Analysis and Summary Report of Operation Guantanamo Naval Base Desalination Facility

United States Department of the Interior

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Analysis and Summary Report of Operation Guantanamo Naval Base Desalination Facility

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Contract No. 14-30-2806

United States Department of the Interior • Rogers C. B. Morton, Secretary
James R. Smith, Assistant Secretary for Water and Power Resources

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FOREWORD

This is one of a continuing series of reports designed to present accounts of progress in saline water conversion and the economics of its application. Such data are expected to contribute to the long-range development of economical processes applicable to low-cost demineralization of sea and other saline water.

Except for minor editing, the data herein are as contained in a report submitted by the contractor. The data and conclusions given in the report are essentially those of the contractor and are not necessarily endorsed by the Department of the Interior.

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ABSTRACT

1. Rapier, P. M. + Rowe, W. H. + Ko, A. C. + DeRienzo, P. P. + Gitterman, H.

2. ANALYSIS AND SUMMARY REPORT OF OPERATION GUANTANAMO NAVAL BASE DESALINATION FACILITY

3. Burns and Roe, Inc., Oradell, New Jersey

4. OSW R&D Progress Report No. , PB- , 235 p, 123 fig, 49 ref.

5. The six-year operating history of the Guantanamo Naval Base 2.25 MGD desalting and power generation facility has been reviewed, analyzed and categorized in terms of plant performance, component reliability and lifetimes for use as guidelines in the design, operation and maintenance of commercial desalting facilities. Since their installation the three 0.75 MGD plants have operated on a reliable commercial basis at rated capacity and performance at costs compatible with the design criteria; at 92.7% on-stream time the three units averaged 2.0 MGD and 6.8 performance ratio, using 195°F top-temperature brine and Hagevap pretreatment with periodic acid cleaning; evaporator vessels were satisfactory except for some failures of waterboxes, mitered elbows and product water trays; evaporator outages due to pump failures were minimal because of redundancy, and only small losses of performance and production resulted; tube failures were limited to 16.95% of the heat rejection tubes, which were due primarily to blockage by foreign objects.

6. Flash distillation + dual-purpose plant economics + operating experience + operating costs + Point Loma plant + *Guantanamo Naval Base Desalting plant + corrosion prevention + design data + feedwater treatment + product water treatment

7. Notes: *New Keyword

1.0 INTRODUCTION

On February 24, 1971, Burns and Roe, Inc. was authorized by the United States Department of the Interior, Office of Saline Water under Contract No. 14-30-2806 to assemble, review, analyze, and summarize the operational and maintenance data which has been accumulating during the six year operating history of the Guantanamo Naval Base desalination and power generation facility.

The objective of this report is to furnish information for use by the Office of Saline Water (OSW) as a guide (1) for planning research and development programs at OSW's experimental facilities and at other locations and (2) for the design, operation and maintenance of commercial desalination facilities, considering plant performance and component reliability and lifetimes that reasonably can be expected in view of the Guantanamo plant operating history.

Reports, design drawings and specifications operating and maintenance manuals, vendors manuals and drawings, and correspondence have been utilized in developing background information and evaporator plant description, including instrumentation. The Guantanamo plant has been operated as a production facility rather than as a research and development facility; however, a considerable amount of the data that have been accumulated is considered to be of a research and development nature.

Operating and maintenance experience is recorded in the "Operation and Maintenance Supervisors" weekly and monthly summary reports to the Navy Public Works Center, special reports, PWC laboratory data, and correspondence. This experience, as well as reports, logs, and other data at the Guantanamo site which were reviewed and discussed with plant personnel, has been utilized in developing information on plant production, water quality and costs, plant operation, maintenance, and performance.

2.0 SUMMARY AND CONCLUSIONS

Well designed desalination plants can be operated by production personnel on a reliable, continuing, production basis to produce satisfactory water and electric power at costs and production rates compatible with the design criteria.

The 1965-1971 six year Guantanamo operation averages are listed below.

1) Water production averaged 1.99 million gallons per day compared with a rated daily capacity of 2.25 million gallons per day.

2) Reported average water cost (exclusive of electric power and fixed charges) was substantially the projected cost of $1.00/1000 gal.

3) The performance ratio for the Gitmo units averaged 6.6 pounds of product per 1000 BTU at the brine heater, which was anticipated in the engineering design criteria. The Point Loma average performance ratio of 7.2 pounds of product per 1000 BTU was slightly below the anticipated 7.5 performance ratio.

4) With provision for downtime to accomplish major overhaul, the average on stream time for each evaporator has been:

a. Point Loma - 89%
b. Gitmo #1 - 94%
c. Gitmo #2 - 95%

Heat recovery tubing has performed with no failures during the six year life of the evaporators. Brine heater tubes have had very few failures and no replacements. Heat reject tube failures for each evaporator during the 6 years have been:

a. Point Loma - 8.26%
b. Gitmo #1 - 25.5%
c. Gitmo #2 - 17.1%

Ruptured reject tubes have been replaced on two occasions and no replacement tubes have failed.

Pump failures occurred, but with redundant installed pumping capacity, plant outages due to pumping failure were minor. Pump life in many cases was approximately six years.

Evaporator vessels performed quite satisfactorily except the product water trays, but water boxes required replacement and were redesigned.

Butterfly valves have performed satisfactorily, with rubber seated valves performing well with flows of low velocity and low temperature. Mitre joint elbows in high pressure brine service failed and were replaced with smooth sweep elbows.

Improved desalination operations could result from further study and modification of:

1) Circulating sea water pretreatment, screening and backflushing to prevent heat-reject tubing blockage.

2) Specifications for heat reject stage tubing to reduce tube failures.

3) Specifications for pump materials of construction to increase pump life.

4) Post treatment procedures to result in less corrosion of water distribution system.

5) Additional material balances between corrosion products in effluent streams and corrosion rates of plant equipment.

6) Oxygen scavenging techniques for brine feed to reduce tube fouling by corrosion products.

7) Specifications for materials of construction to reduce corrosion to increase life of product troughs.

8) Operating conditions which affect deposits on Demister screens with related effect on evaporator performance.

3.0 BACKGROUND INFORMATION

3.1 Plant History

Establishment of the Naval Base at Guantanamo Bay in 1903 created the need for both electrical power and fresh water to satisfy the needs of military personnel and to perform the functions for which the base was established.

The electrical power requirements presented no great problem and were satisfied by power generated with Diesel engine driven generators.

The requirements for fresh water were not so easily satisfied. Water from wells was brackish and the rainfall was insufficient to supply the need even if it could be collected and stored. The fresh water for the base was supplied from the Yateras River under contract with the Cuban Government. Termination of the agreement by the Cuban Government in February 1964 necessitated establishment of a new source of supply.

Water can be and has been shipped from mainland U. S. or other islands, but the cost of delivering potable water by tanker or barge from the nearest available sources was approximately $5.89 per thousand gallons (9), several times the cost of desalted water.

On March 5, 1964, the Chief of U.S. Navy Bureau of Yards and Docks announced the President had directed that the Guantanamo Naval Base be made self-sufficient in the shortest possible time for providing permanent adequate power and water to meet the base requirements. Investigation of various alternatives led to the selection of the dual purpose facility described herein as the most economical and tactically feasible means of assuring an uninterrupted supply of both power and water.

A target date of July 26, 1964, was set for the first sea-water conversion plant to be on stream, to coincide with the Anniversary of the date that Castro declared the liberation of Cuba, with the other units to be completed shortly thereafter. The 15000 KW electrical power generation plant was scheduled for completion within 17 months, or June 1965. The first water produced by the Pt. Loma unit was on July 26, 1964. The actual completion date of the entire facility, including two additional evaporators, boiler plant, and electric power plant, was February 5, 1965, or about 5 months ahead of schedule.

3.1.1 Point Loma Evaporator

The Pt. Loma evaporator had been operated at Pt. Loma (San Diego) California for a period of 26 months from January 1, 1962, through February 26, 1964.

Operating experience while at Pt. Loma included satisfactory scale control at evaporator temperatures of 200° F. with a polyphosphate (Hagevap)* treatment and at temperatures up to 250° F. and a brine concentration factor of 1.5, with the acid treatment process.

The experience at Pt. Loma illustrates the substantial improvement that can be realized from higher evaporator operating temperatures. The Pt. Loma evaporator originally contained 36 stages and was designed for and satisfactorily produced 1,000,000 gpd at a performance ratio of 11.2 for a brine heater outlet temperature of 200° F. and a sea - water temperature of 60° F. Increasing the brine heater outlet temperature increased the production to 1,250,000 gpd and the performance ratio to 11.7. A further increase in the brine heater temperature to 240° F. resulted in a water production rate of 1,400,000 gallons per day.

The OSW and the U.S. Navy jointly agreed that to expedite the Guantanamo project this multi-stage flash evaporator should be dismantled and reassembled at Guantanamo.

When the Pt. Loma evaporator was dismantled in February 1964, only 28 stages were shipped to Guantanamo with stages Nos. 25 to 32 omitted. The lower brine heater operating temperature (195° vs 200° F.) and the higher prevailing seawater temperature (85° vs 60° F.) at Guantanamo required that the number of stages be reduced. This evaporator, complete with instruments and auxiliary equipment, was transported to Gitmo and installed as part of the overall facilities at Guantanamo Bay, Cuba.

Since the original Pt. Loma evaporator was designed as a demonstration plant, different tube materials were installed for testing in the various stages. The tube materials used included 90-10 copper nickel, aluminum brass, and steel. The flash chamber shell design was all of steel construction. The steel tubing material contained in stages Nos. 25 to 32 showed definite signs of corrosion. There was no evidence, however, of severe erosion or corrosion in the steel flash chambers.

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*Registered Trademark of the Calgon Corp.

3.1.2 Gitmo No. 1 and No. 2 Evaporators

To further expedite the program, agreement was reached to use an existing Westinghouse design for the 750,000 gpd evaporators. This design, of evaporators to be supplied to Harvey Aluminum Co., St. Croix, Virgin Islands, originally included 22 BWG titanium Condenser tubes. For substituting 90-10 Cu-Ni condenser tubes, past practice would have dictated an 18 BWG tube. A compromise was reached to use 20 BWG 9-10 Cu-Ni tubes in order to maintain a lower in-tube brine velocity.

3.2 Plant Description

The plant is located on Fisherman's Point at the northwestern tip of the Naval Base and is protected from the Caribbean Sea to the south. It is supplied with fuel oil by NSD via pipeline from the tank farm. Other necessary items can be received by ships which can be unloaded at N.S.D. piers on Base and stored in N.S.D. Warehouse to be requisitioned by the water plant. The plant is accessible from the base via Sherman Avenue and Mc Calla Hill Road and is easily serviced by aircraft using the airstrip at Leeward Point. Figure 3-1 is an aerial view of the plant with the power plant building in the middle and the three units which comprise the desalination plant on the right.

Three 1000 KW capacity auxiliary GM Diesel generators are installed at the extreme northeast corner of the site in a north-south line with the transformers and switchgear for the Diesel generators situated at the west end of the Diesel generators. A contract has been let for installation, in the near future, of two - 2000 KW Diesel generators.

The power plant, shown on the right side of Fig. 3-2 is located between the existing seaplane ramp at Fisherman's Point and the Coast Guard Pier. The three boilers are installed on an east-west line along the north side of the site. The two turbines are installed to the south of the boilers with Turbine No. 1 on the west and No. 2 on the east, while the phase bus ducts run through the south wall of the plant to main and auxiliary transformers.

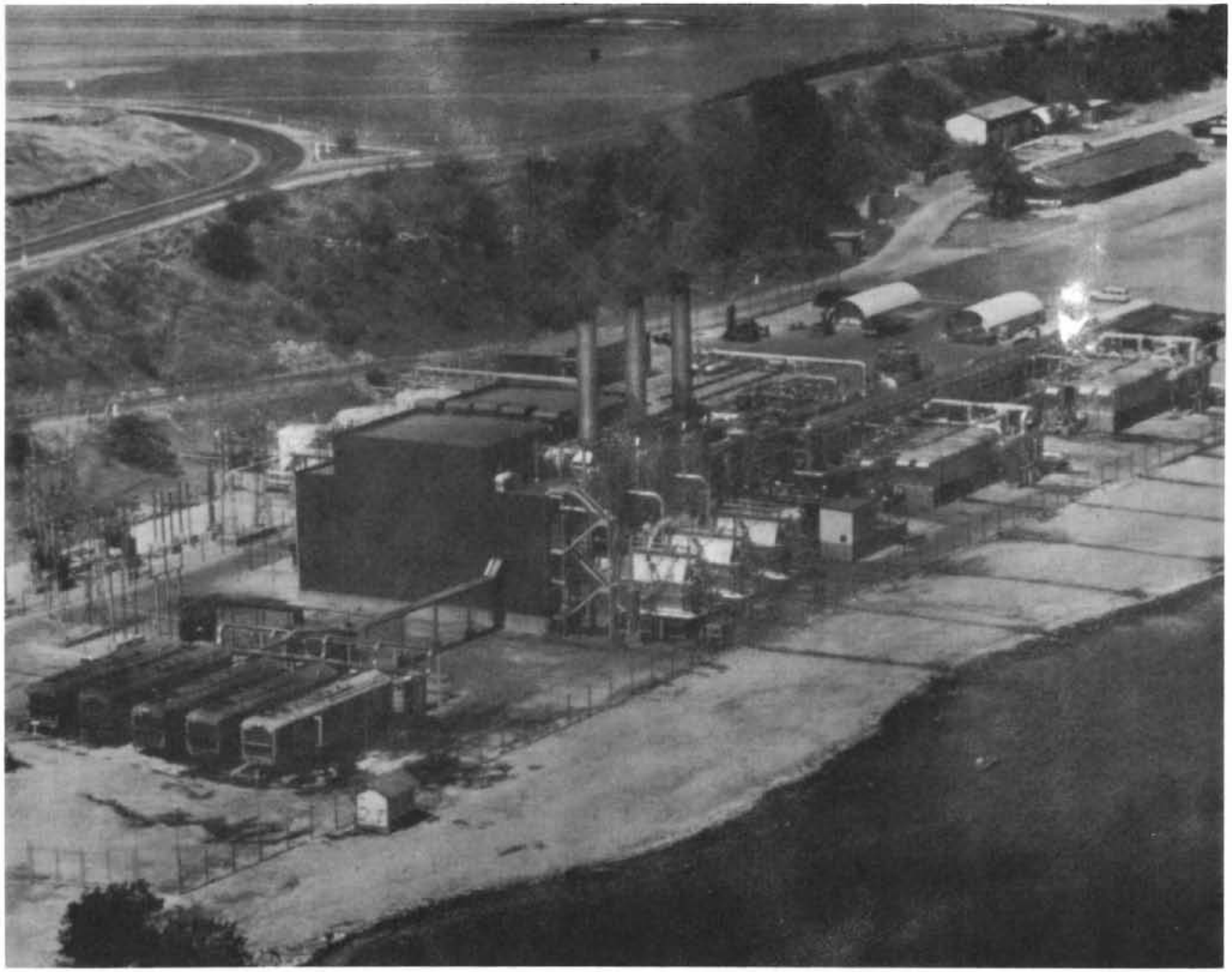


Figure 3-1

VIEW OF GUANTANAMO PLANT FROM THE EAST

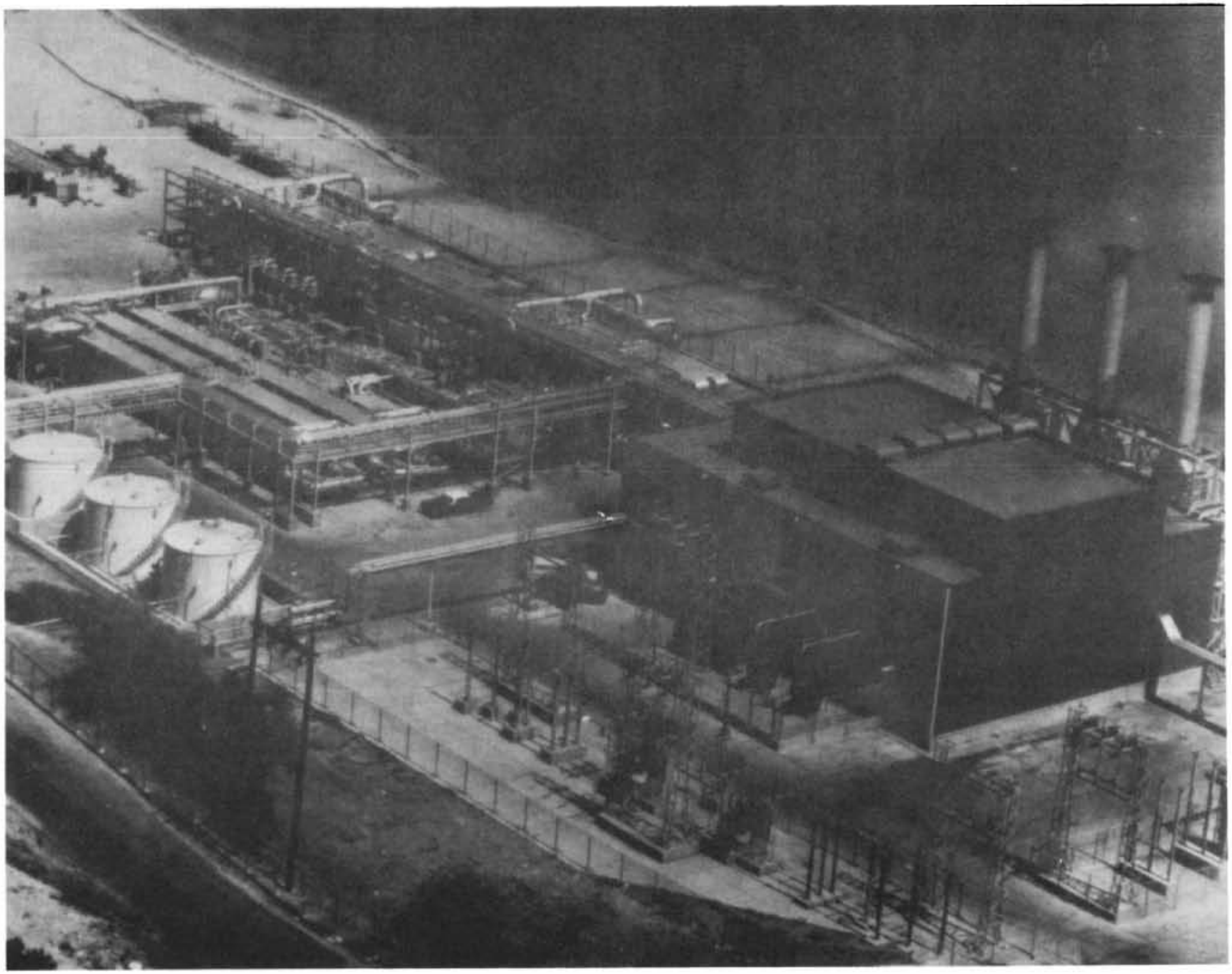


Figure 3-2

VIEW OF GUANTANAMO PLANT FROM THE SOUTH

3.3. Major Components

The seawater conversion plant installed at Guantanamo Bay, Cuba, includes three evaporators: Gitmo No. 1 and No. 2 and Pt. Loma, each evaporator having a design output rating of 750,000 gpd for a total plant production of 2,250,000 gpd. Three 630 psig 830° F. boilers (each 120,000 lb/hr. capacity) supply steam to two condensing 7500 KW turbo-generators equipped with automatically controlled extraction pressure bleed points. Turbine extraction steam, at a predetermined pressure of approximately 10-25 psig is used for the brine heaters.

The west end of the Pt. Loma unit is shown in Fig. 3-3 and the west end of the Gitmo units is shown in Fig. 3-4.

3.4 Plant Design Aspects

The dual purpose plant was designed to make the base independent of outside sources of power and water. (The boilers are designed for operation on Navy "special grade" fuel oil.) The combination of steam-turbine generators and modern MSF evaporators produces power and water as economically as did the former combination of power from Diesel generators and water purchased from the Cuban Government.

The three 1/3 capacity evaporators permit shutdown of units for scheduled or emergency repair, while the remaining units continue to produce water. The 1/2 capacity turbine generators can also be operated independently to permit shutdown of one for maintenance while operating the other. If necessary, electric generating capacity may be supplemented with the three auxiliary Diesel generators which are installed as standby electrical generating capacity. Additional back-up generating capacity is also supplied by other Base Diesel units.

The two steam turbines are each equipped with a full capacity condenser (65,000,000 Btu/hr.) to permit power generation whenever the evaporators are not operated. The facility is also provided with a pressure reducing and desuperheating station to permit operation of the evaporators when no extraction steam is available.

The three 1/2 capacity boilers permit one boiler to remain off the line, if desired, while producing power and water at rated capacity.

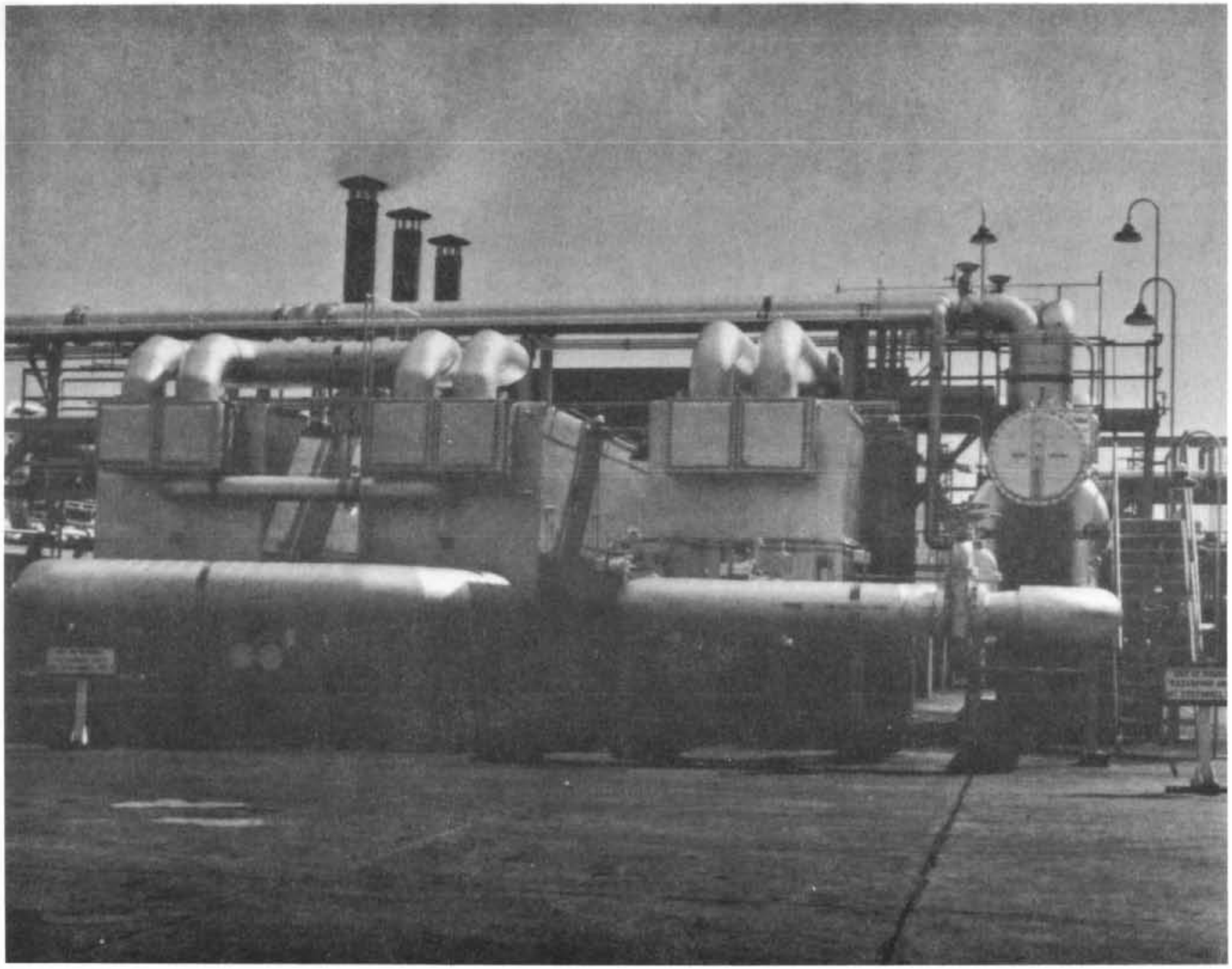


Figure 3-3
WEST END OF POINT LOMA UNIT

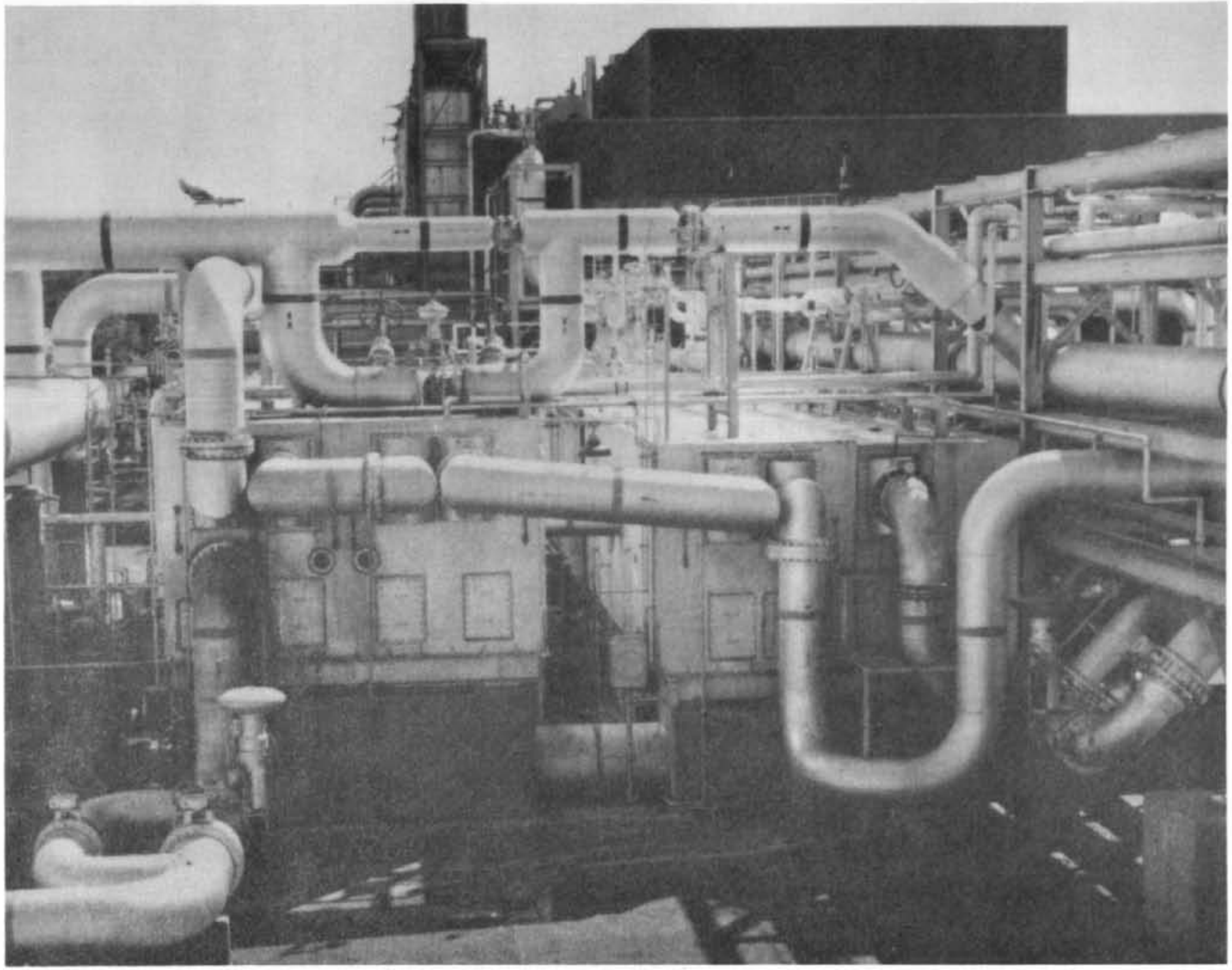


Figure 3-4

WEST END OF GITMO UNITS

A polyphosphate treatment, Hagevap, or PD8, is used for sea-water treatment for the three evaporators. The selection of this treatment at a top brine temperature of 195^{o} F. was made in view of the shipping problems for the relatively large quantities of sulfuric acid that would be required for higher temperature operation. However, the evaporator and auxiliary equipment, including the recycle pumps and brine heater, were designed for a maximum brine heater outlet temperature of 250^{o} F.

Facilities are also provided for continuous addition of sulfuric acid to the makeup seawater during acid cleaning.

3.5 Overall Process Description

Raw seawater for the multi-stage flash evaporators is taken through trash racks from Guantanamo Bay, shock treated with chlorine for control of marine growth, and pumped through the condenser tubes of the heat-rejection section of each of the three evaporators. The warm seawater is rejected to the sea with some of the warm water diverted and used as makeup, which is treated with polyphosphate for scale control.

Makeup is degassed or deaerated, added to the lowest temperature stage and mixed with the brine, which, following blowdown, is then recycled through the condenser tubes of the heat recovery section for preheating on its way to the brine heater. Following the brine heater, the brine is "flashed down" through successively lower pressure stages undergoing an irreversible, adiabatic, heat-and-mass transfer process until it reaches the coldest stage. Concentrated brine blowdown is discharged to the sea. Product water is post-treated through a limestone bed, treated with chlorine and flouride, and then pumped to a 20,000,000 gal. capacity storage for distribution to consumers.

SUMMARY

4.0 EVAPORATOR PLANT DESCRIPTION

Multistage Flash Evaporators Typical Design and Operating Data (1)

Item	Point Loma		Gitmo Nos. 1 & 2 (EA)
Product Capacity, GPD	750,000		750,000 (EA)
Number of streams	2		1
Concentration Ratio	1.5		1.5
Perf. Ratio #Prod/#Steam	7.5		6.6
No. Heat Recovery Stages	26		12
No. Heat Reject Stages	2		3
Temp. Sea Water	85°F		85°F
Temp. Out-Brine Htr.	195°F		195°F
Temp. Rise-Brine Htr.	10°F		15°F
Temp. Blowdown	105°F		100°F
Tubes, Heat Reject. Ga	18 BWG		20 BWG
" " " Mat'l	ASME-SB111, Aluminum Brass, Type "B"		90-10 CuNi
No./Stage,Size,Surface Area	716, 5/8" OD, 7028 ft^2 (or sq.ft.)		1064, 5/8" OD, 10,500
Heat Reject, in tube Vel.	4.73 ft./sec.		7.24 ft./sec.
Stream	"A"	"B"	-
Tubes, Heat Recovery	18 BWG	18 BWG	20 BWG
Stages 25-26, Mat'l.	ASME-SB111,Al-Br,Type "B"	ASME-SB111, 90-10 Cu-Ni	-
No./Stage,Size,Total Area	532,3/4" OD, 3,133 ft^2	607, 3/4" OD, 3,575 ft^2	-
In tube Velocity	5.91 ft./sec.	5.18 ft./sec.	-
Stages 5-24, Mat'l.	ASME-SB111,Al-Br,Type "B"	ASME-SB111,Al-Br,Type "B"	-
No./Stage,Size,Total Area	532,3/4" OD, 31,329 ft^2	532, 3/4" OD, 31,329 ft^2	-
In tube Velocity	5.91 ft./sec.	5.91 ft./sec.	-
Stages 1-4, Mat'l.	ASME-SB111,Al-Br,Type "B"	ASME-SB111, 90-10 Cu-Ni	-
No./Stage,Size,Total Area	532,3/4" OD, 6,266 ft^2	607, 3/4" OD, 7,150 ft^2	-
In tube Velocity	5.91 ft./sec.	5.18 ft./sec.	-
Stages 1-12, Mat'l	-	-	90-10 Cu-Ni
No./Stage,Size,Total Area	-	-	1076,5/8", 63,708 ft^2
In tube Velocity	-	-	7.75 ft./sec.
Tube Sheet Mat'l.,Stages 1-4	ASME SB 171 90-10 Cu-Ni	ASME-SB 171 90-10 Cu-Ni	90-10 Cu-Ni
Stages 5-28	ASME SB 171 Naval Brass	ASME-SB 171 Naval Brass	
Tubes Brine Heater	18 BWG, Al-Brass	18 BWG, 90-10 CuNi	20 BWG, 90-10 Cu-Ni
No.,Size,Surface Area	532,3/4" OD, 1472 ft^2	607, 3/4" OD, 1680 ft^2	437, 1" OD, 2,800 ft^2
In tube Velocity	5.91 ft./sec.	5.18 ft./sec.	6.33 ft./sec.
Recycle Flow (2)	1,640,000 lbs./hr.	1,640,000 lbs./hr.	2,933,000 lbs./hr.
Makeup Flow (2)	781,000 lbs./hr.		781,000 lbs./hr.
Seawater Flow (2)	1,150,000 lbs./hr.		2,900,000 lbs./hr.
Blowdown Flow (2)	521,000 lbs./hr.		521,000 lbs./hr.
Vessel Mat'l.	Steel		Mild Steel

4.0 EVAPORATOR PLANT DESCRIPTION

Typical design and operating data for the Point Loma Unit and Gitmo Units Nos. 1 and 2 are summarized and tabulated for convenience of reference on the preceding page.

4.1 Point Loma Unit

The Point Loma Unit consists of a 28-stage flash evaporator, a brine heater and air ejector with the pumps, controls and chemical treatment equipment required for complete operation as an independent unit. A steam supply from the extraction steam header, electrical power and air supply for pumps and controls, a seawater supply from the circulating water system, and a fresh water supply (for the product pump gland seals) are the only external requirements for operation of the unit. Fig. 4-1 illustrates the Point Loma Unit schematically. In Fig. 3-2, a photographic representation of the entire Guantanamo facilities, the four long, low rows of rectangular equipment behind the oil tanks are the five vessels of the Point Loma evaporator.

Vessel V-100 contains stages No. 1-4 with 60 ft. long tubes and stages No. 5-8 also with 60 ft. long tubes. Vessel V-101 contains stages No. 9-12 and stages No. 13-16 each with 60 ft. long tubes. Vessel V-102 contains stages No. 17-20 and stages No. 21-24 each with 60 ft. long tubes. Vessel V-103 contains stages No. 25-26 with 30 ft. long tubes. Vessels V-100 to V-103 inclusive house the heat recovery stages.

Vessel V-104 contains the heat rejection stages No. 27-28 with 60 ft. tubes.

Throughout this report references will be made to the "A" recycle stream and the "B" recycle stream of the Point Loma unit at Guantanamo. The "A" stream refers to that part of the evaporator and the side of the brine heater equipped with aluminum brass tubes only, while the "B" stream refers to that part of the evaporator which includes the 90-10 Cu-Ni tubes and the Cu-Ni tube side of the brine heater.

The Point Loma Unit brine heater is illustrated in Fig. 4-2. Each of the two pipe connections, visible at the end of the brine heater, conducts one of the two separate brine recycle streams.

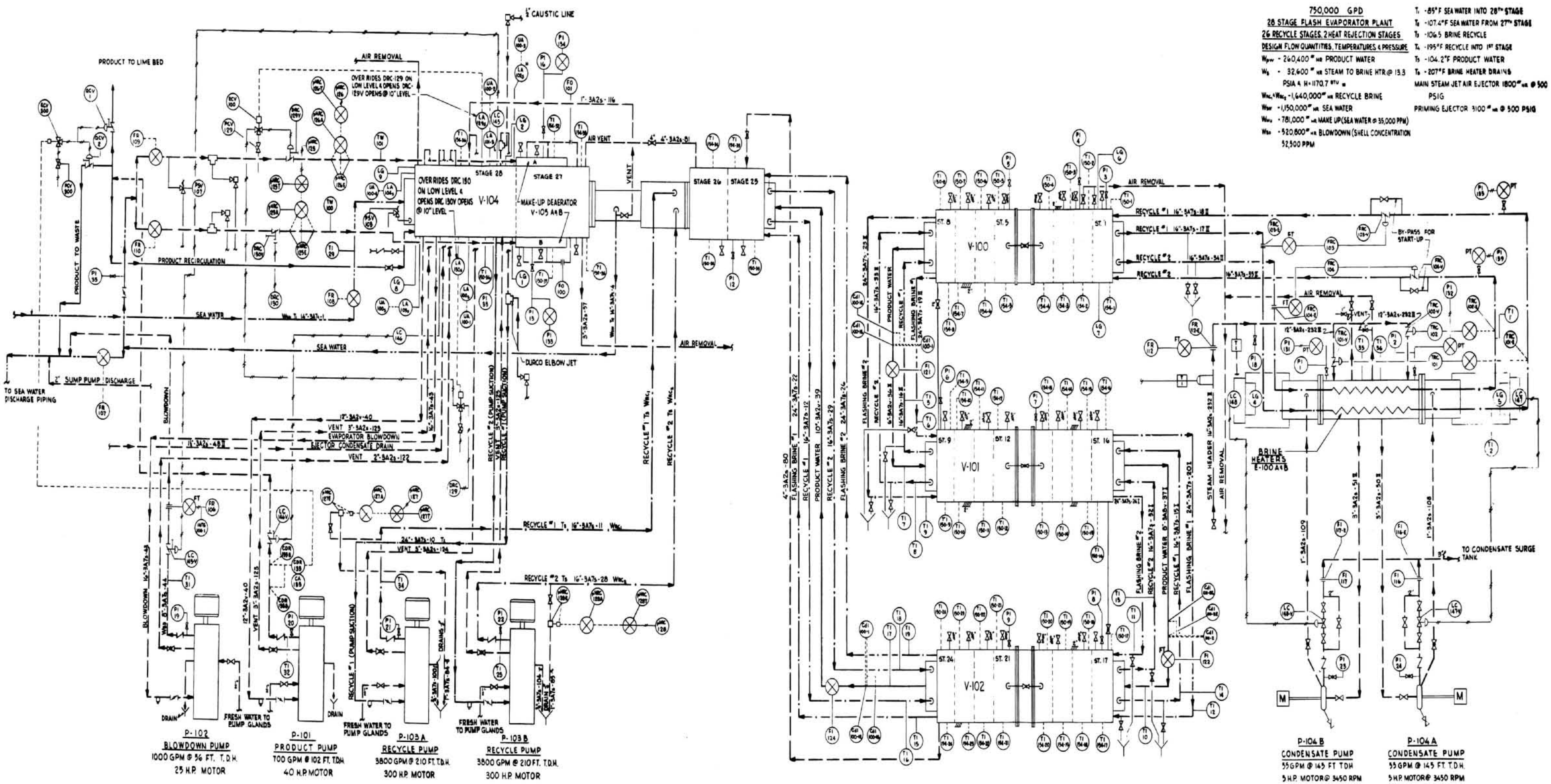


Figure 4-1 SCHEMATIC OF POINT LOMA UNIT

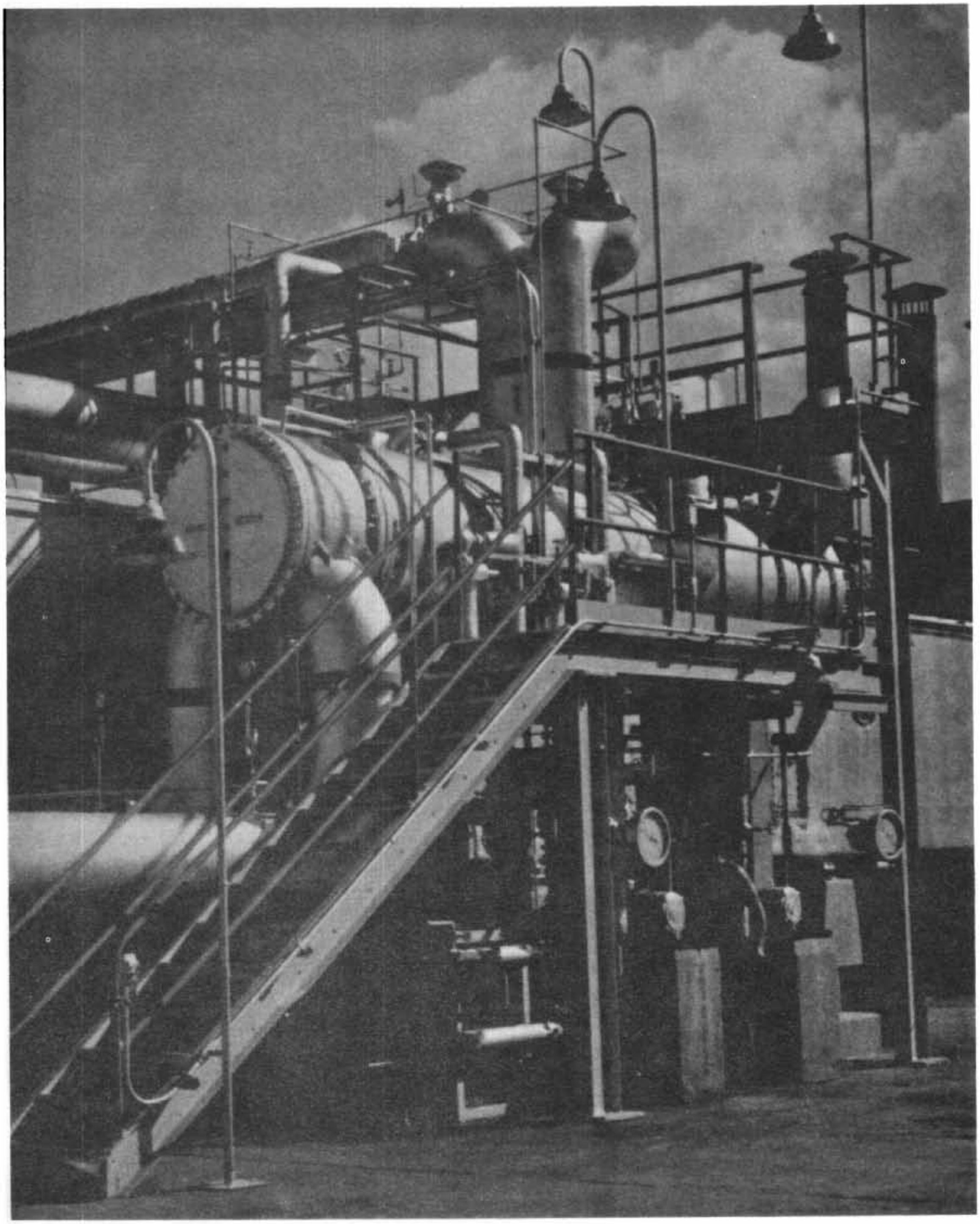


Figure 4-2

POINT LOMA UNIT BRINE HEATER

4.2 Gitmo Unit No. 1

The Gitmo Unit No. 1 is a 15 stage flash evaporator. Gitmo No. 1 is equipped with complete and separate auxiliaries permitting the unit to produce water independently of the other two evaporators, except that all three units are dependent on one common circulating seawater system and one Product Water Treatment System. All three units also depend on a common source of steam, fresh water, and electric power.

A typical simplified schematic diagram of one Gitmo unit is shown in Fig. 4-3. A photographic illustration of the west end of Gitmo Unit No. 1 is shown in Fig. 4-4.

The 15 stages of the Gitmo Unit No. 1 are contained in two vessels. In Fig. 4-4 the large enclosure on the left is vessel VS-200 containing stage Nos. 1-2, 3-4, 5-6, and 7-8 with 60' 3 13/16" long tubes for each pair of stages. Vessel VS-300 is on the right in Fig. 4-4 and contains stages Nos. 9-10, 11-12, and 13-15 with 60' 3 13/16" long tubes for each of the three series of stages. The relative locations of the Gitmo Unit No. 1 stages can be seen in Fig. 4-5. The internal arrangement of two adjacent stages is shown schematically in Fig. 4-6.

4.3 Gitmo Unit No. 2

Gitmo No. 2 evaporator plant is identical to Gitmo No. 1 Unit.

4.4 Auxiliary Systems

4.4.1 Seawater Systems

4.4.1.1 Seawater Intake System

Seawater is initially collected in an offshore underwater concrete seawater intake equipped with a fish cap. The intake, which is partially buried in the bay bottom, places the inlet approximately 18 ft. below the mean low water level of the bay. A 66" I.D. concrete pipe approximately 140 ft. long connects the seawater intake to the open top concrete intake structure located on land, about 20 ft. behind the seawall. The floor of the intake structure is 9 ft. below mean low water level of the bay providing 7 to 11 ft. depth of seawater, depending on the tide.

The intake structure is divided into two separate compartments 42 ft. long by 6'2" wide by 18' high, each of which may be closed off at the seaward, intake end, with stop-logs. This permits one compartment to be pumped out for maintenance while the other compartment is available for operation. Each compartment is fitted with a trash rack, traveling, spray-washed screen, screen wash pump, and circulating seawater pump.

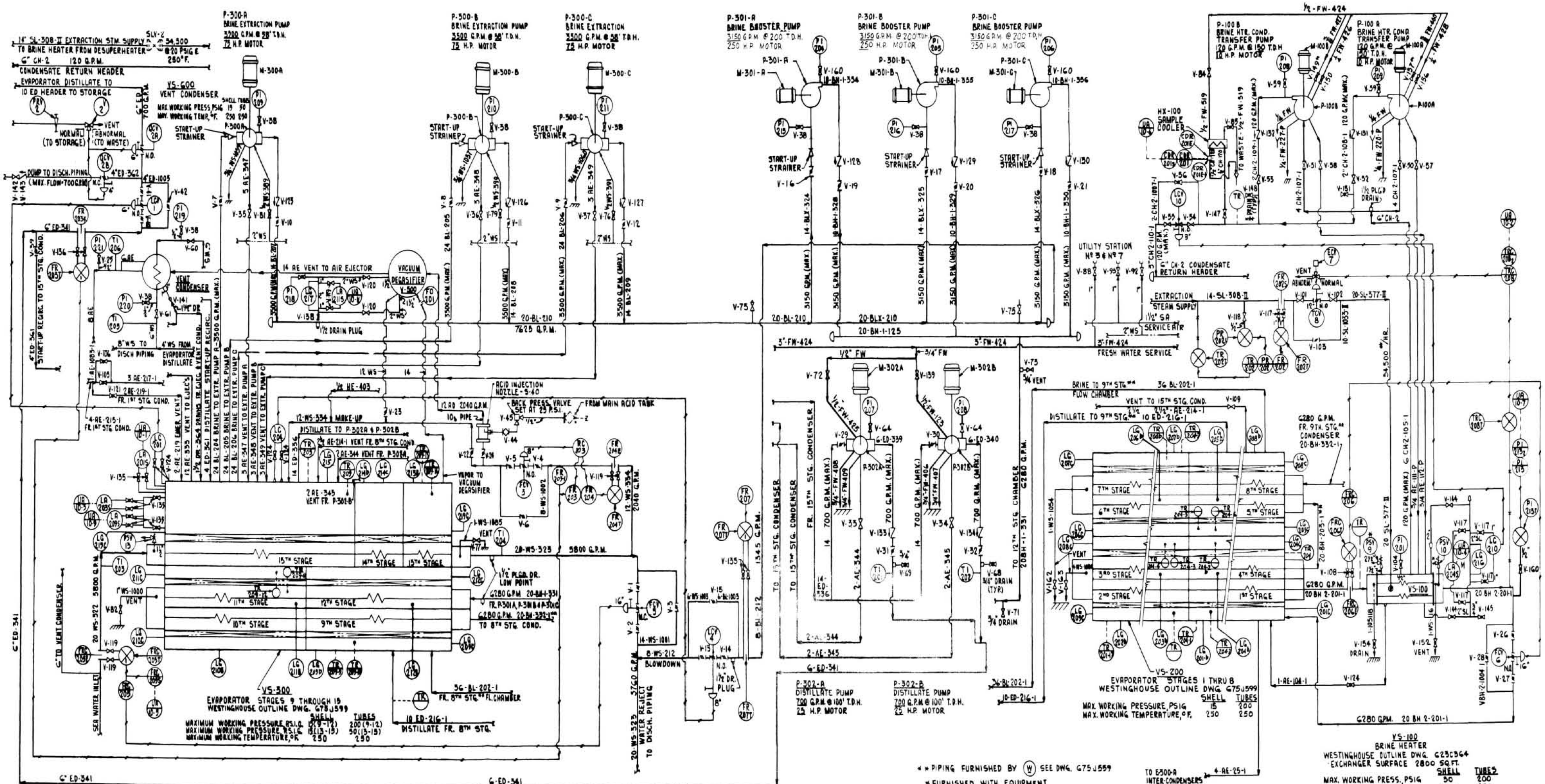


Figure 4-3

SCHEMATIC OF ONE GITMO UNIT

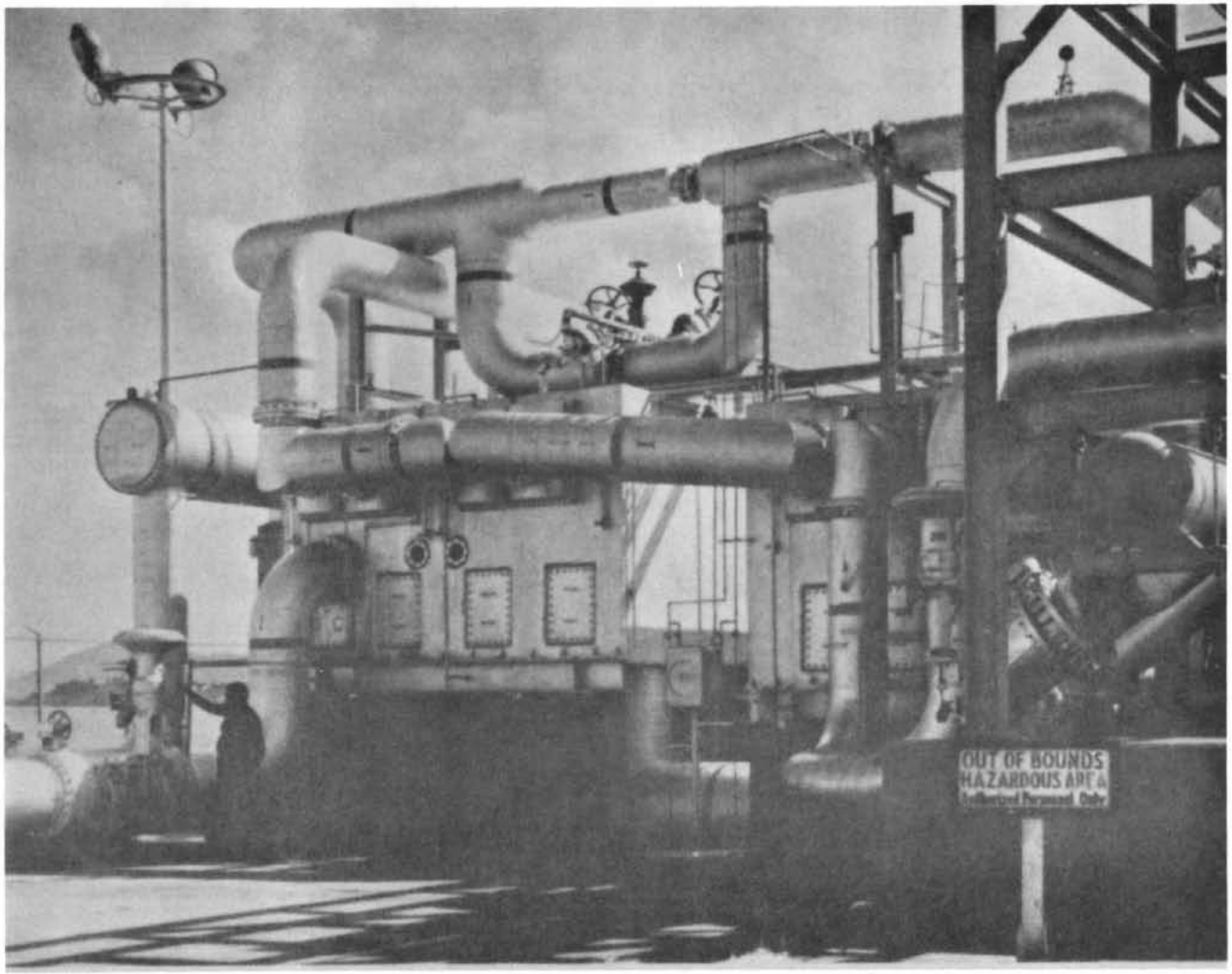


Figure 4-4

VIEW OF WEST END OF GITMO UNIT NO. I

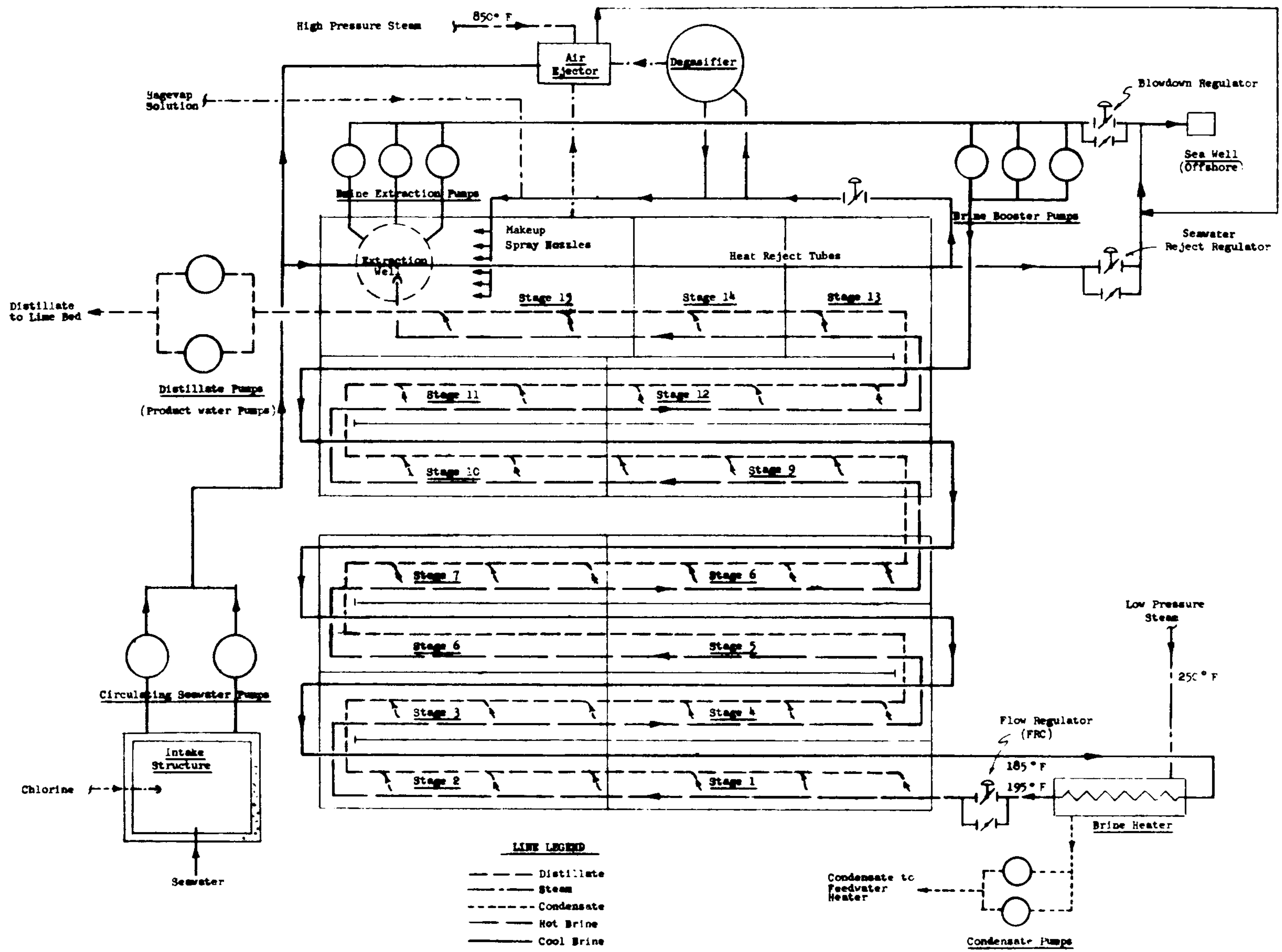
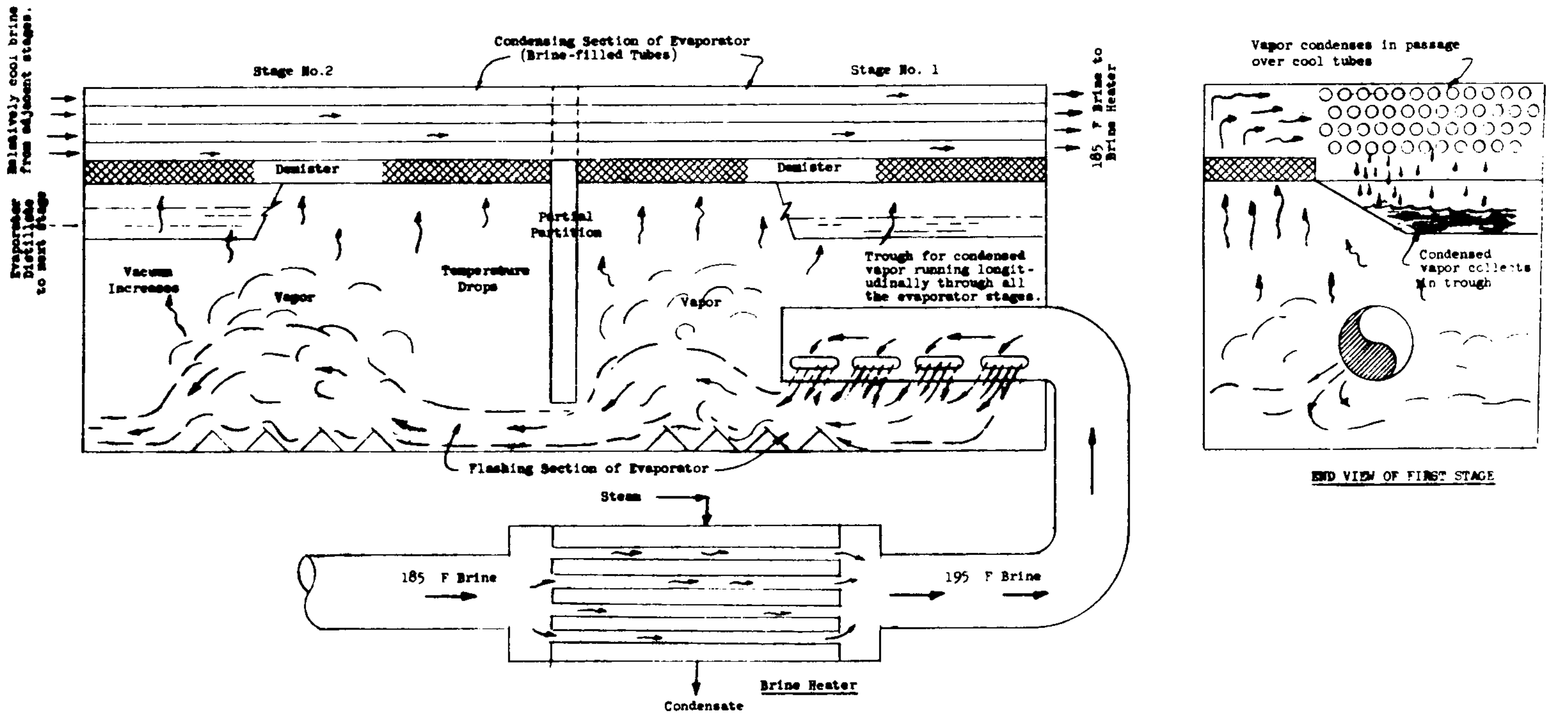


Figure 4-5

ARRANGEMENT OF GITMO UNIT EVAPORATOR



LONGITUDINAL SECTION THROUGH FIRST & SECOND STAGES

Figure 4-6

INTERNAL SCHEMATIC OF TWO ADJACENT STAGES

OF A GITMO UNIT EVAPORATOR

A schematic diagram of the intake system is shown in Fig. 4-7. Fig. 4-8 is a photograph showing the top of the intake structure and the seawater circulating pump drive motors.

