Review and evaluate the technical proposals of the power plant bidders for process and instrumentation.

PROCESS ENGINEERING SUPERVISOR
September 1988 to July 1992

Supervised and performed process design and optimization, process simulation, equipment sizing, preparation of mechanical flow diagram.

Coordinating with Operations Group for the partial commissioning of the 110 MWe fluid collection and disposal system.

PROCESS DESIGN ENGINEER
September 1986 to August 1988

Performed process design and optimization process simulation, equipment sizing, preparation of mechanical flow diagram and piping and instrumentation diagram.

PROCESS ENGINEER
May 1984 to August 1986

Process monitoring and control instrumentation of the existing geothermal fluid collection and disposal system and power plants.

Research studies on system improvements such as silica scaling on reinjection pipe lines, studies on protective coating applicable to geothermal plant facilities and others.

FIELD DRILLING ENGINEER
October 1982 to April 1984

Preparation of drilling programs and cementing Programs. Identify drilling tools and Fishing tools requirements. Supervised drilling rig constructors for smooth drilling operation.

MUD ENGINEER
July 1982 to September 1982

Prepare mud drilling programs, identify drilling mud consumables to be used. Direct mud technicians on the proper mixing of chemicals to attain the desired mud properties.

MUD TECHNICIAN
September 1980 to July 1982

Analyzed the drilling mud properties to ensure that the right mud properties are achieved and maintained throughout the drilling operations.

HERMAN V. GUILLEN

SUMMARY

Fifteen years experience on plant design, procurement comissioning and operation of cross country pipeline and plant station facilities as well as processing plants of geothermal steam fields, oil refineries and chemical plants.

Work coverage begins from conceptual design, project planning, cost estimating, detailed engineering, materials procurement, construction assistance, on up to plant start-up and commissioning.

In charge of the overall activities of the Engineering Design Department comprised of engineers and draftsmen with piping, mechanical equipment, civil, structural, on up to research and development experience.

EDUCATION

Bachelor of Science in Mechanical Engineering
De La Salle University
Manila, Philippines
1976

Masters in Business Administration
(candidate, 40 units)
Ateneo Graduate School of Business
Makati, Metro Manila
Philippines
1983

Undergraduate Studies to Supplement Training
Program on Direct Use Application of Geothermal Energy
Oregon Institute of Technology
Klamath Falls, Oregon 97601
USA
1987

LICENSE

Registered Mechanical Engineer
Manila, Philippines
1977

PERSONAL

Birthdate: [redacted]
Civil Status: Married, Three Children
Statistics: Height 5'5", Weight 160 lbs., Excellent Health

KEY QUALIFICATIONS

Preparation of design concepts, project schedules and cost estimates, including project violability studies.

Identification of total engineering development strategy necessary to generate a piping and instrumentation diagram, general plant arrangement plan and overall engineering activities.

Site selection for major equipment of the plant.

Identification of a suitable match between supply capabilities and demand requirements of the system to attain optimum efficiency in plant operation.

Preparation and evaluation of various design concepts and selection of the most technically and economically viable scheme.

Formulation of process operation parameters and selection of equipment to ensure plant safety and operability.

Establishment of design guides and criteria needed for the implementation of detailed engineering designs including preparation of technical specifications for equipment and piping materials.

Preparation of procedures for plant start-up, commissioning, shutdown and trouble shooting.

Review and approval of detailed engineering designs made by various engineering sections: Civil, Structural, Process, Piping, Mechanical, Instrumentation and Electrical.

Organization and direction of the project team.

Preparation of man-hour estimates as well as the operating expense budget of the department.

Monitoring and control of work progress, including close supervision of engineering design.

Preparation of terms and references for consultancy services and the establishment of actual needs of consultants as well as directing the work of the consultants.

Review and approval of bidding documents prior to issuance to vendors and subsequently, preparation and finalization of the technical evaluation of bid offers.

PROFESSIONAL EXPERIENCE:

PHILIPPINE NATIONAL OIL COMPANY - ENERGY DEVELOPMENT CORPORATION
Geothermal Division
Engineering and Construction Department
Fort Bonifacio, Makati, Metro Manila
Philippines

PERIOD: **August 1987 to March 1994**

POSITION: **Engineering Design Manager**

PERIOD: **March 1994 to Present**

POSTION: **Engineering Design Department Manager**

RESPONSIBILITIES

Establish engineering design criteria and guidelines for detailed engineering and material procurement.

Preparation of design concept and cost-benefit analysis needed for the establishment of optimum plant efficiency as well as in resolving plant operation problems.

Supervision, planning coordination, organization, implementation and control of overall engineering design and procurement activities of a project.

Negotiation and technical discussion on interface data, terms and conditions of the contract with the client.

Establish overall design concept.

ACHIEVEMENTS

Completede the total engineeringand procurement requirements of three major geothermal projects in the Philippines with a total combined capacity of 230 MW.

Reduced the total project cost by about 30% or $18 million by reducing design pressures to their minimum limit, establishment of seismic zonation, and standardization of material requirements.

Implemented project documentation procedures for proper control of issuance of drawings and bidding documents.

Provided complete engineering support to two operating plants (225 MW) to keep them running efficiently and at the same time maintain their rated capacity.

Completed design concepts of the next major geothermal projects with a total plant capacity of 550 MW.

PERIOD: **July 1983 to August 1987**

POSITION: **Supervising Mechanical Engineer**

PERIOD: **August 1986 to July 1988**

POSITION: **Project Officer, PNOC-UNDP Project on Geothermal Application**

PERIOD: **January 1983 to June 1983**

POSITION: **Project Coordinator**

PERIOD: **November 1979 to January 1983**

POSITION: **Systems Design Engineer (Process/Piping)**

PARSONS INTERNATIONALS LTD.
Mechanical Process Section
Makati, Metro Manila
Philippines

PERIOD: **January 1978 to November 1979**

POSITION: **Mechanical Process Engineer**
Piping Engineer (part time)

DELTA MOTORS CORPORATION (TOYOTA)
Automotive Manufacturing Division
Parts Fabrication Plant
Paranaque, Metro Manila
Philippines

PERIOD: **March 1977 to January 1978**

POSITION: **Engineering Assistant**

TECHSERVE INC.
Mechanical Design Section
Quezon City
Philippines

PERIOD: **September 1976 to March 1977**

POSITION: **Mechanical Process Engineer**

PERIOD: **April 1975 to May 1975**

POSITION: **Summer Job Trainee**

World Environment Center 419 Park Avenue South Suite 1800 New York, NY 10016 USA
Tel: (212) 683-4700 FAX: (212) 683-5053

WEC/US-AEP

Environmental Business Exchange (EBE) Trip Reports

Febuary 22, 1995

Trip Reports as per Cooperative Agreement (CA) AEP-0015-A-00-2055-00 in Support of the U.S.-Asia Environmental Partnership

EBE ID#	EBE DATES	TITLE OF TRIP REPORT
INDI-1I	11/7-23/93	Oil Absorbent Demonstration
INDI-1K	12/6-29/93	Review of Incinerator Operations, Indian Thermal and Cyno Clean
INDI-2	4/23 - 5/6/94	Review of Pollution Prevention Control Technology in the Textile Industry
INDI-5	4/30 - 5/10/94	Clean Coal Technology Evaluation
INDI-1P (1&2)	5/94-8/94	Clean Technology for Paper Mills - Esvin - Parts 1&2
INDI-1R	6/18-30/94	Evaluation of Biological Formulations for Industrial Wastestreams Treatment (Premier Ziba)
INDI-1Q	6/18-7/1/94	Indian Boilers Manufacturers' Association Trade Mission
PHIL-8	9/27-10/6/94	Technical Assistance on H2S Gas Abatement Systems (PNOC)
HONG-1	10/23-11/9/94	Coleman Energy and Environmental Systems Technology Transfer
KORE-1	12/9-22/93	Fuel Gas Desulfurization Technology Assessment (KEPCO)
INDI-1L	1/17-2/23/94	Corporate Environmental Mission (IT Corporation Exchange)
INDI-4	3/11-30/94	Evaluation of CS_2 Recovery in Rayon Mills