4.4.1.2 Circulating Seawater System

The functions of this system are to provide an adequate continuous flow of cool seawater to the following destinations:

a) The tubes of both main condensers.
b) The evaporators of the Point Loma Unit.
c) The evaporators of the two Gitmo Units.
d) The tubes of the two fresh water heat exchangers.
e) The tubes of the gland seal condensers of the turbines.
f) The tubes of the turbine lube oil coolers.
g) The Point Loma air ejector condensers.
h) The Gitmo Units' degasifier vent condensers.
i) The air coolers of the turbine generators.
j) The Gitmo Units' air ejector condensers.

A schematic diagram of the Circulating Seawater system is shown in Fig. 4-9. The circulating seawater supply to turbine oil coolers and gland steam condensers is shown schematically in Fig. 4-10.

In order to provide filtered water and lubrication to the seals of the seawater circulating pumps, a sub-system called the Circulating Seawater Pump Gland Seal System is provided. This system also affords a measure of cooling to the shafts and glands by virtue of its absorption of heat from these pump components. Although provisions are made for drawing seawater for the seal system from the screen wash pumps or from Seawater Circulating Pump P-9-A, the first mentioned source must be employed immediately prior to the start-up of the seawater circulating pumps; this is done to insure that the large pumps will be effectively sealed until they build up enough pressure in their own discharge manifold to provide their own gland seal water. Fig. 4-11 shows the schematic piping diagram for the circulating pumps gland seal water system.

A reinforced concrete seal well is located a few yards offshore from the retaining wall and serves as a baffled chamber through which used seawater is discharged back to the bay.

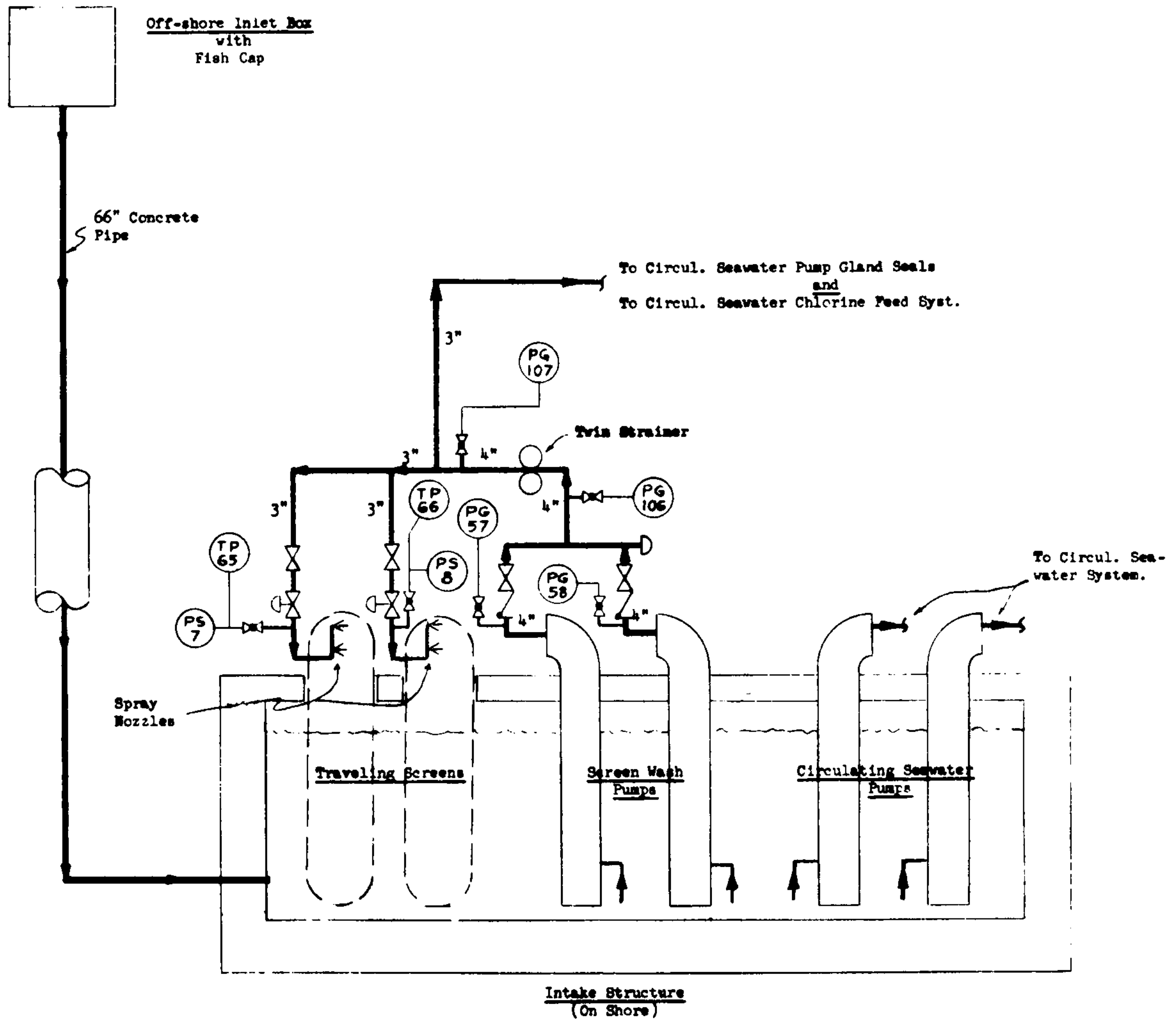


Figure 4-7

SCHEMATIC OF SEAWATER INTAKE SYSTEM

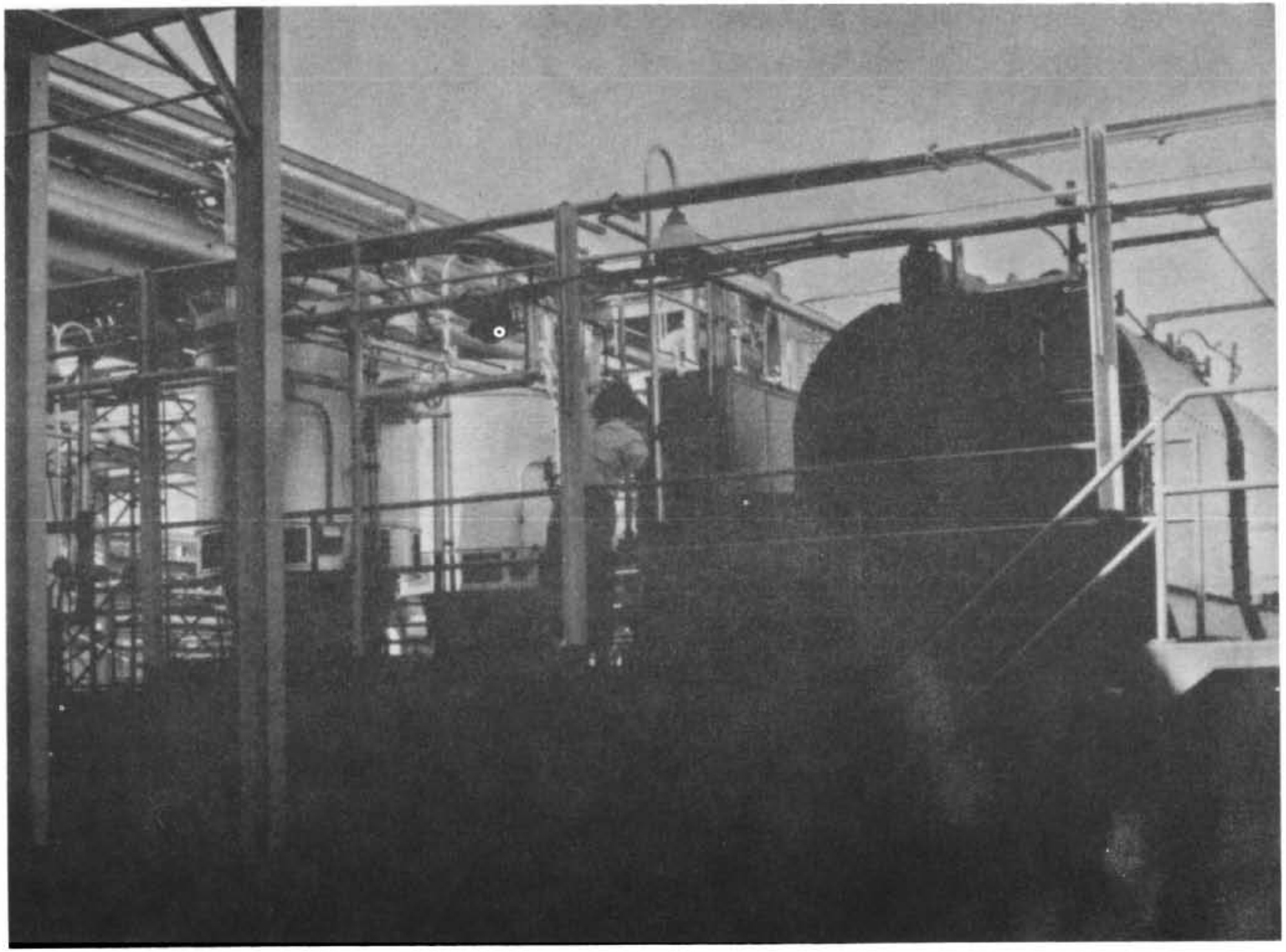


Figure 4-8

SEAWATER INTAKE STRUCTURE

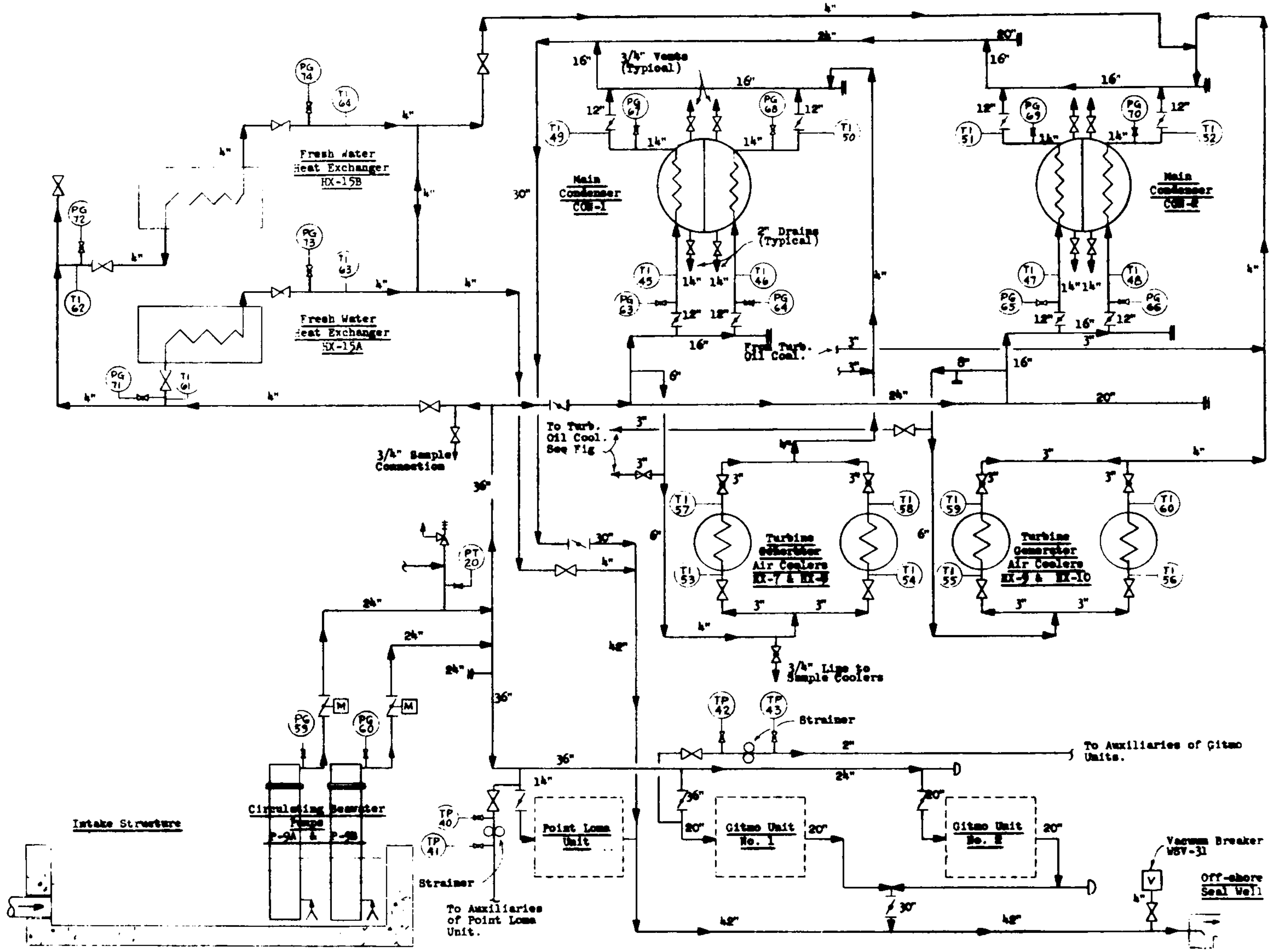


Figure 4-9

SCHEMATIC OF CIRCULATING SEAWATER & PORTIONS OF SEAWATER SERVICE SYSTEM

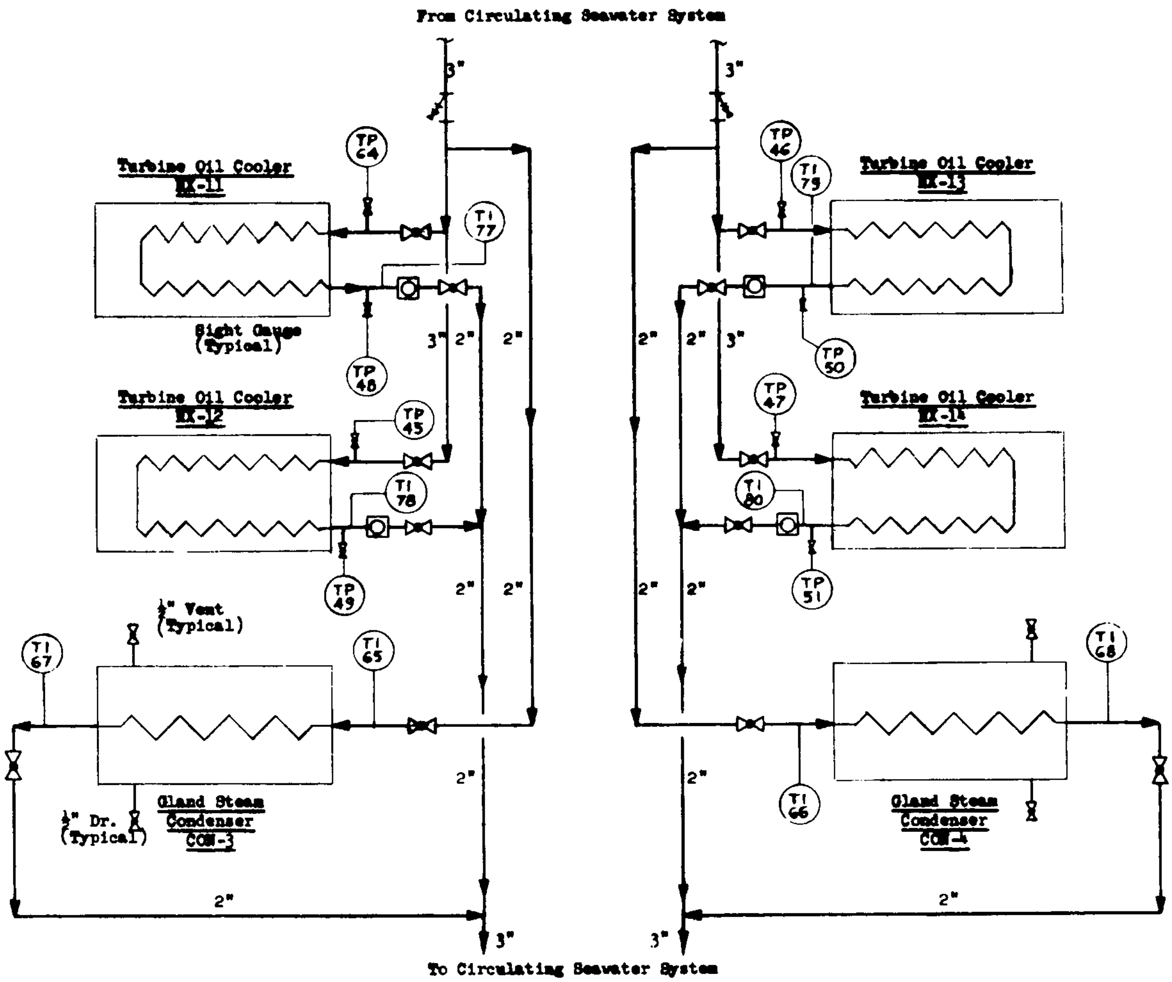


Figure 4-10

SCHEMATIC OF SEAWATER SERVICE SYSTEM

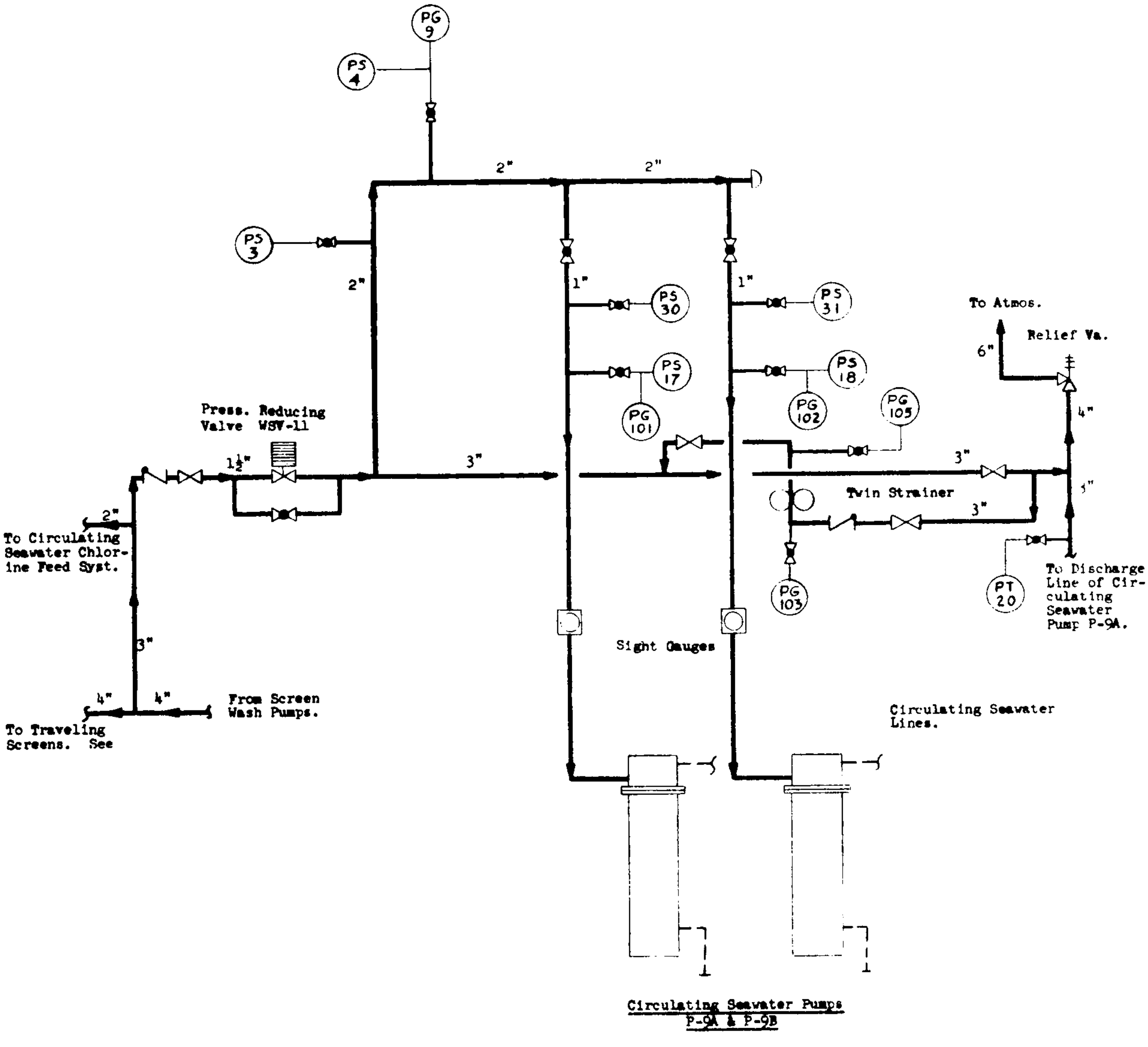


Figure 4-11

SCHEMATIC OF CIRCULATING SEAWATER PUMP GLAND SEAL SYSTEM

Because of its proximity to shore, the slope of the shore and the overall height of the box (15' -2"), the seal well is partially submerged below the high water line. An internal, inverted "L" baffle, 4' -6" forward of the rear wall of the seal well, dips below the low water level and keeps any flotsam from floating up into the 42-inch line upstream of the baffle. The inverted "L" horizontal leg forms a vented lid over the rear half of the seal well. The front of the trapezoidal well is open on top and in the front above the high water line.

4.4.2 Make-up Seawater and Treatment

4.4.2.1 Make-up Seawater System

Part of the warm seawater, discharged from the heat rejection stages, is diverted and used as make-up feedwater to the evaporater. The make-up compensates for water produced by evaporation and for the blowdown which maintains a constant brine concentration, generally about 1.5 times normal seawater.

4.4.2.2 Evaporator Acid Feed Systems

Acid feed systems consist of equipment used periodically to remove scale from the Point Loma and Gitmo Unit evaporators by treating them with sulphuric acid. The system's principal components are a sulphuric acid storage tank, associated simplex controlled-volume pumps for directing the acid to the evaporator, the necessary tank-fill and the pump suction and discharge piping, and related controls.

Although scale-formation is deterred continually by means of the Hagevap Feed System described in article 4.4.2.3 of this chapter, over a period of weeks some softer scale still does manage to accumulate in the evaporator and brine heater. To remove it, an Evaporator Acid Feed System is activated to inject sulphuric acid into the evaporator makeup, upstream of the degasifier or deaerator. The sulphuric acid 5000 gallon storage tank (V-260) is of 3/8 inch thick carbon steel. It is a horizontal vessel 8' -0" in diameter by 11' -6" long. It is supported on cradles so that the tank bottom is about 4' -6" above grade and is situated in the northwest corner of the Point Loma Unit, adjacent to the caustic storage tank; this latter tank, no longer in use, is the smaller one shown in Fig. 4-12.

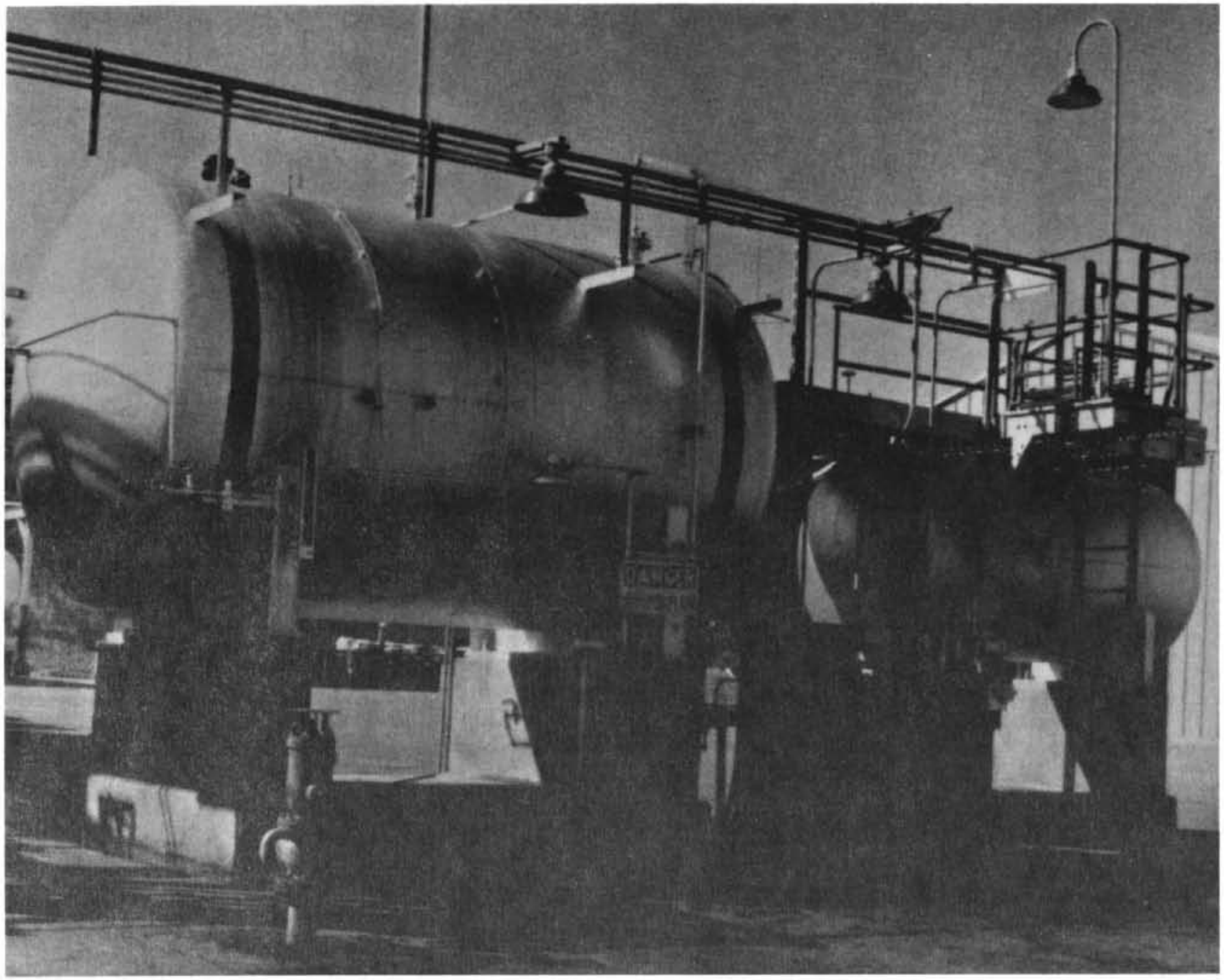


Figure 4-12

SULPHURIC ACID STORAGE TANK

4.4.2.3 Evaporator Hagevap Feed Systems

Whenever seawater is pumped through equipment and heated, as it is in the Point Loma and the Gitmo seawater conversion units, foaming of the seawater is troublesome and hard scale develops on the heat exchange surfaces. To minimize such scaling and foaming, three separate Hagevap Feed Systems have been provided to continually inject Hagevap (a phosphate solution) and an anti-foaming agent into the water conversion units. One such system is for the Point Loma Unit while the second and third systems are for Gitmo Units No. 1 and No. 2, respectively.

The Point Loma system consists of a package unit including two open top, agitated, solution tanks, one pump and the related piping and instruments needed for injecting Hagevap into each of the two 8-inch seawater make-up lines upstream of the two deaerators of the Point Loma evaporator. The Hagevap system must dissolve dry Hagevap powder in fresh water and dispense it to the seawater make-up lines. Figure 4-13 is a schematic of this system.

The Gitmo No. 1 and Gitmo No. 2 Hagevap feed systems are each similar to the Point Loma system except that each consists of only one tank and one pump since the Gitmo 1 and 2 units have only a single make-up line supplying the evaporator 15th stage. The tank, pump and access platform of one Gitmo Unit Hagevap System can be seen in Fig. 4.14.

4.4.2.4 Circulating Seawater Chlorine Feed System

To prevent mussels, algae, barnacles, slime and similar marine life from collecting in the off-shore circulating seawater inlet box and in the succeeding piping and equipment, the Circulating Seawater Chlorine Feed System has been provided. It is illustrated schematically in Fig. 4.-15.

The chlorine evaporator (shown on the right in Fig. 4-16), is a floor-mounted, electrically-heated Fischer & Porter Co. Model 71V1006 unit capable of evaporating 6000 pounds of liquid chlorine per 24-hour period. Current chlorine consumption rates and ambient temperatures do not require it to be operated.

The chlorine dispenser is a floor-mounted, manually-operated "Fischer & Porter" model 70-C4310B unit. Part of this unit can be seen on the left side of Fig. 4-16.

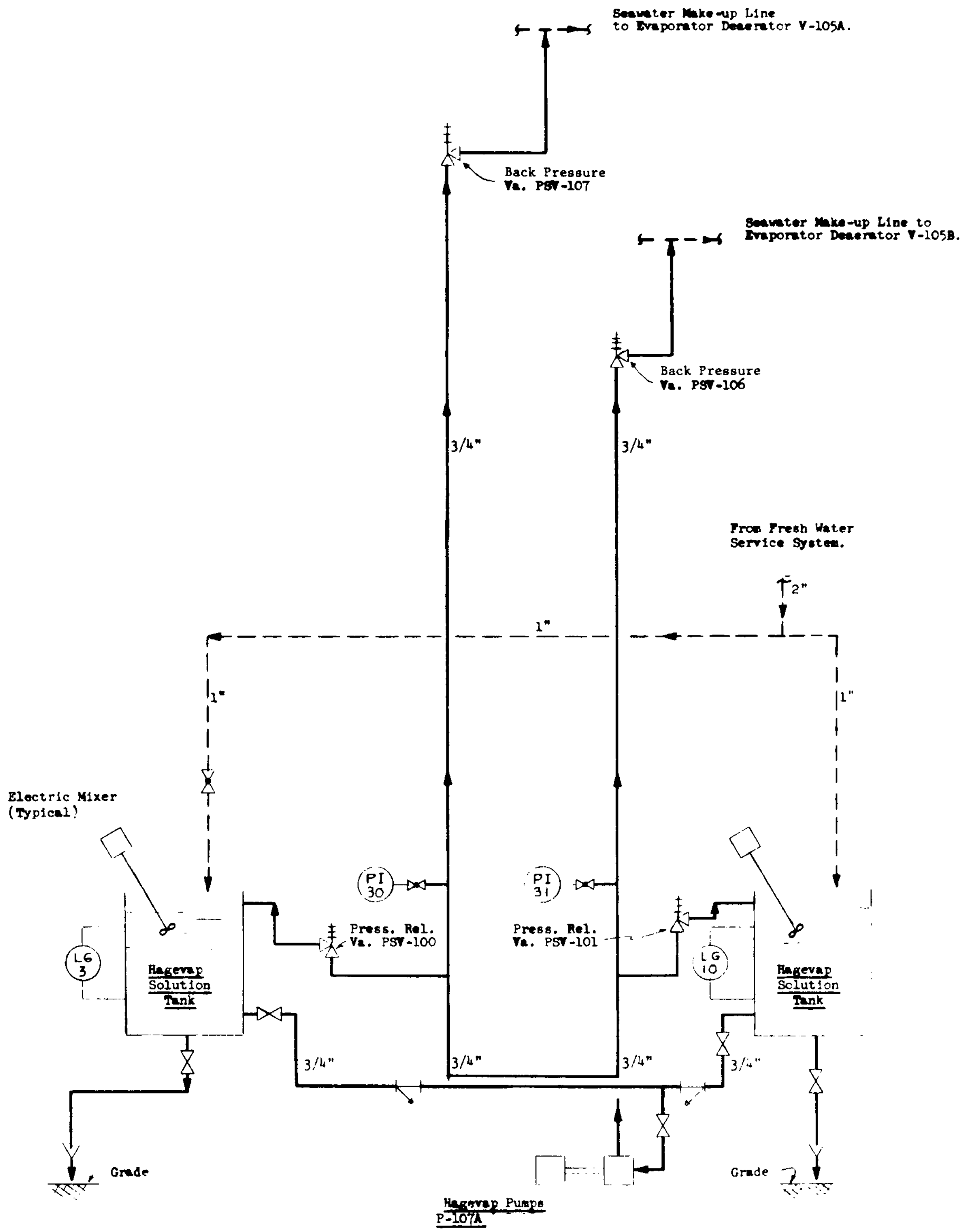


Figure 4-13

SCHEMATIC OF POINT LOMA HAGEVAP SYSTEM

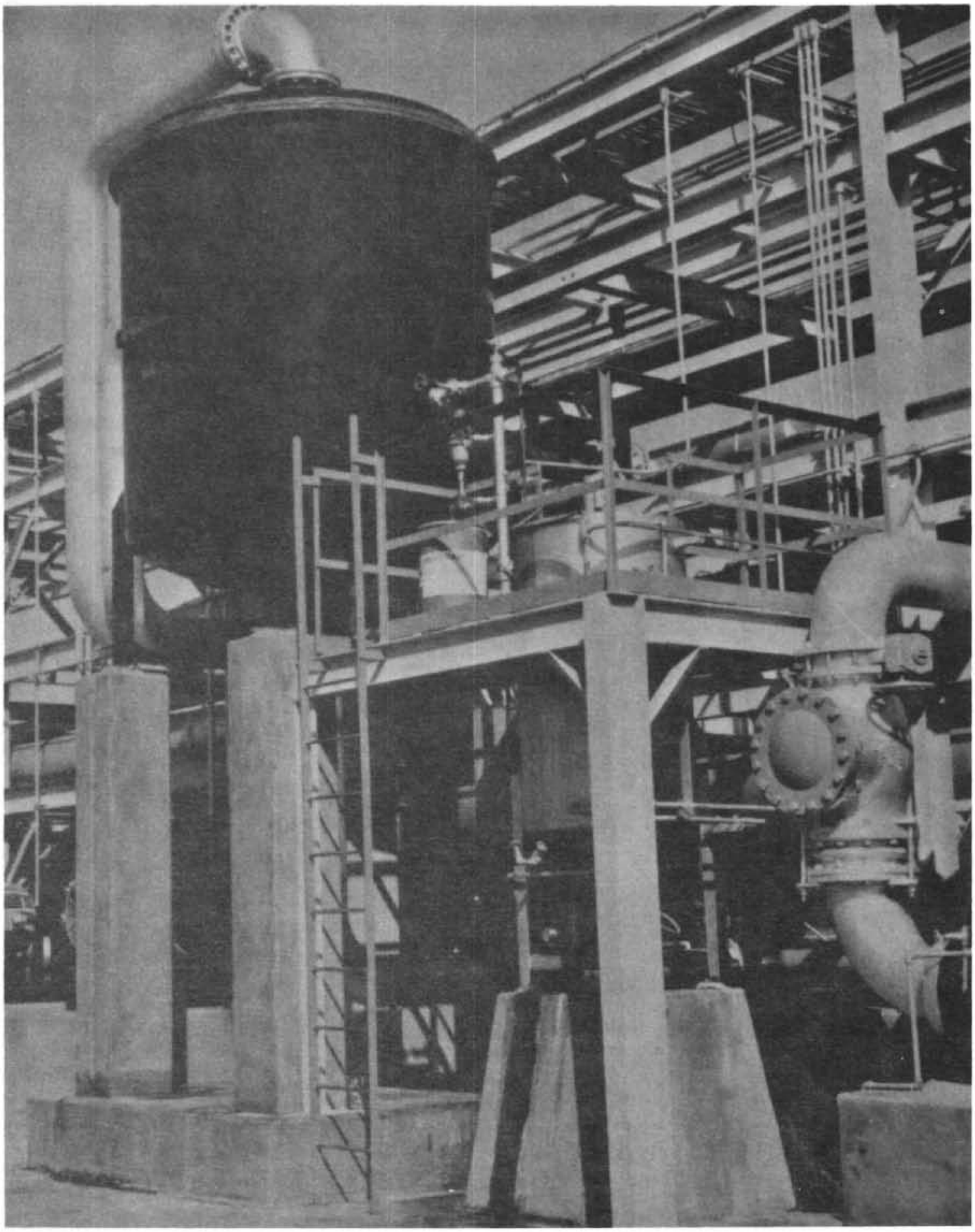


Figure 4-14

TYPICAL GITMO UNIT HAGEVAP EQUIPMENT

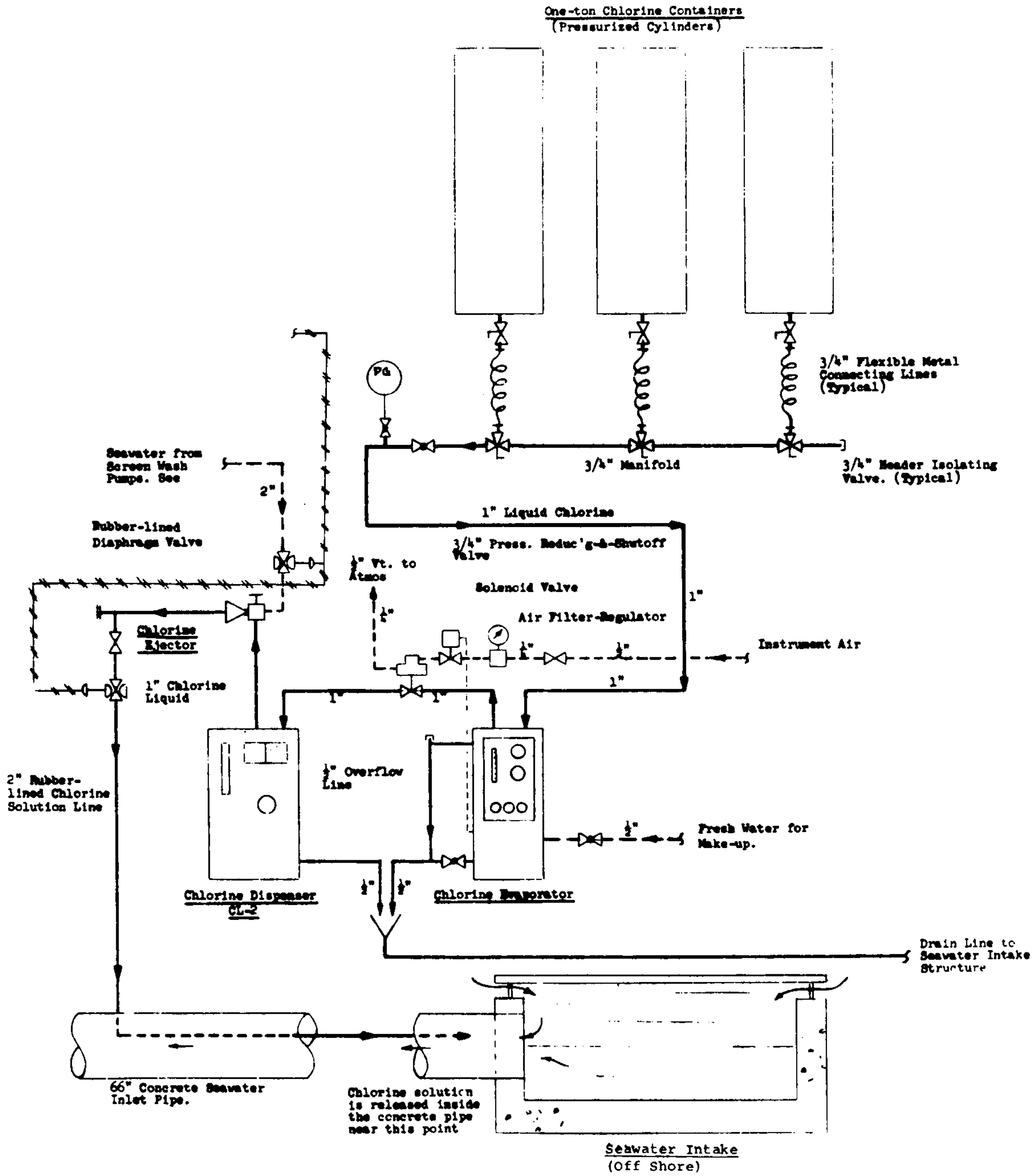


Figure 4-15

SCHEMATIC OF CIRCULATING SEAWATER CHLORINE FEED SYSTEM

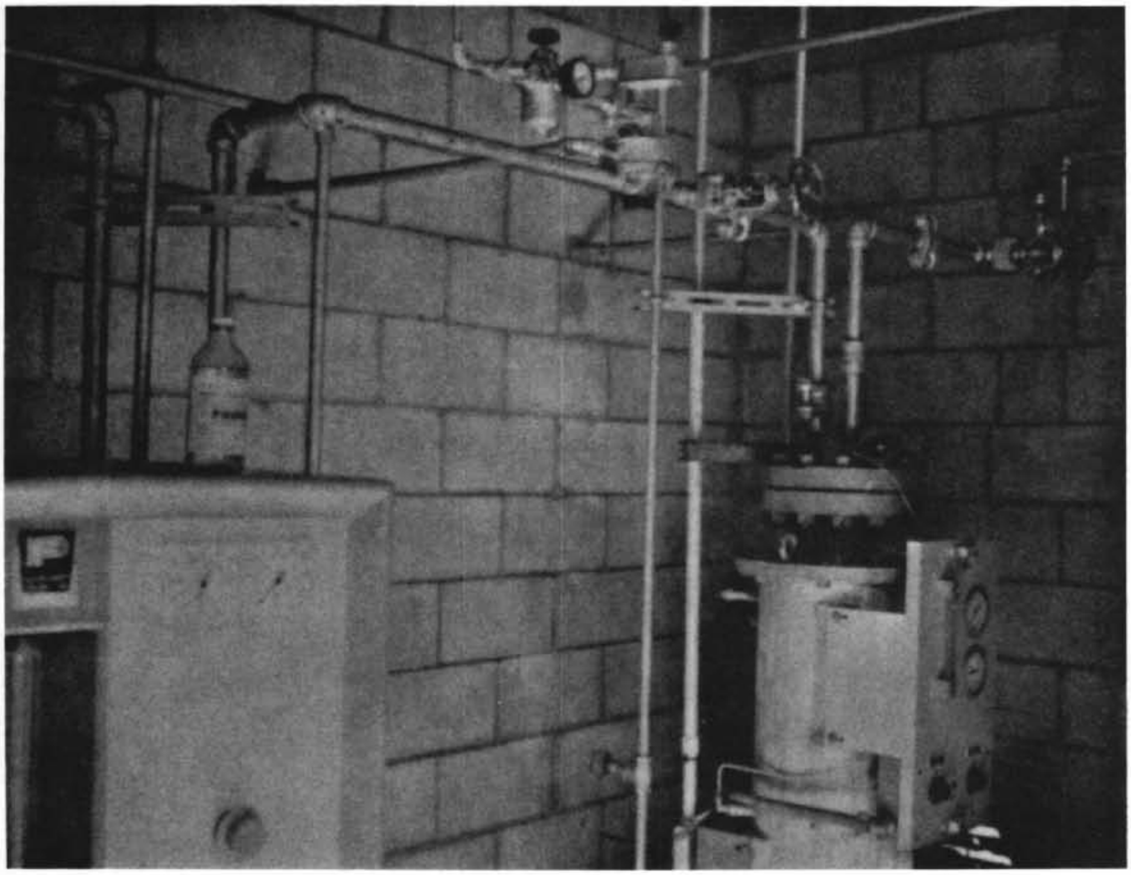


Figure 4-16

VIEW OF CIRCULATING SEAWATER
CHLORINE FEED EQUIPMENT

The nominal capacity of the unit is 2,000 pounds per 24-hour period of chlorine gas and air mixtures, but this capacity can be varied by manipulation of the manual rate valve, by variation of the gas mixture pressure (upstream of the dispenser), and by variation of the downstream vacuum (at the chlorine ejector).

The ejector is a Model 71J1321 unit by the Fischer & Porter Co. Its three main connections are equipped with 125-lb. flanges while a fourth connection, a ½-inch tap, is used for a water pressure gauge connection. In this installation, the water pressure gauge is integral with the chlorine dispenser. A ½-inch line runs from the ejector to the dispenser to inter-connect them.

4.4.3 Deaeration Systems

4.4.3.1 Point Loma Plant

The Point Loma Unit has two integral make-up seawater vacuum deaerators mounted on the heat rejection end of the evaporator.

Seawater flows through the heat rejection tubes of the twenty-eighth and twenty-seventh stages to provide counterflow cooling and condense the flashed steam. Part of the in-tube seawater coolant from the twenty-seventh stage of the evaporator flows into the deaerator for makeup while the remainder discharges to the off-shore sealwell for disposal. The concentrated brine is blown down from stage No. 28 and the remaining brine is recycled to the tubes of the heat recovery section.

4.4.3.2 Gitmo Plants

The Gitmo Units have one make-up seawater vacuum deaerator each. Each vacuum deaerator is an 8-foot diameter by 12-foot cylindrical vessel manufactured by Westinghouse. The vessel is capped by a flanged and dished head which has a centrally located, 18-inch flanged drain nozzle. The vertical shell of this vessel contains a special flanged inlet to afford insertion of an internal 12-inch spray header and another, lower, horizontal 14-inch flanged vent outlet.

Two 1½-inch flanged nozzles, a horizontal one on the vessel shell and a vertical one out the bottom head of the vessel, serve as connection points for an instrument "strongback".

Internally, the deaerator contains a 12-inch horizontal pipe spray header and a series of circular baffles and baffle supports. Seven equally-spaced slots along the lower half of this spray header allow the entering water to spray down through the baffles below. This pipe is constructed of 90:10 copper-nickel to withstand the corrosive effects of seawater.

The baffles, of three different types, are all circular, 1/8" thick and drilled with thousands of one-inch holes. These baffles, 14 in number, are placed horizontally, one above the other, throughout the middle and lower half of the deaerator. As seawater from the spray pipe cascades down through the holes of these baffles, it is stripped by steam (admitted through the top of the deaerator) and deaerated. The non-condensables collect beneath the lowest baffle and are drawn off the deaerator through the aforementioned 14-inch shell nozzle. The baffles, of which ten are 7' -10¼" in diameter and three are 6'-11" in diameter, are made of copper-nickel alloy.

The shell, heads and nozzles are fabricated of carbon steel, coated internally with a 6 to 8 mil coating of Keysite 100. The shell and heads are designed for a maximum working pressure of 15 psig and a maximum working pressure of 15 psig and a maximum working temperature of 250°F.

4.4.4 Vacuum Systems

Each of the three evaporators has a separate and complete vacuum system for removing air from the associated evaporator prior to start-up and then to extract air and noncondensable gases continuously from the vapor-condensing sections of the evaporator. Accordingly, each evaporator vacuum system consists of two separate ejectors, a hogging ejector and an evaporator ejector.

A schematic diagram of the Point Loma vacuum system is shown in Fig. 4-17. Fig. 4-18 illustrates the Point Loma unit vacuum system, which is installed on top of the evaporator. The vacuum systems for Gitmo 1 and 2 units are shown schematically in Fig. 4-19. A photograph of the Gitmo vacuum system is shown in Fig. 4-20.

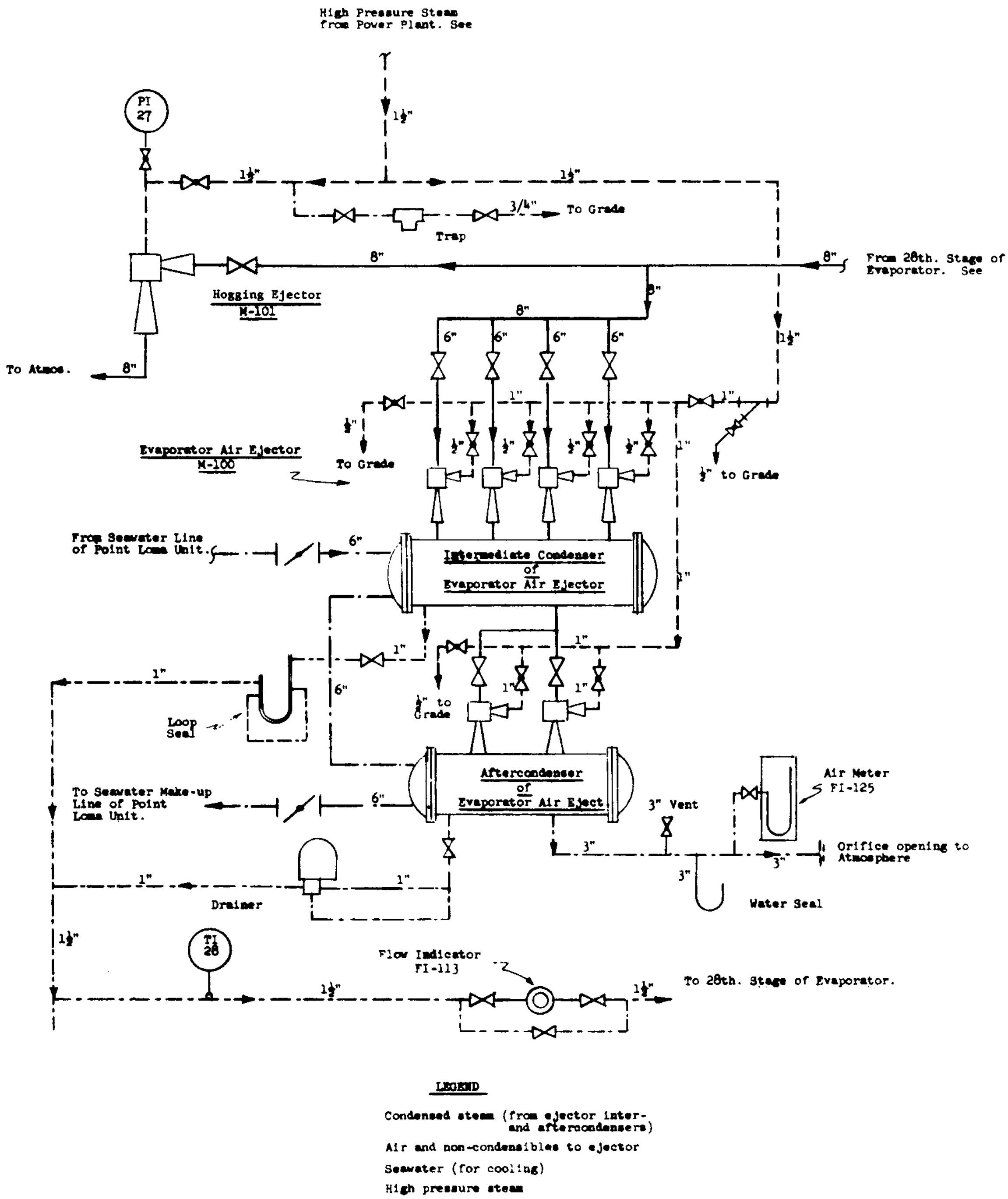


Figure 4-17

SCHEMATIC OF POINT LOMA AIR EJECTOR SYSTEM

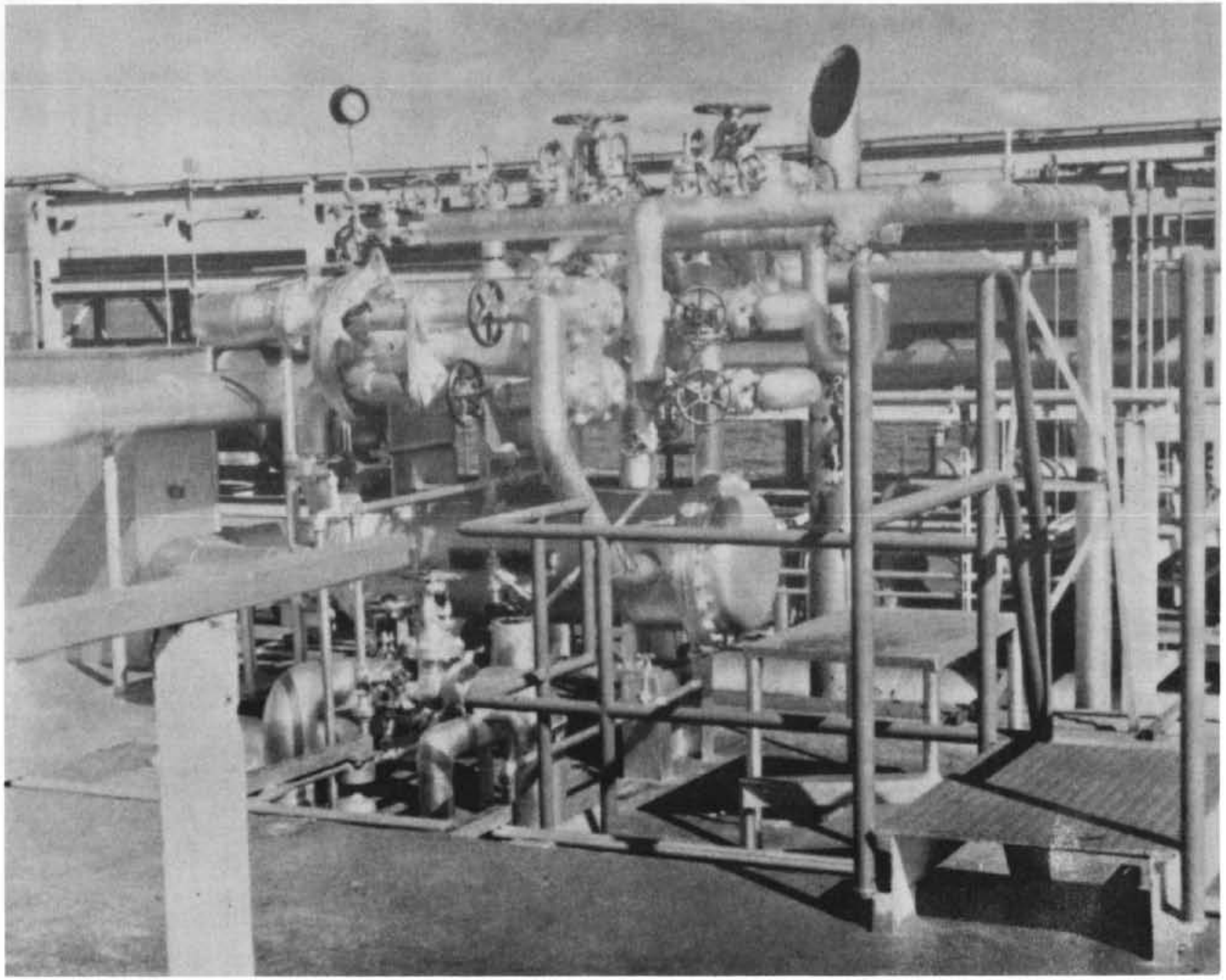


Figure 4-18

POINT LOMA UNIT AIR EJECTOR SYSTEM

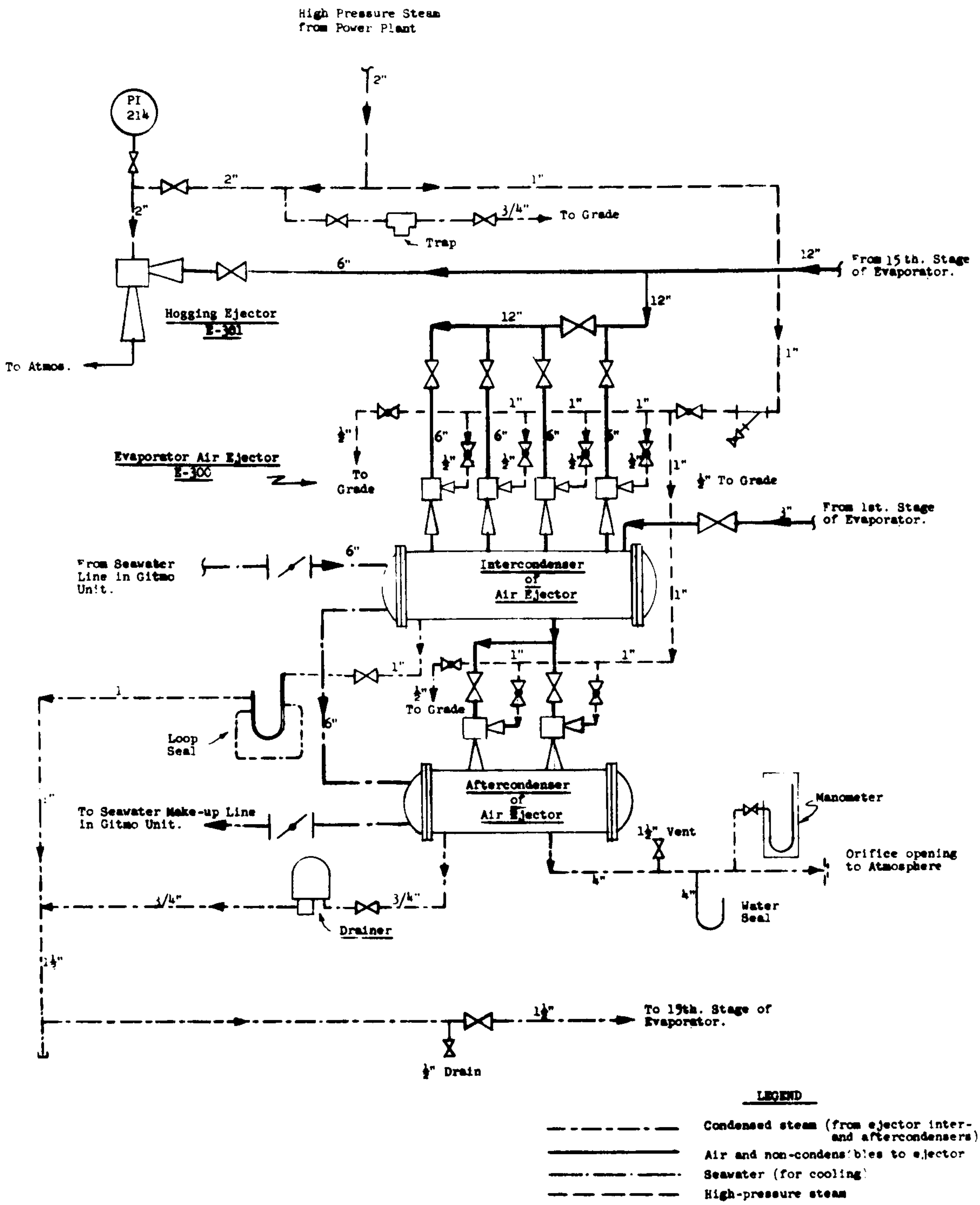


Figure 4-19

SCHEMATIC OF A TYPICAL GITMO UNIT AIR EJECTOR SYSTEM

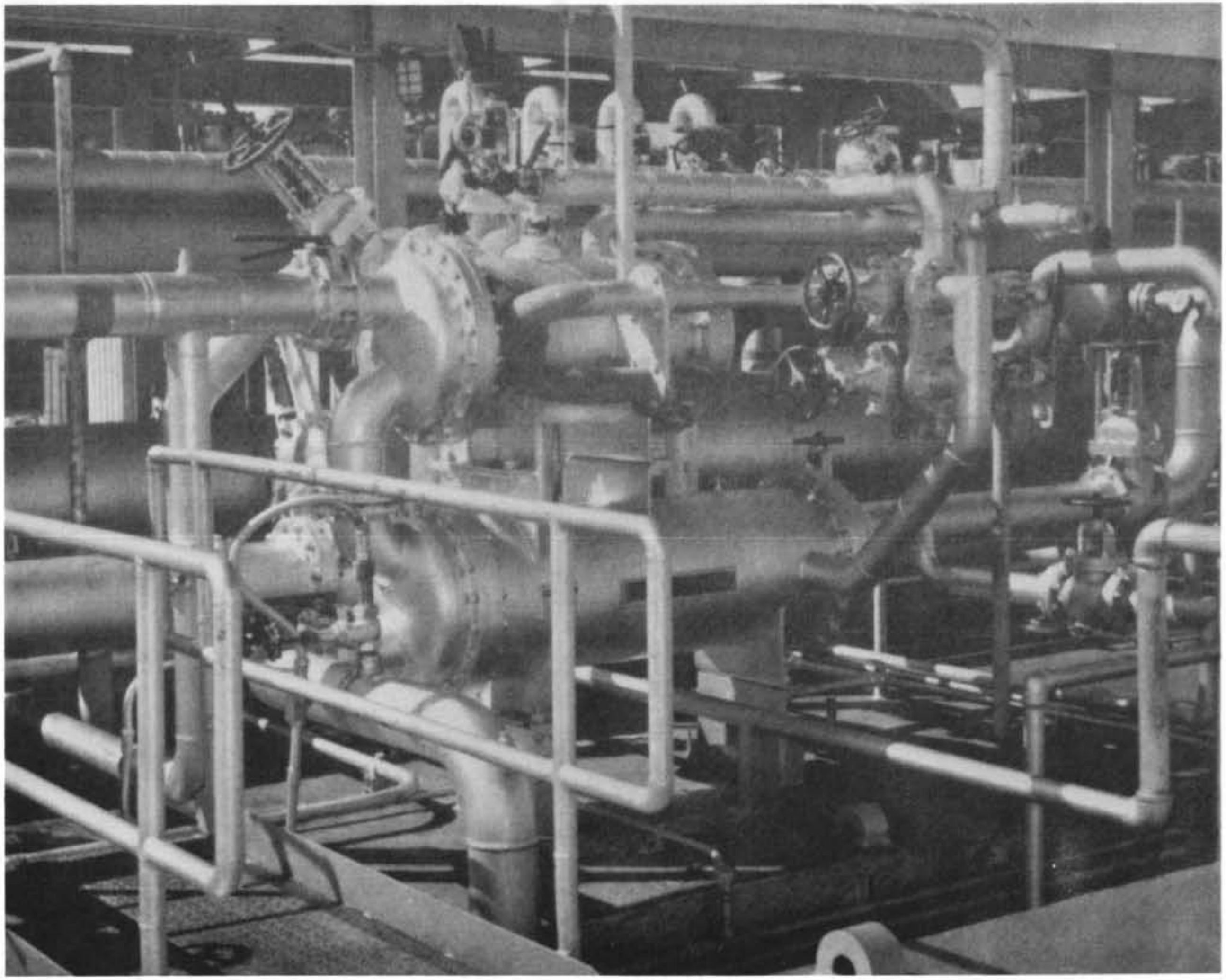


Figure 4-20

TYPICAL GITMO UNIT

The hogging ejector used in each of the three seawater conversion units is a Westinghouse size p-90 single-element unit capable of extracting 900 cfm of free dry air (measured under 15" Hg. vacuum at 70°F). This rating holds for the ejector when it is operated with 550 psig, 825°F steam. Both inlets and the single outlet are flanged. The hogging ejector discharges to atmosphere.

The main evaporator air ejector for each of the three evaporators, a Westinghouse, two-stage, size F-300 air ejector, which includes four first-stage ejector elements and two second-stage elements, is capable of extracting gases and air equivalent to 135 pounds per hour of free dry air measured at 1" Hg absolute pressure and 71.5°F. This rating is based on the use of operating steam at 500 psig and 825°F temperature and the passage of 520 gpm of coolant through the intermediate and after-condensers. The four first-stage elements of this type of ejector can be clearly seen near the top center of Fig. 4-20.

The total heat transfer surface area of the intermediate and after-condenser is 295 sq. ft. The tubes of the two condensers are arranged so that the coolant, first entering the intermediate condenser and finally exiting from the after-condenser, makes a total of four passes. The after-condenser is the short, flanged exchanger visible slightly above the center portion of Fig. 4-20. The larger, horizontal vessel below that is the inter-condenser.

As part of the ejector package, Westinghouse supplied the six globe valves at each steam inlet nozzle, the six gate valves at air suction nozzles, the steam manifold piping and the stream strainer and globe valve at the inlet and of the steam manifold. Also included with each package are the loop seal, the "Fischer" continuous drainer, and the associated valves in the condensate outlet lines. The after-condenser vent piping, along with its valving, its water seal and its air meter, are also part of the package.

4.4.4.1 Steam Jet Air Ejector Condenser Cooling

The original piping arrangements provided for the use of distillate for cooling the steam jet air ejector condensers on each of the three evaporator units. This arrangement resulted in two disadvantages:

(1) No distillate for cooling during start-up and
(2) Increased temperature of product water leading to consumer dissatisfaction.

4.4.4.2 Modifications to SJAE Condenser Cooling

The disadvantages of using distillate for SJAE Condenser cooling were serious enough to justify corrective measures. Consequently, the system was repiped to bypass distillate around the condensers and supply the condensers with seawater for condensing motive steam. When using seawater as the cooling medium, zinc anodes are installed on the interior of SJAE inter and after condenser heads to provide corrosion protection. Fig. 4-21 shows SJAE condenser seawater cooling piping for the Pt. Loma unit and Fig. 4-22 for the Gitmo units. Gitmo No. 1 unit has been converted to SJAE condenser seawater cooling and Gitmo No. 2 is being converted.

4.4.5 Vent Systems

The non-condensable gases from the last stage of the evaporator and the dissolved gases released from the vacuum deaerators are vented to the steam-jet vacuum system. Each stage of the evaporator is vented to a subsequent stage operating at a lower pressure or directly to the vacuum system as shown on the flow diagram Figs. 4-23 and 4-24. External stage vents are provided for each stage with manually-adjustable vent control valves. Local temperature indicators are furnished in each stage vent line to facilitate adjustment and assure adequate venting from each stage.

The Point Loma integral deaerator is internally vented to the shell of the twenty-eighth stage condensing section and no separate air removal line from the deaerator run to the Point Loma ejectors. Each Gitmo vacuum deaerator, however, has a separate, external 14-inch vent line running to a vent condenser; the vent condenser, in turn, has an 8-inch air removal line connecting it to the air removal header served by the main evaporator air ejector's four first-stage elements. The main air removal line, a 12-inch pipe from the fifteenth stage of the Gitmo evaporator, compares with the 8-inch air removal line of Point Loma.

Each Gitmo unit vent condenser is a Patterson-Kelley PK Type DW 18-138 four-pass heat exchanger having a heat exchange surface of 518 sq. ft. This surface enables a given vent condenser to liquify approximately 1540 lbs. per hr. of water vapor. The rating is based on the passage of 500 gpm of raw seawater through the tubes, with the water entering at $84^{o}F$ and leaving at $90.2^{o}F$.

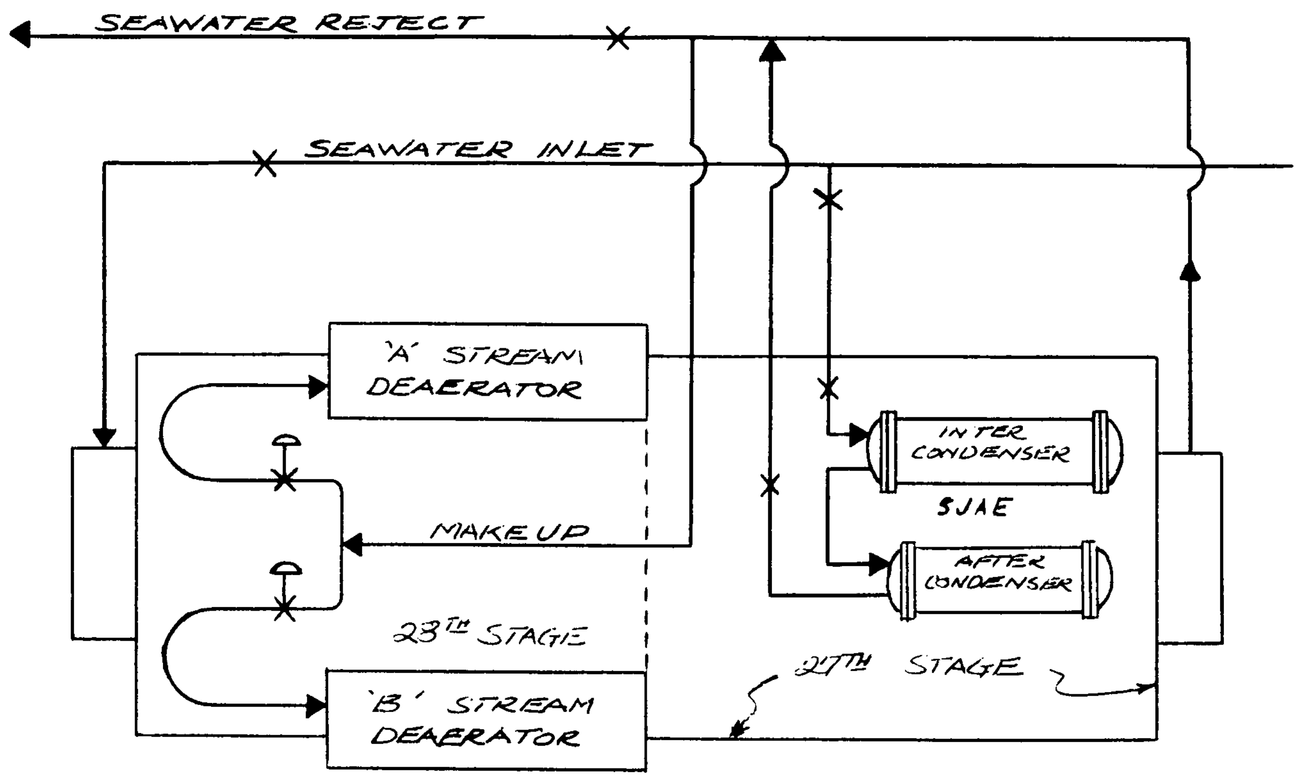


Figure 4-21

PT. LOMA SJAE CONDENSER SEAWATER COOLING

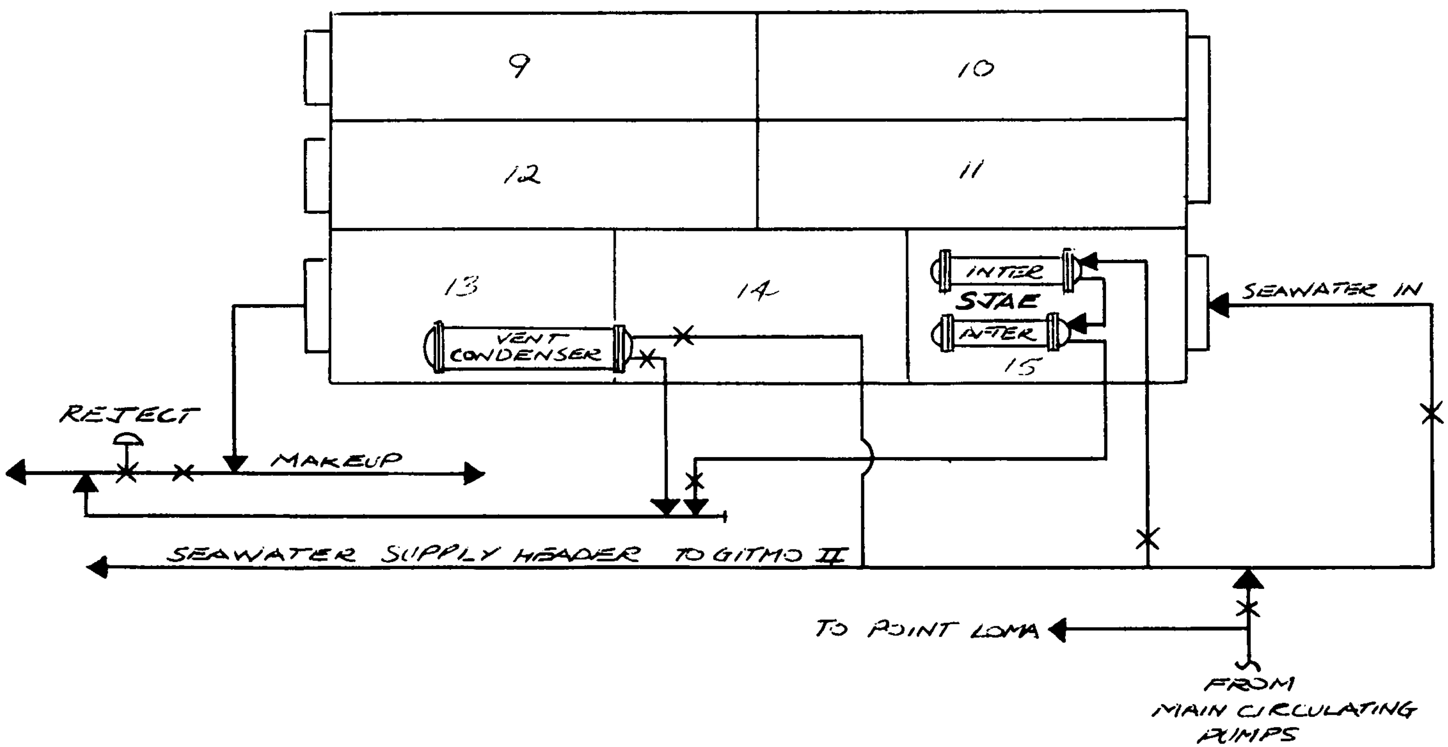


Figure 4-22

GITMO 1 & 2 SJAE CONDENSER SEAWATER COOLING

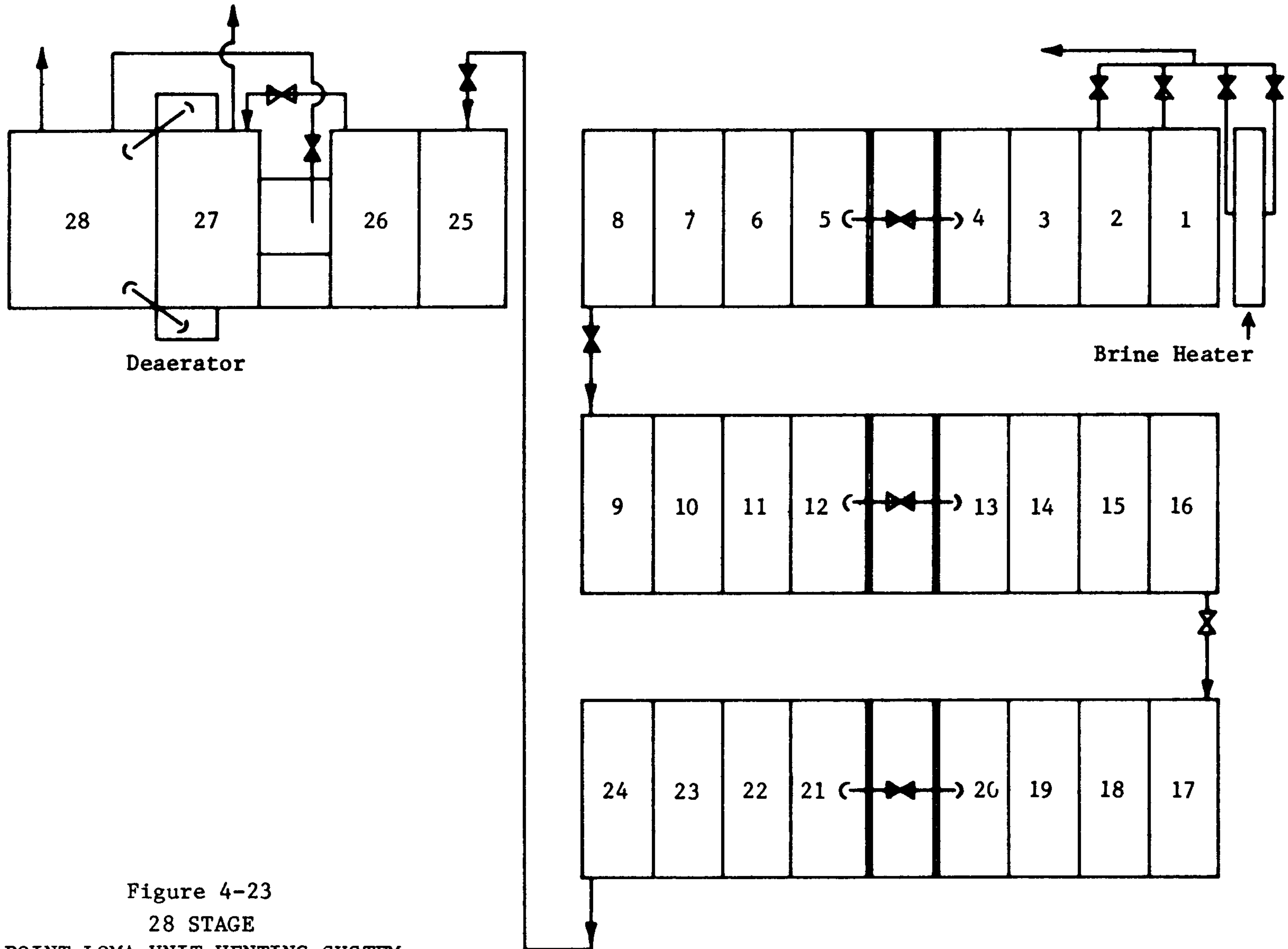


Figure 4-23
28 STAGE
POINT LOMA UNIT VENTING SYSTEM

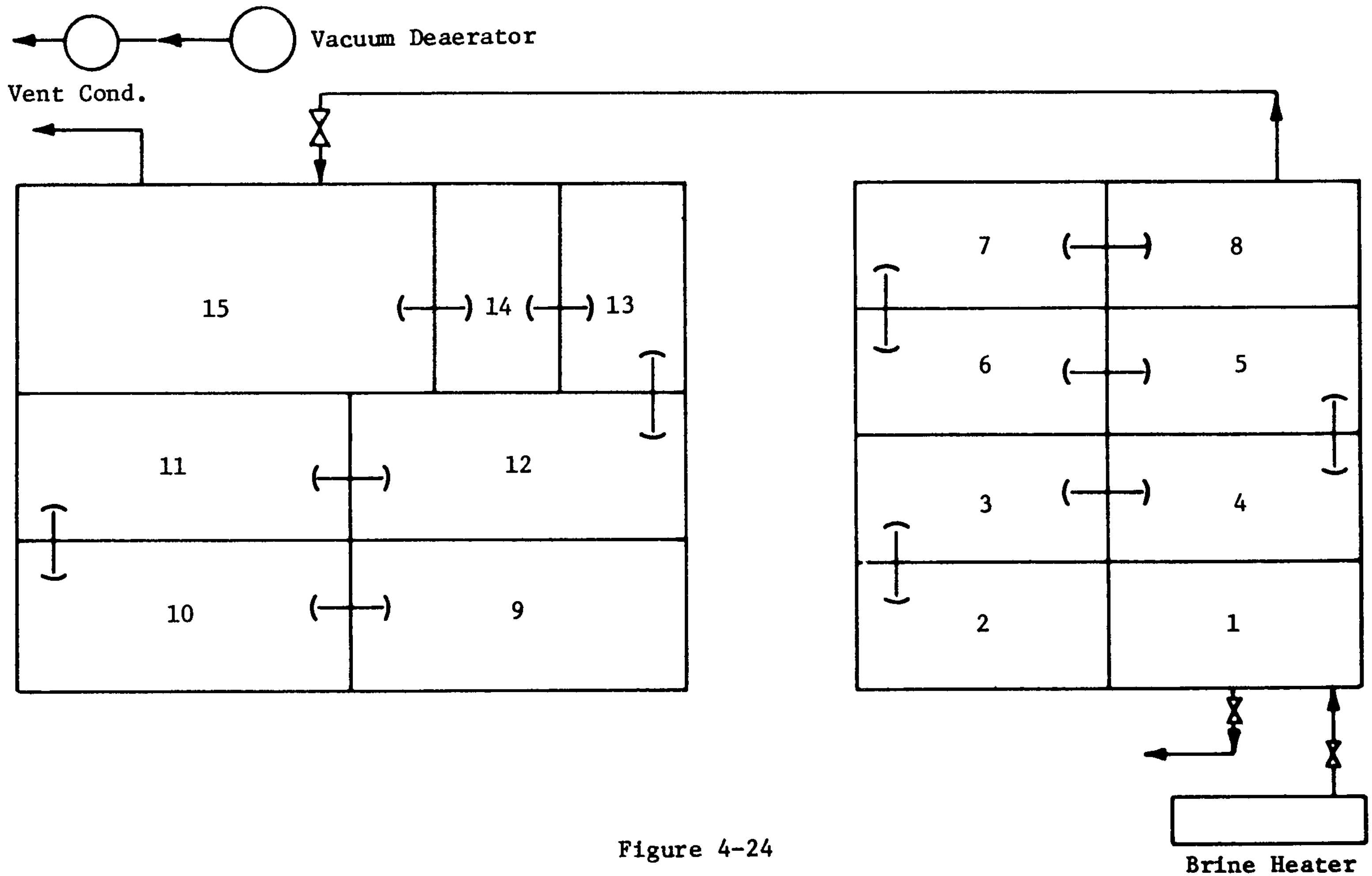


Figure 4-24
15 STAGE GITMO UNITS VENTING SYSTEM

The #316 stainless steel tubes of the condenser are 3/4" O.D. x 18 B.W.G. and are designed for a working pressure of 50 psig at a temperature of 250°F. The shell is also constructed of type #304 stainless steel for a working pressure of 15 psig at 205°F.

The head of each vent condenser has a 5-inch flanged inlet and a similar type outlet; the unit's single vapor inlet is a 14-inch flanged nozzle while its two vapor outlets are both 5-inch flanged nozzles.

The evaporator venting system for the Point Loma Unit Fig. 4-23 and the Gitmo Units are shown on Fig. 4-24.

4.4.6 Pumping Systems

Materials of construction are discussed in Section 9.0, "Materials and Performance".

4.4.6.1 Seawater Circulating Pumping System

The two seawater circulating pumps are Westinghouse, single stage, Frame 24 MN, vertical, impeller-type circulating units capable of delivering 14,000 gpm of seawater each against a TDH of 85 feet. These pumps have a 17'-2" high suction casing and each is mounted from the top of the intake structure so that the bottom inlet end of the pumps is 16" above the floor of the structure. The horizontal, 24-inch diameter discharge nozzle of each pump is located 12'-2" above the inlet end of the suction casing and, accordingly, these nozzles and their adjacent discharge valves are somewhat above the high water level in the intake structure.

Each pump is driven by a T-33 frame, vertical Westinghouse squirrel-cage, induction motor, operating on 4160-volt, 3-phase, 60-cycle power, rated 300 horsepower at 712 rpm. Each motor is totally enclosed and fan-cooled. Either motor may be started manually if the gland seals are provided with water at adequate pressure, but they are also under the automatic influence of the pressure switches in the gland seal water system.

For rated production of 2,250,000 MGD product water, operation of both seawater circulating pumps is necessary.

4.4.6.2 Screen Wash Pumping System

Three functions of the screen wash pumps are:

a. to supply screened seawater for washing the traveling screens.
b. to provide a minimum pressure at the gland seals of the large circulating seawater pumps.
c. to provide screened seawater for the nearby Seawater Chlorine Feed System.

The two screen wash pumps are Food Machinery Corp. Peerless vertical, wet pit type units each capable of delivering 200 gpm of screened seawater at a discharge pressure of 85 psig. The water pumped is drawn from the intake structure, downstream of the traveling water screens, through the open-ended, vertical suction casing of the pump and is discharged through a 4-inch check valve and gate valve into a common 4-inch discharge header. The header then conducts the flow through one side or the other of a 4-inch "Zurn" model 560 FYS twin-basket strainer. Flow proceeds from the strainer to a manifold that permits flow to four possible destinations:

a. To the screen wash piping of Traveling Screen TS-1.
b. To the screen wash piping of Traveling Screen TS-2.
c. To the nearby Chlorine Ejector.
d. To the gland seals of either circulating seawater pump.

4.4.6.3 Acid Pumping Systems

Two pumps designed for sulfuric acid service are associated with this system. Each pump is piped to service one evaporator unit with sulphuric acid.

4.4.6.4 Brine Recycle Pumps

The two Point Loma brine recycle pumps (P103A & P103B) are Westinghouse Frame 122 RN, vertical, 2-stage, 3800-gpm at 210 ft. TDH centrifugal pumps. The brine enters through a 24"D inlet connection and flows out through a 12" D discharge connection. A 2-inch vent line also leads from each pump casing back to the evaporator. Both recycle pumps are operated for rated water production.

The pumps are each driven by a direct connected, vertical, 300-hp. 890-rpm motor operating on 440-volt, 3-phase, 60-cycle power. Both recycle pumps and their motors can be seen in Fig. 4-33. They are the two large units on the left side of the picture.

4.4.6.5 Brine Extraction Pumps

Gitmo No. 1 and No. 2 recycle systems each include three Brine Extraction Pumps (A, B, & C) which are Westinghouse Frame 14 RN, vertical, single stage, 3500-gpm at 58 ft. TDH, centrifugal pumps. Brine enters through a 24" D inlet connection and leaves through a 14" D discharge connection. Two of the three pumps are operated for rated water production. These pumps are shown in Fig. 4-25 and deliver brine to the Brine Booster Pumps and also to blowdown.

The pumps are each driven by a direct connected, vertical, 75 hp 700 RPM Westinghouse squirrel-cage, totally-enclosed, fan-cooled motor operating on 440 volt, 3-phase, 60 cycle power.

4.4.6.6 Brine Booster Pumps

Gitmo No. 1 and No. 2 recycle systems each also include three Brine Booster Pumps (A, B, & C), which are Ingersoll-Rand, No. 10, Type ALV, horizontal, single stage, double suction, centrifugal, of 3150 gpm capacity at 200 ft. TDH. Two of the three pumps are operated for rated water production.

The pumps are each driven by a 250 hp, 1750 rpm, Westinghouse direct connected, horizontal, squirrel cage, totally-enclosed, fan cooled, induction motor operating on 440 V, 3 phase, 60 cycle power. The brine booster pumps move recycle brine through the heat recovery stage tubing with the brine picking up heat while vapors from the flashing brine and flashing distillate are condensed.

4.4.6.7 Blowdown Pump

The Point Loma blowdown pump is a 1000gpm at 56 ft. TDH Westinghouse Frame 81 RN, single-stage, vertical pump. Water enters the pump through a 16" D suction inlet and leaves through an 8" D discharge connection. Emergency blowdown operations for the Point Loma unit are discussed in Section 6.1.3.

The blowdown pump drive is a Westinghouse direct connected vertical, 40-hp, 1780-rpm, 440-volt, 3-phase, 60-cycle A.C. motor.

Gitmo No. 1 and No. 2 units do not have separate blowdown pumps. Blowdown is drawn from the brine extraction pump discharge header prior to the brine booster pump suction connections.

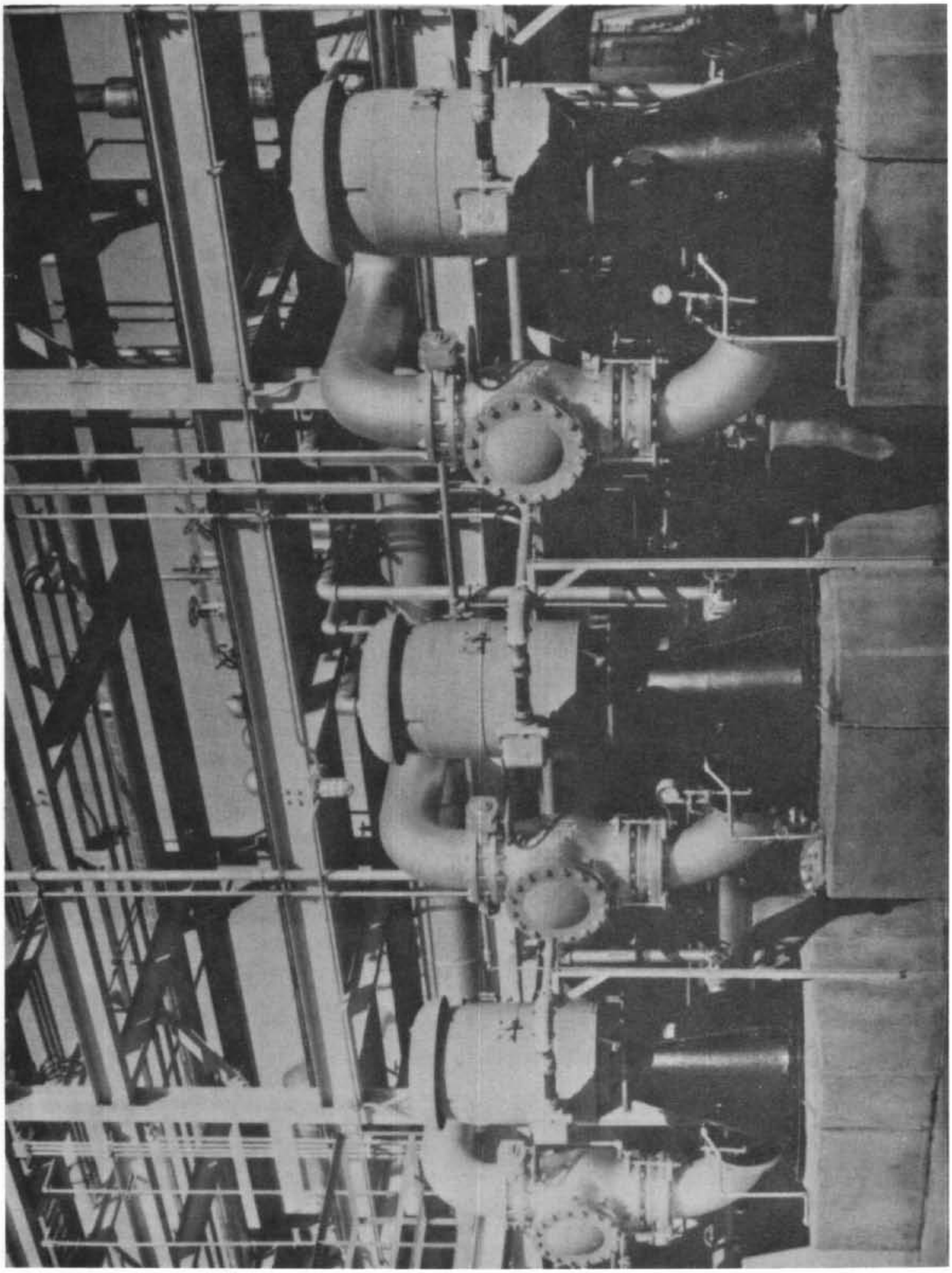


Figure 4-25
GITMO UNIT BRINE EXTRACTION PUMPS

4.4.6.8 Product Pumps

The Point Loma pump is a Westinghouse Model 61RN, single stage vertical pump installed in its own suction well. It is rated at 700 gpm when operating at a TDH of 102 ft. The 24" O.D. suction casing contains a horizontal 12-inch, flanged suction nozzle, a 6-inch, horizontal discharge nozzle and a 2-inch vent line connection.

The product pump is driven by a direct connected, vertical 40-hp, Westinghouse Model ABFC motor. This squirrel-cage induction motor is fan-cooled and is mounted in a 364 UP frame; it operates on 440-volt, 3-phase, 60-cycle power at 1780 rpm.

In September, 1968 a backup Pt. Loma product water pump was installed and put into operation. The pump is a Worthington, double suction, horizontal centrifugal pump, 1450 GPM capacity at 50 feet of head, direct connected to a G.E. 25 H.P. 1750 RPM motor. The stand-by pump permits continued operation in event of failure of main Pt. Loma product pump.

Emergency product pumping operations for the Point Loma Unit are discussed in Section 6.1.3.

Gitmo No. 1 and No. 2 each have two product water pumps, which are also referred to as "Distillate Pumps" on the Fig. 4-3 schematic of the Gitmo units. These pumps are Ingersoll-Rand #12APHC, two-stage, vertical units. Each one is rated for 700 gpm at 100 ft. TDM. The impellers of these pumps are immersed in 15½ inch diameter suction wells. Fig. 4-26 illustrates the upper portions of these pumps and their drivers.
The pumps are driven by individual 25-hp Westinghouse direct connected Model AC-LL-A motors, frame 324 UP. The motors are vertical, solid-shaft, totally-enclosed fan cooled squirrel-cage induction units, 1750 rpm, operating on 440- volt, 3-phase, 60-cycle power.

One of the two product pumps associated with each evaporator has sufficient capacity for rated water production. The second product pump is maintained as a "standby".

4.4.6.9 Brine Heater Condensate Pumps

The two Point Loma pumps (P-104A and P-104B) are horizontal centrifugal units that can each pump 120 gpm of condensate when operating at a TDH of 150 ft. Both pumps must be operated since the heater is internally divided with one half for heating recycle stream "A" and the other half for heating recycle stream "B".

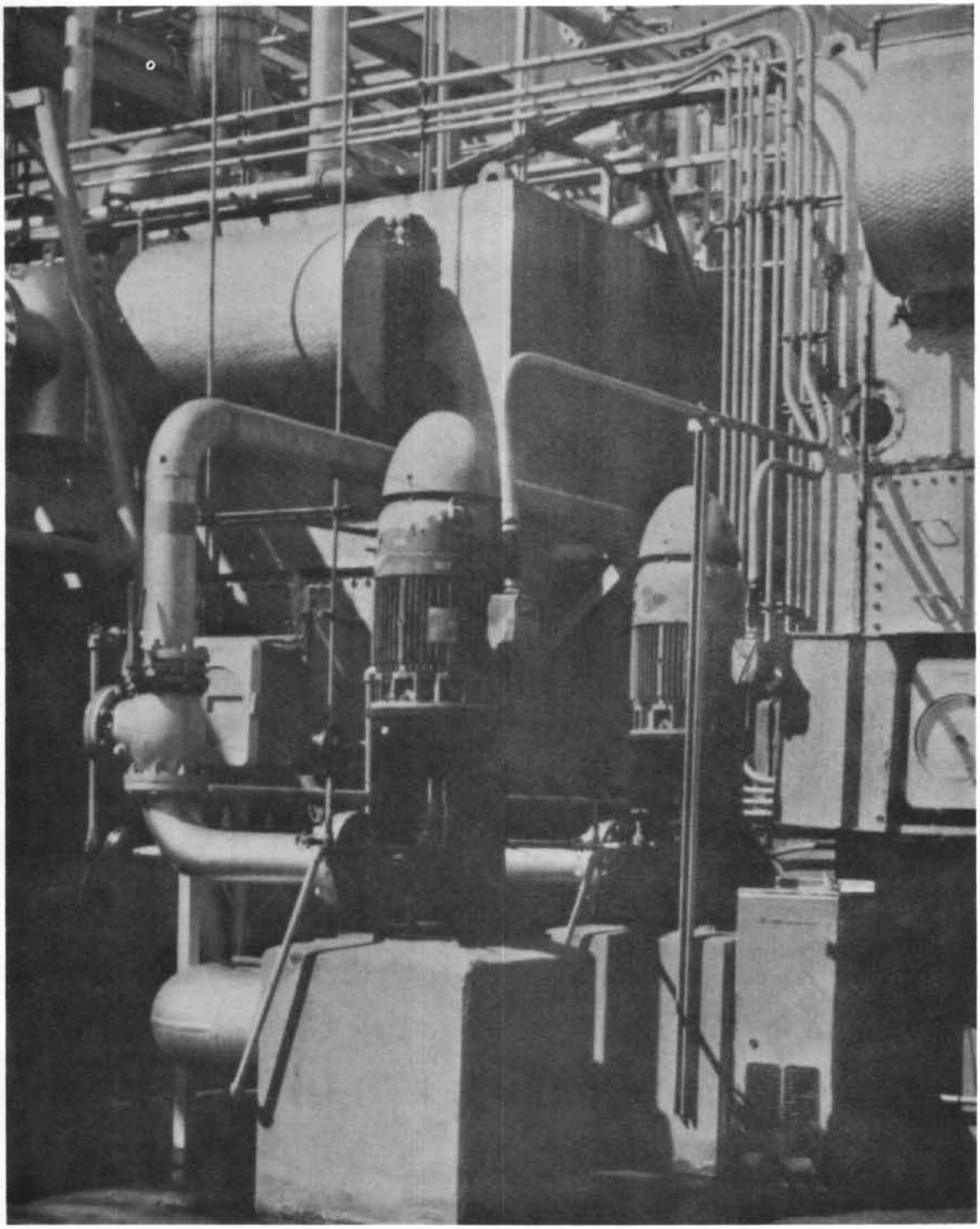


Figure 4-26

TYPICAL GITMO UNIT PRODUCT PUMPS

The driver for each pump is a Westinghouse Model TBFC, 10-hp, 3500-rpm, horizontal, totallv-enclosed, fan-cooled, 230/460 V, 3-phase, 60 cycle squirrel-cage motor. They are close-coupled to the pumps. These drivers can also be seen in the lower foreground of Fig. 4-27.

Gitmo No. 1 and No. 2 each have two Brine Heater Condensate pumps which are Ingersoll Rand Model A.C. horizontal, centrifugal pumps rated at 120 gpm when operating against a TDH of 150 ft. These pumps, which are also known as the "Brine Heater Drain Pumps" are situated beneath the brine heater as can be seen in Fig. 4-28.

The brine heater condensate pumps are driven by direct connected individual horizontal Westinghouse Model TBFC, 3500 rpm totally enclosed, fan-cooled motors operating on 230/460 volt, 3-phase, 60-cycle power.

4.4.7 Instrumentation

A central control room contains all instrumentation and controls necessary for controlling and monitoring plant operations. All power plant pumps and the main seawater circulating pumps can be started and stopped remotely from this control room. Fig. 4-29 is a plan of control room on the operating floor of the power plant building. Containing several control panels and consoles, it is the nerve center of the power generation and seawater conversion facilities. Among these control panels there are three evaporator control panels, one for each of the seawater conversion units. A complete detail of instrumentation is given in Section 10.0 and some details are described in Article 4.4.8 of this report.

In addition to the instruments and other control items in this room a vacant panel is located there on the north wall for use in connection with a possible future Gitmo Unit No. 3.

The Point Loma and Gitmo evaporator pumps, the product export pumps and the boiler makeup pumps are started locally at the individual motor control centers.

4.4.8 Piping and Valves

4.4.8.1 Seawater Intake Piping and Valves

Seawater piping and valves are also discussed in section 4.4.1.1., and section 9.4 particularly discusses materials and performance. Seawater intake piping and valving is shown in Fig. 4-7.

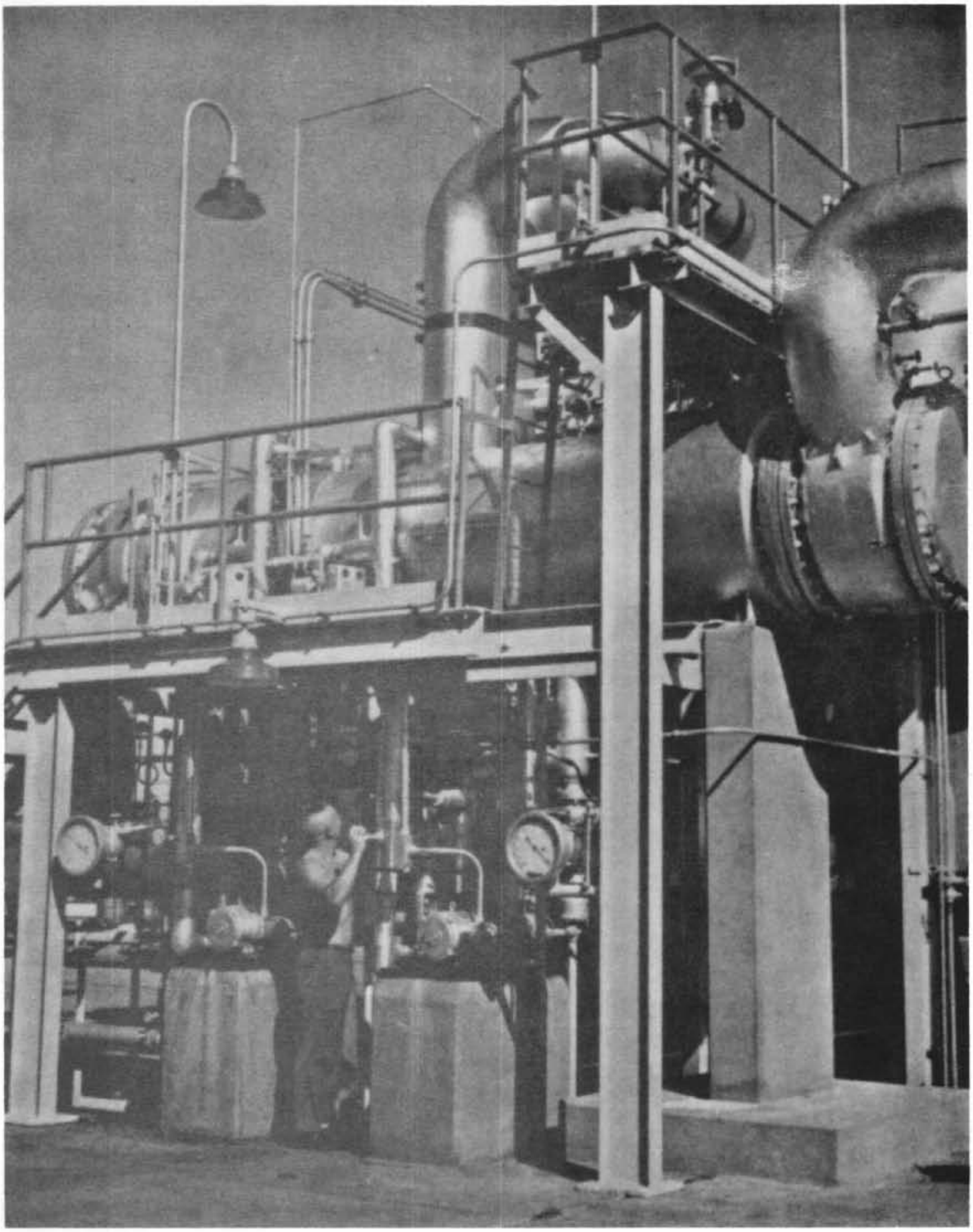


Figure 4-27

POINT LOMA UNIT BRINE HEATER AND ITS CONDENSATE PUMPS

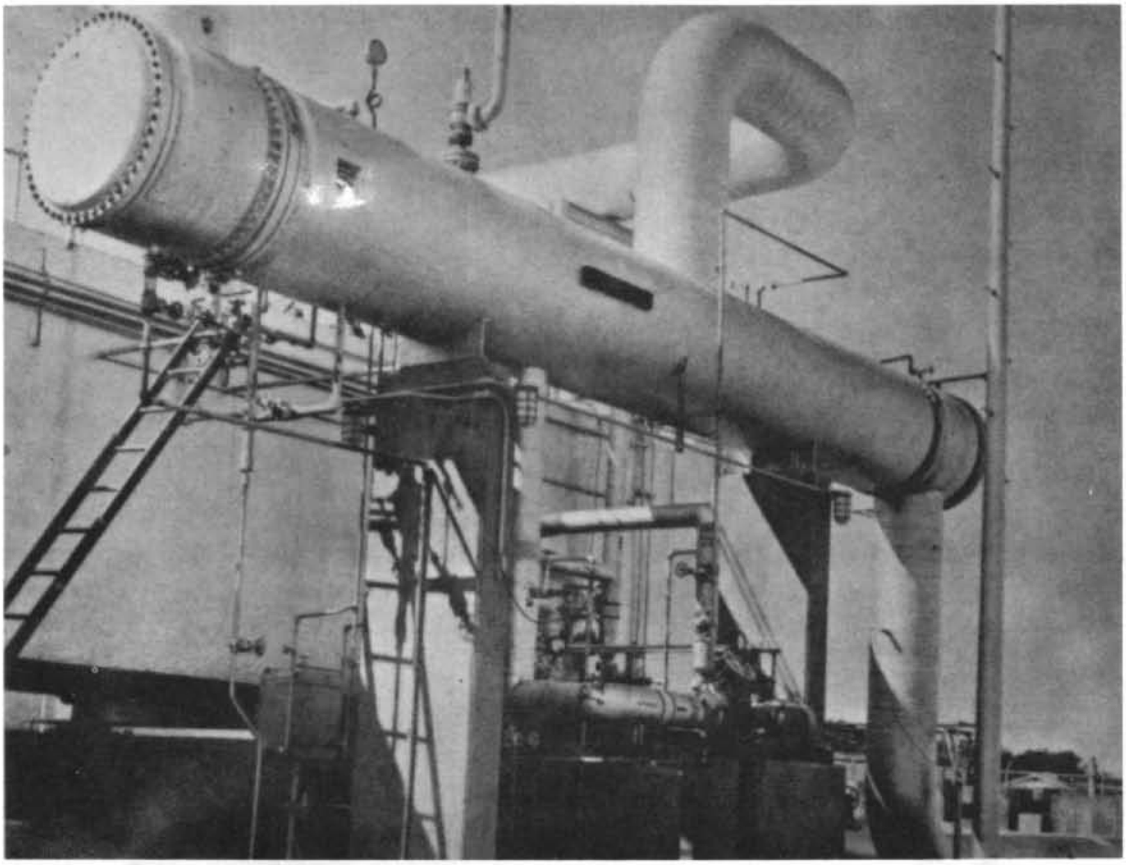


Figure 4-28

BRINE HEATER OF GITMO UNIT NO. 2

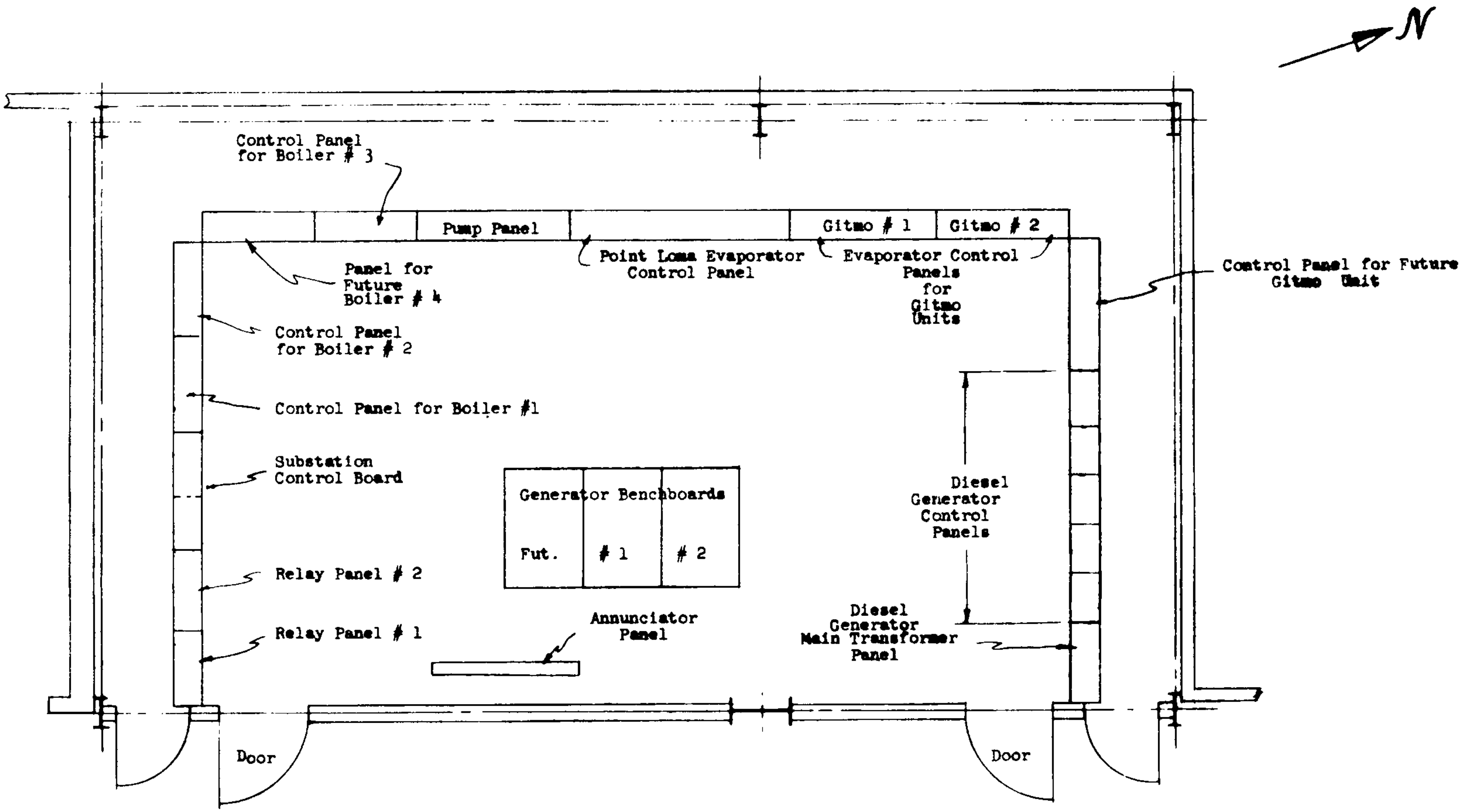


Figure 4-29

PLAN OF CONTROL ROOM

The 3-inch branch off the screen wash pump 4-inch discharge header directs flow through a pressure reducing valve station to the Circulating Seawater Pump Gland Seal System. Down stream of its connection to the gland seal system, the 3-inch line taps into the discharge line of one of the circulating seawater pumps (P-9A). This permits counterflow whenever the gland seal system, the traveling screen wash nozzles, or the Chlorine injection System do not individually or collectively get enough seawater to operate simultaneously. The piping schematic is shown in Fig. 4-11.

4.4.8.2 Circulating Seawater Piping and Valves

The screened seawater is pumped from one or both of the intake structure compartments by the two circulating seawater pumps located there. Piping and valves are shown schematically in Fig. 4-9, including pipe sizes and connections. The 36-inch supply line is equipped with a butterfly valve downstream of a 14" branch line to the Point Loma Unit. This valve permits isolation of the Gitmo Units. The 36" line continues to the Gitmo Units above ground. At this point, it splits into a 24" main line, a 3-inch branch, and a 20-inch branch, the larger branch going to the fifteenth stage of the evaporator of Gitmo Unit No. 1 and the smaller line supplying the seawater service headers of both Gitmo Units. Finally, the 24" main line supplies Gitmo Unit No. 2 through a similar 20-inch branch, while a spare 20" branch is blanked off for future use.

The two 20-inch branches to the Gitmo Units are each equipped with a butterfly valve similar, except as to size, to the one in the 14-inch branch to the Point Loma Unit. These valves are used for balancing flows between the two units.

The circulating seawater piping and valves are also discussed in section 4.4.1.2 and section 9.4 See section 8.5 for discussion of reject condenser back flushing.

4.4.8.3 Circulating Seawater Pump Gland Seal Piping and Valves

The pipe and valving for the circulating seawater pump gland seal system is shown schematically in Fig. 4-11 and is also discussed in section 4.4.1.2.

4.4.8.4 Acid Feed Piping and Valves

The acid feed piping and valves system has been modified since system was installed, to permit independent simultaneous continuous feed to any two of the three evaporators. In addition to use for acid cleaning,

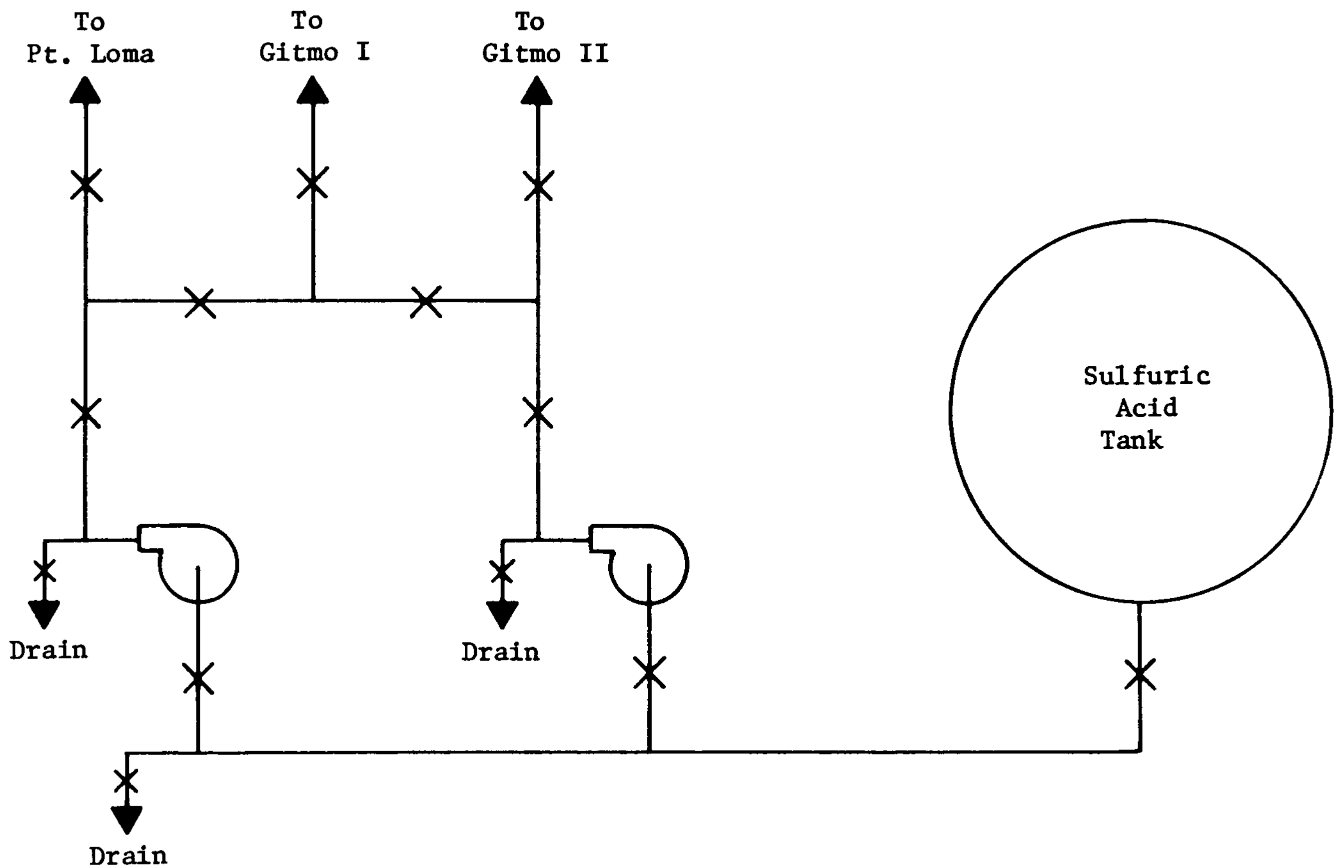


Figure 4-30

ACID FEED PIPING AND VALVES

the system may also be used for acid pretreatment of make-up, permitting operation at brine temperatures of up to 240° with pH control. A schematic diagram of the acid feed piping and valves is shown in Fig. 4-30. The valving arrangement permits any two evaporators to be supplied with the correct rate of feed to each unit.

4.4.8.5 Hagevap System Piping and Valves

The Hagevap piping and valves for the Point Loma unit are shown schematically in Fig. 4-13. The Hagevap solution is delivered to each of the seawater make-up pipe lines upstream of the deaerators.

Fig. 4-31 shows schematic Hagevap piping and valves for Gitmo No. 1 and No. 2 units.

Piping and valve materials are discussed in section 9.4.

4.4.8.6 Circulating Seawater Chlorine Feed Piping and Valves

The circulating seawater chlorine feed piping and valves are shown schematically in Fig. 4-15. The three header isolating valves are standard 3/4", 3 part Chlorine Institute valves. The 2" seawater supply control valve is a Grinell valve. A 2" manually-operated Grinell control valve is located in the chlorine solution discharge line upstream of the connection to the rubber hose to permit regulation of the total chlorine solution delivered to the off-shore diffuser.

4.4.8.7 Seawater Make-up Piping and Valves

Seawater make-up piping for the Point Loma unit includes two 8" lines supplied with seawater from the heat reject section seawater discharge line. Each 8" line contains a butterfly control valve (DRC-129V & 130V) which regulates make-up flow to maintain proper recycle brine concentration. The make-up piping delivers make-up seawater to the integral Point Loma deaerators, and from the deaerators to the flashing brine pool immediately prior to blowing down.

The two 8-inch make-up lines and their respective DRC valves can be seen entering the evaporator deaerators in the foreground of Fig. 4-32.

The Gitmo make-up piping begins as a 12-inch line at the 20-inch seawater outlet line from the tubes of the heat rejection section. From here it runs to the upper, side inlet of the vacuum degasifier which, through its spraying action removes air and other non-condensable

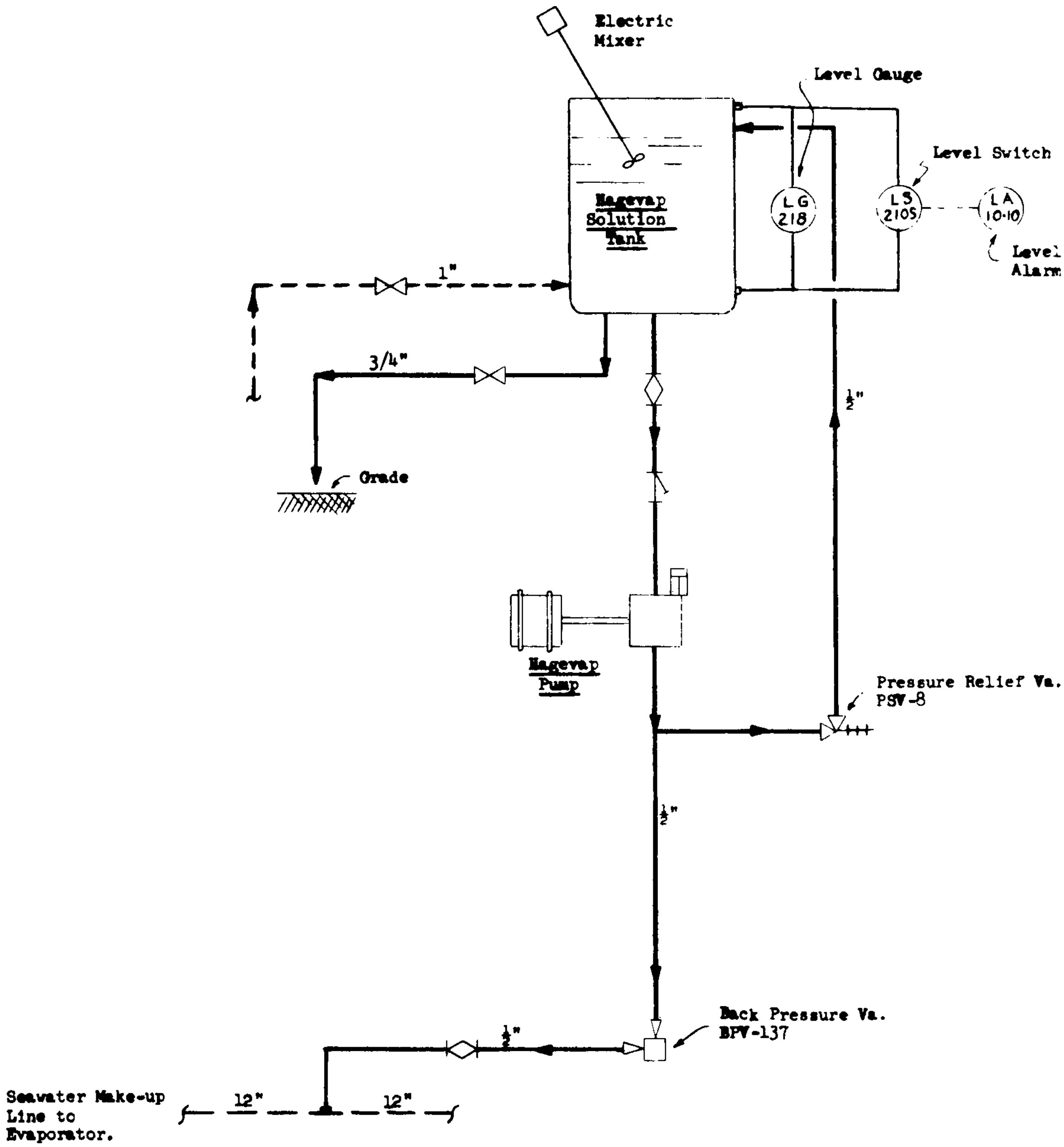


Figure 4-31

SCHEMATIC OF TYPICAL GITMO UNIT HAGEVAP SYSTEM

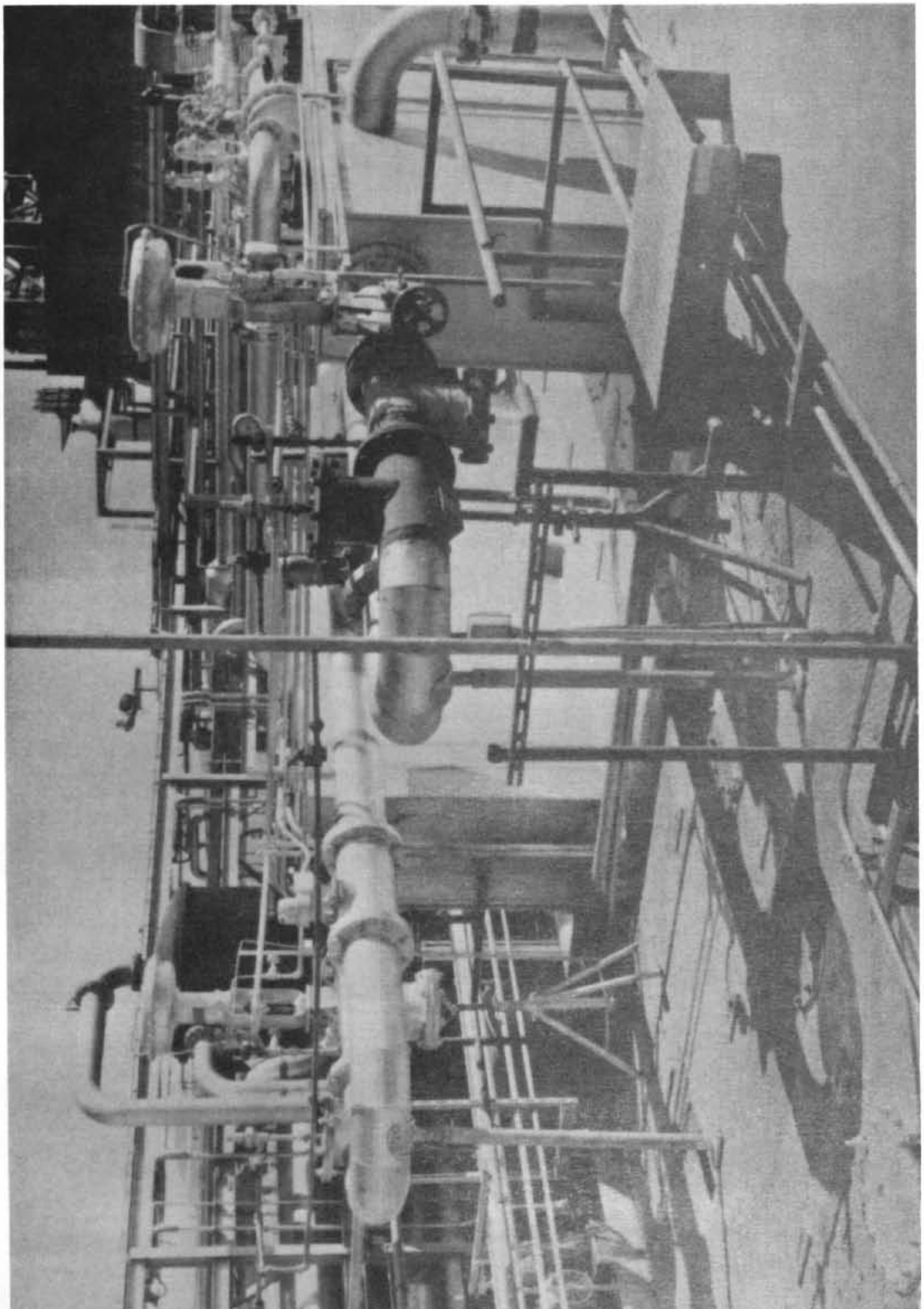


Figure 4-32

POINT LOMA UNIT DEAERATORS AND SEAWATER MAKE-UP LINES gases from the water. Leaving the vacuum degasifier at its bottom connection, the de-aerated make-up flows through a 12-inch valved line to Stage No. 15. In this flashing chamber of the evaporator it is dispersed through a perforated internal spray header.

An air-operated control valve (FCV-3) situated in the 12-inch line near its point of origin determines the amount of seawater that is allowed to flow to the spray header. The valve regulates the flow in proportion to the quantity of product water that is drawn off the distillate trough of Stage No. 15; a controller between FCV-3 and a flow-sensing controller (FR-203E) located in the product water line out of the evaporator makes this interaction possible.

The saline concentration of the brine is regulated by manually setting the above controller for the desired proportion of seawater make-up. Blowdown is by level control of the brine in the last stage and varies automatically with the make-up rate. When considerable blowdown is needed, as during unit shutdown, the seawater make-up control valve may be operated manually.

4.4.8.8. Brine Recycle Piping and Valves

The brine which remains after make-up seawater has been added and the product water and blowdown have been removed is taken from the Point Loma Unit twenty-eighth stage shell by the two recycle pumps through separate 24-inch lines. The discharge from the pumps enters the tubes of the heat recovery section at the 26th stage and flows forward to the brine heater. The recycle brine flow in each brine heater outlet line is controlled by a butterfly valve (FRC-103V and FRC-104V, respectively).

One of the two FRC valves, with its horizontal handwheels, can be seen in Fig. 4-33, just behind the dark-colored casing of the second pump from the left.

The typical Gitmo extraction well is connected by individual 24-inch recycle lines to the suction sides of three brine extraction pumps. These identical pumps have individual 14-inch lines which empty into a common 20-inch brine header.

The discharge header of the Gitmo extraction pumps also serves as a suction header for three identical brine booster pumps which pump the recycling brine into a common 20-inch recycle line leading to the tubes of the heat recovery section at stage No. 12.

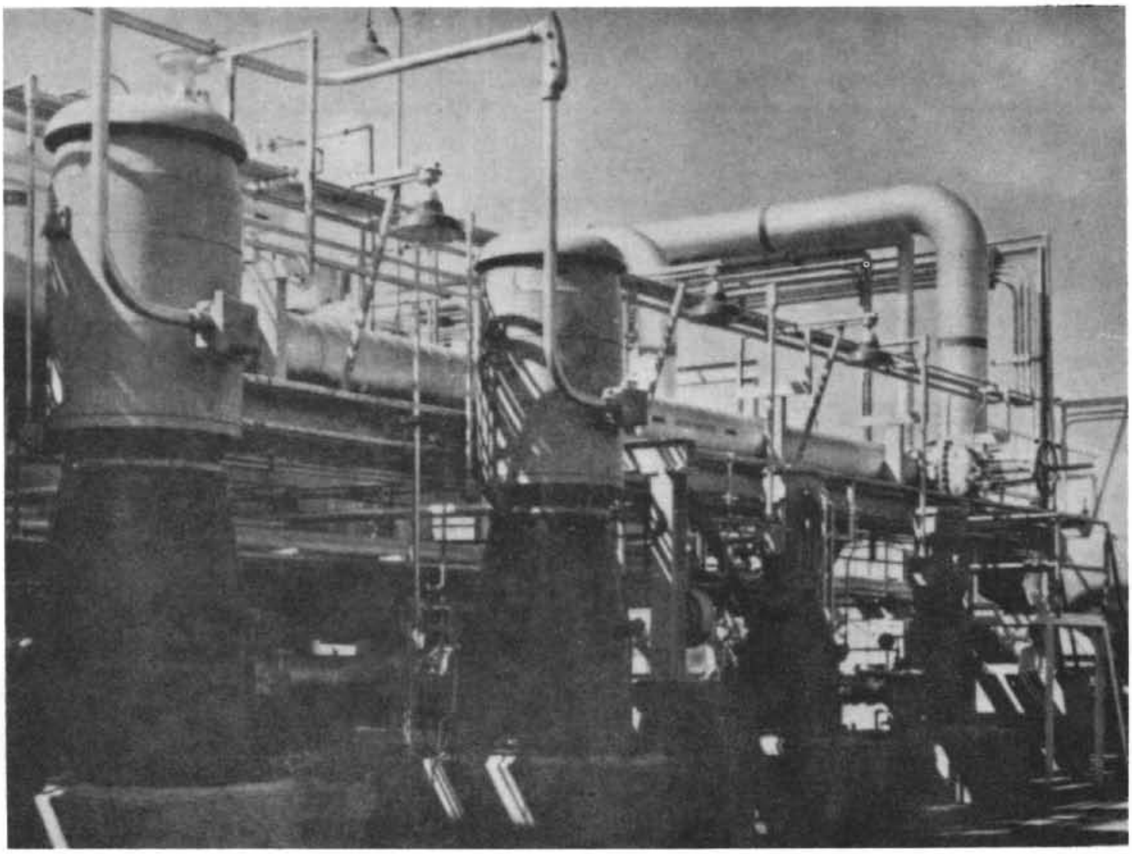


Figure 4-33
POINT LOMA UNIT PUMPS

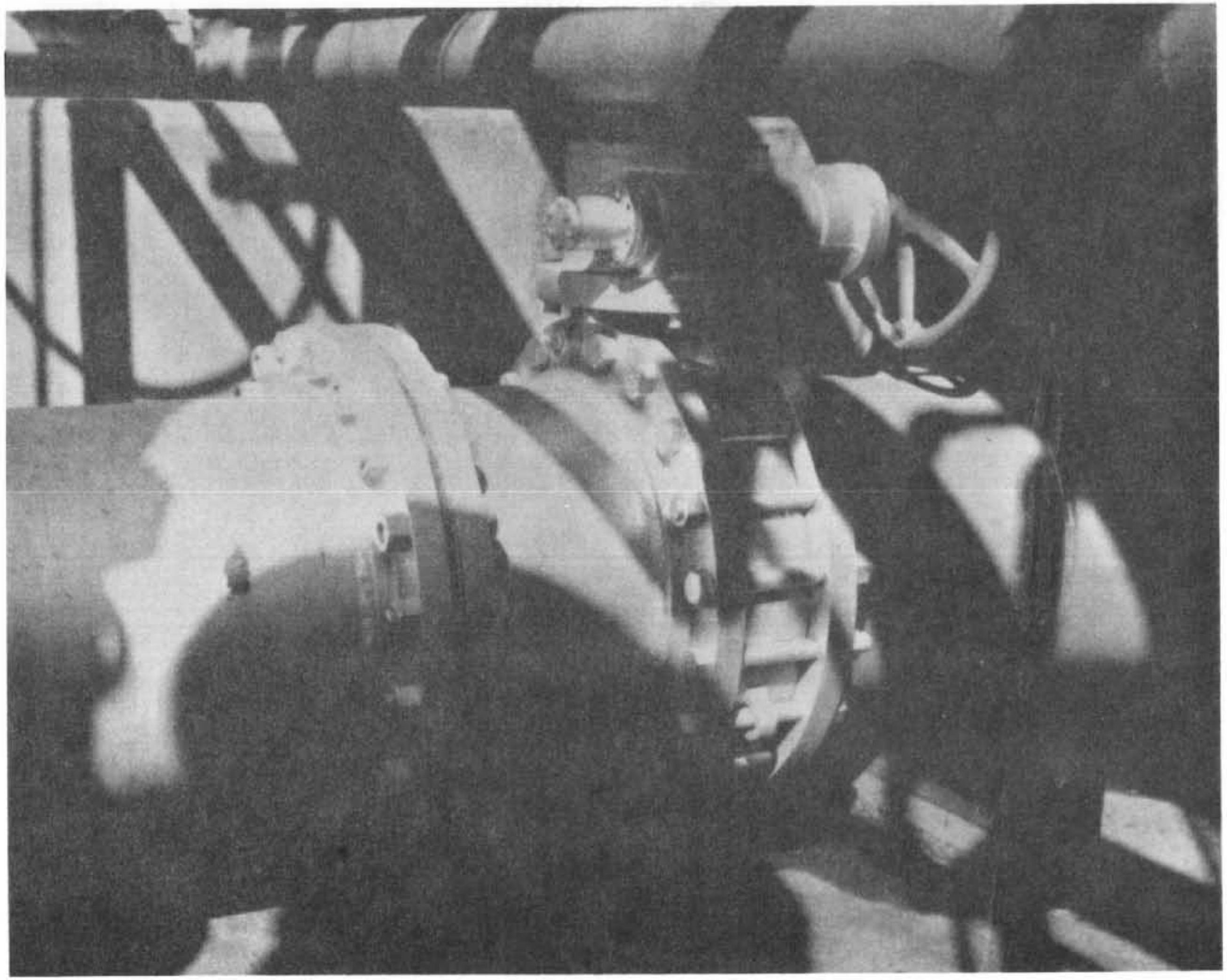


Figure 4-34

HAND-OPERATED BUTTERFLY VALVE IN
TYPICAL GITMO UNIT EXTRACTION LINE

The suction line to each Gitmo brine extraction pump contains a 24-inch, manually-operated butterfly valve for isolating the pump when it is on standby duty or undergoing repairs. One of these valves is illustrated in photographic Fig. 4-34.

Similar type 14-inch valves, as well as individual check valves and rubber-expansion joints, are also provided in the discharge lines of these pumps. The discharge valves and the pumps themselves are depicted in Fig. 4-25.

The 14-inch suction line of each Gitmo booster is equipped with a manually-operated butterfly valve of the type used at the extraction pumps and for the same purpose.

Similar type valves, individual check valves, and rubber expansion joints are also provided in the booster pumps' 10-inch discharge lines.

4.4.8.9 Brine Blowdown Piping and Valves

The 16-inch Point Loma blowdown pump suction line contains only a manually-operated butterfly valve. The 8-inch discharge line is equipped with a check valve and a control valve (LC-145V) that responds to air signals from level controller LC-145 on evaporator Stage No. 28. This control valve can also be manually operated during start-up and shutdown of the Point Loma Unit. A valved 2-inch line vents the upper part of the blowdown pump casing back to the evaporator.

The Gitmo brine blowdown piping begins at the downstream end of the 20-inch line which serves as the discharge header of the extraction pumps and suction header of the booster pumps. This 8-inch blowdown terminates at connection into the 20-inch seawater reject line. An air operated control valve (LCV-4) is located in the line near its terminus to regulate the amount of blowdown.

The Gitmo blowdown valve (level controller LCV-4) is equipped with the customary block valves and a globe valve bypass. The valve can be operated manually during unit start-up and shutdown when level control in the 15th stage is critical.

4.4.8.10 Brine Heater Condensate Piping and Valves

Each Point Loma condensate pump takes suction from the brine heater compartment that it drains via a 2-inch line containing only a manually operated gate valve. A one-inch line from each pump casing vents the pumps back to the brine heater.

The 2-inch discharge line from each Point Loma pump empties into a common 3-inch header that conveys the condensate to a 6-inch collection header near the condensate surge tank in the Power Plant. Each 2-inch line contains a check valve followed by a control valve (LC-147V and LC-148V, respectively) that is operated by air signals from a level controller (LC-147 and LC-148) mounted on the brine heater. The two separate control valves are required because the heater is internally-divided (one half for Recycle Stream "A" and one half for Recycle Stream "B"); each heater compartment, accordingly, has differing condensate levels and requires separate level controllers.

The condensate generated in each of the Gitmo brine heaters leaves the bottom of each heater shell through a 6-inch vertical line that branches into two 4-inch lines connected to the suction sides of two brine heater condensate pumps and discharges through individual 2-inch lines into a common 3-inch header. This header, in turn, empties into the 6-inch condensate return header which conveys the condensate from all three seawater conversion units back to the condensate surge tank in the Power Plant.

The level of condensate in the brine heater is controlled by a level controller (LC-210) mounted off a "strong-back" line on the heater. This controller transmits air signals to a level control valve (LCV-10) situated in the 3-inch condensate transfer pump discharge header; when the condensate level gets too high LCV-10 will open.

4.4.8.11 Product Water Piping and Valves

The Product Water piping discussed here simply conveys evaporator distillate from the evaporator to the lime bed. Equipment for further chemical treatment of the evaporator distillate (including the lime bed itself) and for pumping the treated water off-site are part of the Product Water Quality System Description, Section 7.1.

Product water from the Point Loma Unit evaporator is tapped off the bottom of the twenty eighth stage through a single 12-inch line which is connected to the suction nozzle of the unit's product pump. A level controller (LC-146), mounted on this last stage, controls flow through a 6-inch control valve (LC-146V) situated in the pump's 8-inch discharge line. By the opening of this valve, product water is directed farther along the 8-inch line until it reaches a juncture of this line with a 6-inch line (to the lime bed), a 4-inch product water reject line (to waste) and a 2-inch product water recirculation line (back to the Point Loma evaporator's twenty eighth stage). Each of these three branch lines contains a valve; the portion of the total output of the pump that follows each route depends upon the degree of opening of the three valves located at this juncture.

Point Loma product water piping and valves are shown schematically in Fig. 4-1.

The product water piping for Gitmo Units 1 and 2 is similar to that of the Point Loma Unit except for line sizes. Product water is removed from the last stage of each Gitmo evaporator as in the Point Loma Unit.

Gitmo product water piping, including sizes, is shown schematically in Fig. 4-3.

5.0 PLANT PRODUCTION

5.1 Base Requirement Criteria

Under a separate navy contract (5), in 1960 an engineering study developed the base usage and projected requirements for both water production and electric power generation.

5.1.1 Water Production

From 1945 to 1959, the annual demand for potable water increased from a low of 605 million gallons (for 1946) to a high of 795 million gallons (for 1957). The water requirement estimated by the Navy Public Works Office was 800 MGPY or 2.192 million GPD average.

Based on the above engineering study and on other considerations, three multi-stage flash evaporators, each of 750,000 GPD rated capacity, were installed in 1964 and 1965.

5.1.2 Electric Power

The electric power demand for the period 1945 to 1959 according to the engineering study increased from 14 million KWH in 1945 to 35.5 million KWH in 1959.

For 1960 on, the Navy P.W.O. estimated a demand of 40.1 million KWH per year. Allowing for a 75% load factor, the total electrical generating capacity was estimated at nearly 49 million KWH per year.

Allowing for peak demands and the additional electric load for the desalination plant, a total generator capacity of 10,500 KW was estimated.

There were three government-owned generating stations up to eighteen years old within the base with a total permanently installed capacity of 7,750 KW, and all Diesel engine driven.

In 1964-1965 two steam turbine generators of 7,500 KW capacity were installed for the selected dual-purpose plant. The electrical generating capacity becomes somewhat less when steam is extracted from the turbines for the desalination plant.

In addition, five W.W.II surplus Navy 500 KW Diesel-driven generators were installed for startup and standby service. By 1969, these Diesel generators were replaced by three 1,000 KW Diesel generators as the smaller units became worn out and beyond economical repair.

5.2 Water Production

5.2.1 Daily, Monthly and Annual Basis

From 1965 through 1970, the potable water production at GITMO was as follows:

Daily production was a low average of 1.77 MGD for 1970 to a high average of 2.08 MGD for 1968 and a six year average of 1.99 MGD.

Monthly production was a low average of 53.9 million gallons for 1970 to a high average of 63.5 million gallons for 1968 and a six year average of 60.5 million gallons per month.

Annual production was lowest at 646.8 million gallons in 1970 and was highest at 761.9 million gallons in 1968 and a six year average of 728 million gallons per year.

Figure 5-1 shows the summary of monthly water production for each evaporator unit from 1965 through 1970.

Figure 5-2 shows the combined potable water production for each year, averages for months and days for this same period. Also shown for comparison is the potable water consumption (or demand) for the base by year, averages per month and per day.

5.2.2 Percent On-stream

Figures 5-3 and 5-4 show a comparison of each plant for percent of on-stream time from 1965 through 1970. On-stream times are estimated from the difference between total time and total time of scheduled and unscheduled outages (see 5.3) in each year. The on-stream time of the Point Loma unit was at a low of 67.76% in 1970 and a high of 95.85% in 1968. The overall six year average was 89.38% from 1965 through 1970. The Gitmo No. 1 unit had a low of 91.01% in 1965 and a high of 96.12% in 1968, and the overall six year average was 93.65%. The Gitmo No. 2 unit was low at 93.76 in 1966 and high at 97.30% in 1968. The overall six year average was 95.21% from 1965 through 1970. Figure 5-5 shows a comparison of each plant for percent of on-stream time from starting date through 1970.

	Production			Consumption		
Year	Total for Year	Avg. Per Mo.	Avg. Per Day	Total Per Year	Avg. Per Mo.	Avg. Per Day
1964	198	-	-	-	-	-
1965	710.(a)	59.1	1.94	719(d)	61.5(d)	2.01(d)
1966	739.0	61.5	2.02	735	61.1	2.01
1967	759.7	63.3	2.08	747	62.1	2.02
1968	761.9	63.5	2.08	744	62.3	2.04
1969	750.(b)	62.5(b)	2.06(b)	743	61.0(e)	2.03(e)
1970	646.8	53.9	1.77	636	53.0	1.78
'65-'70 avg.	729.(c)	60.5	1.99	721	60.2	1.98

(a) Based on 11 Mos. data expanded to full year
(b) Based on 9 Mos. data expanded to full year
(c) Does not include 1964
(d) Based on 4 Mos. data
(e) Based on 7 Mos. data

Figure 5-1

GITMO WATER PRODUCTION AND CONSUMPTION
(million gallons)

1964

DATE / EVAPORATOR UNIT	GITMO #1	GITMO #2	PT. LOMA	TOTAL	AVE.DAILY PROD.	PEAK DAILY PROD.
Prod. Per Mo. Jan.						
Feb.						
Mar.						
Apr.						
May						
Jun						
Jul						
Aug			18.8	18.8	0.61	
Sep	13.7	-	22.5	36.1	1.41	
Oct	22.0	-	25.1	47.1	1.52	1.61
Nov	20.8	-	23.3	44.0	1.47	1.66
Dec	17.1	12.7	22.2	51.9	1.77	2.31
Totals Per Year	73.6	12.7	119.9	197.9		
Ave. Per Month	19.9	15.1	22.4			
Ave. Per Day	.651	.488	.731		1.35	
Percent On-Stream	94.23	87.36	95.44			
Base Consumption Ave. Per Mo. for Year						
Base Consumption Ave. Per Day for Year						

1965

DATE	GITMO #1	GITMO #2	PT. LOMA	TOTAL	AVE.DAILY PROD.	PEAK DAILY PROD.
Jan	12.5	21.2	10.8	44.5	1.44	2.20
Feb	15.5	19.0	16.9	51.3	1.83	2.26
Mar	18.6	22.0	20.0	60.7	1.96	2.30
Apr	21.6	20.2	20.9	62.7	2.09	2.36
May						
Jun				55.8	1.86	2.19
Jul	20.8	20.1	21.0	61.9	2.00	2.29
Aug	23.2	22.0	21.9	67.2	2.24	2.33
Sep	21.3	20.7	20.2	62.3	2.08	2.27
Oct	18.9	20.2	22.7	61.9	2.00	2.41
Nov	17.8	20.6	15.9	54.3	1.81	2.40
Dec	24.1	20.6	22.7	67.4	2.17	2.39
Totals Per Year				650.0	(11 Mos.)	
Ave. Per Month		20.7		59.1		
Ave. Per Day				-	1.94	
Percent On-Stream	91.01	95.13	89.44			
Base Consumption Ave. Per Mo. for Year				61.5		
Base Consumption Ave. Per Day for Year					2.01	

1966

DATE	GITMO #1	GITMO #2	PT. LOMA	TOTAL	AVE.DAILY PROD.	PEAK DAILY PROD.
Jan	20.3	23.0	22.0	65.3	2.11	2.38
Feb	19.3	20.7	16.2	56.3	2.01	2.40
Mar	24.0	19.3	25.9	69.2	2.23	2.54
Apr	22.3	22.8	23.3	68.3	2.28	2.44
May	21.5	20.4	20.8	62.7	2.02	2.39
Jun	17.1	19.3	20.2	56.5	1.88	2.22
Jul	18.3	19.6	21.0	58.9	1.90	2.21
Aug	20.2	21.1	21.7	63.0	2.01	2.21
Sep	18.6	20.9	21.7	61.2	2.04	2.20
Oct	21.1	22.3	17.8	61.3	1.98	2.33
Nov	18.7	19.8	17.8	56.3	1.88	2.37
Dec	18.7	19.5	21.8	60.0	1.94	2.37
Totals Per Year	240.1	248.7	250.2	739.0		
Ave. Per Month	20.0	20.7	20.8	61.5		
Ave. Per Day	.658	.682	.686	-	2.02	
Percent On-Stream	92.00	93.87	92.13			
Base Consumption Ave. Per Mo. for Year				61.1		
Base Consumption Ave. Per Day for Year					2.01	

1967

DATE	GITMO #1	GITMO #2	PT. LOMA	TOTAL	AVE.DAILY PROD.	PEAK DAILY PROD.
Jan	19.4	21.0	22.8	63.2	1.94	2.36
Feb	18.0	16.1	22.5	56.6	2.02	2.37
Mar	21.8	22.7	23.4	67.9	2.19	2.47
Apr	21.2	21.6	20.5	63.2	2.11	2.36
May	22.0	22.2	26.0	70.1	2.26	2.35
Jun	19.1	20.5	24.6	64.2	2.14	2.32
Jul	20.2	22.1	25.6	67.8	2.19	2.32
Aug	18.6	21.4	23.3	63.3	2.04	2.23
Sep	18.9	21.1	23.0	62.9	2.10	2.25
Oct	17.4	19.8	21.7	58.9	1.90	2.12
Nov	19.6	18.9	22.2	60.7	2.02	2.30
Dec	19.0	21.5	20.4	60.9	1.97	2.19
Totals Per Year	235.2	248.9	276.0	759.7		
Ave. Per Month	19.6	20.8	23.0	63.3		
Ave. Per Day	.645	.682	.756	-	2.08	
Percent On-Stream	94.79	94.05	95.27			
Base Consumption Ave. Per Mo. for Year				62.1		
Base Consumption Ave. Per Day for Year					2.02	

1968

DATE / EVAPORATOR UNIT	GITMO #1	GITMO #2	PT. LOMA	TOTAL	AVE.DAILY PROD.	PEAK DAILY PROD.
Prod. Per Mo. Jan	17.5	21.5	21.2	60.2	1.94	2.31
Feb	19.9	21.4	20.2	61.5	2.12	2.38
Mar	22.8	20.3	22.3	65.5	2.11	2.34
Apr	20.9	21.5	22.0	64.4	2.13	2.30
May	21.0	22.1	23.1	66.2	2.14	2.34
Jun	20.8	20.3	21.2	62.4	2.08	2.18
Jul	21.1	21.1	23.8	66.0	2.13	2.33
Aug	21.3	22.0	22.6	65.9	2.12	2.29
Sep	19.0	18.9	21.6	59.6	1.99	2.24
Oct	20.6	21.8	22.3	64.6	2.08	2.25
Nov	20.0	21.1	22.3	63.3	2.11	2.23
Dec	18.0	22.8	21.4	62.3	2.01	2.26
Totals Per Year	242.9	254.8	264.0	761.9		
Ave. Per Month	20.2	21.2	22.0	63.5		
Ave. Per Day	.664	.697	.721	-	2.08	
Percent On-Stream	96.12	97.30	95.85			
Base Consumption Ave. Per Mo. for Year				62.3		
Base Consumption Ave. Per Day for Year					2.04	

1969

DATE	GITMO #1	GITMO #2	PT. LOMA	TOTAL	AVE.DAILY PROD.	PEAK DAILY PROD.
Jan	16.8	21.5	21.9	60.2	1.94	2.31
Feb	19.7	19.3	19.5	58.5	2.09	2.35
Mar	21.8	21.5	23.4	66.7	2.15	2.33
Apr	21.8	19.7	22.2	63.7	2.12	2.29
May	21.5	21.9	22.9	66.2	2.14	2.28
Jun	18.4	19.4	18.7	56.4	1.88	2.25
Jul	22.9	18.8	22.7	64.4	2.07	
Aug	21.6	21.0	20.5	63.1	2.03	
Sep	21.8	20.7	21.2	63.8	2.11	2.32
Oct	22.8	21.5	21.8	66.1	2.13	2.33
Nov	20.5	20.4	19.7	60.6	2.02	2.19
Dec	20.1	20.7	21.6	62.4	2.01	
Totals Per Year	249.7	246.4	256.1	752.1		
Ave. Per Month	20.8	20.5	21.3	62.7		
Ave. Per Day	68.5	67.5	70.3	-	2.06	
Percent On-Stream	95.81	97.01	95.81			
Base Consumption Ave. Per Mo. for Year				61.0		
Base Consumption Ave. Per Day for Year					2.03	

1970

DATE	GITMO #1	GITMO #2	PT. LOMA	TOTAL	AVE.DAILY PROD.	PEAK DAILY PROD.
Jan	20.1	20.7	21.6	62.4	2.01	2.21
Feb	19.2	20.7	17.9	57.7	2.06	2.38
Mar	21.3	23.5	2.3	47.1	1.52	2.10
Apr	15.8	22.2	20.6	58.7	1.96	2.29
May	21.0	19.0	13.5	53.5	1.72	2.06
Jun	21.1	20.8	6.0	47.8	1.59	1.92
Jul	18.7	18.9	15.5	53.2	1.72	2.14
Aug	23.1	22.5	9.5	55.2	1.78	2.13
Sep	19.2	17.3	10.6	47.2	1.57	1.93
Oct	22.2	21.3	10.6	54.1	1.74	2.06
Nov	19.1	19.7	16.6	55.5	1.85	2.24
Dec	24.5	23.1	6.9	54.4	1.75	2.23
Totals Per Year	245.3	249.7	151.6	646.8		
Ave. Per Month	20.4	20.8	12.6	53.9		
Ave. Per Day	.672	.685	.415	-	1.77	
Percent On-Stream	92.15	93.92	67.76			
Base Consumption Ave. Per Mo. for Year				53.0		
Base Consumption Ave. Per Day for Year					1.78	

Start-Up Dates
- Pt. Loma July 26, 1964
- Gitmo #1 Sept 7, 1964
- Gitmo #2 Dec 4, 1964

Days Operated in Start-Up Month
- Pt. Loma July 2 Days
- Gitmo #1 Sept 21 Days
- Gitmo #2 Dec 26 Days

Peak Construction for one day
3,266,000 Gal. on 8 Nov., 1968

Figure 5-2

GITMO WATER PRODUCTION
(Millions of Gallons)

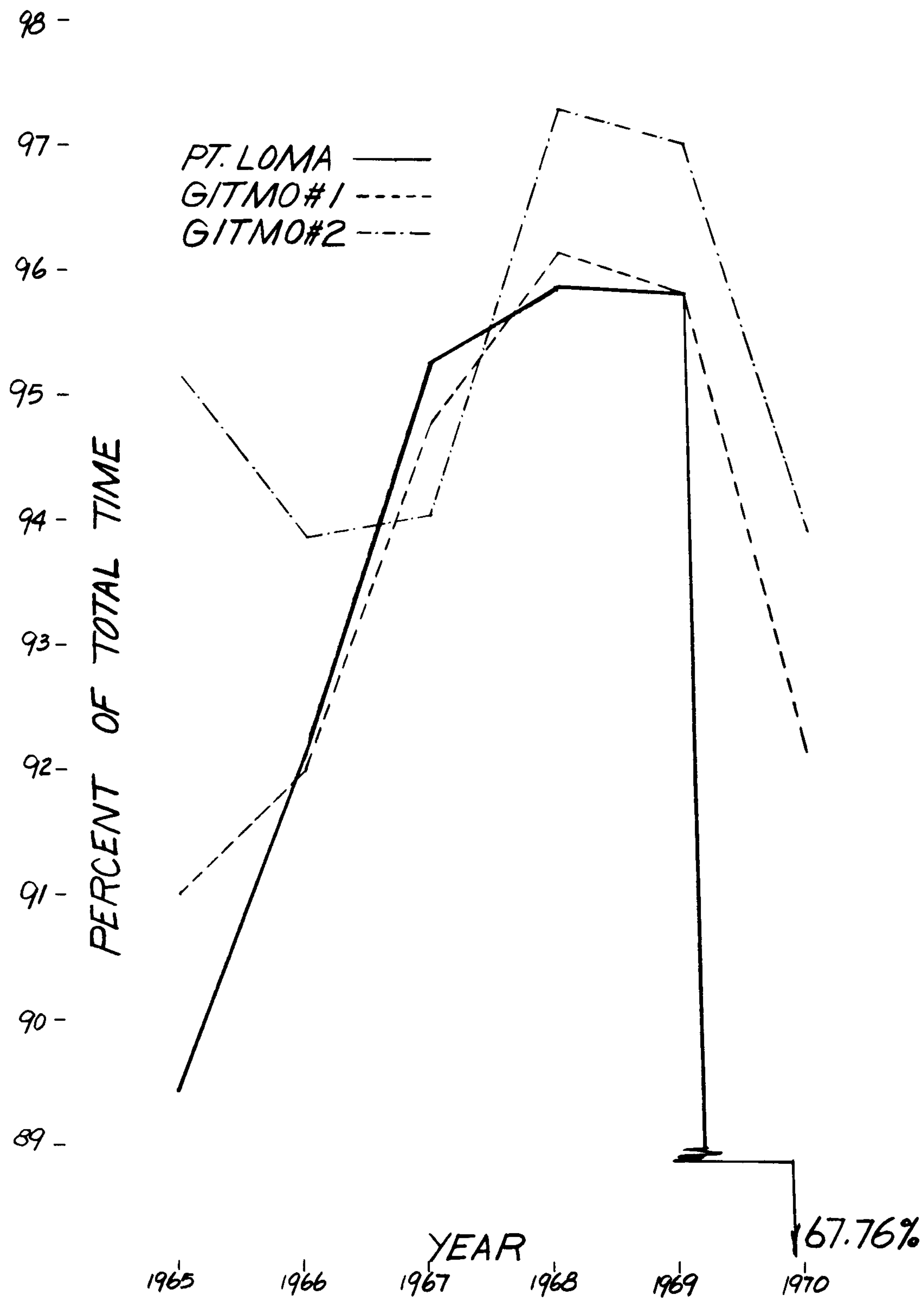


Figure 5-3
ON STREAM TIME

Scheduled & Unscheduled Outages	Pt. Loma		Gitmo #1		Gitmo #2	
	Percent Outage	Percent On Stream	Percent Outage	Percent On Stream	Percent Outage	Percent On Stream
1965	10.56	89.44	8.99	91.01	4.87	95.13
1966	7.87	92.13	8.00	92.00	6.13	93.87
1967	4.73	95.27	5.21	94.79	5.95	94.05
1968	4.15	95.85	3.88	96.12	2.70	97.30
1969	4.19	95.81	4.19	95.81	2.99	97.01
1970	32.24	67.76	7.85	92.15	6.08	93.92

Figure 5-4

Percent of Outages and Percent of On Stream Time from 1965 to 1970

	Pt. Loma	Gitmo #1	Gitmo #2
Total Hours	56,352	55,368	53,280
Total Outage Hours	5,756	3,502½	2,604
Total On Stream Hours	50,596	51,865½	50,676
Percent Outage	10.21	6.33	4.89
Percent On Stream	89.79	93.67	95.11

Figure 5-5

Percent of Outages and Percent of On Stream Time from Starting Date to the End of 1970

5.3 Evaporator Outages

5.3.1 Scheduled Outages

An evaporator scheduled outage is an outage which is scheduled at least a day or more ahead of the shutdown time of the plant for repair and maintenance services or, sometimes, for product water storage at high inventory level. Figures 5-6 and 5-7 show a comparison of each plant for percent of scheduled outages from 1965 through 1970. Unless the scheduled outage time is specified in the monthly [7] and weekly [6] reports of the plant, most of these times are estimated based upon the ratio of the actual water production and the rated water production.

Scheduled outages of the Point Loma unit were at a low of 3.36% in 1968 and a high of 31.86% in 1970. The overall six year average was 9.91% from 1965 through 1970. The Gitmo #1 unit had a low scheduled outage of 3.79% in 1968, with a high of 7.35% in 1970, and the overall six year average was 5.27% from 1965 through 1970. The Gitmo #2 unit scheduled outage was low at 2.36% in 1968 and high at 5.81% in 1970. The overall six year average was 4.39% from 1965 through 1970.

All outages are expressed as a percent of total hours (24 hours per day, 365 days per year).

	Pt. Loma		Gitmo #1		Gitmo #2	
Scheduled Outages	Hours	Percent Outage	Hours	Percent Outage	Hours	Percent Outage
1965	819	9.35	566	6.46	393	4.49
1966	609	6.95	512	5.84	469	5.35
1967	358	4.09	349	3.98	471	5.38
1968	295	3.36	333	3.79	207	2.36
1969	339	3.87	367	4.19	260	2.97
1970	2,791	31.86	644	7.35	509	5.81

Figure 5-6

Scheduled Outages from 1965 to 1970

5.3.2 Causes of Scheduled Outages

The causes of scheduled outages for the three water plants from start-up date through the end of 1970 are as follows:

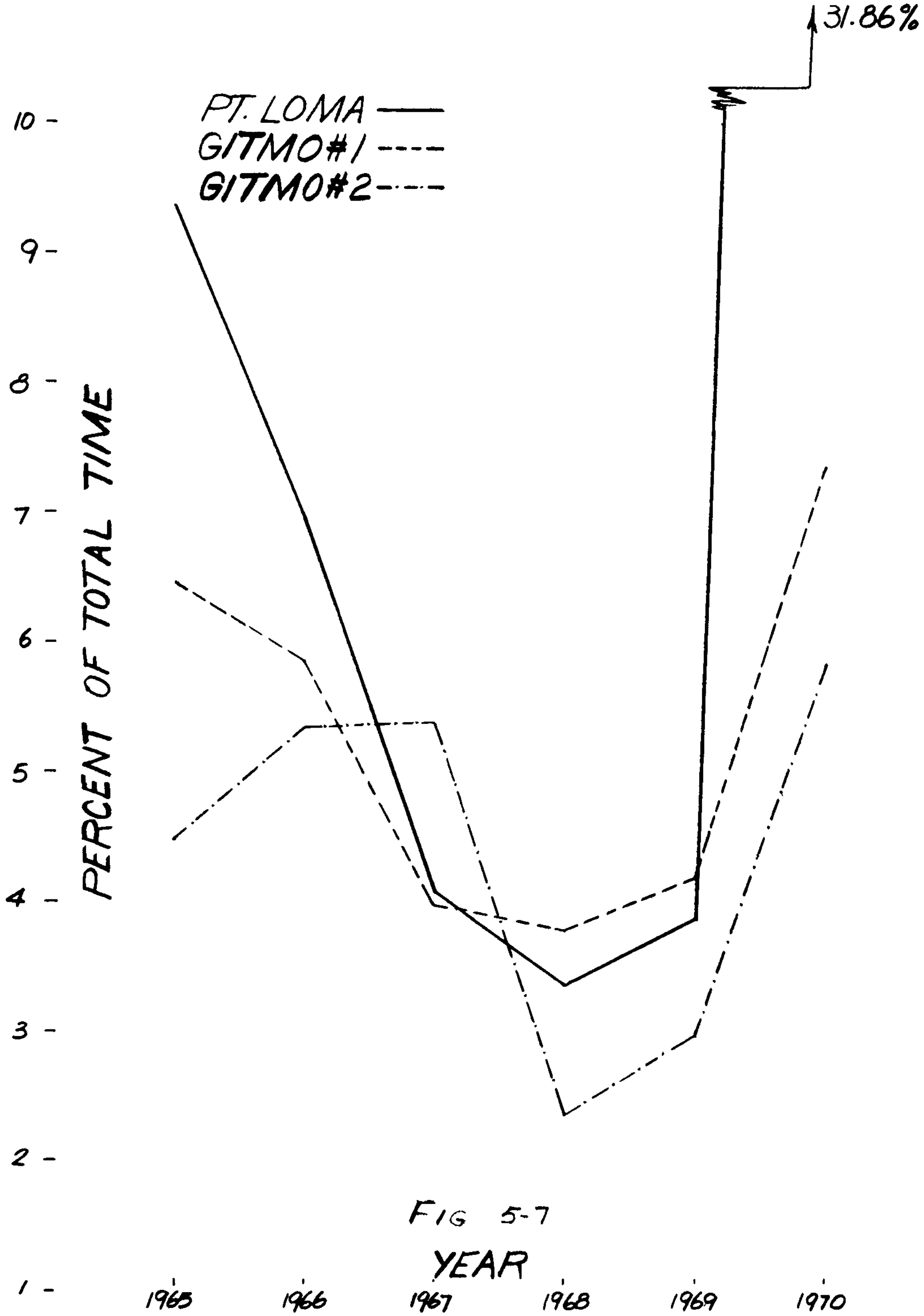


Figure 5-7

SCHEDULED OUTAGES

1. Due to high chlorides in product. This occurred mostly due to the rupture of the tubes in the heat reject stages.
2. Evaporator Water Box Leaks.
3. Water storage in high level. When the product water inventory reached 12 million gallons (storage capacity) from 1964 through the middle part of 1967 and 20 million gallons (storage capacity) from the latter part of 1967 on, a cutback of water production rate from one to three plants or a shutdown of one plant occurred. Shutdown for water storage in high level is considered a scheduled outage.
4. Evaporator piping leaks.
5. Evaporator valves - leaks.
6. Evaporator inspection.
7. Evaporator cleaning.
8. Evaporator miscellaneous maintenance. This includes outages for all the small items being repaired and replaced in the water plant.
9. Evaporator Steam Supply miscellaneous maintenance. This includes outage due to items being repaired and replaced in the power plant.

Figures 5-8 and 5-9 show the breakdown of the causes of scheduled outages in terms of hours each year and percent of total scheduled outage hours for each of the three plants.

5.3.3 Unscheduled Outages

An evaporator unscheduled outage is an unplanned outage, during which shutdown of the plant is necessary to protect equipment or for repair and other maintenance service required for the production of acceptable product. Figures 5-10 and 5-11 show a comparison of each plant in percent of unscheduled outages from 1965 through 1970. Unless the unscheduled outages time is specified in the monthly and weekly reports of the plant, most of these times are estimated based upon the ratio of the actual water production and the design water production rate.

The unscheduled outages in the Point Loma unit had a low of 0.32% in 1969 to a high of 1.21% in 1965 and an overall six year average of 0.71% from 1965 through 1970. The Gitmo #1 unit had no outages in 1969 and a high of 2.53% in 1965, with an overall six-year average of 1.09%.

Scheduled Outages	Pt. Loma		Gitmo #1		Gitmo #2	
	Hours	Percent	Hours	Percent	Hours	Percent
High Chlorides	131	2.46	385	13.40	197	8.53
Evaporator Water Box Leaks	1123½	21.11	236	8.21	70	3.03
Water Storage in high level	1159	21.78	809	28.15	733	31.75
Evaporator Piping Leaks						
Recycle Piping	(194)	(3.65)	(9)	(0.31)	(nil)	(nil)
Makeup Piping	(80½)	(1.51)	(39)	(1.36)	(21)	(0.91)
SJAE Piping	(232½)	(4.37)	(40)	(1.39)	(20)	(0.87)
Vent Piping	(72)	(1.35)	(5)	(0.17)	(5)	(0.22)
Product Piping	(189)	(3.55)	(3)	(0.11)	(nil)	(nil)
Others Piping	(35)	(0.66)	(27)	(0.94)	(51)	(2.21)
Total Piping	803	15.09	123	4.28	97	4.21
Evaporator Valves	162½	3.05	28	0.98	nil	nil
Evaporator Inspection	212	3.98	112	3.90	64	2.77
Evaporator Cleaning	311½	5.85	305½	10.63	196	8.48
Evaporator Miscellaneous Maintenance	823½	15.47	610	21.23	679	29.41
Evaporator Steam Supply Miscellaneous Maintenance	596½	11.21	265	9.22	273	11.82
Total	5322½	100.00	2873½	100.00	2309	100.00

Note: ( ) = Sub heading data

Figure 5-8

1. High Chlorides
2. Evaporator Water Box Leaks
3. Water Storage in High Level
4. Evaporator Piping Leaks
5. Evaporator Values
6. Evaporator Inspection
7. Evaporator Cleaning
8. Evaporator Misc. Maintenance
9. Evaporator Steam Supply Misc. Maintenance

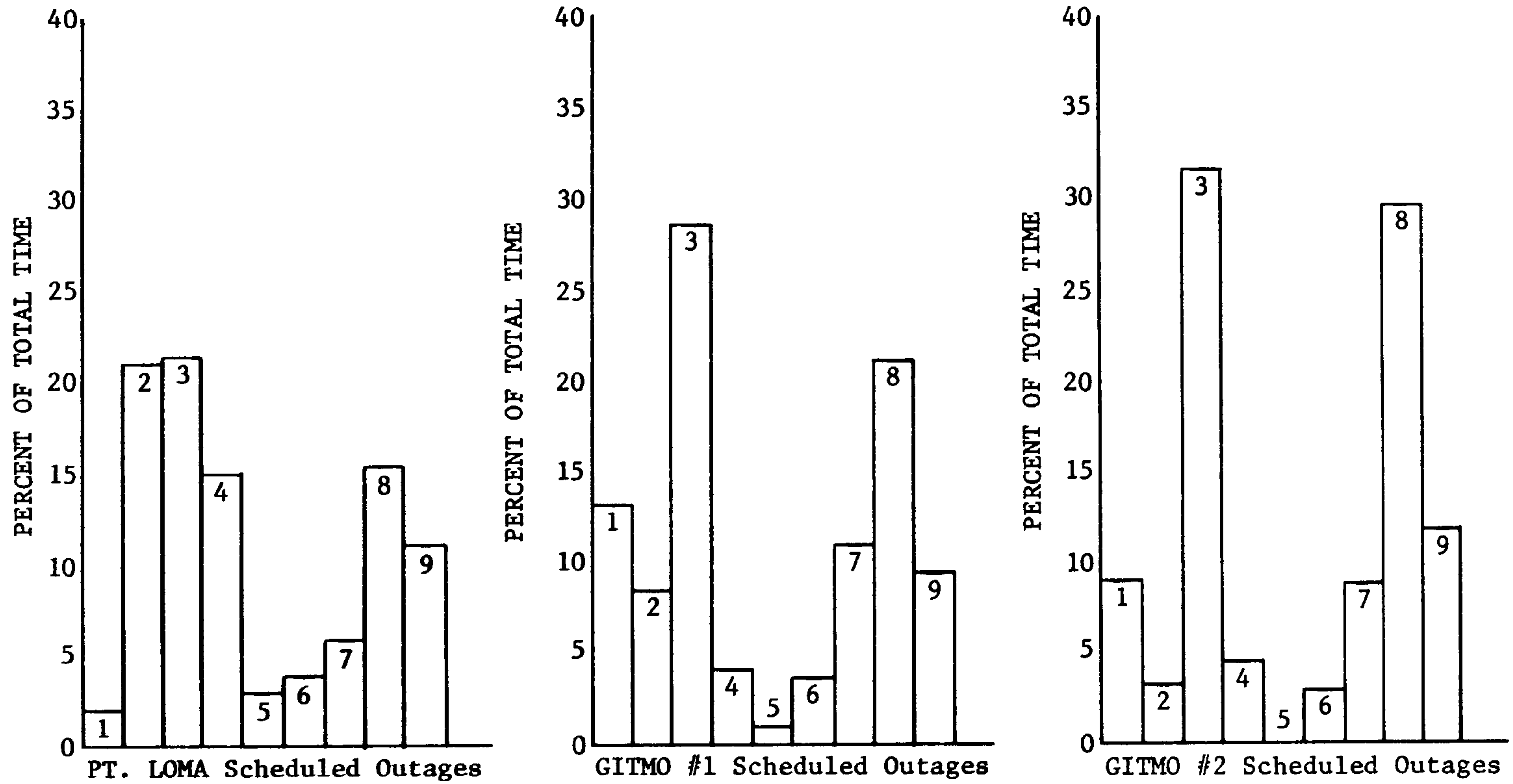


Figure 5-9

CAUSES OF SCHEDULED OUTAGES

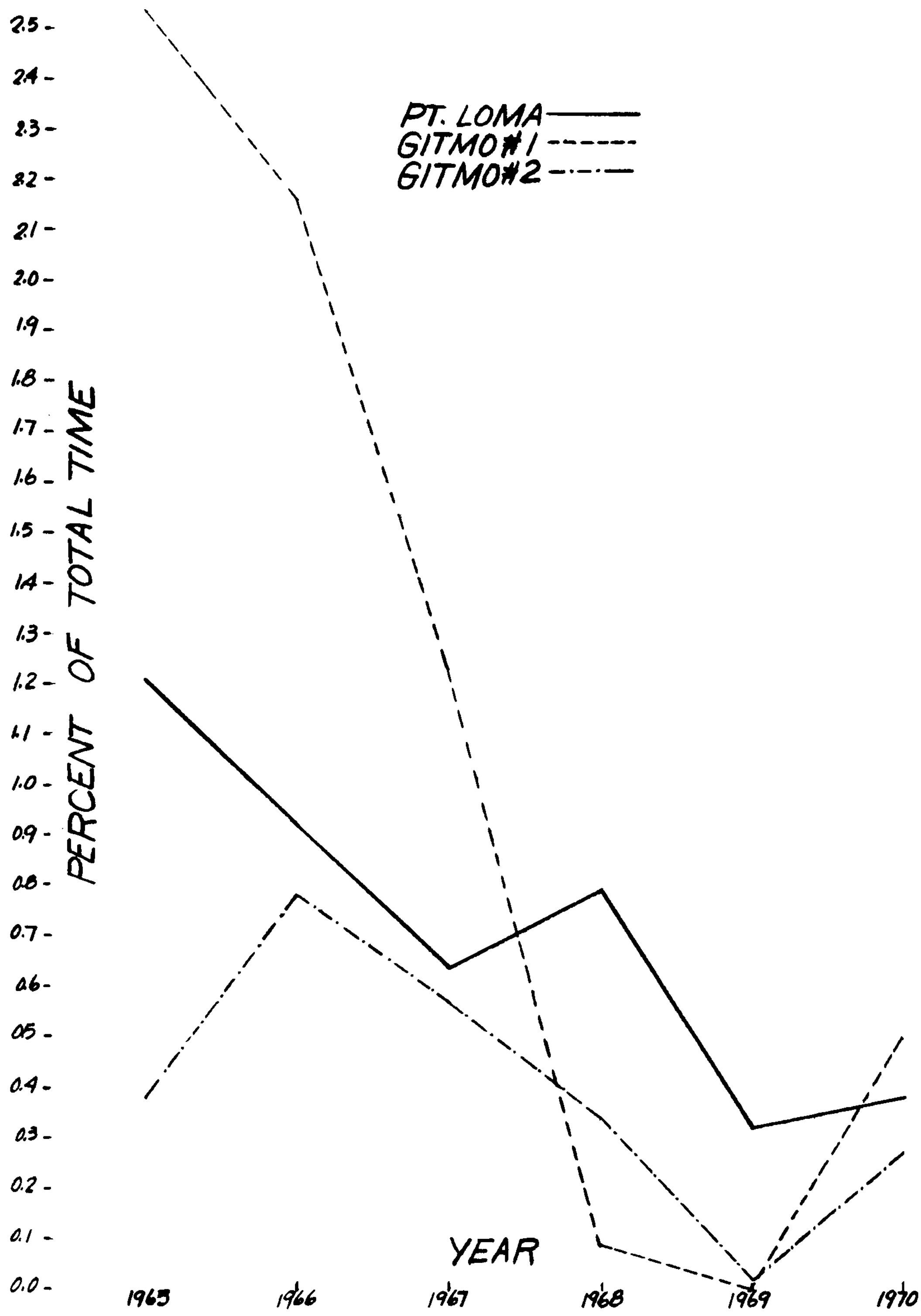


Figure 5-10

UNSCHEDULED OUTAGES

The Gitmo #2 unit had a low of 0.02% in 1969, a high of 0.78% in 1966, and an overall six year average of 0.39% from 1965 through 1970.

Unscheduled Outages	Pt. Loma Hours	Pt. Loma Percent Outage	Gitmo #1 Hours	Gitmo #1 Percent Outage	Gitmo #2 Hours	Gitmo #2 Percent Outage
1965	106	1.21	222	2.53	33	0.38
1966	81	0.92	189	2.16	68	0.78
1967	56	0.64	108	1.23	50	0.57
1968	69	0.79	8	0.09	30	0.34
1969	28	0.32	0	0	2	0.02
1970	33	0.38	44	0.50	24	0.27

Figure 5-11

Unscheduled Outages

5.3.4 Causes of Unscheduled Outages

The causes of unscheduled outages for each of the three water plants from start-up date through the end of 1970 are as follows:

1. Evaporator Steam Supply Miscellaneous Maintenance. These unscheduled outages occurred mainly due to power and boiler failures.
2. Due to high chlorides in product. This is mostly due to rupture of the tubes in the heat reject stages.
3. Evaporator Water Box Leaks.
4. Evaporator Piping Leaks.
5. Evaporator Valves.

Figures 5-12 and 5-13 show the breakdown of the causes of unscheduled outages in terms of hours each year and percent of total unscheduled outage hours for each of the three plants.

5.4 Plant Production Discussion

5.4.1 Effect of Dual-Purpose Plant Feature on Water Production

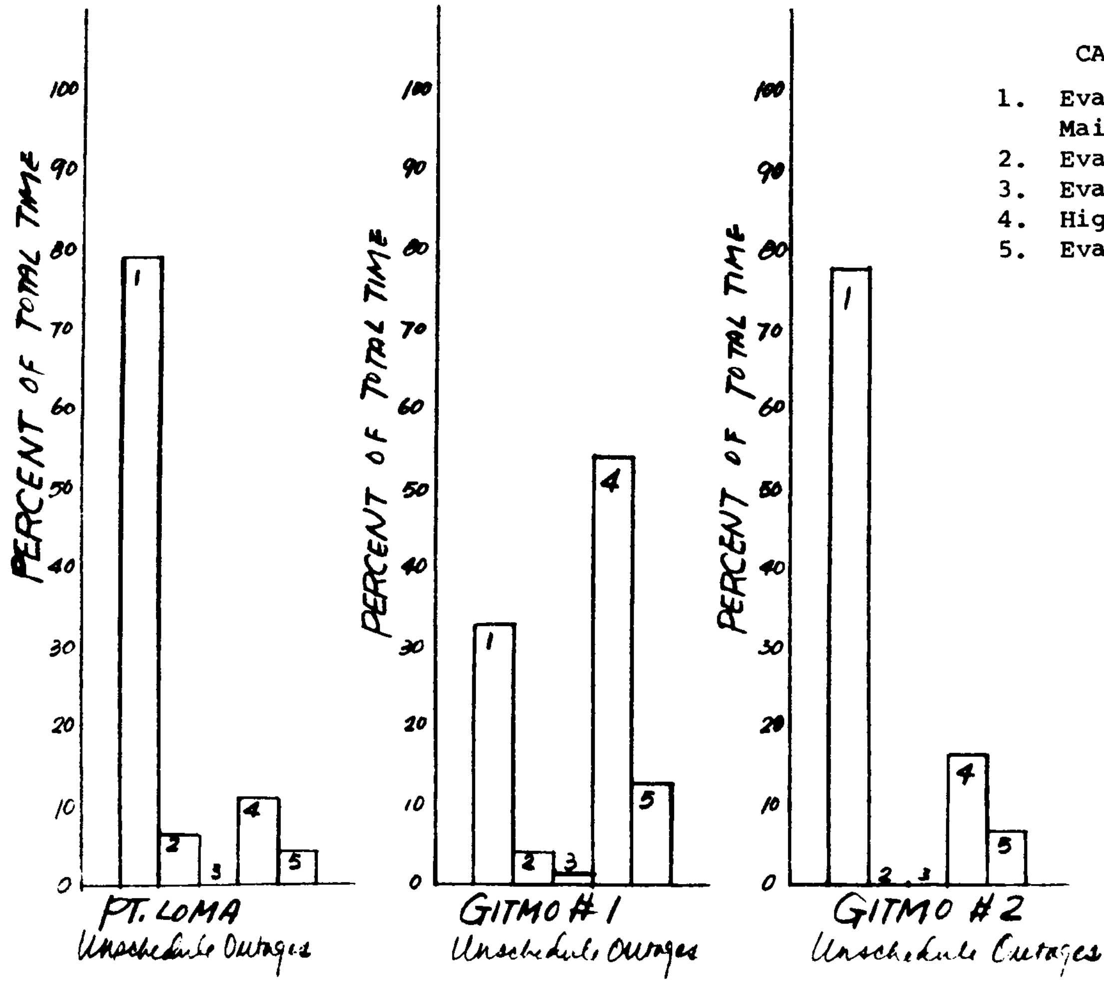
The effect on water production of the dual-purpose plant feature, including extraction steam for the evaporators, has likely been no different from the effect on water production of single-purpose plant feature. Boiler or steam failures and electric power failures have shut down the evaporators on occasion. However, a single purpose plant could also be expected to suffer similar interruption of steam and electric power supply.

Unscheduled Outages	Pt. Loma		Gitmo #1		Gitmo #2	
	Hours	Percent	Hours	Percent	Hours	Percent
Evaporator Steam Supply Miscellaneous Maintenance	342	78.89	202½	32.19	227½	77.12
High Chlorides	44	10.15	329½	52.38	47	15.93
Evaporator Water Box Leaks	20½	4.73	64½	10.26	20½	6.95
Evaporator Piping Leaks						
Recycle Piping	(27)	(6.23)	(nil)	(nil)	(nil)	(nil)
Vent Piping	(nil)	(nil)	(9½)	(1.51)	(nil)	(nil)
SJAE Piping	(nil)	(nil)	(15)	(2.39)	(nil)	(nil)
Total Piping	27	6.23	24½	3.90	nil	nil
Evaporator Valves	nil	nil	8	1.27	nil	nil
Total	433½	100.00	629	100.00	295	100.00

Note: ( ) = Sub heading data

Figure 5-12

CAUSES OF UNSCHEDULED OUTAGES



CAUSES OF UNSCHEDULED OUTAGES

1. Evaporator Steam Supply Misc. Maint.
2. Evaporator Piping Leaks
3. Evaporator Values
4. High Chlorides
5. Evaporator Water Box Leaks

Figure 5-13

CAUSES OF UNSCHEDULED OUTAGES

On October 14, 1970 [6] and possibly other occasions during the night when electrical loads were at a minimum, the temperature was increased in one or more evaporators. The excess steam may or may not have been available had the plant been a single-purpose plant.

The dual-purpose plant has a single seawater circulating system which supplies cooling water to the water plant heat reject sections, as well as supplying cooling water to the turbo-generator condensers. During such time as one of the two seawater circulating pumps may be out of service for repair, or the condition of one or both seawater circulating pumps may be such that insufficient circulating seawater is available, the dual-purpose plant permits some latitude in method of operation. During the part of the day when the electric load is high, more cooling water can be directed to the turbine condensers and water production cut back. During the night when the electric load is not as great, cooling water to the turbine condensers can be cut back and water production increased.

The product water storage tank can absorb water production fluctuations, increasing the average water production and more fully utilizing the steam generating capacity and/or seawater circulating capacity.

5.4.2 Basis for PRV Desuperheating Station in Dual-Purpose Plant

The steam pressure reducing valve desuperheating station in the dual-purpose plant permits operation of the water plant at full capacity when one or both of the extraction turbines are not operating. During normal operation the PRV Desuperheating Station is not used, since expansion of the high pressure steam through the turbine for power generation is more efficient than throttling the high pressure steam through the pressure reducing valve.

During the life of the two turbine generators one or the other has been down for total of approximately 6% [13] of the plant operational hours. The PRV desuperheating station has enabled steam supply for capacity operation of the water plant during the combined 6% turbine-generator down time, whereas the evaporators would otherwise have been able to operate at no more than approximately two-thirds capacity [14] if dependent entirely on extraction steam.

Since the Gitmo dual-purpose plant installation was on a "crash" basis, early production of water was of great importance. The start-up dates [9] for Evaporators were as follows:

Date	Evaporator
July 26, 1964	Pt. Loma
September 7, 1964	Gitmo #1
December 4, 1964	Gitmo #2

The turbine generator start-up dates [9] were as follows:

Date	Turbine Generator
December 20, 1964	TG-1
January 14, 1965	TG-2

The PRV desuperheating station thus enabled partial capacity water production approximately five months earlier and full capacity approximately six weeks earlier than would have been possible using only extraction steam.

5.4.3 Basis for Full-Size Turbo-Generator Condensers

Full-size turbine-generator condensers have been selected to permit continued rated power generation during the time one or more evaporators may be shut down. Inability to condense full steam flow in the turbine condensers during evaporator shutdown would result in undercapacity electric power generation or turbine exhaust to the atmosphere, which would be impractical.

During such time as one or more evaporators may be shut down for a few hours to plug tubes, weld a pipe leak, or for the performance of other routine maintenance, the full capacity turbine condensers permit uninterrupted power generation.

5.4.4 Effect of 6-Years' Operation on Evaporator Production and Performance Ratio

The effects on the plant performance ratio in a dual-purpose plant include the extraction of steam from the power plant to the evaporator, the production of water, and the performance of the brine heater.

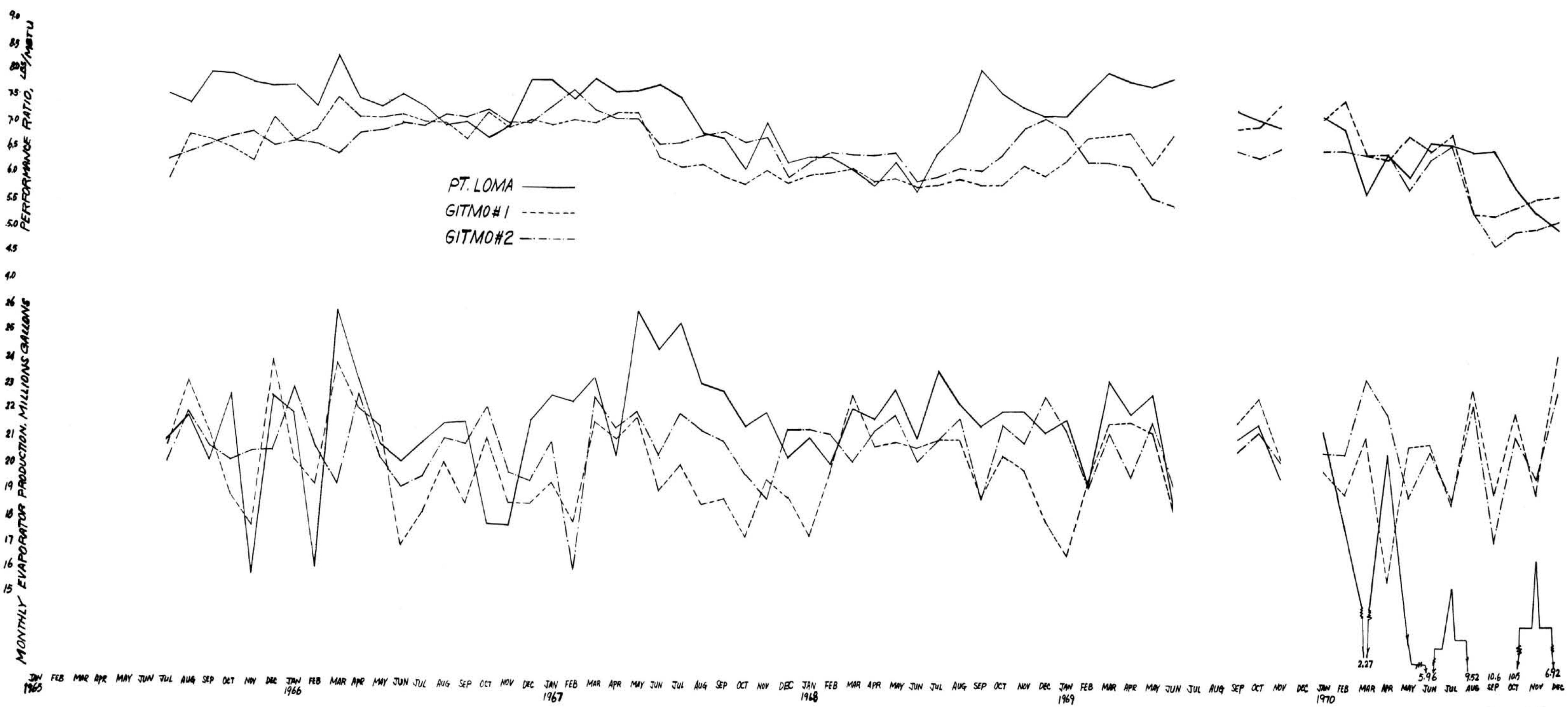
Figure 5-14 shows the monthly plant performance ratio (7) and monthly evaporator production (7) for the three plants from 1965 through 1970. The figure shows no significant deterioration and trend for the three plants in the six years of operation, except in 1970. In 1970 the Point Loma unit production dropped because of outages for maintenance services. Throughout the six year operation regular maintenance services for the three plants permitted realization very nearly the designed performance ratio. The Point Loma unit average was about 3.7% lower than the design performance ratio of 7.5 lb/Mbtu, while the Gitmo #1 and #2 units were about the same as the design performance ratio of 6.6 lb/Mbtu.

The performance ratio of the Point Loma unit had a low monthly average of 5.17 lb/Mbtu in December, 1970 and a high of 8.35 lb/Mbtu in May, 1966. The overall six year average was 7.22 lb/Mbtu from 1965 to 1970. The Gitmo #1 unit had a low monthly average of 5.43 lb/Mbtu in September, 1970 and a high of 7.61 lb/Mbtu in February, 1970. The overall six year average was 6.61 lb/Mbtu from 1965 through 1970. The Gitmo #2 unit had a low of 4.87 lb/Mbtu in September, 1970 and a high of 7.40 lb/Mbtu. The overall six year average was 6.58 lb/Mbtu from 1965 through 1970.

The evaporator water production of the Point Loma unit had a low of 2.3 million gallons for March, 1970 and a high of 26 million gallons for May, 1967. The overall six year average was 19.8 million gallons per month. The Gitmo #1 unit had a low of 12.5 million gallons in January, 1965 and a high of 24.5 million gallons in December, 1970. The overall six year average was 20 million gallons per month. The Gitmo #2 unit had a low of 16 million gallons in February, 1967 and a high of 23.5 million gallons in March, 1970. The overall six year average was 20.7 million gallons per month.

In the six years of operation for the three plants the performance ratio was, in general, directly proportional to the water production except in a few cases, when one of the three plants had low production and high performance ratio. This could have been influenced by the extraction steam pressure from the turbines to the evaporator, the performance of the brine heater, or other variables.

Performance ratios for each of the three plants over the six year period are tabulated on Figure 5-15.



PERFORMANCE RATIO, LBS/MBTU
MONTHLY EVAPORATOR PRODUCTION, MILLIONS GALLONS
PT. LOMA
GITMO#1
GITMO#2
2.27
5.96
9.52
10.6
10.5
6.92
1965
1966
1967
1968
1969
1970

Figure 5-14

	Pt. Loma						Gitmo #1						Gitmo #2					
	Performance Ratio, lb/Mbtu						Performance Ratio, lb/Mbtu						Performance Ratio, lb/Mbtu					
	1965	1966	1967	1968	1969	1970	1965	1966	1967	1968	1969	1970	1965	1966	1967	1968	1969	1970
Jan.		7.78	7.89	6.47	7.28	7.32		6.71	7.03	6.13	6.44	7.27		6.71	7.03	6.13	6.44	7.27
Feb.		7.37	7.53	6.47	7.74	7.07		6.94	7.14	6.18	6.87	7.61		6.94	7.14	6.18	6.87	7.61
Mar.		8.35	7.93	6.24	8.12	5.83		7.55	7.08	6.26	6.91	6.60		7.55	7.08	6.26	6.91	6.60
Apr.		7.54	7.69	5.94	7.95	6.60		7.17	7.29	6.00	6.97	6.50		7.17	7.29	6.00	6.97	6.50
May		7.38	7.70	6.39	7.87	6.18		7.17	7.28	6.08	6.38	6.96		7.17	7.28	6.08	6.38	6.96
Jun.		7.60	7.82	5.82	8.01	6.81		7.22	6.44	5.91	6.93	6.67		7.22	6.44	5.91	6.93	6.67
Jul.	7.56	7.36	7.58	6.56		6.78	5.97	7.09	6.26	5.97		7.00	5.97	7.09	6.26	5.97		7.00
Aug.	7.41	7.01	6.91	6.99		6.65	6.80	7.07	6.31	6.07		5.49	6.80	7.07	6.31	6.07		5.49
Sep.	8.00	7.09	6.82	8.17	7.41	6.69	6.71	6.76	6.09	5.96	7.07	5.43	6.71	6.76	6.09	5.96	7.07	5.43
Oct.	7.99	6.79	6.22	7.72	7.24	5.96	6.55	7.26	5.95	5.97	7.12	5.57	6.55	7.26	5.95	5.97	7.12	5.57
Nov.	7.83	7.02	7.12	7.45	7.10	5.49	6.32	6.98	6.21	6.34	7.52	5.76	6.32	6.98	6.21	6.34	7.52	5.76
Dec.	7.75	7.89	6.36	7.28		5.17	7.15	7.13	5.97	6.14		5.81	7.15	7.13	5.97	6.14		5.81

Figure 5-15

PERFORMANCE RATIO FROM 1965 TO 1970

5.4.5 On Stream Availability

When product water storage is at a high level, a shutdown of one plant may be required. This outage does not affect the availability of the water plant. The on stream availability includes water storage, high level outage time, plus on stream time (Section 5.2.2).

Figures 5-16 and 5-17 show the percent of on stream availability for the three plants from 1965 through 1970. The Pt. Loma unit had a yearly low of 71.81% in 1970 and a yearly high of 96.47% in 1967. The overall six years' average was 91.58%. The Gitmo #1 unit had a yearly low of 92.82% in 1970 to a yearly high of 96.12% in 1968. The overall six year average was 95.14% from 1965 through 1970. The Gitmo #2 unit had a yearly low of 94.70% in 1970 to a yearly high of 98.63% in 1965; the overall six year average was 96.61% from 1965 through 1970.

Figure 5-18 shows the outage for water storage in high level for each of the three plants from 1965 through 1970.

Year	Pt. Loma		Gitmo #1		Gitmo #2	
	% Outage-Water Storage at High Level	% of On Stream Availability	% Outage-Water Storage at Hi. Level	& of On Stream Availability	% Outage-Water Storage at Hi Level	% of on Stream Availability
1965	5.19	94.63	4.94	95.95	3.50	98.63
1966	2.79	94.92	2.76	94.76	2.37	96.24
1967	1.20	96.47	0.53	95.32	1.71	95.76
1968	0.00	95.85	0.00	96.12	0.00	97.30
1969	0.00	95.81	0.06	95.87	0.00	97.01
1970	4.05	71.81	0.67	92.82	0.78	94.70

Figure 5-16

Water Plant On Stream Availability

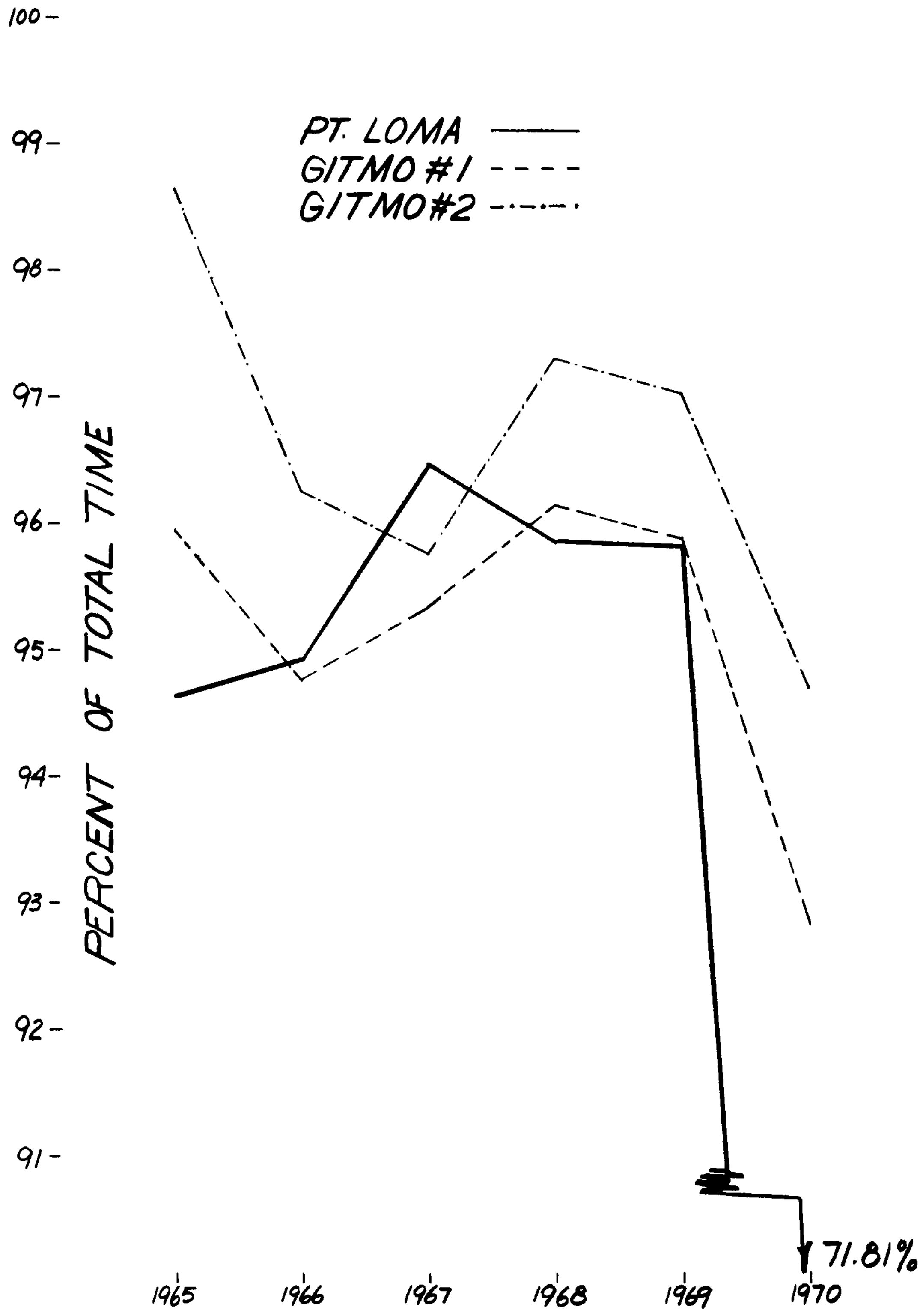


Figure 5-17
ON STREAM AVAILABILITY

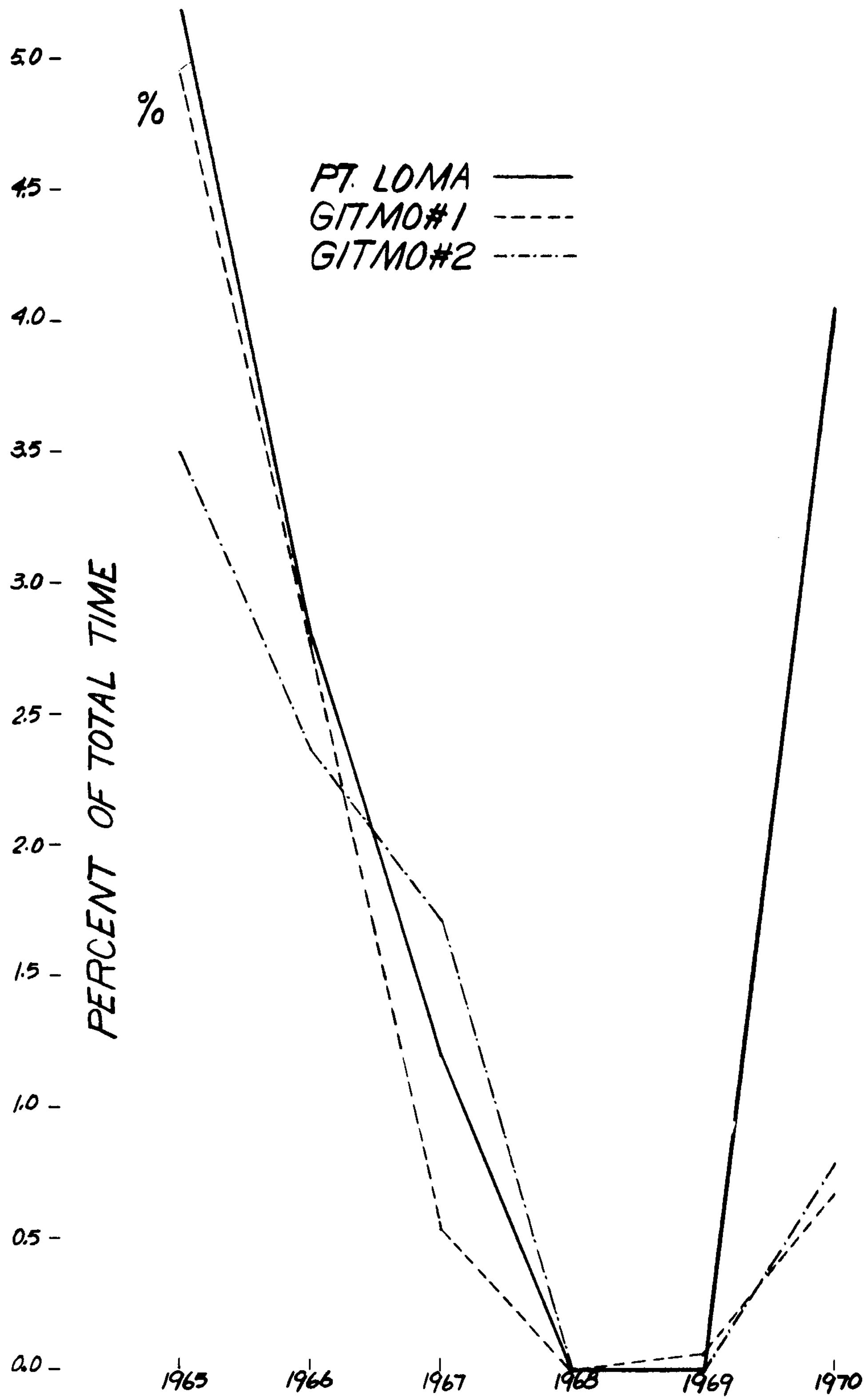


Figure 5-18

% OUTAGES FOR WATER STORAGE AT HIGH LEVEL

6.0 EVAPORATOR PLANT OPERATIONS

6.1 Procedures

6.1.1 Start-up

Start-up procedures as described here are not detailed and refer to "normal start-up". Normal start-up implies that the evaporator unit is cold and that all valves, switches, etc. had been properly opened or closed as the case may be. It is also assumed that normal start-up will be followed by operation of the evaporator unit for an appreciable length of time at rated capacity. This start-up procedure is to be followed only when adequate utilities are available, including steam, electrical power and instrument compressed air.

Normally, one evaporator unit is started up at one time, and it is assumed that chlorine-treated circulating seawater supply is adequate, Hagevap solution properly mixed and available, and post-treatment facilities available and operating. The initial charge of seawater must be accompanied with Hagevap injection in all evaporators.

6.1.1.1 Pt. Loma Evaporator Start-up (12)

1. Check that suction valves on all pumps are open and that discharge valves are cracked open. Check that A & B Hagevap tank levels are adequate.

2. Admit seawater to unit and close down on seawater reject valve to insure sufficient cooling for SJAE condensers.

3. Start filling vessel to start-up level. When level in 28th stage reaches approximately 36", secure filling vessel with 6" in the 1st stage.

4. Check and start air ejector. Admit steam and adjust to 500 psi steam pressure; start pulling vacuum.

5. Start one recycle pump on split system and start pumping brine to brine heater and first stage. Check FRC valve. Vent water boxes. Adjust valves to maintain 75 lb. back pressure on brine heater.

6. Drain and warm up L.P. steam line. With recycle flow established, open L.P. steam line stop and start feeding steam to brine heater. When condensate is at normal level, start brine heater drain pumps. Control room operator must feed steam slowly so as not to place too much load on turbine extraction or boilers.

7. Start Product Pump. Maintain approximately 2" level from top of glass in 28th stage product trough. Open city water supply to raise level and open reject valve to lower level.

8. Start hogger. As brine temperature reaches 170°F and vacuum is 26" Hg. or more, secure hogger and start increasing brine flow and increasing brine temperature.

9. Start blowdown pump and have control room operator add make-up. Start Hagevap pump. Maintain 28th stage temperature below 120°F by adding make-up to increase the blowdown.

10. Open product water reject valve and, as product water becomes acceptable (by chemical test), open valve to lime pit and secure reject valve.

11. Increase chlorine and fluoride injection.

6.1.1.2 Gitmo #1 and #2 Evaporator Start-up (12)

1. Check that suction valves on all pumps that are to be used are open and discharge valves are cracked open. Check that the Hagevap tank level is adequate.

2. Admit seawater to unit. On Gitmo Unit #1, close down on seawater reject valve to insure sufficient cooling for SJAE condensers.

3. Fill vessel to approximately 24" in 15th stage, and, if necessary, operate brine extraction pump. Control extraction pump discharge valve to maintain at least 6" level in 15th stage.

4. Start circulating cooling water through SJAE condensers. Admit steam to Air Ejector and adjust to 500 psi steam pressure and start pulling vacuum on unit.

5. Start brine flow and vent water boxes.

6. With recycle flow established, admit steam to brine heater and start condensate pump when condensate reaches normal level.

7. Start hogging ejector as vacuum reaches 15" and secure hogging ejector when vacuum reaches 26".

8. Increase brine flow while increasing brine temperature.

9. Start Hagevap injection and bring unit up to capacity production.

10. Chemically test product water and, when acceptable, shift flow from reject to lime pit and post-treatment.

6.1.2 Shutdown

Shutdown procedures described here refer to "normal shutdown", which means the systematic, unhurried cessation of operations of a particular plant. The described procedures are general and not intended for instruction of evaporator operators.

6.1.2.1 Pt. Loma Evaporator Shutdown

1. Send Product to waste, open product dump valve, shut off control air supply to automatic valve, and secure product valve to lime pit.

2. Secure Hagevap pump. Check back pressure on product master meter (1-2 lb). Keep a close check on lime bed level and reduce chlorine and fluoride feed.

3. Secure air ejector, securing the air extraction valves first to maintain vacuum on unit and hold levels in 28th stage.

4. Control Room operator starts lowering steam flow to brine heater until brine temperature out of heater reaches 140°F, at which time steam is completely shut off. Shut down brine heater condensate pumps.

5. Control Room operator will lower brine flow. When brine temperature out of brine heater reaches 130°F the recycle, blowdown and product pumps are stopped. As much make-up as can be blown down is taken in to help cool the recycle brine. City water is used to maintain product level in the 28th stage.

6.1.2.2 Gitmo Evaporator Shutdown (12)

1. Send product to waste and reduce chlorine and fluoride feed.

2. Start decreasing steam flow and brine recycle flow with steam decreasing at a faster rate.

3. Secure one set of brine recycle pumps when brine flow reaches 3,400 gpm.

4. Maintain 300 gpm cooling water flow through SJAE condensers; maintain 3/4 glass in 15th stage product trough, maintain at least

6" in 15th stage gage glass, taking on additional make-up, if necessary.

5. Shut off steam flow when brine flow reaches 2,000 gpm; shut off brine heater condensate pump.

6. Shut down remaining brine recycle pumps when brine outlet temperature reaches 130°F.

7. Shut off blowdown, make-up, Hagevap feed, and steam to SJAE.

8. Fifteen (15) minutes after steam is shut off SJAE, shut off SJAE cooling water.

9. Shut down product pump.

10. Open drains, break vacuum on vessel.

6.1.3 Emergency Procedures

6.1.3.1 Emergency Shutdown (12)

Emergency partial shutdown procedures are put into operation when unexpected plant difficulties develop which result in inadequate supply of steam at desired pressure. The steam supply to any operating brine heater is reduced by one half, and the operator closely monitors steam supply. If steam failure is quickly overcome, normal operations are resumed. If steam failure persists, all efforts are made to maintain turbine-generator operations to avoid electric power failure. The steam supply to the brine heaters is completely shut off; distillate is diverted to waste; brine recycle control valve bypasses are opened and the recycle valves slowly closed; and brine heater condensate pumps are shut down. The steam supply to the steam jet air ejectors is shut down and valves operated to bottle up vacuum. If steam failure is corrected before electric power failure, the evaporator plant is started up, using start-up procedures somewhat different than the normal start-up, depending on the length of time steam was not available.

If loss of instrument air occurs before, or without, loss of power, certain valves will close automatically, and manual control will be required to maintain brine level in the last stage. It may be necessary to shut down recycle pumps or extraction pumps, as the case may be.

If steam and electric power fail, emergency full shutdown is carried out. In addition to previously described emergency measures, certain recorder controllers are backed off to zero settings, and one of the seawater circulating pumps is tripped out. Start-up of evaporators is not attempted until normal quantities of high-pressure and low-pressure steam, electric power, and instrument air are again available or can be made instantly available.

6.1.3.2 Pt. Loma Product Pump Emergency (7)

The Pt. Loma unit was installed with a single product pump. On occasion, such as March, 1968, it has been necessary to remove the product pump from service for maintenance or replacement of parts. In order to maintain the Pt. Loma unit in service, while the product pump is down, piping and valving was installed to allow the blowdown pump to serve as product pump and recycle pump to handle blowdown. After repair and reinstallation of the product pump, all pumps are returned to normal service.

6.1.4 Response Time for Start-up and Shutdown

Normal response time for start-up is approximately 1½ hours to bring recycle flow and operating temperatures to normal. Normal shutdown time is one hour to bring recycle brine temperature down to 140-150^{o}F, at which point the steam valve may be closed. Thirty (30) minutes is adequate time to shut down sufficiently for certain emergency repairs that do not require complete shutdown. Recycle brine temperature should be reduced to 130^{o}F prior to stopping units.

The Pt. Loma unit will begin to produce product at brine temperature of 175^{o}F, while the Gitmo units will begin to produce product with 185^{o}-190^{o}F brine temperatures.

Except for initial shakedown, there has been little change in start-up and shutdown response time. However the responsibility for start-up and shutdown operations has been shifted from the shift engineer to the evaporator operator.

6.2 Normal Chemical Treatment

Seawater is corrosive to many metals but is an excellent medium for marine growth and shellfish. Screens remove fish and other larger objects but allow passage of smaller living matter. Thus, chemicals are used to control corrosion and to inhibit marine growth.

Chlorine is injected into the seawater inlet piping, usually for 15 minutes each hour, to kill living organisms.

A phosphate solution, made with Hagevap and fresh water, is injected into the makeup seawater to control scaling of heat transfer surfaces.

Anti-foam may be used to reduce consumption of Hagevap (See section 6.2.1).

Sulfuric acid is injected into the evaporator units periodically, as needed to clean the system or portions thereof.

6.2.1 Hagevap Treatment

Hagevap, a dry phosphate compound, when mixed with fresh water, (one pound of Hagevap to 3-3/10 gallons water) is injected into each evaporator brine makeup line. This solution controls scale formation, and except at low dosages, also controls foaming and carryover.

Initially, at Gitmo, the recommended addition of Hagevap was 56 lb/day per evaporator unit, or at 3 ppm. By late November, 1965 this was reduced to 2.7 ppm. In April, 1967 tests [7] were made which indicated that Hagevap could be reduced to 1.3 ppm on all evaporator units with the addition of Hagen formula C-100 anti-foam at one pint/day per unit.

The September, 1970 monthly report [7] states that Hagevap is required when the evaporators are operated at approximately 195°F brine heater outlet temperature. However, the amount of Hagevap was reduced to 0.6 ppm. "It appears that more or less than 0.6 ppm injection decreases the time between sulfuric acid cleaning..."

During 1970, based on design rate of brine makeup, the average concentration of Hagevap per month follows;

Month	Hagevap
February	1.6 ppm
April	1.6 ppm
May	1.7 ppm
June	0.94 ppm
July	1.3 ppm
August	0.75 ppm
September	0.74 ppm
November	0.38 ppm

Note that above concentration rates are based on brine makeup rate.

6.2.2 Sludge Buildup and Effects

A study was reported in August, 1967 [8] on the effect of sludge buildup on recycle brine tubes. This applied to Gitmo #2 at Guantanamo Bay, Cuba.

While Hagevap does inhibit scale formation on evaporator heat transfer surfaces, up to a maximum brine temperature of about 195°F, the adherent sludge reduces heat transfer and increases flow friction loss. Tests were made before and after sulfuric acid cleaning of the recycle brine system, in March and in April, 1967.[8] The results are briefly summarized here:

(a) Acid cleaning reduced the pressure drop across the 12 heat recovery stages by 8-9 psi, or about 13%, and heat transfer was improved 30%.
(b) Pressure reduction through the brine heater after acid cleaning was nil; however, the steam condensate temperature from the brine heater was reduced 7-8°F indicating improved heat transfer.
(c) The temperature rise for brine at 5700 gpm through the brine heater remained at 14-15 °F for the two series of tests before and after acid cleaning. However, the overall heat transfer U-value was improved about 30% by acid cleaning the brine heater.

Acid cleaning improved the performance ratio from about 6.3 to 7.0 lb of product water per pound of steam.

It was indicated in the report [8] that sulfuric acid is effective in removing sludge formed at brine outlet temperatures below 180°F. However, it appears to be much less effective at higher brine operating temperatures (185-200°F).

6.2.3 Cleaning Procedures for Each Evaporator

Adherent sludge is removed weekly by recirculating sulfuric acid cleaning while the evaporators are in operation producing product water. Excessive sludge formation is indicated by an increase in brine heater condensate temperature beyond normal level.

The normal procedure is to inject sulfuric acid into the evaporator seawater makeup stream, maintaining the brine recycle at a pH value above 7.0 for approximately 4-5 hours, at other times up to 48 hours (January 1, 1967 on Gitmo #1). Occasionally, sulfamic acid has been used in the past, particularly when the brine heater needs a more effective acid to remove adherent sludge. Sulfamic acid is not presently used for cleaning.

The pH value of the recycle brine is maintained by taking grab samples of brine, making a pH determination on the sample, and adjusting acid feed rate as required.

When acid cleaning is inadequate, mechanical cleaning, drilling or lancing of tubes is done. For this type of cleaning the evaporator must be shut down. In January of 1968 [7] the tubes of one brine heater were severely plugged with hard deposits and had to be cleaned mechanically. Tubes may be lanced using air or water, depending on the nature of the material to be removed.

6.2.4 Criteria for Cleaning

The pressure drop across the tube side of the brine heater gives an indication of the amount of scale formed. The normal pressure drop through Gitmo #1 or #2 brine heaters is about 2 psi. A high pressure drop, such as the 11 psi drop experienced on March 8, 1967, indicates need for cleaning.

Higher than normal condensate temperature from the brine heater is the best indication of need for acid cleaning the brine heater tubes.

Another criteria for cleaning is the brine temperature out of the last heat recovery stage. A higher-than-normal brine temperature indicates low performance and may indicate need for acid cleaning.

6.2.5 Effect of Dose Variation (6,7)

Chlorine, added to seawater to control marine growth, is varied according to need. Daily amount of chlorine injection has varied from 250 lb/day down to 31 lb/day. Injection periods have varied from 10 minutes every hour at 1500 lb/day rate down to 10 minutes every 8 hours at 1500 lb/day rate. The feed rate has been as low as 500 lb/day rate.

Chlorine injection is increased when marine growth appears to be great and decreased when possible to reduce chemical cost. The chlorine residual has varied from 0.4 ppm to 2 ppm during injection period and is checked regularly.

Chlorine is also used in the product water. A small amount is added to the distillate just before the lime bed to control algae growth on the limestone or coral. More is added after the lime bed for final treatment of product water in storage. The feed rates are varied, according to need based on analyses.

Hagevap added for scale control to seawater makeup has ranged from 4 ppm down to 0.6 ppm with brine heater outlet temperatures of 195-200°F. At brine temperatures above 200°F, sulfuric acid alone is used continuously with anti-foam. At the normal brine temperature of 195°F, Hagevap can be used in conjunction with sulfuric acid for scale control. In a report of June 4, 1970 [7] Hagevap was reduced from 4 ppm to 2 ppm when sulfuric acid was added, but at no reduction in combined Hagevap and acid chemical cost. As Hagevap is reduced, anti-foam must be added to control foaming. (See, also, section 6.2.1 on Hagevap treatment.)

Sulfuric acid is used for periodic acid cleaning of the evaporator units as described in section 6.2.3. It is also used continuously with anti-foam, without Hagevap, for scale control, when the brine heater is operated above 200^{o}F to increase evaporator output. (The water production increases with increased brine temperature.) The pH is maintained at 7.5 to 7.8 at these higher brine temperatures.

Fluoride used for treating product water is added at rates to maintain drinking water standards of U.S. Department of Health and Welfare (0.8 ppm maximum at 90.5^{o}F). See Figure 7-3 on treated water analysis.

Hexametaphosphate is added as a post-treatment to product water before storage. It is added to control corrosion of the base water supply system within reasonable limits. It has been used since 1967 and averaged about 3 ppm in 1969.

Limestone, coral and lime are used to raise the pH value of the product water in the lime bed. When the non-carbonate hardness is not sufficiently high to meet drinking water standards, lime is added after the lime bed which is also called the "coral bed".

A summary of treated water analyses for years 1964 through 1969 is shown in Figure 7-3.

6.2.6 Consumption of Chemicals

Chemicals used for seawater treatment, product water treatment, and post-treatment of product water are shown in Figure 6-1.

For all three evaporators the chemical consumption has decreased for Hagevap, chlorine and fluoride. Chemical consumption has increased for sulfuric acid, anti-foam and hexametaphosphate.

6.2.7 Cost of Chemicals for Treating Evaporator Seawater and Product Water

The evaporator chemical cost for all three evaporators for a twelve-month period from June, 1965 through May 31, 1966 was reported [10] to be $0.052 per 1,000 gallons of product water.

CHEMICAL	6/1/65-5/31/66[10]	1966[a]	1970
Chlorine, lb			
For Seawater	36,500		
For Prod. water	27,400		
Sub-total	63,900	42,400	28,000
Hagevap, lb	55,300	36,000	15,900
Anti-Foam, pt	-	-	915
Sulfuric acid, lb	64,800	145,000	513,000
Sulfamic acid, lb	-	5,600	-
Fluoride lb	-	7,930	5,000
Hexametaphosphate, lb	(not used)	(not used)	24,300
Limestone, lb	1,100,000	78,000	78,000 (est.)
Lime, lb	-	-	36,000 (est.)

(a) Chemicals based on first four months, intended for inventory control. Note that (a) overlaps with (10).

Figure 6-1

YEARLY CHEMICAL REQUIREMENTS
FOR THREE EVAPORATORS AT GITMO

By early 1967 additional chemicals were added for post-treatment of the product water on the way to base storage tanks (to reduce corrosion in the base supply system).

The total cost of all chemicals used by the three evaporators in 1970 was $0.056 per 1000 gallons of product water and included seawater treatment, product water treatment and post-treatment of the product water.

A detailed cost of chemicals used in 1970 is included in Figure 6-2.

6.3 Acid Treatment Tests

6.3.1 Description of Tests

The sulfuric acid pretreatment tests were all conducted during production operation of the evaporators. Data was collected to the extent permitted by production equipment and facilities and the time available to the production crew.

6.3.2 Effect on Top Temperature, Capacity and Heat Rate

During 1970 [6] tests were made for extended periods with heated brine at higher than normal Gitmo temperatures. To control scale sulfuric acid was used for some of these runs. A summary of average data collected for six periods of evaporator operation for Gitmo No.1 and No.2 is shown in Figure 6-3.

For the test on Gitmo No. 1, sulfuric acid was used for pH control from August 13 through 17, 1970. Brine was heated to 237^{o}F and product water averaged 918,000 gallons per day and the heat rate 5.05 for the five-day period.

For seventeen days, July 2-18, 1970, Gitmo No. 1 was operated on pH control with sulfuric acid injected continuously to maintain pH at 7.5-7.8. For this period product water averaged 815,000 gpd, and the heat ratio averaged 7.07. See Figure 6-4 for more information.

Maximum and minimum values of reported data on all six test runs are shown in Figure 6-4 and 6-5.

During 1967 [29] and 1969 [30] acid treatment tests of shorter duration were run on the Pt. Loma evaporator. A summary of the test data is shown in Figure 6-6. As with the Gitmo units, the effect of acid treatment is an increase in top brine temperature, capacity and improved heat rate or performance ratio.

CHEMICAL	6/1/65-5/31/66 Avg. Mo.	Unit Cost	1970 Avg. Mo. Used	1970 Avg. Unit Cost	1970 Chem. Cost/Mo.
Chlorine:					
For seawater	2,280				
For Prod. water	3,040				
Sub-total	5,320 lb.	$0.07	2,328 lb.	$0.07	$ 163
Hagevap	4,600 lb.	$0.48	1,325 lb.	0.48	636
Anti-Foam	-	-	76 pt.	0.046	35
Sulfuric Acid	5,400 lb.	$0.10	42,728 lb.	0.039	1,662
Fluoride	-	-	416 lb.	0.12	50
Hexametaphosphate	-	-	2,024 lb.	0.122	248
Limestone	9,200 lb.	$0.01	6,500 lb. (est)	0.01	65
Lime	-	-	3,000 lb. (est)	0.05 (est)	150
Totals					$3,009

Total Chemical Cost Reported(10) for 12 months (6/1/65-5/31/66) was $38,540.
Product Water Produced in this Period (1,000 gallons) = 752,600
Cost of Chemicals per 1,000 gallons of Product Water = $0.052

1970 Chemical Cost 12 x $3,009 = $36,200
1970 Product Water (1,000 gallons) = 646,800
1970 Chemical Cost per 1,000 gallons of Product Water = $0.0558 or $0.056
Note: A considerable supply of limestone was available at this base. Estimated amounts of limestone and lime were used for 1970.

Figure 6-2

COST ESTIMATE FOR CHEMICALS USED FOR THREE EVAPORATORS AT GITMO FOR TREATING SEAWATER, PRODUCT WATER AND POST-TREATING PRODUCT WATER

Evaporator	Gitmo 2	Gitmo 2	Gitmo 1	Gitmo 1	Gitmo 1	Gitmo 1
Test Period	6/11-26	8/1-18	7/27-8/12	7/2-18	8/13-17	8/19-30
Days Tested	16	18	17	17	5	12
Avg. Steam Temp. to B/H	262°F	275	274	273	279	272
Avg. Steam Press. to B/H	20.4	25.1	24.8	24.1	26.6	23.7
Avg. Cond. Temp. from B/H	212	220	220	227	244	212
Approx.Brine Temp.from B/H	200	205	206	215	237	200
Avg. Steam Flow to Evap.	39,400	45,800	46,100	40,600	64,100	43,100
Avg. Water Prod (1000gpd)	695	730	793	815	918	678
Avg. Heat Rate $\left(\frac{\text{lb/prod}}{\text{1000 btu}}\right)$	6.8	5.54	6.13	7.07	5.05	5.60
Scale Control						
H_2SO_4 + Anti-foam for pH Control	No	Yes	Yes	Yes	Yes	No
Hagevap and lb/day	No	No	No	No	No	Yes,24
Acid Clean. during test	No	No	Yes,6 hr	No	No	No
No.Days after acid cleaning when tests started	1	3	1	1	10	16

Notes:
1. Evaporators generally in poor condition.
2. Escalated brine temperatures used when Pt. Loma Evaporator was secured for repairs.
3. Brine temperatures from brine heater taken for test periods July 27 - August 12, 1970 and August 13-17, 1970. Others were estimated.
4. All tests listed run in 1970.

Figure 6-3

SUMMARY OF SCALE CONTROL
ACID TREATMENT TESTS

Gitmo #1

Test	pH Control			pH Control		
Scale Control	Sulfuric Acid			Sulfuric Acid		
Test Dates	7/2-7/18/70			7/27-8/12/70		
Brine Heated to	Approx. 215°F			Brine at 206° Avg.		
	Max.	Min.	Avg.	Max.	Min.	Avg.
Product Water (1000gpd)	947	568	815	997	653	793
Evaporator Steam (1000 lb/da)	1,111	753	976	1,530	846	1,108
Steam Temp. to B/H (°F)	280	265	273	278	261	274
Steam Press. to B/H (psig)	25	23	24.1	26.3	19.4	24.8
Condensate from B/H (°F)	240	204	227	242	208	220
Brine Temp. from B/H (°F)	-	-	215	240	196	206
Heat Rate (lb Prod./1000btu)	8.02	6.25	7.07	7.61	5.11	6.13
Duration of Test	17 days			17 days		
Acid Cleaning	Before Test			Aug. 2-3 and Aug. 6 (6 hr)		

Test	pH Control			Hagevap at Higher Brine Temp.		
Scale Control	Sulfuric Acid			Hagevap 24 lb/da + 1 Pt. Anti-Foam		
Test Dates	8/13-17/70			8/19-30/70		
Brine Heated to	236.6°F Avg.			205°F Avg.		
	Max.	Min.	Avg.	Max.	Min.	Avg.
Product Water (1000gpd)	927	910	918	713	644	678
Evaporator Steam (1000 lb/da)	1,556	1,541	1,540	1,140	953	1,033
Steam Temp. to B/H (°F)	280	279	279.4	279	259	272
Steam Press. to B/H (psig)	27	26	26.6	27.6	17.5	23.7
Condensate from B/H (°F)	244	243	243.6	215	208	212
Brine Temp. from B/H (°F)	237	236	236.6	-	-	200
Heat Rate (lb Prod./1000btu)	5.11	4.98	5.05	6.01	5.10	5.60
Duration of Test	5 days			12 days		
Acid Cleaning	No			No		

Figure 6-4

TESTS ON EFFECT OF TOP TEMPERATURE CAPACITY AND HEAT RATE

Gitmo #2

Scale Control	None			Sulfuric acid + 1 Pt. Anti-Foam		
Test Dates	6/11-26/70			8/1-19/70		
Brine Heated to	Normal Temperature			205°F		
	Max.	Min.	Avg.	Max.	Min.	Avg.
Product Water (1000gpd)	733	638	695	880	568	731
Evaporator Steam (1000 lb/da)	969	758	860	1,482	878	1,100
Steam Temp. to B/H (°F)	270	253	262	283	269	275
Steam Press. to B/H (psig)	26.2	16.9	20.4	26	24	25.1
Condensate from B/H (°F)	216	203	212	240	203	220
Brine Temp. from B/H (°F)	-	-	(est.) 200	-	-	(est.) 205
Heat Rate (lb Prod/1000btu)	8.13	6.23	6.80	6.35	4.56	5.54
Duration of Test	16 days			18 days		
Acid Cleaning	Just before test			3 days before test		

Figure 6-5

TESTS ON EFFECT OF TOP TEMPERATURE,CAPACITY AND HEAT RATE

Test Period	April, 1967	March 26, 1969
Hours Tested	36	2
Average Steam Temperature to Brine Heater, °F	-	270
Average Steam Pressure to Brine Heater, psig	-	19
Average Condensate Temperature from Brine Heater, °F	-	236
Approximate Brine Temperature from Brine Heater, °F	211	215
Average Steam Flow to Brine Heater, lb/hr	-	39,318
Average Water Production, 1,000 gpd	913.3	1,065.6
Average Product Water Temperature, °F	100	108
Average Heat Rate, lb Prod/1,000 btu	8.48	9.72
Scale Control H_2SO_4 + Anti-foam	yes	yes
Recycle Brine Concentration Ratio	1.5	1.5
pH	7.8	7.5

Figure 6-6

PT. LOMA ACID TREATMENT TESTS

6.3.3 Conditions Affecting Blowthrough

Acid treatment tests which were for the purpose of exploring possibilities and economics of greater water production were conducted at higher brine temperatures ranging from 200 to 240°F. The higher brine temperatures result in higher stage pressures and higher stage pressure drops, particularly with increasing pressure difference per degree at higher temperatures.

In preparing for the tests with acid pretreatment of the seawater makeup, consideration was given to the possibility of blowthrough due to increased flashdown per stage.

Since the Pt. Loma and Gitmo units were designed for 250°F brine temperature, no problem with orifice sizes was foreseen, and no problem with blowthrough was experienced during the acid treatment tests.

The tests were conducted for a relatively short period of time, and operation at elevated temperatures was not expected to continue. Should the evaporators be run indefinitely at an elevated temperature, temperature profiles would be obtained and the orifice openings reset, if necessary.

6.3.4 Acid Consumption for Tests

Acid consumption for acid pretreatment is approximately 110 ppm [31] or for a makeup flow of 781,000 lb/hr, the acid feed rate is 86 lb/hr when producing water at design rate of 750,000 gpd and 1.5 brine concentration. As the production rate increases, makeup and acid feed rates increase proportionately.

Since Hagevap is not used with acid pretreatment, a very small amount of anti-foam agent is also added.

6.3.5 Treatment Costs

Cost of sulfuric acid for tests is assumed to be $.04/lb delivered in 55 gal drums.[30] The $.04/lb does not include an in-plant handling cost for dumping drums. Drums have been dumped by labor drawn from the operating crew, but this practice would not be satisfactory for the larger quantities of acid required for continued complete acid pretreatment. Unit cost of acid at $.04/lb is $.11/1,000 gal of product.

If acid were delivered in bulk, the increase for acid treatment versus Hagevap treatment could be approximately $.05/1,000 gal product. Tests indicated improvement in heat rates of over 20% (See Figure 6-6) increase above design. A 10% improvement in heat rate should more than offset a $.05/1,000 gal increase in chemical cost due to acid treatment versus Hagevap treatment.

6.3.6 Conditions Affecting Blowdown

With normal heated brine temperature the brine concentration ratio is held at about 1.5. The blowdown flow rate for these conditions has varied from 1245 gpm in 1964, 1350 gpm in 1965, down to 850 in 1969 for Gitmo #1 and #2. In 1970, when sulfuric acid was used in Gitmo #2 for pH control, with 1.8 brine concentration and at brine temperatures 200°, 212° and 240°F, the blowdown flow was decreased to 440-510 gpm to reduce consumption of acid. These were short test runs conducted on September 23 and 24, 1970, and more data is shown on Figure 6-7 and 6-8.

6.4 Performance of Evaporator

6.4.1 Performance Ratio

6.4.1.1 Effect of Sludge Build-up

The adherent sludge build-up on the evaporator heat transfer surfaces reduces the performance ratio by decreasing heat transfer, and increases resistance to flow of evaporator feedwater through heat exchanger tubes.

Tests [(8)] were made before and after acid cleaning of the evaporator. Based on measured product water flow and brine heater steam flows, the results of the tests show an increase in performance ratio following acid cleaning. Tests No. 1 and No. 2 show performance ratio improvements of 6.5 to 7.0 and 6.1 to 7.0, respectively. (See Section 6.2.2, Sludge Build-up and Effects)

6.4.1.2 Change Over a Period of Time

The change in the performance ratio over the six-year period is relatively small compared to the overall performance ratio average. Figure 5-14 shows no significant deterioration or trend for the 3 plants in the six years of operation. (See, also, Section 5.4.4)

Tests [(8)] were made over a period of 24 hours without acid cleaning for sludge build-up versus performance ratio based on product water and brine heater steam. The results of the tests show a decrease in the performance ratios from 6.75 to 6.67 for Test No. 1 and 6.2 to 6.1 for Test No. 2.

6.4.1.3 Effect of Decrease Dosage of Hagevap

Throughout the six-year period dosage of Hagevap had been reduced three times and sulfuric acid dosage increased. (See, also, Section 6.2.5) In Figure 5-14 performance ratios from 1965 through 1970 show little change with the decreased dosage of Hagevap during this period. (See, also, Section 5.4.4)

6.5 Discussion of Data on Operating Variables

Figures 6-7, 6-8 and 6-9 list test data on operating variables. Tests are made infrequently and usually when attempting to isolate some deficiency such as restricted flow, poor heat transfer, high temperature of brine heater condensate, high temperatures of recycling brine from the last stage, or when comparative data are requested.

6.5.1 Temperatures

6.5.1.1 Brine Temperature

During 1970 there was need and an opportunity to operate Gitmo #1 and #2 with escalated brine tempeatures. Data were assembled to indicate the relationship between brine heater outlet temperatures and the resulting product water output.

Although these evaporators were known to be in poor condition, there was need to obtain more product water while the Pt. Loma evaporator was down for repairs. In addition, this presented an opportunity to check several methods of scale control while operating at the higher brine temperatures necessary to obtain higher production.

Data used for this study were selected for the period between June 11, 1970 and September 30, 1970. Average values for periods of relatively uniform operation were plotted, Figure 6-10, showing water production versus brine heater outlet temperatures.

As was expected, the water production increased as the brine heater outlet temperature was increased.

It was not possible to hold all other variables constant during this period. However, averaging values for periods of relative uniformity yielded results that suggest a casual relationship between the two variables considered.

These tests on Gitmo #2 on September 23 and 24, 1970 are also plotted. These were short tests at three brine temperatures. These points

FLOWS	DESIGN DATA	2 OCT. 1964	26 MAR. 1965	27 MAY 1965	22 OCT. 1965	19 NOV. 1965	1-10 MAY 1968	29 NOV. 1968	31 JUN. 1969	11 AUG. 1969	1-7 AUG. 1969	5 MAY 1970	2-18 JUL. 1970	27 JUL.12 AUG.1970	13-17 AUG. 1970	11-30 AUG. 1970	1-30 SEP. 1970	1-3 JAN 1971
SEA WATER G.P.M.		5,400				6,270		3,900	3,750	4,400		3,700						
REJECT "		3,630				4,750				3,020		2,450						
MAKE-UP "		1,770				1,520				1,380		1,250						
BLOW DOWN "		1,245				1,020				850		820						
DISTILLATE "		525	542	542	540	500	492	505	555	530	518	430	565	554	638	470	443	607
RECYCLE "		6,150	6,180	6,150	6,000	5,500		6,000	5,900	5,700		6,100						
STEAM #/Hr.			37,300	40,200		37,500	41,000	38,000	39,000	39,500	33,800	35,100	40,600	46,100	64,100	43,100	42,000	51,500
TEMPERATURES °F																		
SEA WATER, IN/OUT		89/				80/96				89/103		85/92						
REJECT/MAKE-UP						96/96				103/104		92/92						
BLOW DOWN						94				100		112						
S.J.A.E., IN/OUT		97/102				92/												
STEAM, °F/P.S.I.G.			304.6/22.1	257/6.8	252/	250/15.1	274/21			270/19	251/13.4	258/	273/24.1	274/24.8	279/26.6	272/23.7	273/23	264/18.3
CONDENSATE			258.1	218	209	212	204			202	204.5	203	227	220	244	212	225	221
BRINE TO B/H			182.8	180.6	182	180		179	179	182		183						
BRINE FROM B/H		196	195.4	194	195	194		196	195	196		197	215 est.	206 est.	237 Ave.	200 est.	215 est.	
BRINE FROM 15th ST.		99	99		97	94			98	100		114						
DISTILL. FROM 15th ST.					93	92				98		111						
BRINE CONC. & or SP.GR			1.008	1.008	1.5/	1.036				1.5		1.029						
SCALE TREATMENT					HAGEVAP	HAGEVAP				HAGEVAP		HAGEVAP	H_2SO_4 Anti-Foam	H_2SO_4 Anti-Foam	H_2SO_4 Anti-Foam	HAGEVAP	H_2SO_4 Anti-Foam	
DAYS AFTER ACID CLEAN.			40	41	6	28	4		6	17	25 Av.	34	1	1	10	24#/day 16	29	
PERFORMANCE																		
PROD. WATER 1,000 G.P.D.		756	780	780	751	720	709	728	799	764	747	620	815	793	918	678	639	873
HEAT RATE #/1000 Btu			7.18	6.8		6.7	6.07	6.7	7.17	6.73	7.61	6.25	7.07	6.13	5.05	5.6	5.43	5.94
NOTES		Test	4 Hr.Test	4 Hr.Test	Test	Test	Ave.Value	Test	Test	Test	Ave.Values	Test Exclusive Press.Drop &High Temp. From 15th St.	(Scale Control Tests) 17 Days	17 Days	5 Days	12 Days	Ave.For Sept.	Ave.For 3 Days
REFERENCE		Temp. Profile (23)	20 PSIG Extract. Test Data (10)	10 PSIG Extract. Test Data (10)	Temp. Profile (23)	Evap. Perf.Data (22)	Mid.-Mid. (24)	Temp. Profile (23)	Temp. Profile (23)	Evap. Perf.Data (22)	Mid.-Mid. (24)	Evap. Perf.Data (22)	Evaporator Performance Data & Temp. Profile			(22,23)	Mo.Report Mid-Mid (7)	Mid.-Mid. (7)

Figure 6-7

GITMO #1

OPERATING VARIABLES - FLOWS & TEMPERATURES

FLOWS	26 MAR. 1965	27 MAR. 1965	22 OCT. 1965	27 MAY 1965	APR.-AUG. 1968	18 JAN. 1969	30 JAN. 1969	11-26 JUN. 1970	1-18 AUG. 1970	23 SEP. 1970	24 SEPT. 1970	24 SEP. 1970
SEA WATER GPM				5,750	4,240	4,500	4,350			3,600	3,600	3,600
REJECT "				3,880	2,800	2,960				2,600	2,600	2,630
MAKE-UP "				1,870	1,440	1,540				1,000	1,000	970
BLOW DOWN "				1,350	940	1,020				440	500	510
DISTILLATE "	522	466	520	520	500	520	525	482	507	560	500	460
RECYCLE "	5,860	5,410	6,200	6,000	5,570	5,900	6,000			5,600	5,800	5,800
STEAM #/Hr.	38,900	36,000		39,000		39,000	37,000	39,400	45,800	55,000	43,000	38,000
TEMPERATURES °F												
SEA WATER, IN/OUT				82.4/96.8		82/96				90/112	90/112	90/112
REJECT/MAKE-UP				96.8/96.8		96/96						
BLOW DOWN				95		96						
S.J.A.E. IN/OUT				95/100.4		96/100						
STEAM TO B/H, °F/P.S.I.G.	288.2/22.6	245/10.2	255/	245/12.5		267/		262/20.4	275/25.1	285/23	280/24	276/23
CONDENSATE FROM B/H		225	216	207		206		212	220	244	223	209
BRINE TO B/H	180.4	172.4	182	181.4		182	181			212	192	183
BRINE FROM B/H	193.9	185.8	195	194	195	196	194	200 est.	205 est.	240	212	200
BRINE FROM 15th ST.			97	94		96				118	111	109
DISTILLATE FROM 15th ST.			94	91								
BRINE RECYCLE, CONC.or SP.GR	1.008 in B/H	1.013 in B/H		1.034	1.5 Conc.	1.035				1.8 Conc. 1.046 S.g.	1.8/1.045	1.8/1.043
SCALE TREATMENT				HAGEVAP	HAGEVAP	HAGEVAP	H_2SO_4	NONE	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4
DAYS AFTER ACID CLEANING	40	41	11	4		3 (After down for Repairs)	1	1	3	33	34	34
PERFORMANCE												
PROD.WATER (DISTILLATE) 1,000 G.P.D.	752	671	750	750		750	756	695	730	806	720	735
HEAT RATE #PROD/1,000Btu	6.82	6.62		7.08		6.67	7.16	6.8	5.54	5.26	5.90	6.73
NOTES	4 Hr. Test Calc.St. Flow Ave.Values	4 Hr. Test Calc.St. Flow Ave.Values	Test	Test Adjust. Flows To Bal.	Avg. 12 Composite Samples Approx. one/wk 14 Apr.to	Test	Test	Scale Control Tests Without HAGEVAP 16 Day Ave.	18 Day Ave.	(Evaporator in Poor Condition. Tests run to provide data at several Brine Temps before sched. outage.)		
REFERENCE	20 P.S.I.G. Extract Test Data (10)	10 P.S.I.G. Extract Test Data (10)	Temp. Profile (23)	Evap.Perf. Data (22)	4 Aug.'68 Letter Reports (11)	Evap.Perf. Data (22)	Temp. Profile (23)	(24)	(24)	(22)	(22)	(22)

Figure 6-8

GITMO #2

OPERATING VARIABLES - FLOWS, TEMPERATURES

FLOWS	DESIGN DATA	31 AUG. 1964	2 OCT. 1964	26 MAR. 1965	27 MAR. 1965	17 DEC. 1965	4 FEB. 1969	26 MAR. 1969	10-12 OCT 1969
SEA WATER GPM			3,000					3,500	
REJECT "			990					1,700	
MAKE UP "		800/780	1,005/1,005					900/900	
BLOW DOWN "			1,415					1,060	
DISTILLATE "		572	595	546	462	533	555	740	
RECYCLE A/B "		3840/3920	3880/3880	6700 Tot.	6100 Tot.		3,000/3,000	3,000/3,000	
STEAM #/HR				41,000	38,205		33,000	39,320	34,600
TEMPERATURES °F.									
SEA WATER, IN/OUT								82/110	
REJECT/MAKE UP								110/110	
BLOW DOWN									
S.J.A.E. IN/OUT			119/127			104/109			
STEAM TO B/H, °F/PSIG				276/18.8	239/6.3			270/19	244/12.7
CONDENSATE FROM B/H				236	222			236/235	221/222
BRINE IN TO B/H				183.1	172.4		188	215/215	
BRINE OUT OF B/H		195/196	195/195	195.5	185		200	225/225	
BRINE FROM 28th St.		118/120	118/119					110/110	
DISTILLATE FROM 28th St.			119 to S.J.A.E			104		108	
BRINE RECYCLE, CON. &/OR SP.GR.				1.008 In B/H	1.008 In B/H			1.035/1.036	
SCALE TREATMENT								H_2SO_4 to ANTI-FOAM	
DAYS AFTER ACID CLEANING				40	41	24	6	34	17
PERFORMANCE									
PROD. WATER (DISTILLATE) 1,000 G.P.D.		806	857	786	666	768	799	1,066	700
HEAT RATE #PROD/1,000 BTU				7.01	6.19		8.33	9.72	7.10
NOTES		Test	Test	4 hr. Test Ave. Values	4 hr. Ave. Values	Test S.J.A.E.	Data Just Before Sched. Outage	Test	3 Day Ave.
REFERENCE		Temp. Profile (23)	Temp. Profile Adjust. (23)	20 PSIG Extract Test (10)	10 PSIG Extract Test (10)	S.J.A.E. Perf. Data (25)	Temp. Profile (23)	Evap. Perf. Data (22)	Mid.-Mid. (24)

Figure 6-9

POINT LOMA
OPERATING VARIABLES - FLOWS, TEMPERATURES

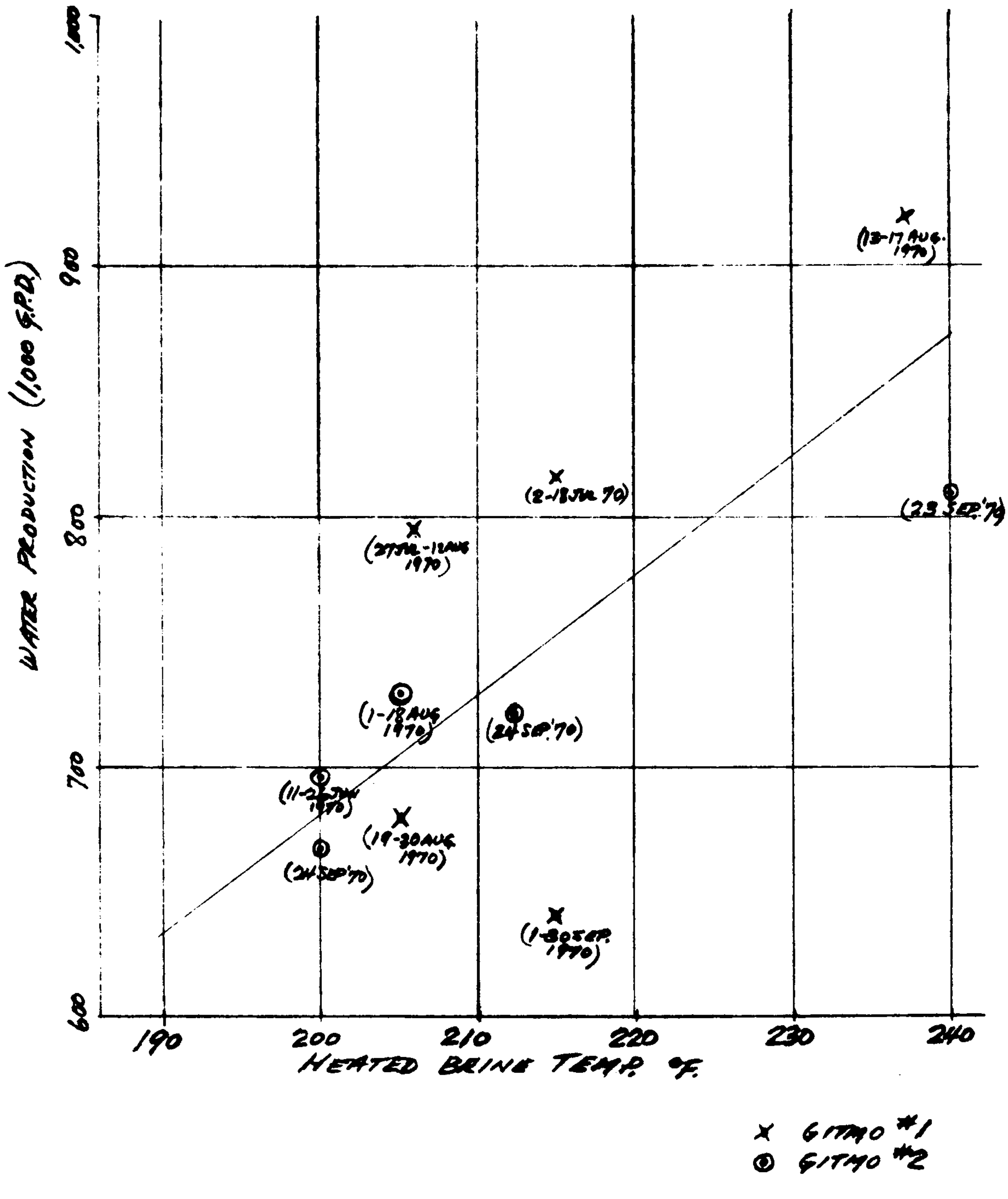


Figure 6-10

PRODUCT WATER VS. HEATED BRINE TEMP.

FORM BR 6002-1

correspond well to the straight line representing the average values for extended periods of operation.

6.5.1.2 Product Water Temperature

Test data for Gitmo #1 with seawater flow of 6,270 gpm shows distillate water from 15th stage at 92°F. Similar test data for the same evaporator with seawater flow of 4,400 gpm shows distillate water from 15th stage at 98°F. This higher temperature was partly due to higher seawater temperature on the same date.

As discussed in Section 4.4.4.1, the original evaporator installation produced product water at a higher temperature due to the use of product water for cooling the steam jet air ejector condensers. Pt. Loma SJAE performance data for December 17, 1965 [25] indicates an average temperature rise of 5.3°F for product water cooling the SJAE condensers.

6.5.1.3 Seawater Temperature

The reported seawater temperature at Gitmo has varied from 80°F to 90°F as noted on Figures 6-7, 6-8, and 6-9. The lowest reported temperature was in November, 1965 and the highest reported temperature in September 1970. In October, 1964 and April, 1969 89°F was reported.

The Singmaster and Breyer report of August 22, 1960 [5] reported available information on seawater temperature in the range of 77 to 88°F.

6.5.1.4 Blowdown Temperature

Blowdown temperatures of the Gitmo #1 and #2 units have normally operated at 94 to 100°F. Higher temperatures up to 112°F have been reported but are not normal and may be an indication of some malfunction and poor production. The Point Loma plant normally operates at 105°F Blowdown temperature.

6.5.1.5 Steam Temperature

Referring to data from Figures 6-7, 6-8, and 6-9, at normal heated brine temperatures (195°-200°F) steam temperature has varied from about 250°F at 12.7 psig used in 1965 to about 285°F at 23 psig used in 1970.

The steam temperature may be raised to overcome possible reduced heat transfer as sludge or scale builds up in the brine heaters. After cleaning the brine heater (with acid or mechanically as necessary) a lower steam temperature may be used. Steam temperature may also be increased to increase the brine heater outlet temperature when higher production rate is desired.

6.5.1.6 Condensate Temperature from Brine Heater

As a brine heater builds up with sludge and, thereby, heat transfer is reduced, the condensate temperature increases and is used as a guide for acid-cleaning the unit. In general, the condensate temperature increases as sludge builds up, even though the brine heater outlet temperature is constant.

With escalated brine temperatures necessary to obtain increased product water, the condensate temperature is correspondingly higher.

Brine heater condensate temperatures have ranged from 202°F to 244°F for the Gitmo units and from 221°F to 236°F for Pt. Loma.

6.5.2 Flows

Data on flows is tabulated in Figures 6.7, 6-8, and 6-9.

6.5.2.1 Heat Reject Cooling Water Flow

The Gitmo #1 and #2 seawater flow rates for heat reject cooling have varied from a maximum of 6,300 gpm to 3,600 gpm. The reported reason for low flow rate is the deterioration of the two seawater pumps. The direct effect of reduced seawater flow is higher temperature of the distillate water from the heat reject stages, higher blowdown temperatures and lower performance. The distillate temperature has varied from about 92°F in late 1965 to over 106°F in mid-1969 on Gitmo #1 and to about 109°F in September, 1970 on Gitmo #2 with brine heated to normal temperature of 200°F (maximum).

Variation in Pt. Loma seawater flow has been less than for the Gitmo units, with flow rate maintained at 3,500 to 3,000 gpm.

Reduction of seawater flow for reject cooling contributed to reduced product water production and lower performance ratios.

6.5.2.2 Recycle Brine Flow

The recycle brine flow has been held nearly constant for Gitmo #1 and #2 at approximately 6,100 to 5,500 gpm. For Pt. Loma the flow has varied from a total of about 7,760 gpm to about 6,000 gpm.

6.5.2.3 Product Water Flow

The product water flow for the units has been held close to the design rating; however, increasingly during 1969 and 1970 higher brine temperatures were maintained to overcome deficiency of heat reject cooling water flow and decreasing heat reject transfer surface due to plugged tubes, particularly in Gitmo #1 and #2 units.

At brine temperature of 195^{o}-200^{o}F water production for Gitmo #1 and #2 has varied from 525 gpm to 480 gpm, and for Point Loma, water production has varied from 580 gpm to 555 gpm.

At elevated brine temperatures Gitmo #1 has produced up to 638 gpm and Point Loma up to 740 gpm distillate product.

6.5.2.4 Steam Flow

The steam flow for the evaporators has been varied by adjusting the steam pressure to the brine heaters as demand for product water changes. Steam flows for the Gitmo Unit has varied from approximately 64,000 to 34,000 lb/hr and for Point Loma from approximately 38,000 to 33,000 lb/hr.

6.5.2.5 Makeup Flow

Makeup flow for Gitmo #1 and #2 units varied from approximately 4,700 gpm to 2,500 gpm at normal 1.5 concentration ratio. The higher rates were during higher production rates. When operating at a concentration ratio at 1.8 and rated production, the makeup rate for Gitmo #2 was approximately 1,000 gpm. Point Loma A/B makeup flow has varied from approximately 1,000/1,000 gpm to 800/800 gpm.

6.5.2.6 Blowdown Flow

Blowdown flow for Gitmo #1 and #2 has varied from approximately 1,300 gpm to 1,000 gpm during normal operations with 1.5 concentration ratio. Gitmo #2 blowdown rate, when operating at 1.8 concentration ratio, dropped to approximately 500 gpm. Point Loma blowdown flow was recorded at approximately 1,400 gpm at a production rate of approximately 857,000 gpd to 1,000 gpm at a production rate of 1,066,000 gpd.

6.5.2.7 Heat Reject Flow

By definition, Heat Reject Flow is the seawater flow for heat reject section cooling less makeup flow.

6.5.3 Chemical Analyses

During the summer of 1968[11] a series of chemical analyses were made on six evaporator flow streams. Samples were secured each hour for 24 hours from 0800 one day to 0800 the next. These samples were mixed to form composite sample for a 24-hour period. Chemical analyses of each composite sample were made approximately one week apart from April 14 to August 4.

A summary of all these analyses showing average values for twelve composite samples is contained in Figure 6-11.

During this test period brine was heated to 195°F; the brine concentration was 1.5, and Hagevap was used for scale control. Hagevap was used April 14 through May 5 at 3.5 ppm and was then reduced to 1.5 ppm for the balance of the sampling test period. With the reduced Hagevap, anti-foam C-1 was injected to stop carryover (priming).

During December, 1965 [6] chemical analysis of Gitmo #1 product, blowdown, and recycle streams was accomplished while operating at various operational conditions. Results of these analyses are shown in Figures 6-12, 6-13, and 6-14. Data for the period December 13, 1965 through December 21, 1965 was taken during operation with Hagevap pretreatment and brine heater outlet temperature of 195°F. Data for the period December 27, 1965 through December 29, 1965 was taken during operation with acid pretreatment and brine heater outlet temperature of 195°F. Recycle brine concentration was 1.5 throughout.

6.5.3.1 Evaporator Distillate

Section 7.2 discusses the range and average chemical analysis of the evaporator distillate for the years 1964 through 1970.

Samples for these tests were taken at the lime bed inlet before addition of any chemicals.

Figure 6-16 shows the chemical analyses of twelve composite samples of evaporator distillate for the period April 4, 1968 through August 4, 1968, as well as averages for each component for Gitmo #2.

Figure 6-12 shows the results of the 1965 tests on Gitmo #1 product water (distillate).

LINE NO.	REFERENCE SECTION	SAMPLE SOURCE	ALKALINITY P	ALKALINITY M	CALCIUM Ca	MAGNESIUM Mg	CHLORIDE Cl	SULFATE SO_4	SOLUBLE COPPER	SOLUBLE IRON	pH	VOLATILE SOLIDS	FIXED SOLIDS	INSOLUBLE COPPER	INSOLUBLE IRON	SUSPENDED SOLIDS	FLOW MILLION # PER DAY
1	6.5.3.4	SEA WATER PPM (AT PLANT BOUNDARY)	16	103	374	1,580	21,300	2,790	0.064	0.104	7.66	5.5	6.9	0.86	2.85	12.4	51.8
2	6.5.3.6	SEA WATER REJECT PPM	18	110	364	1,560	21,400	2,790	0.04	0.08	7.95	5.5	7.1	0.46	2.97	12.6	34.3
3	6.5.3.5	SEA WATER MAKE-UP OUT OF DEGASIFIER PPM	16	108	369	1,614	21,600	2,790	0.08	0.10	7.75	22.3	23.0	2.53	2.79	45.3	17.6
4	6.5.3.7	BRINE BLOW-DOWN PPM	52	155	539	2,370	30,900	4,170	0.09	0.07	8.30	7.5	9.7	1.61	2.46	17.2	11.7
5	6.5.3.1	DISTILLATE PPM	0	4	2	7	96	8	0.045	0.075	7.85	1.3	1.1	0.21	0.46	2.34	6.48
6	6.5.3.3	BRINE RECYCLE (AT BRINE HEATER OUTLET) PPM	51	155	540	2,330	31,100	4,200	0.18	0.09	8.23	8.7	12.2	1.73	2.82	21.0	69.0

DURING THE PERIOD APRIL 14 THRU AUGUST 4, 1968 24 SAMPLES OF EACH FLOW WERE TAKEN, ONE EACH HOUR, ON 12 DAYS APPROXIMATELY ONE WEEK APART. THESE SAMPLES FOR EACH COLLECTING DAY WERE MIXED TOGETHER TO FORM A COMPOSITE SAMPLE FOR THAT DAY. CHEMICAL ANALYSES WERE THEN MADE. ABOVE TABLE SHOWS THE AVERAGE VALUE FOR THESE SERIES OF ANALYSES. (11)

FIG. 6-11

GITMO #2 CHEMICAL ANALYSES OF COMPOSITE FLOW SAMPLES

SAMPLE DATE	CHLORIDES PPM	pH	NICKEL PPM	IRON PPM	COPPER PPM	ALUMINUM PPM	MO AIK.
12/13/65	11	7.0	0	0.15	0	0	4
12/13/65 PM	16	7.0	0	0.15	0	0	7
12/14/65	13	7.0	0	0.2	Trace	0	4
12/14/65 PM	13	7.0	0	0.12	0	0	7
12/15/65	16	7.0	0	Trace	Trace	0	4
12/15/65 PM	14	7.0	0	Trace	Trace	0	7
12/20/65	6	6.9	0	0.09	0.05	Trace	4
12/20/65	7	6.9	0	0.09	0.05	Trace	6
12/21/65	8	6.9	0	0.08	0.05	Trace	6
AVERAGE	12	7.0	0	0.10	0.01	Trace	5
HAGEVAP PRETREATMENT							
12/27/65	21	6.9	0	0.26	Trace	Trace	3
12/27/65 PM	32	6.9	0	0.20	Trace	Trace	9
12/28/65	10	6.9	0	0.17	Trace	Trace	3
12/28/65 PM	10	6.9	0	0.15	Trace	Trace	5
12/29/65	12	6.9	0	0.18	Trace	Trace	4
12/29/65 PM	17	6.9	0	0.14	Trace	Trace	5
AVERAGE	17	6.9	0	0.18	Trace	Trace	5
ACID PRETREATMENT							

Figure 6-12

GITMO NO. 1 - PRODUCT WATER ANALYSIS [32]

SAMPLE DATE	CHLORIDES PPM	pH	NICKEL PPM	IRON PPM	COPPER PPM	ALUMINUM PPM	MO ALK.
12/13/65	-	8.3	Trace	0.2	0.02	0.5	187
12/13/65 PM	-	8.3	Trace	0.2	0.02	0.5	187
12/14/65	-	8.3	Trace	0.22	0.02	0.5	187
12/14/65 PM	-	8.3	Trace	0.41	0.02	0.5	187
12/15/65	32,600	8.3	Trace	0.1	0.02	0.5	188
12/15/65 PM	32,800	8.3	Trace	0.1	0.02	0.5	188
12/20/65	34,300	7.1	Trace	1.5	0.03	0.5	22
12/20/65	34,000	8.1	Trace	0.42	0.02	0.5	27
12/21/65	30,500	5.0	Trace	2.0	0.05	0.7	13
AVERAGE	27,400	7.8	Trace	0.57	0.02	0.5	132
HAGEVAP PRETREATMENT							
12/27/65	38,250	7.7	Trace	0.47	0.04	0.6	23
12/27/65 PM	36,100	6.9	Trace	0.46	0.03	0.5	38
12/28/65	38,150	7.7	0.01	0.33	0.04	0.6	29
12/28/65 PM	37,150	7.3	0.01	0.55	0.05	0.6	29
12/29/65	46,000	7.7	0.01	0.6	0.04	0.6	33
12/29/65 PM	34,750	7.7	0.02	1.2	0.05	0.6	40
AVERAGE	38,400	7.5	0.01	0.60	0.04	0.6	32
ACID PRETREATMENT							

Figure 6-13

GITMO NO. 1 - BLOWDOWN ANALYSIS [32]

SAMPLE DATE	CHLORIDES PPM	pH	NICKEL PPM	IRON PPM	COPPER PPM	ALUMINUM PPM	MO ALK.
12/13/65	-	8.3	Trace	0.2	0.02	0.5	185
12/13/65 PM	-	8.3	Trace	0.2	0.02	0.5	185
12/14/65	-	8.3	Trace	0.63	0.02	0.5	185
12/14/65 PM	-	8.3	Trace	0.51	0.02	0.5	185
12/15/65	33,200	8.3	Trace	0.61	0.03	0.5	188
12/15/65 PM	31,400	8.3	Trace	0.21	0.03	0.5	188
12/20/65	36,000	6.8	Trace	1.2	0.03	0.6	17
12/20/65	35,800	7.9	Trace	0.1	0.03	0.5	25
12/21/65	32,000	5.0	Trace	0.32	0.05	0.6	15
AVERAGE	33,680	7.7	Trace	0.44	0.03	0.5	130
HAGEVAP PRETREATMENT							
12/27/65	38,300	7.7	Trace	0.14	0.03	0.6	23
12/27/65 PM	37,900	7.7	Trace	0.10	0.04	0.6	33
12/28/65	36,500	7.1	0.02	0.53	0.05	0.6	23
12/28/65 PM	35,600	7.1	0.02	0.56	0.05	0.6	26
12/29/65	40,300	7.7	0.02	0.40	0.04	0.6	30
12/29/65 PM	43,500	7.7	0.02	0.52	0.05	0.6	33
AVERAGE	38,700	7.5	0.01	0.38	0.04	0.6	28
ACID PRETREATMENT							

Figure 6-14

GITMO NO. 1 - RECYCLE BRINE HEATER OUT ANALYSIS (32)

COMPOSITE SAMPLE DATE	ALKALINITY (P)	ALKALINITY (M)	CALCIUM PPM	MAGNESIUM PPM	CHLORIDE PPM	SULFATE PPM	DISSOLVED COPPER PPM	DISSOLVED IRON PPM	pH	SUSPENDED SOLIDS PPM	VOLATILE SOLIDS PPM	INSOLUBLE COPPER PPM	INSOLUBLE IRON PPM	FIXED SOLIDS PPM	PROD. FLOW RATE MILL #/DAY	NON-CARB. HARDNESS (CALCIUM)	NON-CARB. HARDNESS (MAGNES.)	FLUORINE
APR 14/15,'68	-	111	384	1650	20,400	2,834	0.12	0.15	7.95	-	-	-	-	-	49.8			
APR 21/22,'68	0	65	377	1675	20,400	2,967	0.11	0.06	7.10	11.2	4.6	2.6	4.0	6.6	49.8			
APR 28/29,'68	20	118	370	1572	21,000	2,982	0.17	0.04	8.05	13.4	4.3	0.4	2.5	9.1	50.4			
MAY 5/6,'68	18	112	376 (88)	1661 (335)	21,000	2,053	0	0	7.9	12.1	5.1	0.08	4.8	7.0	57.8			
MAY 19/20,'68	16	105	363	1580	20,800	2,900	0	.01	7.7	15.6	7.3	0.5	2.9	8.3	52.8	(255	1245	1.1
MAY 26/27,'68	19	102	365	1670	21,400	2,860	0.07	0.15	8.0	12.4	5.2	0.68	2.95	7.2	58.8		COMBINED WITH CHLORINE)	
JUN 2/3,'68	18	104	404	1390	20,800	2,790	0.09	0.19	7.65	11.4	8.0	0.56	2.84	3.4	56.2			
JUN 9/10,'68	15	100	391	1618	20,800	2,880	0.06	0.05	7.75	8.0	5.1	0.28	2.63	2.9	49.8			
JUN 16/17,'68	19	98	384	1660	20,800	2,790	0.05	0.21	8.05	13.8	3.8	2.50	2.76	10.0	49.2			
JUN 30/JUL 1,'68	14	95	398	1615	20,430	2,800	0.03	0.08	8.15	10.0	1.3	0.34	2.48	8.7	56.4			
JUL 29/30,'68	21	111	404	1462	24,160	2,805	0.05	0.11	8.3	13.7	8.8	0	2.81	4.9	48.0			
AUG 4/5,'68	18	116	274	1458	23,500	2,850	0.02	0.20	8.35	14.7	7.4	1.50	2.67	7.3	48.0			
AVERAGES	16	103	374	1580	21,300	2,790	0.064	0.104	7.66	12.4	5.5	0.86	2.85	6.9	51.8			

FIG. 6-15 SEA WATER AT PLANT BOUNDARY

COMPOSITE SAMPLE DATE	ALKALINITY (P)	ALKALINITY (M)	CALCIUM	MAGNESIUM	CHLORIDE	SULFATE	DISSOLVED COPPER	DISSOLVED IRON	pH	SUSPENDED SOLIDS	VOLATILE SOLIDS	INSOLUBLE COPPER	INSOLUBLE IRON	FIXED SOLIDS	FLOW RATE MILL #/DAY
APR 14/15,'68	-	3	3	10	116	6	0.11	0.12	7.9						6.36
APR 21/22,'68	0	5	1	10	78	10	0.06	0.05	7.15	0.3	0.1	0.2	0.0	0.2	6.19
APR 28/29,'68	0	3	2	4	89	5	0.04	0.16	8.05	5.4	4.8	0.6	0	0.6	6.24
MAY 5/6,'68	0	4	1	7	75	0	0	0	8.45	2.0	0	0.24	1.7	2.0	6.06
MAY 19/20,'68	0	5	1	5	62	5	0	0.10	6.95	6.6	0	0.2	1.9	6.6	6.76
MAY 26/27,'68	0	4	0	7	68	15	0.06	0	7.15	0	0	0	0	0	6.0
JUN 2/3,'68	0	4	3	7	94	10	0.06	0.08	7.9	0	0	0	0	0	5.67
JUN 9/10,'68	0	4	2	5	137	7	0.04	0.06	8.1	0	0	0	0	0	5.64
JUN 16/17,'68	0	4	3	9	123	10	0.04	0.13	7.55	0.8	0.2	0.52	0.08	0.6	5.64
JUN 30/JUL 1,'68	0	5	3	5	75	7	0.04	0.14	7.95	8.4	8.3	0.02	0.08	0.1	5.64
JULY 29/30,'68	0	5	3	6	106	8	0.05	0.03	8.65	0.7	0.1	0.22	0.38	0.6	5.28
AUG 4/5,'68	0	5	4	8	134	10	0.03	0.03	8.45	1.6	0.4	0.30	0.90	1.2	5.76
AVERAGES	0	4.2	2.2	7	96	8	0.045	0.075	7.85	2.34	1.3	0.21	0.46	1.1	5.93

FIG. 6-16 EVAPORATOR DISTILLATE

NOTES

1. SAMPLES COLLECTED ONCE PER HOUR FROM 0800 THE FIRST DAY TO 0800 THE NEXT DAY AND STIRRED TOGETHER.
2. BRINE TEMPERATURE AT OUTLET 195°F. HAGEVAP LP AT 3.5 PPM THRU APR. 28th THEN 1.5 PPM, PLUS C-1 ANTI-FOAM.
3. THE EVAPORATOR WAS ACID CLEANED ON APRIL 13th, THE DAY BEFORE FIRST SET OF SAMPLES WERE COLLECTED.
4. THE SEA WATER WAS CHLORINATED 2 HRS. EACH 8 HRS. AT 1500#/DAY (FEED RATE) FOR RESIDUAL OF 2 PPM. (FEED RATE 7 1/2 PPM)
5. AFTER THESE TESTS CHLORINE WAS REDUCED TO NORMAL.

GITMO #2 SEA WATER AND PRODUCT WATER
COMPOSITE SAMPLE ANALYSES (11)

6.5.3.2 Treated Product Water Analysis

Section 7.3 discusses the chemical analyses of treated product water for 1964 through 1969. Samples for those tests were taken after the lime bed and after treating with chlorine and fluoride at Water Conversion and Power Generation Plant #4. Sodium hexametaphosphate was introduced early in 1967 but was added at a point beyond the lime bed (at Water Plant #3). However, it was injected at the lime bed outlet starting June 9, 1969. This change accounts for some of the differences between the 1968 and 1969 analyses.

6.5.3.3 Recycle Brine Analysis

Analysis of Gitmo #2 Recycle Brine in 1968 is shown in Figure 6-18 and the Gitmo #1 Recycle Brine analysis is shown in Figure 6-14. The 1965 Gitmo #1 tests cannot be considered conclusive but indicate no great difference in the iron and copper content of the recycle stream when comparing Hagevap versus Acid pretreatment.

6.5.3.4 Seawater Analysis

Figure 6-15 shows the chemical analyses of twelve composite samples of seawater at plant boundary for the period April 14, 1968 through August 4, 1968. The average values are also shown. These analyses apply to Gitmo #2. The Guantanamo Bay seawater analysis in the area of the plant is indicated in Figure 6-19.

6.5.3.5 Seawater Makeup Analysis

Chemical analysis of twelve composite samples of seawater makeup are shown in Figure 6-20. These samples were taken from Gitmo #2 during the period April 14 to August 4, 1968. In addition to the above, in late 1969 and early 1970 makeup samples were obtained from both Gitmo #1 and #2 deaerator exit and analyzed for dissolved oxygen. The results of these tests [33] are shown in Figure 6-22.

6.5.3.6 Seawater Reject Analyses

The results of the analysis of the twelve composite samples from Gitmo #2 during mid-1968 are shown in Figure 6-21 for the seawater reject stream.

6.5.3.7 Brine Blowdown Analyses

Analysis of twelve composite samples of Gitmo #2 Blowdown are shown in Figure 6-17. These samples were obtained April 14 to August 4, 1968.

COMPOSITE SAMPLE DATE	ALKALINITY P	ALKALINITY M	CALCIUM PPM	MAGNESIUM PPM	CHLORIDE PPM	SULFATE PPM	DISSOLVED COPPER PPM	DISSOLVED IRON PPM	pH	SUSPENDED SOLIDS PPM	VOLITILE SOLIDS PPM	INSOLUBLE COPPER PPM	INSOLUBLE IRON PPM	FIXED SOLIDS PPM	FLOW RATE MILLION # PER DAY
APR 14/15,'68	-	155	528	2,480	30,000	4,175	0.38	0.08	8.4	-	-	-	-	-	11.3
APR 21/22	47	162	507	2,560	29,600	4,391	0.09	0.03	8.07	9.8	1.5	2.0	6.3	8.3	12.2
APR 28/29	52	165	507	2,423	30,000	4,192	0.06	0	8.4	8.9	0	1.4	1.0	8.9	11.5
MAY 5/6	56	163	561	2,397	30,000	4,035	0.07	0	8.35	15.0	8.3	1.2	3.8	6.7	12.0
MAY 19/20	52	154	507	2,380	30,400	4,310	0	0.01	7.65	26.4	11.4	2.4	2.1	15.0	13.5
MAY 26/27	42	136	534	2,440	31,000	4,250	0.10	0.09	7.75	16.8	3.0	1.98	1.33	13.8	12.1
JUN 2/3	49	145	548	1,945	29,400	4,040	0.12	0.09	8.4	18.3	12.3	2.20	2.26	6.0	11.3
JUN 9/10	53	151	569	2,420	30,200	4,180	0.06	0.08	8.25	14.5	12.2	1.46	0.84	2.3	11.8
JUN 16/17	51	146	555	2,380	29,600	4,080	0.01	0.15	8.45	17.4	4.0	1.74	2.58	13.4	11.3
JUN 30-JUL 1	50	153	602	2,390	32,430	4,170	0.09	0.05	8.7	23.3	9.6	1.58	1.60	13.7	11.3
JUL 29/30	55	162	575	2,082	34,380	4,100	0.04	0	8.75	19.4	9.3	0.50	2.78	10.1	10.6
AUG 4/5,'68	63	169	486	2,330	34,400	4,240	0.08	0.17	8.7	19.4	10.7	1.30	2.43	8.7	11.5
AVERAGES	52	155	539	2,370	30,900	4,170	0.092	0.07	8.3	17.2	7.5	1.61	2.46	9.7	11.7

FIG. 6-17 BRINE BLOWDOWN

COMPOSITE SAMPLE DATE	P	M	Ca	Mg	Cl	SO_4	Cu	Fe	pH	SUSP. SOLIDS	VOL. SOLIDS	INSOL. cu	INSOL. Fe	FIXED SOLIDS	FLOW RATE MILLION # PER DAY
APR 14/15,'68	-	155	521	2,380	30,000	4,149	0.56	0.07	8.4	-	-	-	-	-	70.8
APR 21/22	42	160	507	2,320	29,400	4,543	0.16	0.03	7.88	10.8	2.3	1.9	6.6	8.5	69.6
APR 28/29	51	164	500	2,420	29,800	4,220	0.19	0.09	8.35	14.6	2.6	1.5	1.6	12.0	70.2
MAY 5/6	53	160	521	2,422	30,000	4,109	0.06	0	8.35	15.4	8.7	1.1	4.7	6.7	69.6
MAY 19/20	51	154	541	2,380	30,800	4,310	0.04	0.04	7.5	16.6	8.2	1.5	2.7	8.4	69.0
MAY 26/27	52	156	534	2,490	31,200	4,290	0.14	0.09	7.25	11.9	0.5	1.98	2.15	11.4	69.0
JUN 2/3	44	142	548	2,139	29,800	4,090	0.14	0.08	8.35	18.0	12.3	1.48	2.51	5.7	71.1
JUN 9/10	53	148	562	2,425	30,600	4,210	0.10	0.11	8.2	17.1	12.2	1.42	2.22	4.9	69.0
JUN 16/17	50	143	555	2,380	30,000	4,090	0.41	0.13	8.4	14.1	3.3	2.56	2.15	10.8	67.2
JUN 30-JUL 1	47	151	602	2,390	32,430	4,220	0.09	0.09	8.7	23.9	11.0	0.94	2.36	12.5	66.6
JUL 29/30	53	161	589	2,050	34,800	4,165	0.13	0.04	8.75	19.1	9.7	1.94	2.10	9.4	67.2
AUG 4/5,'68	59	171	507	2,340	34,400	4,250	0.08	0.28	8.7	69.1	25.0	2.70	2.26	44.1	69.6
AVERAGES	51	155	540	2,330	31,100	4,200	0.18	0.09	8.23	21.0	8.7	1.73	2.82	12.2	69.0

FIG. 6-18 RECYCLE BRINE (AT BRINE HEATER OUTLET)

GITMO #2 BRINE BLOW-DOWN AND BRINE RECYCLE ANALYSES

1.	Total Solids in ppm	35,400 ppm
2.	Total Hardness as $CaCO_3$	6,425 ppm
3.	Total Calcium as $CaCO_3$	1,035 ppm
4.	Total Magnesium as $CaCO_3$	5,390 ppm
5.	P. Alkalinity as $CaCO_3$	20 ppm
6.	M.O. Alkalinity as $CaCO_3$	150 ppm
7.	Sulfate as SO_4	2,910 ppm
8.	Chloride as Cl	19,600 ppm
9.	Silica as SiO_2	3.0 ppm
10.	Total Iron as Fe	0.02 ppm
11.	Total Copper	0.01 ppm
12.	Nickel	Trace ppm
13.	Aluminum	0.5 ppm
14.	Color Units	5
15.	Turbidity Units	5

Figure 6-19

GUANTANAMO BAY
SEAWATER ANALYSIS

COMPOSITE SAMPLE DATE	ALKALINITY P	ALKALINITY M	CALCIUM PPM	MAGNESIUM PPM	CHLORIDE PPM	SULFATE PPM	DISSOLVED COPPER PPM	DISSOLVED IRON PPM	pH	SUSPENDED SOLIDS PPM	VOLITILE SOLIDS PPM	INSOLUBLE COPPER PPM	INSOLUBLE IRON PPM	FIXED SOLIDS PPM	FLOW RATE MILLION # PER DAY
APR 14/15,'68	-	113	343	1,700	20,600	2,931	0.13	0.11	8.0	-	-	-	-	-	17.7
APR 21/22	15	114	363	1,710	20,200	2,974	0.11	0.05	7.25	14.4	7.2	2.8	4.4	7.2	18.4
APR 28/29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17.7
MAY 5/6	21	115	345	1,674	21,000	2,019	0	0	7.95	12.0	6.3	1.8	4.1	5.7	18.1
MAY 19/20	19	106	343	1,555	21,000	2,920	0	0.04	7.05	36.2	15.2	2.3	2.8	21.0	20.3
MAY 26/27	18	105	384	1,650	21,400	2,810	0.07	0.06	7.25	15.3	5.9	2.26	2.71	9.4	18.1
JUNE 2/3	15	105	384	1,552	21,000	2,840	0.15	0.12	7.75	83.0	20.9	1.44	2.14	62.1	17.0
JUNE 9/10	13	101	391	1,628	20,800	2,900	0.06	0	7.65	38.1	28.8	3.52	1.90	9.3	16.9
JUNE 16/17	21	103	384	1,660	21,000	2,790	0.09	0.16	8.05	25.4	14.1	2.94	2.56	11.3	16.9
JUN 30/JUL 1	13	101	404	1,640	22,680	2,780	0.08	0.07	8.25	28.7	8.1	3.46	1.80	20.6	16.9
JULY 29/30	8	117	404	1,424	24,160	2,820	0.07	0.34	7.8	115.1	61.1	2.14	3.37	54.0	15.8
AUG 4/5, '68	19	111	315	1,564	23,900	2,870	0.11	0.11	8.15	85.2	55.4	2.64	2.08	29.8	17.3
AVERAGES	16	108	369	1,614	21,600	2,790	0.08	0.10	7.75	45.3	22.3	2.53	2.79	23.0	17.6

FIG. 6-20 MAKE-UP SEA WATER FROM DEGASIFIER

COMPOSITE SAMPLE DATE	P	M	Ca	Mg	Cl	SO_4	Cu	Fe	pH	SUSP. SOLIDS	VOL. SOLIDS	INSOL. Cu	INSOL. Fe	FIXED SOLIDS	FLOW RATE MILLION # PER DAY
APR 14/15,'68	-	115	356	1,620	20,800	2,854	0.03	0.21	8.0	-	-	-	-	-	32.1
APR 21/22	14	115	356	1,640	20,200	2,921	0.05	0.08	7.65	7.9	2.1	0.6	5.2	5.8	31.4
APR 28/29	19	121	356	1,631	21,000	2,973	0.07	0.04	8.05	8.3	0	0.5	2.0	8.3	32.7
MAY 5/6	21	115	345	1,674	20,800	2,089	0	0	7.95	10.7	5.3	0.08	4.9	5.4	34.7
MAY 19/20	20	105	343	1,620	21,000	2,910	0	0.04	7.25	15.4	5.8	0.1	2.5	9.6	32.5
MAY 26/27	19	106	370	1,660	21,200	2,860	0.06	0.06	7.55	14.8	6.0	0.46	2.99	8.8	40.7
JUNE 2/3	19	108	370	1,410	21,000	2,850	0.08	0.08	7.95	15.7	9.6	0.54	2.89	6.1	39.2
JUNE 9/10	14	99	391	1,641	20,800	2,820	0.03	0.07	7.75	10.6	7.5	1.04	2.06	3.1	32.9
JUNE 16/17	15	97	384	1,660	20,800	2,780	0.01	0.15	8.15	14.3	7.0	0.36	2.66	7.3	32.3
JUN 30/JUL 1	15	104	404	1,640	22,300	2,800	0.04	0.06	8.3	8.5	1.0	0.22	2.24	7.5	39.5
JULY 29/30	18	112	390	1,074	23,940	2,825	0.04	0.03	8.45	17.2	6.7	0.92	2.74	10.5	32.6
AUG 4/5,'68	21	118	315	1,430	23,700	2,870	0.05	0.11	8.35	15.0	9.5	0.18	2.48	5.5	30.7
AVERAGES	18	110	364	1,560	21,400	2,790	0.04	0.08	7.95	12.6	5.5	0.46	2.97	7.1	34.3

FIG. 6-21 SEA WATER REJECT

GITMO #2 SEA WATER FROM DEGASSIFIER (MAKE-UP) & SEA WATER REJECT ANALYSES (11)

Date	Gitmo #1	Gitmo #2	Date	Gitmo #1	Gitmo #2
9/15/69	15 - 5	5 - 5	11/17/69	10 - 10	10 - 10
9/16/69	15 - 10	5 - 5	11/19/69	10 - 5	5 - 5
9/17/69	15 - 10	5 - 5	11/21/69	10 - 5	5 - 5
9/18/69	15 - 15	10 -10	11/24/69	10 - 5	5 - 5
9/19/69	10 - 10	5 - 5	11/26/69	5 - 5	5 - 5
9/22/69	15 - 15	5 - 5	11/28/69	10 - 5	5 - 5
9/23/69	15 - 10	5 - 5	12/1/69	5 - 5	5 - 5
9/24/69	15 - 15	5 - 5	12/3/69	10 - 10	5 - 5
9/25/69	15 - 15	10 - 5	12/5/69	10 - 10	5 - 5
9/29/69	10 - 10	5 - 5	12/10/69	15 - 10	15 - 5
9/30/69	15 - 10	5 - 5	12/12/69	25 - 25	5 - 5
10/1/69	15 - 5	15 - 5	12/15/69	15 - 10	10 - 10
10/3/69	10 - 5	5 - 5	12/17/69	15 - 10	5 - 5
10/6/69	15 - 10	5 - 5	12/19/69	15 - 10	0 - 0
10/8/69	10 - 5	5 - 5	12/22/69	10 - 5	5 - 0
10/10/69	15 - 10	5 - 5	12/24/69	0 - 0	5 - 0
10/13/69	10 - 10	5 - 5	12/29/69	5 - 5	0 - 0
10/15/69	15 - 10	10 - 5	12/31/69	10 - 5	5 - 0
10/20/69	10 - 10	5 - 5	1/2/70	10 - 5	5 - 5
10/23/69	15 - 10	10 - 5	1/5/70	10 - 10	5 - 0
10/27/69	5 - 5	5 - 5	1/7/70	10 - 5	5 - 5
10/29/69	10 - 5	5 - 5	1/9/70	10 - 5	5 - 5
11/3/69	10 - 5	5 - 5	1/12/70	5 - 5	5 - 5
11/5/69	10 - 5	10 - 5	1/13/70	15 - 10	10 - 10
11/7/69	10 - 5	5 - 5	1/19/70	15 - 10	10 - 5
11/10/69	5 - 5	5 - 5	1/21/70	25 - 20	10 - 5
11/13/69	10 - 5	10 - 5			

The two values recorded for each evaporator for each date represent the results of two separate analysis run on a single sample.

Figure 6-22

DISSOLVED OXYGEN

Make-Up Brine Out of Deaerator

Parts per Billion (33)

In 1965 samples of Gitmo #1 Blowdown were analyzed with results as shown in Figure 6-13.

6.6 Special Data on Operating Variables

6.6.1 Temperature Profiles[22]

A temperature profile of the flashing brine streams for the Point Loma evaporator is shown in Figure 6-23. The uniform temperature drop from stage to stage indicates that each stage is producing its share of product. Typical flashing brine temperature profiles for Gitmo #1 and #2 are shown in Figure 6-24, and represent normal operation. Concurrent flashing brine and distillate temperature profiles for Gitmo #2 are shown in Figure 6-25. A comparison of flashing brine temperature profiles at various elevated brine temperatures is shown in Figure 6-26 for Gitmo No. 2.

6.6.2 Effluent Analyses

Effluent analyses for Seawater Reject is discussed in Section 6.5.3.6, and Brine Blowdown analysis is discussed in Section 6.5.3.7. In evaluating effluent analysis, consideration should be given to comparison with seawater analysis discussed in Section 6.5.3.4.

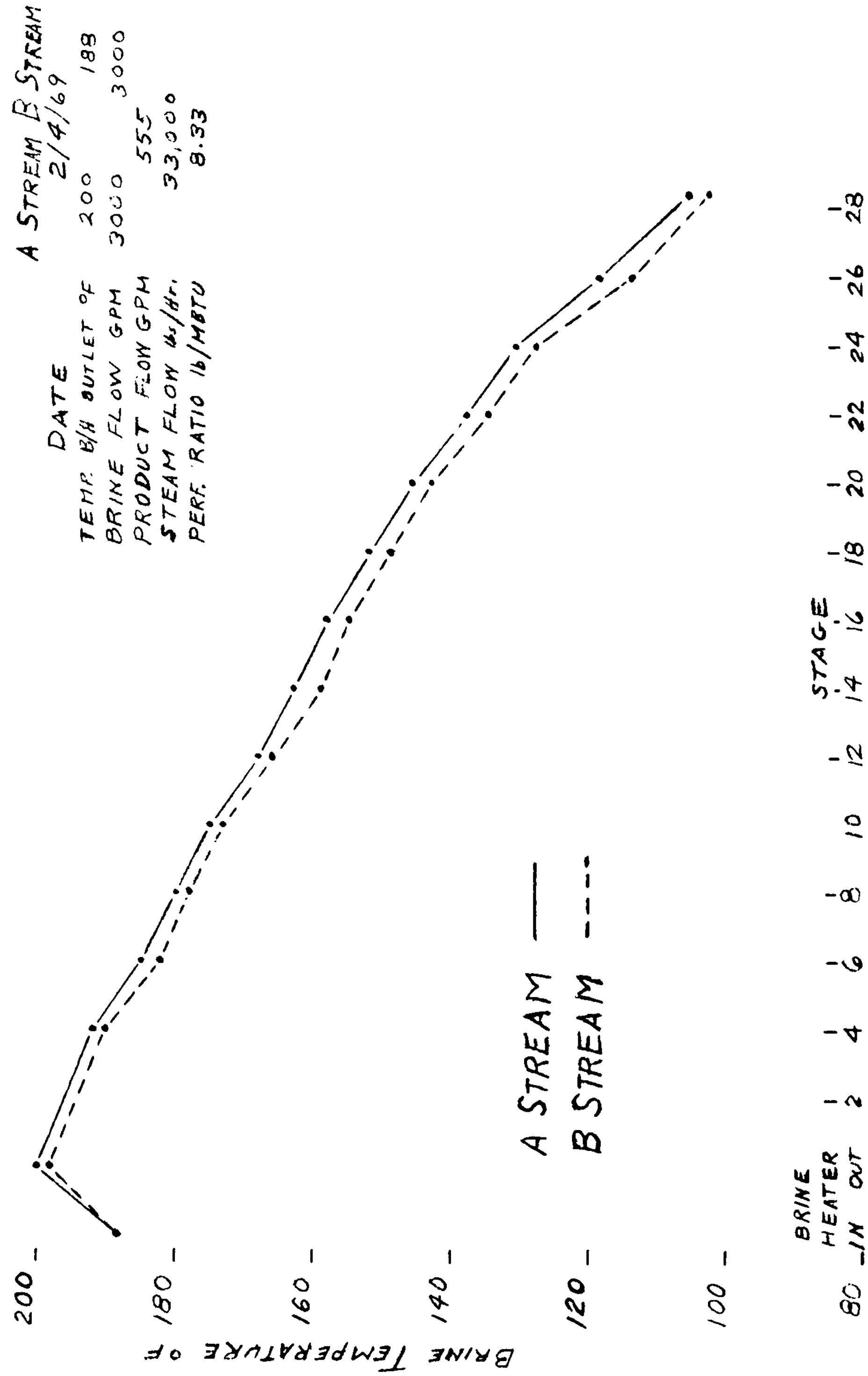


Figure 6-23

TEMPERATURE PROFILES PT. LOMA

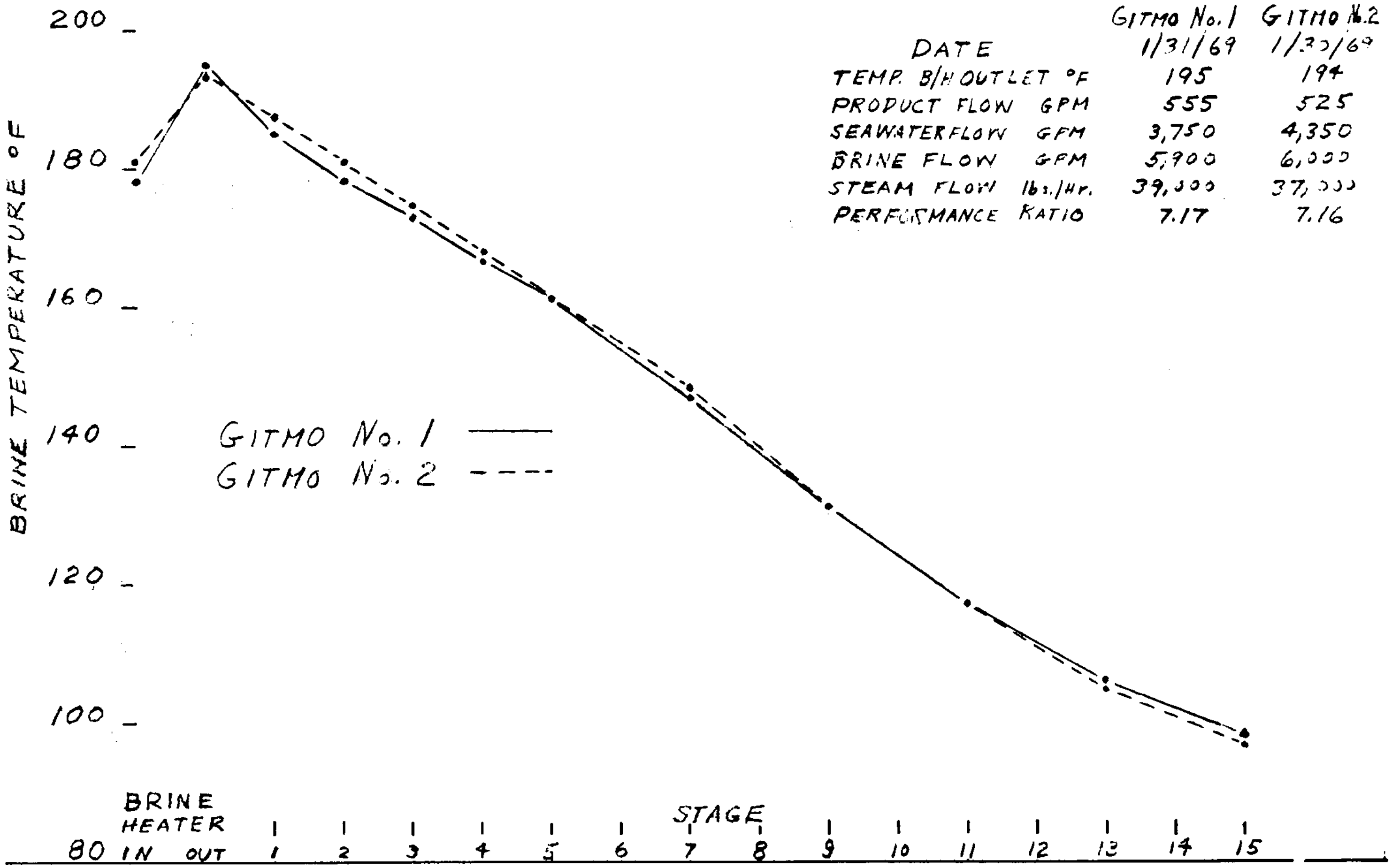


Figure 6-24

TEMPERATURE PROFILES GITMO NO. 1 & NO. 2

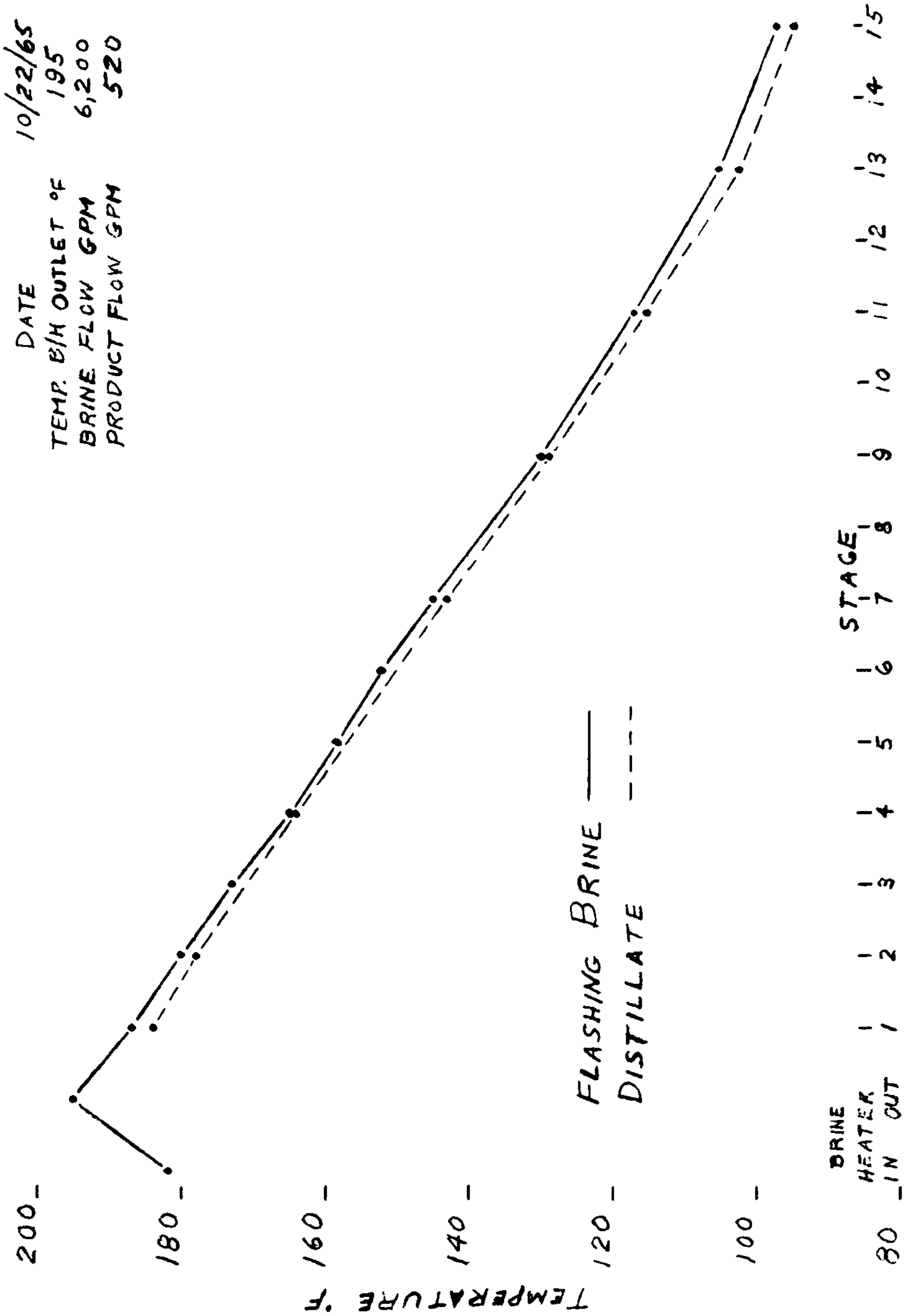


Figure 6-25

TEMPERATURE PROFILES GITMO NO. 2

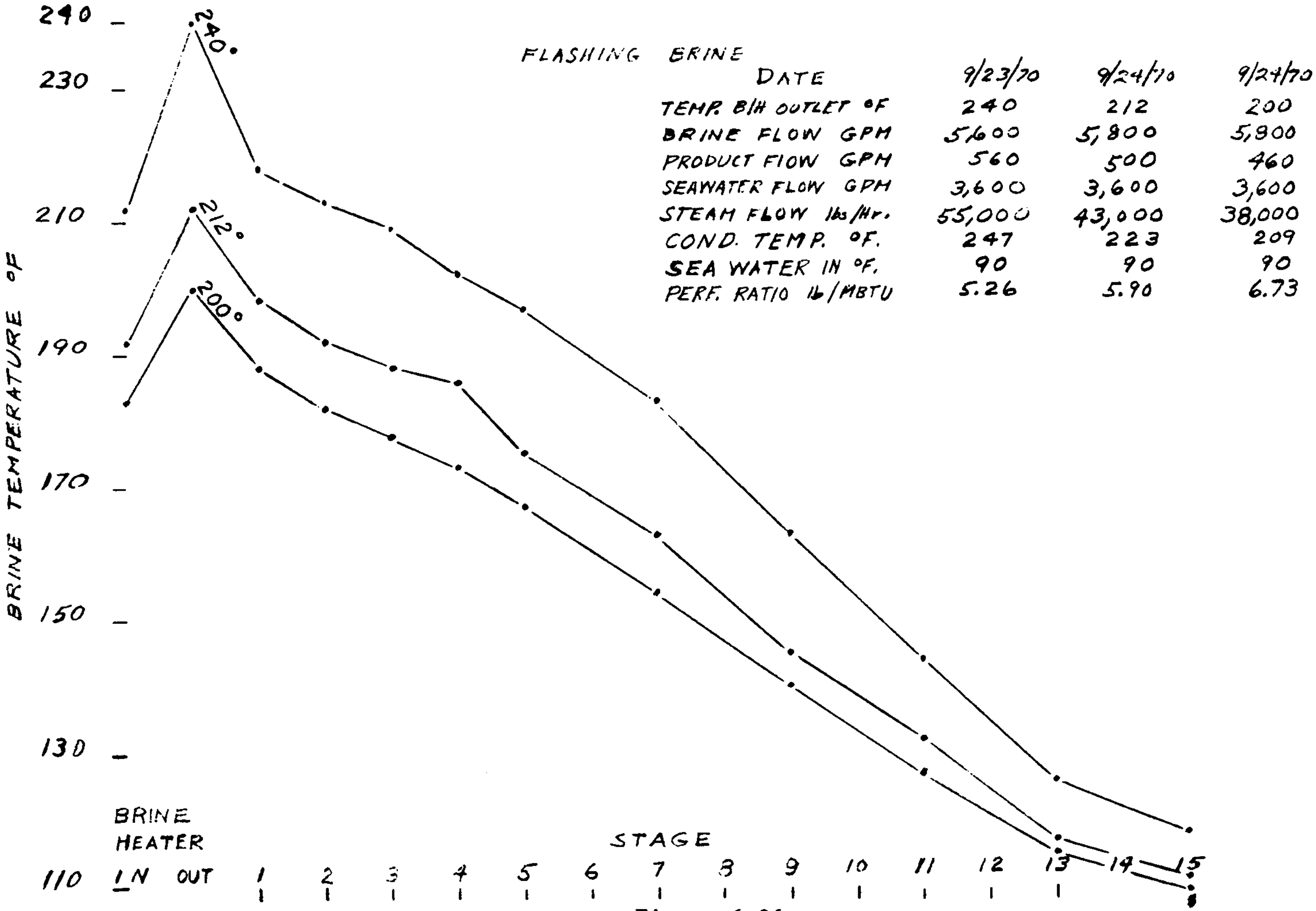


Figure 6-26

TEMPERATURE PROFILES GITMO NO. 2

7.0 PRODUCT WATER QUALITY

7.1 System Description

Product water is the untreated evaporator distillate produced by any one of the three evaporators.

During start-up the product water may be partly recirculated to the respective evaporator, but mostly goes to waste. When laboratory tests indicate that the water is acceptable, the main flow is directed to the water post-treatment system. Water for boiler makeup bypasses post-treatment and is delivered direct to the boiler house condensate surge tank. The product water for base use is post-treated to make it potable, passed through a coral bed to make it less corrosive to the base water distribution system, fluoridated to reduce tooth decay, and chlorinated to kill pathogenic bacteria.

The evaporator distillate (product water) is percolated through a coral (or limestone) bed to raise the pH value and increase hardness. The partially treated water then flows through the clear well, where chlorine and silico fluoride are added to the product water; in addition, lime is added to increase the carbonate alkalinity and hardness, and hexametaphosphate is added to reduce corrosion of the base service water piping system. The partially treated water is again treated in water plant #3 with lime to increase the pH and hardness, and carbon dioxide is added to adjust the pH and supply carbon dioxide for calcium carbonates formation. The post-treated water is then passed through the filter beds for iron removal. Prior to entering the base distribution system, the water is again treated with chlorine.

Figure 7-1 shows a schematic flow diagram for product water post-treatment.

The fully treated product water is pumped to the base water storage system for distribution and use throughout the base. By option, but not usually, the treated water may be pumped directly into the base water distribution main.

7.2 Distillate Analysis

7.2.1 Temperature of Product Water

Seawater at about 85°F, which is used for condensing the water vapor in the evaporator, is responsible for the product water (distillate)

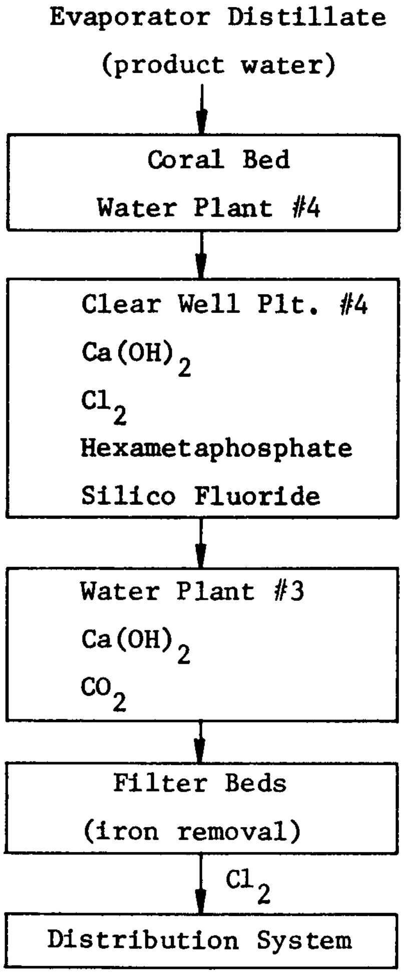


Figure 7-1

PRODUCT WATER POST-TREATMENT FLOW DIAGRAM temperature averages of 104°F or more, as shown in Figure 7-2. See also Section 4.4.4.1, 4.4.4.2 and 6.5.1.2.

7.2.2 Distillate Average Analysis

Average analyses of the evaporator distillate are summarized in Figure 7-2. These data are assembled from operating reports (34, 35) and show ranges of values and averages for the years 1964 through 1970.

In operation, when maximum permissible chlorides (as indicated by the continuously operated conductivity instruments) are reached, the evaporator is shut down for repair or correction. See, also, Section 6.5.3.1.

7.3 Treated Water Analyses

Partially and fully treated product water average analyses are shown in Figure 7-3 and Figure 7-4, respectively. Partially treated product water includes all post-treatment chemicals added at Water Plant #4 and is sampled leaving Water Plant #4. Fully treated product water also includes all post-treatment chemicals added at Water Plant #3 and is sampled going to the distribution storage tank. All miscellaneous data are assembled from the daily product water analyses and daily corrosion reports, (34) and the weekly summary laboratory reports (35).

7.3.1 Treated Water Maximum Permissible Concentrations [36]

Maximum permissible concentrations are indicated in Figures 7-5 and 7-6. These values are from the USPH drinking water standard 1962.

7.4 Corrosion Tests

In 1966 corrosion tests were made in the piping between the evaporators and the lime bed handling product water. Other tests were made in piping handling the base water. Tests were run on coupons of cast iron and on mild steel from 30 to 121 days. As a result of these tests a post-treatment of the product water was commenced early in 1967 to assure corrosion rates below the desired maximum corrosion rate of 5 mils per year.

A solution of hexametaphosphate at about 2 ppm was added to the product water in the discharge line of the distillate booster pumps following the lime bed treatment. Figure 7-7 shows corrosion test data from test period July 27, 1965 to August 24, 1965 (38). Figure 7-8 shows corrosion test data from test period November 11, 1965 to March 12, 1966 (37).

ppm		1964	1965	1966	1967	1968	1969	1970
Alkalinity (P)	Range							
	Avg.				0	0	0	0
Alkalinity (M)	Range	4-8	2-10	5-8	5-12	1-7	2-7	2-4
	Avg.	6	7	7	7	4	3	3
Carbonate	Range	-	-	-	-	0	0	0
	Avg.							
Bi-carbonate	Range	-	-	-	-	1-4	1-7	2-4
	Avg.					3	3	3
Total Chlorides	Range	4-119	2-73	3-120	4-57	13-55	4-61	4-47
	Avg.	17	13	23	26	34	25	25
Chlorine Residual	Range	-	0	0	0	0	-	-
	Avg.							
Fluoride	Range	-	-	-	-	-	-	-
	Avg.							
pH Value	Range	-	6.8-7.9	6.7-6.9	6.5-8.0	5.7-6.9	6.0-7.3	5.5-8.0
	Avg.		7.1	6.8	6.8	6.5	6.5	6.4
Total Hardness	Range	-	Tr.-43	4-24	4-31	4-24	4-17	2-20
	Avg.		7	12	11	13	11	9
Conductivity (Micro mhos)	Range	1-275	2-250	16-164	3-156	13-160	31-150	
	Avg.	50	44	60	67	80	66	64
Dissolved Oxygen	Range					Tr.	0.2-4.1	Tr.
	Avg.						1.5	
Temperature °F	Range					91-108	99-114	-
	Avg.					104	106	
Iron	Range	-	-	-	-	-	0-0.26	0-0.33
	Avg.						0.05	0.13
Copper	Range	-	-	-	-	-	0-0.18	0.01-0.2
	Avg.						0.05	0.08

Figure 7-2

GITMO #1, GITMO #2 AND PT. LOMA EVAPORATOR DISTILLATE ANALYSIS (LIME BED IN WATER PLANT #4)

ppm		1964	1965	1966	1967	1968	1969	1970
Alkalinity (P)	Range				0-6	0-6	0-3	0-3
	Avg.				2	2	0	0
Alkalinity (M)	Range				12-27	8-19	5-21	3-16
	Avg.				17	11	10.4	8.5
Carbonate	Range				-	0-8	0-4	0-12
	Avg.					3.0	0.4	4.0
Bi-carbonate	Range				-	2-14	5-13	0-8
	Avg.					8.5	9.4	4.4
Total Chlorides	Range				10-48	16-62	17-37	12-55
	Avg.				25	35.5	30	25.5
Chlorine Residue	Range				0.1-2.5	0-3.0	0.3-4.0	0.5-3.0
	Avg.				0.84	0.80	1.7	1.8
Fluoride	Range				0.0-1.3	0-2.5	0.3-1.7	Tr.-1.48
	Avg.				0.7	0.90	0.8	0.8
pH Value	Range				8.3-9.1	6.5-9.5	6.2-9.6	6.5-9.95
	Avg.				8.7	8.7	7.8	8.5
Total Hardness	Range				15-27	11-29	14-49	6-25
	Avg.				21.5	23	20	15.8
Conductivity Micro mhos	Range				46-153	66-172	58-258	34-168
	Avg.				92	115	93	85
Dissolved Oxygen	Range				1.0-2.0	1.0-3.7	1.1-6.0	2.3-6.7
	Avg.				1.4	2.0	3.9	3.84
Temperature °F	Range				101-109	95-108	98-114	104-114
	Avg.				105	104	109	108
Dissolved Iron	Range				-	-	0-0.22	0.01-0.34
	Avg.						0.065	0.16
Dissolved Copper	Range				-	-	0-0.25	0-0.18
	Avg.						0.035	0.08
Langelier Index	Range				-0.78-+0.47	-1.64-+0.45	-2.57--0.02	-4.09-+0.37
	Avg.				-0.26	-0.4	-1.77	-1.38

Figure 7-3

GITMO #1, GITMO #2 AND PT. LOMA PARTIALLY TREATED PRODUCT WATER ANALYSIS
(LIME BED OUT WATER PLANT #4)

ppm		1964	1965	1966	1967	1968	1969	1970
Alkalinity (P)	Range					0-14	0-15	0-4
	Avg.					6	3	0.3
Alkalinity (M)	Range	6-12	10-46	10-21	6-38	10-36	5-30	8-20
	Avg.	10	22	17	20	22	15	14.6
Carbonate	Range					0-20	0-30	0-18
	Avg.					5	10	9.8
Bi-carbonate	Range					0-43	0-21	0-11
	Avg.					18	13	4.8
Total Chlorides	Range	9-47	3-54	7-43	9-51	19-77	19-60	15-58
	Avg.	14	20	20	28	37	35	30
Chlorine Residue	Range		0.1-2.5	0.4-2.5	0-2.0	0.2-3.0	2.5-5.0	0.15-4.0
	Avg.		1.3	1.3	0.7	2.1	3.0	2.4
Fluoride	Range		0.5-0.76	0-0.56	0-0.74	0.1-1.2	0-0.7	0.14-1.0
	Avg.		0.7	0.2	0.5	0.7	0.5	0.45
pH Value	Range		7.8-9.5	8.5-8.8	8.5- 9.2	7.8-10	6.5-9.6	7.9-10
	Avg.		8.5	8.6	8.8	8.9	8.3	9.2
Total Hardness	Range		13-50	10-31	7-34	18-58	15-57	13-33
	Avg.		22	20	25	38	30	24
Conductivity (Micro mhos)	Range	12-125	18-140	42-133	48-162	76-222	60-206	62-202
	Avg.	25	50	70	100	140	110	120
Hexametaphosphate	Range				1.0-4.4	0.9-6.5	1.1-10.5	0.43-5.9
	Avg.				1.8	2.1	3.1	2.7
Dissolved Oxygen	Range		1.3-2.0	1.0-2.1	1.5-4.0	0.5-4.8	0.7-5.0	0.8-5.9
	Avg.		1.7	1.7	2.9	3.0	3.5	3.7
Dissolved Iron	Range		0.03-0.13	0.15-0.45	0.11-0.29			
	Avg.		0.07	0.30	0.16			
Dissolved Copper	Range		Tr.-0.13	0.02-0.44	0.01-0.08			
	Avg.		0.06	0.10	0.03			
Temperature	Range				101-103	100-104	99-107	102-108
	Avg.				102	101	103	104
Langelier Index	Range					-1.56-+0.95	-3.31-+1.16	-1.91-+0.98
	Avg.					-0.033	-1.08	-0.245

Figure 7-4

GITMO #1, GITMO #2 AND PT. LOMA TREATED PRODUCT WATER ANALYSIS (WATER PLANT #3)

Physical Standards:

	Maximum Permissible Limit
Turbidity	5 units
Color	15 units
Odor Number	3

Chemical Standards:

	Recommended Concentration Limit	
Alkyl Benzene Sulfonate (ABS)	0.50	ppm
Arsenic (As)	0.01	ppm
Chlorides (Cl)	250.00	ppm
Copper (Cu)	1.00	ppm
Carbon Chloroform Extract (CCE)	0.20	ppm
Cyanide (CN)	0.01	ppm
Fluoride (F)	0.80	ppm
Iron (Fe)	0.30	ppm
Manganese (Mn)	0.05	ppm
Nitrate (NO_3)	45.00	ppm
Phenols	0.001	ppm
Sulfate (SO_4)	250.00	ppm
Total Dissolved Solids (TDS)	500.00	ppm
Zinc (Zn)	5.00	ppm

Figure 7-5

USPH DRINKING WATER STANDARDS 1962

The presence of the following substances in excess of the listed concentrations shall constitute ground for rejection of the supply:

Arsenic (As)	0.05 ppm
Barium (Ba)	1.00 ppm
Cadmium (Cd)	0.01 ppm
Chromium (Cr^{+6})	0.05 ppm
Cyanide (CN)	0.20 ppm
Fluoride (F)	1.00 ppm
Lead (Pb)	0.05 ppm
Selenium (Se)	0.01 ppm
Silver (Ag)	0.05 ppm

Radioactivity:

Sodium (26)	20 uuc/day
Strontium (90)	200 uuc/day
Beta Concentration	1000 uuc/liter

Figure 7-6
USPH DRINKING WATER STANDARDS 1962

7.5 Limestone vs. Coral Treatment

On 18 April 1969, limestone was removed from the lime bed and replaced with coral. (39) The monthly cost of limestone averaged about $92.00 while cost of coral is nil. Thus, the use of coral reduced post-treatment cost approximately 16%.

Prior to the use of coral, laboratory analyses showed coral treatment produced better alkalinity and hardness than limestone. However, in actual plant operation, and based on the daily product water analyses data, limestone treatment showed better alkalinity and hardness than coral. See data tabulated in Figure 7-9.

Figures 7-10 to Figure 7-14 show laboratory analyses of alkalinity and hardness for coral and limestone pilot scale test treatment at various product water flow rates and residence time.

Figure 7-15 and Figure 7-16 show coral and limestone contribution to alkalinity and hardness in actual plant operation. Data for limestone contribution were taken in 1968, while data for coral contribution were taken in 1969, 1970, and 1971.

Beginning on November 1, 1969, (6) $Ca(OH)_2$ (Lime) has been added at water plant #4 and #3 to increase alkalinity and hardness in product water.

7.6 Post-Treatment Costs

The post-treatment cost for product water averaged $611.00 per month (excluding cost of limestone) during 1970. Including 5% of the total chemicals post-treatment cost for maintenance yields the total cost for post-treatment of $0.012 per 1000 gallons of product water. (See Section 6.2.7 for detail cost).

7.7 "Red Water" Problems

The "Red Water" problem refers to the iron and steel corrosion products (rust) included in product water delivered to users.

In addition to the undesirable discoloration of the water, there is indication that too high an iron content in potable water can be detrimental to human health, particularly with children.

Most of the iron content in the product waters originates in the product water piping and distribution system, but some iron is also picked up at water plant #4, particularly during acid-cleaning operations. Causes of the "Red Water" problem that occurred in the distribution system may include the long time storage of product water in the distribution tank, and the corrosion of the distribution piping.

Necessary steps have been used to reduce the iron content at the two water plants. At water plant #4, since a large part of iron from the evaporation is retained in the coral, frequent changes of coral and control of pH during acid cleaning help to minimize the iron content picked up from the evaporators.

(Test Period: 7/27/65 - 8/24/65)

Specimen Number	Date Installed	Date Removed	Days Exposed	Weight Loss (Milligrams)	Avg. Penetration (Mils/yr*)	Location
F-860	7/27/65	8/10/65	14	439	33	Production Water
F-861	7/27/65	8/24/65	28	569	22	
CU-986	7/27/65	8/10/65	14	329	24	
CU-987	7/27/65	8/24/65	28	405	15	
F-862	7/27/65	8/10/65	14	455	34	Base Return Water
F-863	7/27/65	8/24/65	28	523	20	
CU-988	7/27/65	8/10/65	14	50	3.6	
CU-989	7/27/65	8/24/65	28	271	9.7	

* 1 mil/yr = 0.001 inch/yr

Note: F = Cast Iron

Cu = Steel

Corrosion test conducted on the water produced by the Seawater Conversion Plant from 7/27/65-8/24/65

Figure 7-7

CORROSION TEST DATA

(Test Period: 11/11/65-3/12/66)

Specimen Number	Date Installed	Date Removed	Days Exposed	Weight Loss (Milligrams)	Avg. Penetration (Mils/yr*)	Location
CX-446	11/11/65	12/11/65	30	576	19	Production Water
CX-447		1/11/66	61	778	13	
CX-449		2/11/66	92	881	9.6	
CX-448		3/12/66	121	927	7.7	
G-043	11/11/65	12/11/65	30	583	20	Production Water
G-039		1/11/66	61	1108	19	
G-044		2/11/66	92	1244	14	
G-038		3/12/66	121	1264	11	
CX-450	11/11/65	12/11/66	30	290	9.7	Base Water
CX-451		1/11/66	61	384	6.3	
CX-452		2/11/66	92	441	4.7	
CX-453		3/12/66	121	518	4.3	
G-045	11/11/65	12/11/66	30	10	0.4	Base Water
G-042		2/11/66	92	693	8.0	
G-040		3/12/66	121	596	5.2	

* 1 mil/yr = 0.001 inch/yr

Note: G = Cast Iron

CX = Steel

Corrosion test conducted on the water produced by the Seawater Conversion Plant from 11/11/65-3/12/66

Figure 7-8

CORROSION TEST DATA

	LIMESTONE CONTRIBUTION		CORAL CONTRIBUTION					
	1968		1969		1970		1971	
PPM	TOT. ALK.	TOT. HARD.	TOT. ALK.	TOT. HARD.	TOT. ALK.	TOT. HARD.	TOT. ALK.	TOT. HARD.
Jan					8.06	10.70	4.40	6.56
Feb	8.52	10.30			4.14	6.70	4.90	6.28
Mar	9.00	12.46			3.67	6.09	5.48	5.22
Apr	8.30	13.74			3.06	5.66	4.83	6.06
May	7.39	10.75	11.03	12.50	3.40	7.71	2.65	1.12
Jun	7.84	12.14	7.30	15.40	4.86	5.44		
Jul	7.71	11.68	5.17	6.86	7.58	9.00		
Aug	7.87	9.70	3.70	4.70	5.32	8.74		
Sep	8.66	11.85	5.04	9.14	7.20	8.73		
Oct	7.15	11.57	5.25	11.20				
Nov	6.90	11.70						
Dec	7.05	11.30						

Figure 7-9

LIMESTONE & CORAL CONTRIBUTION TO ALKALINITY AND HARDNESS

Coral Experiment Data[40]
9-10 January, 1969

Sample	Tot.Alk.	Tot.Hard.	L.I.	pH	TDS
L.B. inf., 6 days Ave.	4	17	-4.5	6.5	125
L.B. eff., 6 days Ave.	11	28.5	-1.4	8.1	150
L.B. eff., @11 gpm,/100 min.	11	26	-0.3	8.2	125
Coral eff.,					
@11 gpm/ 2 min.	49	72	-0.1	8.55	230
15	17	29	-0.5	8.8	168
30	17	27	-0.3	9.0	170
45	14	24	-0.65	8.85	161
90	15	23	-0.38	9.1	160
185	14	24	-0.5	9.0	160
200	17	28	-1.18	8.15	167
245	14	24	-1.37	8.15	161
290	17	28	-0.72	8.6	169
335	14	24	-1.04	8.45	160
Coral eff., @6 gpm, 45 min.	13	22	-1.4	8.15	157
90	14	23	-1.1	8.4	164
Coral eff., @8 gpm, 45 min.	14	25	-1.07	8.4	162
90	16	29	-0.33	9.0	174
160	16	29	-0.5	8.9	179
170	14	26	-0.52	8.9	166

FIG. 7-10

PRODUCT WATER ANALYSIS

Coral Experiment Data[41]
13-20 January, 1969

Sample	Tot.Alk.	Tot.Hard.	L.I.	pH	TDS
1. Coral eff.,					
@11 gpm,/ 30 min.	15	24	-0.06	9.4	135
75	16	24	-0.2	9.2	136
165	16	24	-0.02	1.4	153
2. Coral eff.,					
@13 gpm,/ 65 min.	14	20	-0.72	8.85	147
135	13	20	-0.64	8.95	143
160	14	16	-0.92	8.7	143
260	14	20	-0.70	8.85	147
310	14	18	-0.75	8.85	145
9. Coral eff.,					
@10 gpm,/ 50 min.	14	19	-0.78	8.8	146
110	14	20	-0.37	9.2	143
155	14	19	-0.72	8.85	146
1530	13	17	-1.13	8.5	125
1575	13	17	-0.98	8.65	129
1665	14	20	-0.92	8.6	133
1695	14	19	-0.93	8.6	132
1730	13	18	-1.38	8.25	130
1920	16	17	-0.50	9.05	131
3705	13	16	-0.78	8.85	89
3815	13	16	-0.52	9.1	89
3895	13	17	-0.28	9.3	90
4150	12	15	-0.31	9.4	87
5770	13	15	-0.38	9.3	82
6355	14	16	-0.51	9.1	88
8170	14	16	-0.24	9.85	89
25. L.B. inf.,					
6 day ave.	3.7	15.5	-3.52	6.36	116
26. L.B. eff.,					
6 day ave.	10.7	28.2	-1.50	8.02	141.2
27. W.P. #3 eff.,					
6 day ave.	25.8	46.3	-0.11	8.82	198.3

Figure 7-11

PRODUCT WATER ANALYSIS

Coral Experiment Data[42]

20-27 January, 1969

Sample	Tot.Alk.	Tot.Hard.	L.I.	pH	TDS
1. Coral eff.,					
@ 10 gpm,/8250 min.	12	16	-0.16	9.5	88
8810	12	15	-0.35	9.35	83
3. Coral eff.,					
@ 6 gpm,/ 60 min.	15	23	-0.10	9.35	102
150	14	16	-0.15	9.15	90
225	14	16	-0.06	9.55	94
285	14	15	-0.10	9.55	93
345	12	19	-0.10	9.5	83
1895	13	18	-0.04	9.15	91
2045	14	18	-0.04	9.6	88
2190	13	17	-0.03	9.65	84
11. L.B. eff.,					
@ 11 gpm,/2190 min.	10	16	-0.57	9.15	70
12. Coral eff.,					
@ 6 gpm,/2325 min.	14	21	-0.23	9.75	104
3975	13	17	-0.04	9.65	90
4125	13	17	-0.04	9.65	90
4175	15	26	-0.08	9.75	91
16. Coral eff.,					
@ 8 gpm,/ 105 min.	12	21	-0.23	9.8	89
165	15	17	-0.35	9.9	96
18. L.B. eff.,					
@ 10 gpm,/ 200 min.	14	19	-0.21	9.25	89
19. Coral eff.,					
@ 8 gpm,/ 225 min.	14	21	-0.39	9.9	91
20. L.B. eff.,					
@ 11 gpm,/ 225 min.	11	19	-0.19	9.35	78
25. Coral eff.,					
@ 8 gpm,/1875 min.	13	18	-0.26	9.85	91
1975	13	18	-0.16	9.75	91
2265	12	21	-0.39	9.9	85
4545	16	20	-0.24	9.8	100
10195	12	21	-0.18	9.75	89
26. L.B. inf.,					
7 day ave.	3	12.3	-3.16	6.9	60
27. L.B. eff.,					
7 day ave.	9.6	19.7	-1.27	8.4	89
29. W.P.#3 eff.,					
7 day ave.	22.6	37.2	-0.45	8.8	144

FIG. 7-12

PRODUCT WATER ANALYSIS

Coral Experiment Data[43]
27 January - 3 February, 1969

Sample	Alkalinity CO_3	Alkalinity HCO_3	Non-carb. Hardness	L.I.	pH	TDS	
1. Coral eff.,							
@10 gpm,/ 180 min.	6	7	8	-.34	9.2	93	
300	8	8	7	-.01	9.4	101	
360	8	8	7	-.29	9.7	105	
420	6	7	11	-.19	9.3	99	
460	10	3	12	-.17	9.3	109	
6. L.L. eff.,							
@11 gpm,/ 480 min.	6	7	6	-.47	9.1	94	
7. Coral eff.,							
@10 gpm,/1440 min.	8	4	4	-.01	9.65	95	
1860	10	2	5	-.11	9.75	100	
2040	0	13	0	-1.33	8.4	76	PO_4 & Cl_2
3000	4	9	0	-1.68	8.05	84	" "
11. L.B. eff.,							
@11 gpm,/3000 min.	2	7	6	-1.76	7.85	79	
12. Coral eff.,							
@10 gpm,/3420 min.	8	4	3	-.30	9.4	94	
3480	12	2	0	-.28	9.4	103	
3540	6	5	2	-.90	8.9	87	
3540	0	13	1	-1.61	8.1	77	" "
3600	8	5	3	-.33	9.3	96	
3600	0	12	3	-.85	8.85	77	" "
4860	0	14	4	-.76	8.8	82	" "
4860	6	7	4	-.01	9.6	92	
5040	0	15	4	-.61	8.9	83	" "
5040	6	9	2	-.15	9.7	94	
6000	8	3	4	-.48	9.25	93	
6390	8	4	6	-.22	9.4	97	
6390	2	10	5	-1.64	8.0	83	" "
10320	4	6	1	-.45	9.45	80	
10320	2	8	1	-1.50	8.4	76	" "

NOTE: Phosphates and Chlorides were also added

FIG. 7-13

PRODUCT WATER ANALYSIS

Coral Experiment Data[44]
3-5 February, 1969

Sample	Alkalinity CO_3	Alkalinity HCO_3	Non-carb. Hardness	Total Hdns.	pH	L.I.
1. Coral/360 min.	4	9	0	13	9.0	-0.75
2. L.B. in/1620 min.	0	3	3	6	8.3	-2.05
3. Coral "	8	2	1	11	9.1	-0.80
4. L.B.out "	0	8	7	15	7.2	-2.61
5. Coral " ($/PO_4$)	6	4	5	15	9.1	-0.66
6. L.B.in/1740 min.	0	2	5	7	7.5	-2.81
7. Coral "	4	7	3	14	9.1	-0.67
8. L.B.out "	0	8	8	16	7.9	-1.87
9. L.B.in/1800 min.	0	3	4	7	7.3	-2.99
10. Coral "	4	4	7	15	8.7	-1.11
11. L.B.out "	0	8	9	17	7.9	-1.85
12. L.B.in/1860 min.	0	4	1	5	7.1	-3.41
13. Coral "	4	3	10	17	9.0	-0.78
14. L.B.out "	0	9	3	12	8.1	-1.78
15. Coral " ($/PO_4$)	2	8	7	17	9.25	-0.45
16. L.B.in/1920 min.	0	3	10	13	7.6	-2.42
17. L.B.out "	0	9	4	13	8.5	-1.36
18. L.B.in/3210 min.	0	5	4	9	7.6	-2.51
19. L.B.out "	0	12	7	19	7.8	-1.80
20. Coral "	4	7	5	16	8.8	-0.89
21. Coral " ($/PO_4$)	2	9	2	13	8.9	-0.89
22. L.B.in/3300 min.	0	4	2	6	7.7	-2.59
23. L.B.out "	0	12	1	13	8.4	-1.36
24. Coral "	4	7	6	17	9.2	-0.46
25. Coral " ($/PO_4$)	2	7	4	13	9.1	-0.76

Flow Rate Through Coral = 12 gpm

FIG. 7-14

PRODUCT WATER ANALYSIS

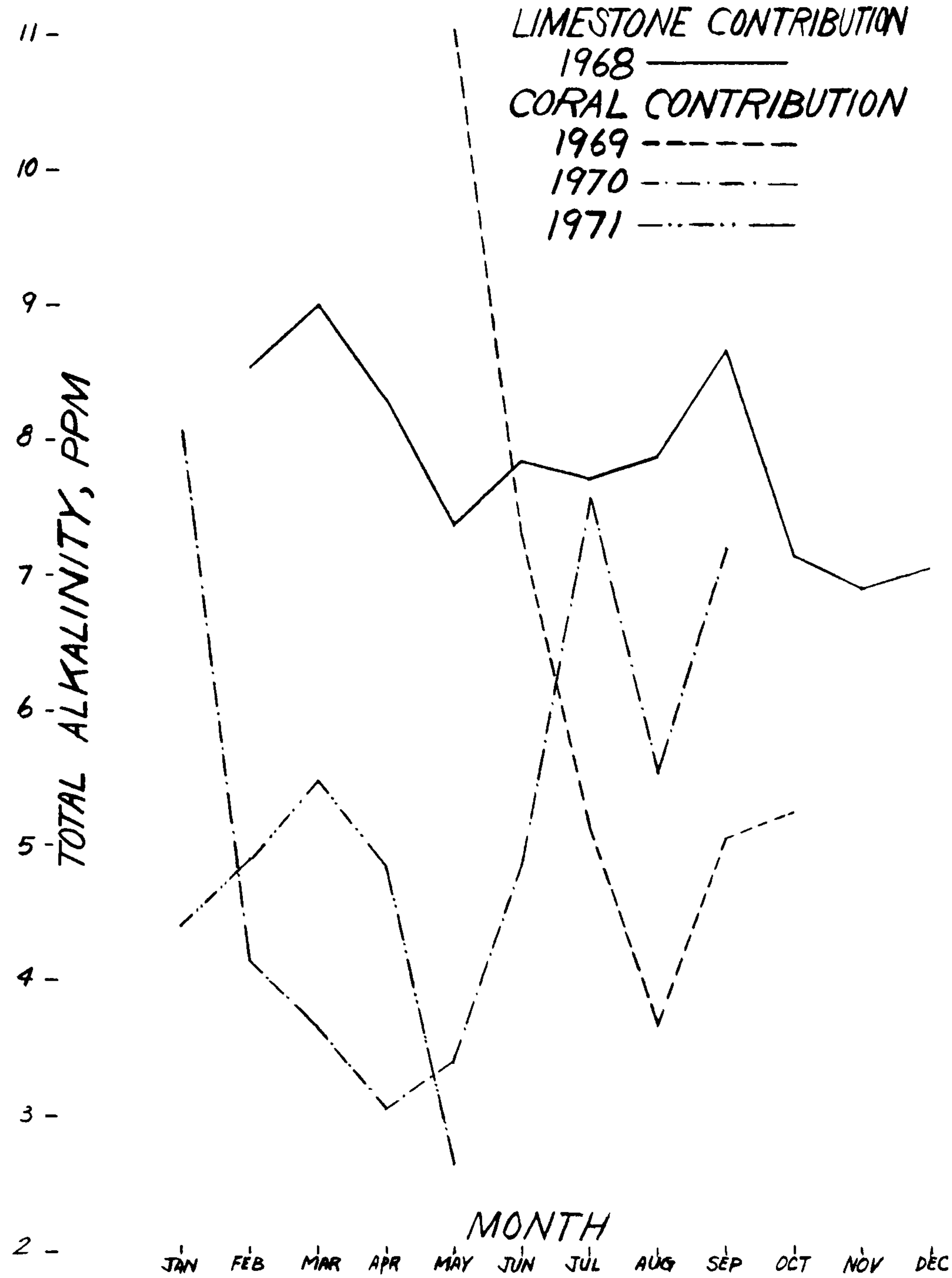


Figure 7-15

LIMESTONE AND CORAL CONTRIBUTION TO ALKALINITY

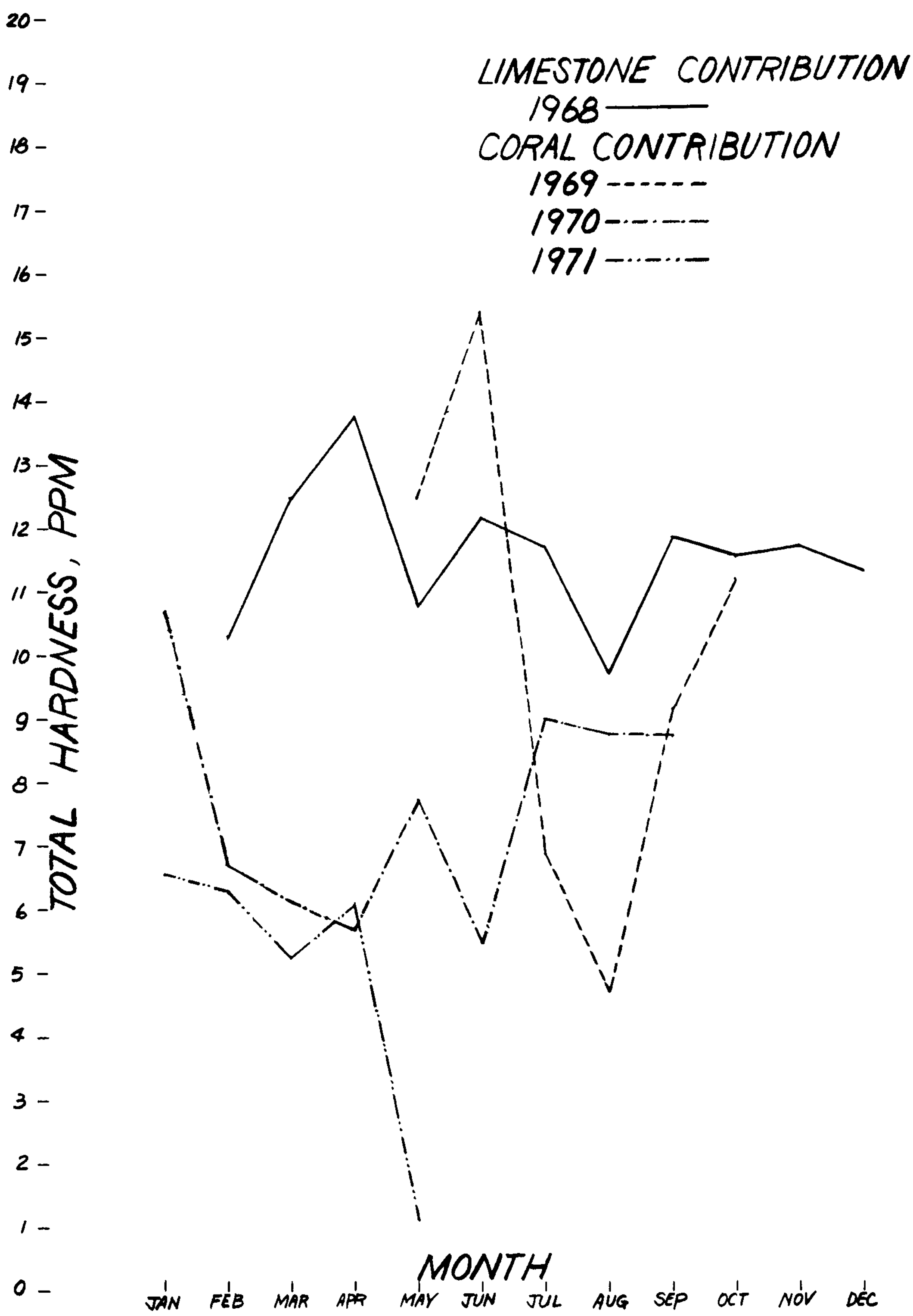


Figure 7-16

LIMESTONE AND CORAL CONTRIBUTION TO TOTAL HARDNESS

8.0 MAINTENANCE PRACTICES

8.1 Maintenance Philosophy

Maintenance philosophy has been primarily the application of sound operating practice to minimize serious maintenance problems. Maintenance philosophy is somewhat determined by plant design to the extent that the plant does include installed spares and is split into three independent trains. A failure of one component may result in no reduction of production and a failure of one train results in loss of only a fraction of total plant production.

The desalting plant, although in a rather isolated location, was not initially provided with warehouse spares of any major components including pumps and motors, and few replacement parts were on hand.

In general, each of the three evaporator units is maintained in operation until product storage is full, or until product quality is below standard (usually due to leaking heat reject tubes), or until continued operation would likely cause unwarranted damage to equipment.

8.2 Preventive Maintenance Procedures and Criteria

Preventive maintenance includes regular lubrication, oil changes, and cleaning and painting of equipment. Maintenance work accomplished by the Maintenance and Operation staff, as scheduled, is usually scheduled with respect to expedient conditions rather than a fixed time schedule such as monthly, quarterly, etc. Criteria include need for water, availability of repair parts or facilities, degree of "off standard" water quality, and likelihood of damage to equipment if operation is continued.

One of the most effective preventive maintenance procedures is the close observance by competent operators for leaks, unusual noise, and unusual instrument readings, with the knowledge of corrective measures to be taken, and the initiative to take necessary action.

During the time that an evaporator is down for any reason, and to the extent that time and maintenance personnel are available, pumps are checked for alignment, valve seats may be inspected, gages and instrumentation are to be checked and calibrated.

8.3 Corrosion Experience, Testing and Control

Corrosion experience, testing, and control as related to product water is discussed in more detail in Section 7.4. Corrosion related to materials and performance of tubing, evaporator vessels, water boxes, piping, pumps, and traveling water screens is discussed in Section 9.

8.3.1 Plant Effluents, Copper, Nickel, and Iron

Test results indicating the copper, nickel, and iron content of plant effluents are included in Section 6.5.3 for blowdown, reject stream, and product water.

8.3.2 Corrosion Product Analyses

The analyses of sea water, product water, distillate, and blow-down are reported in Section 6.5.3. In particular the copper and iron appearing in each of these streams were studied to seek a correlation between the net outflow of these elements and experimental data gathered through the years on the decrease in tube wall thickness due to corrosion.

The data on the copper content of Guantanamo Bay seawater show large variations. For example, the analysis dated February 28, 1964 reports 0.01 ppm for Copper, while the analyses done from April 15 through August 5, 1968 show variations from 0.08 ppm to a high of 2.71 ppm. Similarly the February 28, 1964 analysis shows the seawater iron content to be 0.02 ppm while the 1968 data vary from 2.54 to 4.8 ppm.

Nevertheless, calculations were made to determine the difference between the outflow of copper and iron in all leaving streams and the inflow from the sea to determine if there is a correlation between reported rates of tube corrosion and the net outflows. In attempting these correlations several sets of calculations were made. One set disregarded the February 24, 1964 data since they were so much lower than any of the twelve samples tested during the 1968 period. For this calculation, data from 1968 which were greatly at variance with other 1968 samples were discarded. Thus, the April 22, 1968 and June 17, 1968 data on copper and iron in the seawater were discarded.

A second calculation was made using the analyses from Gitmo 2 during 1968 together with the February 24, 1964 seawater analysis. A third calculation was attempted using the 1964 seawater analysis and the 1965 Gitmo 1 blowdown and product water analyses. The results of these calculations are as follows: The total copper leaving the plant in the heat reject stream, blowdown stream, and product stream is 38.69 pounds per day for the Gitmo 2 plant. The percent time on line is 95.22 as calculated in Section 5.4. Thus the plant operates for 95.22% of the year or 347.5 days per year. The rate of tube corrosion of 90-10 Cu-Ni tubes is reported in a letter from R. H. Jebens of OSW to Burns and Roe dated January 22, 1969.[46] Tube wall corrosion is a function of brine temperature, dissolved oxygen concentration, seawater velocity and pH. The corrosion rate varies from a low 0.2 mil per year to a high of about 16 mils per year. Under the operating conditions of the Gitmo Units, the rate averages 1 to 2 mils per year. The copper loss in the heat rejection, heat recovery and brine heater exchangers was calculated for these corrosion rates.

At 1 mil per year, the loss in copper is 2828 pounds per year for Gitmo #2. The total copper in the Gitmo #2 effluent product water, blowdown and reject streams is 13,445 pounds per year. If the seawater had a copper content of 0.59 ppm, a mass balance would be achieved. In other words, the inflow copper in the incoming seawater stream plus the copper lost due to the 1 mil per year corrosion would equal the outflow of copper in the leaving streams. Neglecting the two aforementioned readings, which are out of line with the others, yields an average copper in the seawater stream of 0.536 ppm. Thus, there is a fair degree of agreement between the 0.59 ppm to give a balance of corrosion copper and the actual 0.536.

At 2 mils per year, the total copper loss due to corrosion would increase to 5666 pounds per year for Gitmo #2 and the intake seawater copper balance would fall to 0.432 ppm. The agreement with the measured 0.536 ppm is still within the accuracy of the averaged chemical analyses.

In summary, the mass balance made from chemical analyses of the in plant streams and expected corrosion rates gives fair agreement and can be used as a rough measure to predict corrosion rates and changes in corrosion rates throughout the plant life.

Similar trial calculations were made toward obtaining an "iron balance" for the Gitmo #2 plant. This time the February, 1964 seawater analysis is .02 ppm and averaged value in 1968 is 2.95 ppm. The 1968 data were again used.

The total iron in the leaving streams is 137.7 lb/hr while the total in the incoming seawater is 152.8 lb/hr. Since the reported iron inflow exceeds the outflow, no corrosions of iron can be accounted for in the iron balance. If the reported chemical analyses are taken as correct, the only plausible explanation is that iron is depositing on interior surfaces and not showing up in the leaving streams. Since the field has reported replacement of tubes in the heat reject section, calculations were made to determine what the corrosion rate in these stages would be.

The total weight of copper in the 3 reject stages consisting of 1064, 5/8 inch, 20 gage 90-10 Cu-Ni tubes was computed as 14,100 pounds. The copper in the reject stream is reported as 0.5 ppm and the rate of flow is 34.3 (10^6) lb/day. Using these data, yields a loss in wall thickness of 10.3 mils per year. This would indicate tube failure in 3 to 4 years which coincides with the reported operating experience. Serious consideration should be given to tubing specifications in the heat rejection section.

The second calculation for possible correlation of copper used the seawater analysis of 1964 and the Gitmo 2 1968 flow stream analyses. No information is available on the kind of chemical analysis performed either in 1964 or 1968. The results differ by so much that the method of analysis must be substantially different. The results of these calculations bear out the incompatibility of these analyses. The small copper content reported in the incoming seawater and the fairly large amounts in the leaving streams indicate that all of the copper in all the heat exchangers would be completely gone in 7.7 year.

The third calculation used in the 1964 seawater analysis and the 1965 Gitmo 1 Blowdown and Product Water analyses. The blowdown and product water streams affect the recovery stages and the brine heater. With the copper ppm reported for blowdown and product streams and the Gitmo 2 flow rates (which are approximately the same as the Gitmo 1 flow rates) the pounds per day of copper in the intake seawater exceeds that in the leaving streams. This of course is not possible and makes one question the accuracy of the chemical analysis reported. The other possibility would be that copper is depositing on the tubes though experience makes this seem highly unlikely.

8.3.3 Corrosion Control Practices

Seawater makeup is deaerated to lower the oxygen content and reduce the corrosion of piping and vessels. pH control of recycle brine is used to minimize corrosion resulting from acid cleaning operations. Chlorine treatment of sea water intake is closely controlled to keep corrosive action of the treated seawater at a minimum. Upon conversion to seawater cooling, the SJAE condenser heads were sandblasted and coated with "plasite" and zinc corrosion plates were installed to prevent corrosion.

Vessel and pipe exterior surfaces are painted for protection from weather corrosion.

8.4 Major Items of Overhaul and Replacement

The major items of overhaul and replacement have been:

1. Condenser tubes in the heat reject stages of the Gitmo #1 and #2 evaporators.
2. Pumps; including the seawater circulating pumps, sulfuric acid pumps, brine heater condensate pumps, Hagevap pumps; Gitmo brine extraction pumps, brine booster pumps, and product pumps; Pt. Loma recycle pumps, product pump, and blowdown pump.
3. Seawater traveling screens.
4. Point Loma and Gitmo water boxes.

8.5 Maintenance Procedure Modifications

Modifications in procedures which bear on maintenance may also involve modifications to equipment and modifications in operating procedures. The maintenance procedure modifications discussed below are of this type.

Chlorine injection for distillate prior to the coral bed was discontinued, and injection accomplished following the coral bed to improve the effectiveness and life of the coral. The coral bed was modified to improve circulation through the coral bed by providing a platform. The modifications were for the purpose of reducing the frequency of coral changes with resulting lower maintenance cost.

A separate and independent boiler plant make-up line from each evaporator was installed to replace a single line from the common product water lime bed influent well. The individual lines permit selection of distillate with the lowest chloride content for boiler make-up even though the other one or two evaporators may continue to be operated with higher chloride distillate. High quality make-up reduces boiler maintenance.

Debris blockage of heat reject section tubes has been a continuing problem. (See Section 9.1.3). In order to minimize this problem, a "backflushing" procedure has been developed and is accomplished without taking an evaporator off stream. No significant loss of production occurs during the backflushing operation.

Gitmo #1 and #2 Reject Condenser Backflushing procedure is as follows:

1. Close butterfly valve (1) on upstream side of blowdown flow control valve which controls the 15th stage level.
2. Open by-pass valve (2) around make-up flow control valve and close makeup control valve by closing instrument air supply valve to increase the 15th stage level quickly to

about 30 inches. Then close the by-pass valve.
3. Close seawater inlet valve (3).
4. Open reverse flow drain valve (4).
5. Close reject flow control valve (5).
6. Open high pressure crossover valve (6) from recycle brine stream, reversing flow through heat reject condensing tubes. Allow 15th stage to blowdown to normal level. Reverse procedure starting with step 6 and establish normal flows.

Procedure item numbers above refer to valve numbers shown on Gitmo #1 and #2 Backflushing Piping Diagram, Figure 8-1.

Pt. Loma Reject Condenser Backflushing procedure is as follows:

1. Turn down brine flow control settings, A & B stream from control room and place 50 psig backpressure at brine heater outlet.
2. Close discharge valve (2) on blowdown pump which controls 28th stage brine level.
3. Open make-up flow control valves, (3) A & B stream, 50% from control room and quickly increase 28th stage brine level to approximately 36 inches. Then close make-up valves.
4. Close seawater inlet valve (4).
5. Open reverse flow drain (5) on 28th stage water box.
6. Close reject flow valve (6).
7. Open high pressure crossover valve (7) from "B" recycle brine stream reversing flow through heat reject condensing tubes. Allow level to blowdown to normal. Reverse procedure beginning with Step 7 and establish normal flow rates.

Procedure item numbers 2-7 above refer to valve numbers shown on Point Loma Backflushing Piping Diagram, Figure 8-2.

The above procedures provide a backflow through the reject condenser tubes for a period of approximately five minutes. The Gitmo #1 and #2 reject condensers are backflushed every two days and the Pt. Loma reject condenser is backflushed approximately once per week.

8.6 Comments and Recommendations

Further work on corrosion/erosion rates may be desirable in developing optimum specifications for desalting plants, particularly reject condenser tube specifications. Means for on-stream backwashing of all condensers using seawater for coolant should be considered in future desalting plant specifications.

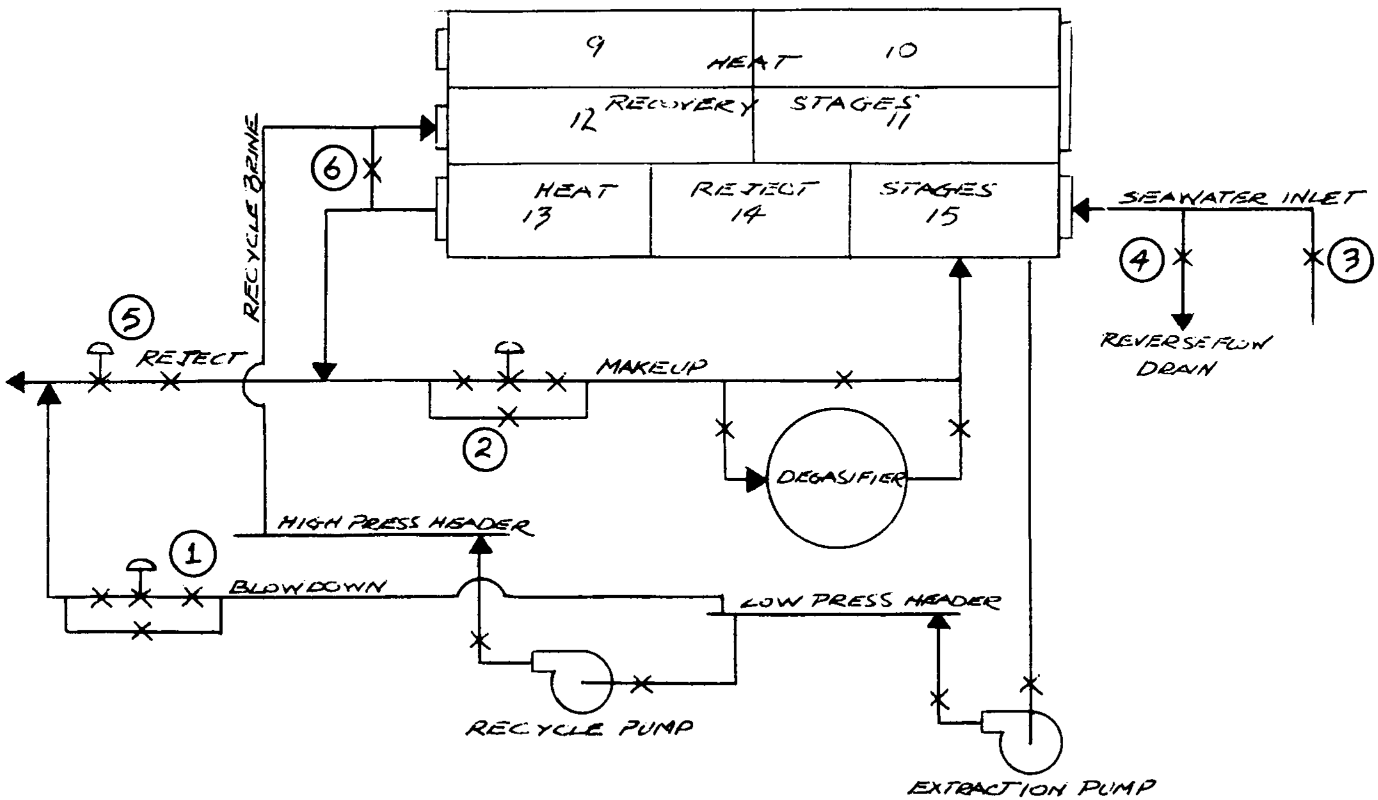


Figure 8-1

GITMO #1 AND #2 BACKFLUSHING PIPING DIAGRAM

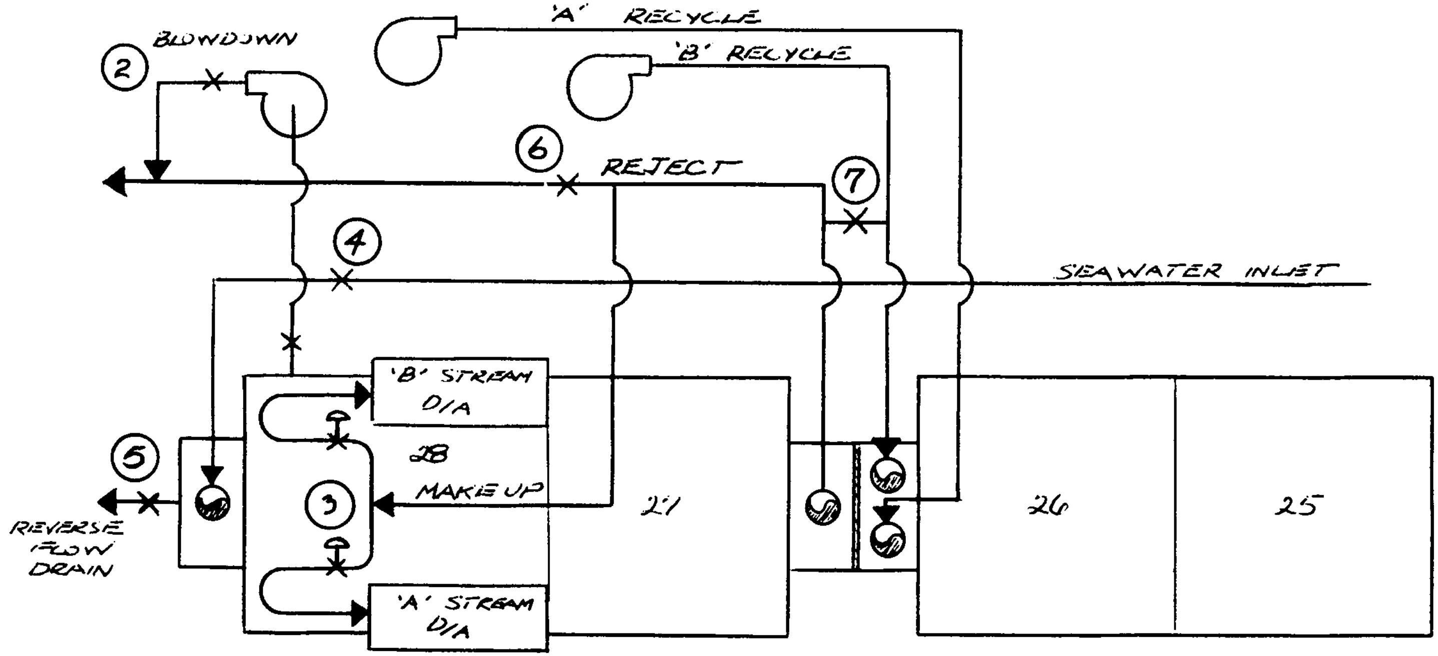


Figure 8-2

POINT LOMA BACKFLUSHING PIPING DIAGRAM

9.0 MATERIALS AND PERFORMANCE

9.1 Tubing Performance and Failures

Corrosion analysis of tubing is discussed in Section 8.3.2.

9.1.1 Materials Specifications

9.1.1.1 Evaporator Heat Reject Stages

See Section 4.0.

9.1.1.2 Evaporator Heat Recovery Stages

See Section 4.0.

9.1.1.3 Brine Heaters

See Section 4.0.

9.1.1.4 Air Ejector Condensers

After Condenser - Total number of tubes 216. ASTM-A-269
Type 316 Annealed 3/4" OD x 20 BWG x 2'9" lg.
Inter Condenser - Total number of tubes 216. ASTM-A-269
Type 316 Annealed 3/4" OD x 20 BWG x 4'9" lg.

9.1.2 Replacement and Repair Schedules

The heat reject tubes failure rate on Gitmo #1 and #2 are 45 and 30 per year respectively, and the Pt. Loma unit stands about 11 per year.

Figure 9-1 shows a breakdown of ruptured tubes plugged and replacement of tubes for each of the three plants during the six years of operation. Gitmo #1 and #2 have had two replacements scheduled, while Pt. Loma unit has had no replacement of tubes in the 6 year period.

Figure 9-2 and Figure 9-3 show a breakdown of ruptured tubes plugged in terms of each year and percent of total tubes ruptured each year. The Pt. Loma unit heat reject tube failure rate was at a low nil % in 1966, and high of 2.1% in 1965. The overall was 8.96% total failures from 1964 through 1970. The Gitmo #1 unit had a low failure rate of 1.97% in 1965 and a high of 7.9% in 1966, the overall was 25.5% total failures from 1965 through 1970. The Gitmo #2 unit had a low failure rate of 0.94% in 1965 and a high of 4.50% in 1969. The overall was 17.1% total failures from 1965 through 1970.

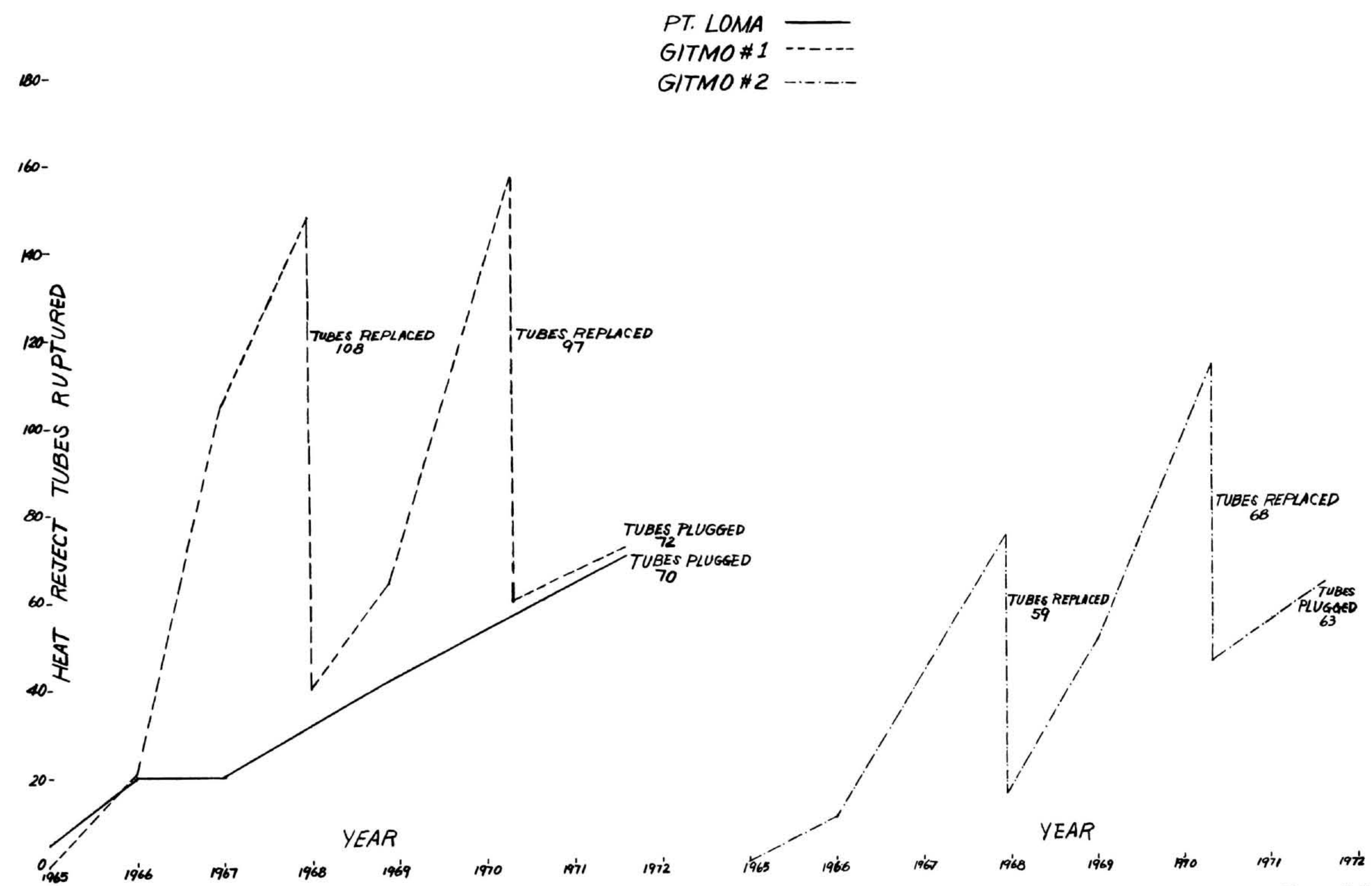


Figure 9-1
HEAT REJECT TUBES RUPTURED

YEAR	PT. LOMA		GITMO #1		GITMO #2	
	NUMBER OF TUBES RUPTURED	PERCENT OF TUBES RUPTURED	NUMBER OF TUBES RUPTURED	PERCENT OF TUBES RUPTURED	NUMBER OF TUBES RUPTURED	PERCENT OF TUBES RUPTURED
1964	5	0.70	--	--	--	--
1965	15	2.10	21	1.97	10	0.94
1966	0	0	84	7.90	33	3.10
1967	12	1.68	43	4.00	33	3.10
1968	11	1.54	30	2.82	33	3.10
1969	10	1.40	67	6.30	48	4.50
1970	11	1.54	27	2.54	25	2.35

FIG. 9-2

PERCENT OF HEAT REJECT TUBES RUPTURED

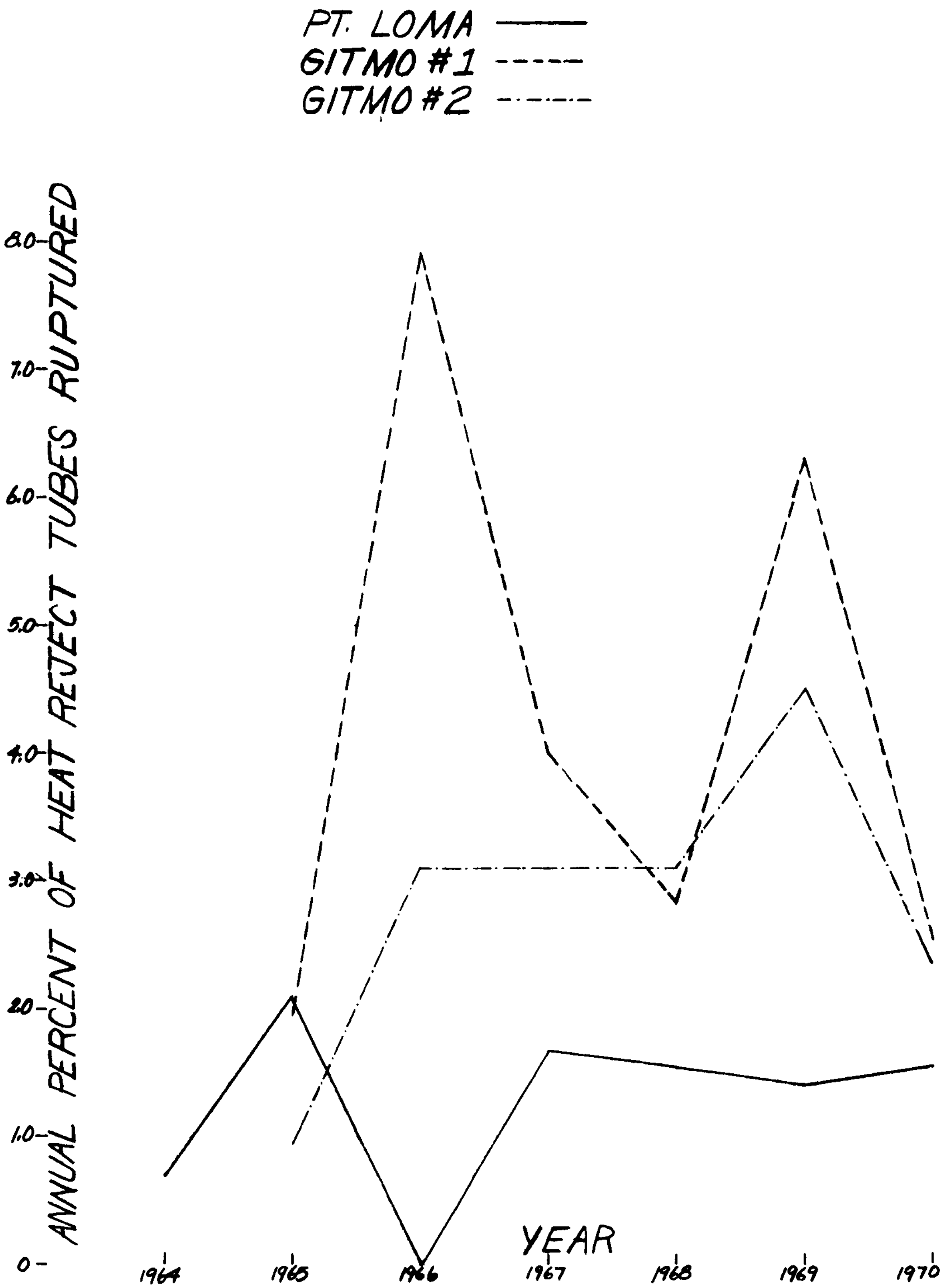


Figure 9-3

ANNUAL PERCENT OF HEAT REJECT TUBES RUPTURED

None of the heat reject replacement tubes have failed since installation.

The tubes in the heat recovery sections of the Pt. Loma evaporator have performed for six years at Guantanamo, plus an additional prior two years at Pt. Loma, California, with no tube failures and no tube replacements. The Gitmo #1 and #2 heat recovery section tubes have been in service for six years at Guantanamo with no failures and no replacements.

The brine heater tubes have performed satisfactorily for the Point Loma, Gitmo #1 and #2 units in the 6 year period. At times the brine heater tubes have had to be cleared by drilling or air and mechanical lancing because of being plugged with Calcium or debris. There has been no replacement of brine heater tubes for the 3 units during the six year period.

From 1965 through 1970, brine heater tubes in the Point Loma unit were cleared only once. Gitmo #1 unit brine heater tubes were cleared about 3 times and the Gitmo #2 unit tubes were cleared only 2 times.

As for the Air Ejector Condenser tubing for the 3 units, inspection of these tubes from time to time indicates good performance. There has been no replacement of tubes in the six year period.

9.1.3 Failure Analysis Including Laboratory Test (Topical Reports)

The Anaconda American Brass Co.[45] submitted a report to Burns and Roe, Inc. on March 27, 1967. The report indicates the cause of the heat reject stage tube failures.

The report is as follows:

"Purpose:

To examine and determine the cause of failure of a section of 5/8" OD x 20 BWG 90-10 Copper Nickel Tubes removed from the heat rejection stage of the Guantanamo Unit #1 flash evaporator.

"Summary:

A tube sample 8½" long was received for examination.

It had been in service for about 2½ years handling sea water on the inside at temperatures varying from 80°F to 97°F. The design tube velocity was about 6.9 fps, but due to a large number of tube failures which were plugged, the tube probably operated for a portion of the time at a velocity of about 7.5 fps. It was acknowledged that sea shells had caused blockage of some of the tubes.

The tube metal was analyzed chemically and spectrographically for composition and purity. Corrosion products and deposits on the inside surface were determined using microchemical techniques. The failed areas were examined microscopically and photomicrographs were prepared to show pertinent details.

"Conclusions:

The outside surface of the tube was in excellent condition.

The failure was from the inside surface and, in our opinion, was the result of deposit attack resulting from lodgement of a foreign object, perhaps a shell, inside the tube.

"Recommendations:

The obvious recommendation is to provide better cleaning of the cooling water before it enters the heat exchanger. We realize this is a difficult path to pursue.

"Discussion:

Chemical analysis of the tube metal showed it to have the following composition:

Analysis No.	1452
Spectrum No.	1126
Micro No.	A 71214
Copper	87.76%
Nickel (by diff.)	9.71%
Iron	1.28%
Manganese	0.51%
Zinc	0.40%
Lead	0.31%
Tin	0.03%

"Spectrographic analysis showed no other impurities to be present in significant amounts.

"The above analyses show the tube metal to be of good composition and purity and to be in accordance with the chemical requirements of ASTM Specification B 111 for 90-10 Copper Nickel condenser tube.

"The inside tube surface contained a dark red film with spotty green corrosion products also present. There were a few black spots present along with cuprous oxide in the form of a thin crystalline deposit underneath a film of rust.

"Analyses of these corrosion products and deposits showed them to comprise the following:

Water Insoluble Constituents

Cupric Oxide	Small
Cuprous Oxide	Large
Nickel Oxide	Very Small
Sulfides	None
Ferric Oxide	Very Large (major constituent)
Silica	Moderately Large
Organic Matter	Very Small
Basic Copper Carbonates	Small) form green product
Basic Copper Chlorides	Very Large)

Water Soluble Constituents

"(The amounts of individual constituents are relative to the total amounts of soluble solids and are small compared to insoluble constituents.)

Carbonates	Trace
Chlorides	Large
Sulfates	Small
Sodium Salts	Moderately Large
Calcium Salts	Large
Silica	Large
Organic Matter	Extremely Large
Ammonium Compounds	None
pH of Concentrated Water Washings	6.0
Total Soluble Solids	51 mg/sq. ft."

9.2 Evaporator Vessels

9.2.1 Material and Specs

Evaporator Shells.	Steel, ASME SA-285-C, FBQ
Evaporator Heads	Steel, ASME SA-285-C, FBQ
Evaporator Troughs, Supports, Baffles, Weirs, etc.	Steel, ASME SA-283-C
Flanges.	Steel, ASME SA-181-11
Bolting.	Alloy Steel, ASME SA-193-B7
Connections.	Steel, ASME SA-283-C, Or ASME SA-106-A
Coating.	The Pt. Loma bidding specification (46) called for all internal steel parts including shell, baffles, troughs, supports, and miscellaneous steel parts of stages 1 through 4 and 28 to be protected with a six to eight mil coating of Heresite P-403, or approved equal, with a minimum of six coats applied to all surfaces spark free. The Heresite was to be applied after sandblasting to a white metal surface and in strict accordance with the manufacturer's recommendations. No internal steel parts in other stages or water boxes were to be surface protected. No surface protection was to be used on any copper alloy parts.

No internal coatings were applied to Gitmo #1 and #2 vessels.

In July 1971, the Pt. Loma, Gitmo #1 and #2 evaporator vessels were measured 3/4 inches thick at the end, top, bottom and side plates.

9.2.2 Corrosion Design Allowance vs Experience

The specification (46) of total corrosion design allowance for the Pt. Loma evaporator vessel is specified as follows:

Pressure parts of the vessels and other equipment manufactured from steel in contact with deaerated seawater or brine shall be designed with a total corrosion allowance in accordance with the following:

Brine Temperature	Corrosion Allowance
under 170°F	0.0625
above 170°F	0.125

These corrosion allowances apply to the shells of all evaporator stages.

For purposes of complying with this requirement when the brine exceeds 170°F in any part of a vessel under operation at the guaranteed capacity point of at least one million gallons per day and at the 250°F design temperature, the total corrosion allowance for the entire vessel shall be 0.125 inches.

All other internals fabricated of steel shall be designed with a total corrosion allowance of 0.0625 inches.

Evaporator vessel interiors were inspected regularly for corrosion. During six years period of operation, all the vessel shells show no excessive corrosion for the three units. On November 1968, a 2" x 4" section of 5th stage roof was removed and a hole was drilled in the 13th stage roof of the Pt. Loma unit. The purpose was to measure metal thickness. In each case, the measurement was approximately 3/4 of an inch. The cover plate for Gitmo #1 and #2 unit shows an estimate of 1/16 inches corrosion on the inside. Due to the corrosion and erosion action, most of the product troughs for the 3 units had experienced leaks and were repaired by welding.

9.2.3 Comments and Recommendations

As of July 1971, the evaporator vessel shells for the 3 units have performed quite satisfactorily. However, consideration should be given to more corrosion resistance for the product troughs in the vessel.

9.3 Evaporator Water Boxes

9.3.1 Materials and Specifications

The Point Loma water boxes were carbon steel, lined with Plasite 7155 when installed at Point Loma. In 1964, all the water boxes were removed, sand blasted, weld built up and plasited again when installed at Gitmo. The Gitmo #1 and #2 water boxes were unlined carbon steel when initially installed.

9.3.2 Case History of Failures

The Plasite holds up well, but is damaged if the coated steel is welded after plasiting. At some time, pipe connections were welded to water boxes after lining, with resulting failure of the lining in the welded area.

Figure 9-4 and Figure 9-5 show the percent outage for water boxes leak for each of the three plants from 1965 through 1970. The Pt. Loma unit had a yearly low of 0.06% in 1965 and a yearly high of 11.07% in 1970. The high rate of failure of Pt. Loma water boxes in 1970 is due to the unsuccessful redesign of the boxes. The overall six years was 2.17% average outage. The Gitmo #1 unit had a yearly low of nil % in 1965 to a yearly high of 1.03% in 1970. The overall six years was 0.57% average outage from 1965 through 1970. The Gitmo #2 unit had a yearly low of nil % in 1965 and 1966 to a yearly high of 0.38% in 1970. The overall six years was 0.17% average outage from 1965 through 1970.

Figure 9-6 shows a breakdown of water box failures for each of the three plants by years. The Pt. Loma unit had a low of 2 failures in 1965 and a high of 50 failures in 1970. The total was 89 failures from 1964 through 1970. The Gitmo #1 unit had no failures in 1965 and a maximum of 20 failures in 1970. The total was 40 failures from 1965 through 1970. The Gitmo #2 unit had no failures in 1965 and 1966 with a maximum of 9 failures in 1970. The total was 21 failures from 1965 through 1970. All water boxes, 8 end boxes and 4 in line, were replaced on the Pt. Loma unit in 1970. The new boxes were redesigned, leaving out the divider which formally separated the A & B streams. Where the old boxes were bolted to the tube sheet, the new boxes had a flange welded to the vessel and the box bolted to this flange. The studs that supported the old boxes were burned off and ground flush with the tube sheet. The new design water boxes proved unsatisfactory and were changed back to the original design with the exception that the stream divider plates were omitted. The new water boxes material is mild steel and the interior of the boxes is coated with Plasite.

Some of the Gitmo #1 and #2 water boxes have been changed from original design to the new design. The new design water boxes are expected to provide smoother and better flow of brine through the water box, reducing likelihood of rupture of the boxes. Figure 9-7 illustrates the flow of brine through the original and new design water boxes. The new design water boxes have been constructed of solid stainless steel and the remaining old design boxes have been lined with stainless steel.

Year	Pt. Loma		Gitmo #1		Gitmo #2	
	Outage Hours	% Outage Water Boxes	Hours	% Outage Water Boxes	Hours	% Outage Water Boxes
1965	5	0.06	0	0	0	0
1966	28½	0.33	29	0.33	0	0
1967	15	0.17	66½	0.76	38	0.43
1968	32	0.36	52	0.59	5	0.06
1969	89½	1.02	63	0.72	14	0.16
1970	970	11.07	90	1.03	33½	0.38

Figure 9-4

PERCENT OUTAGES FOR WATER BOX LEAKS

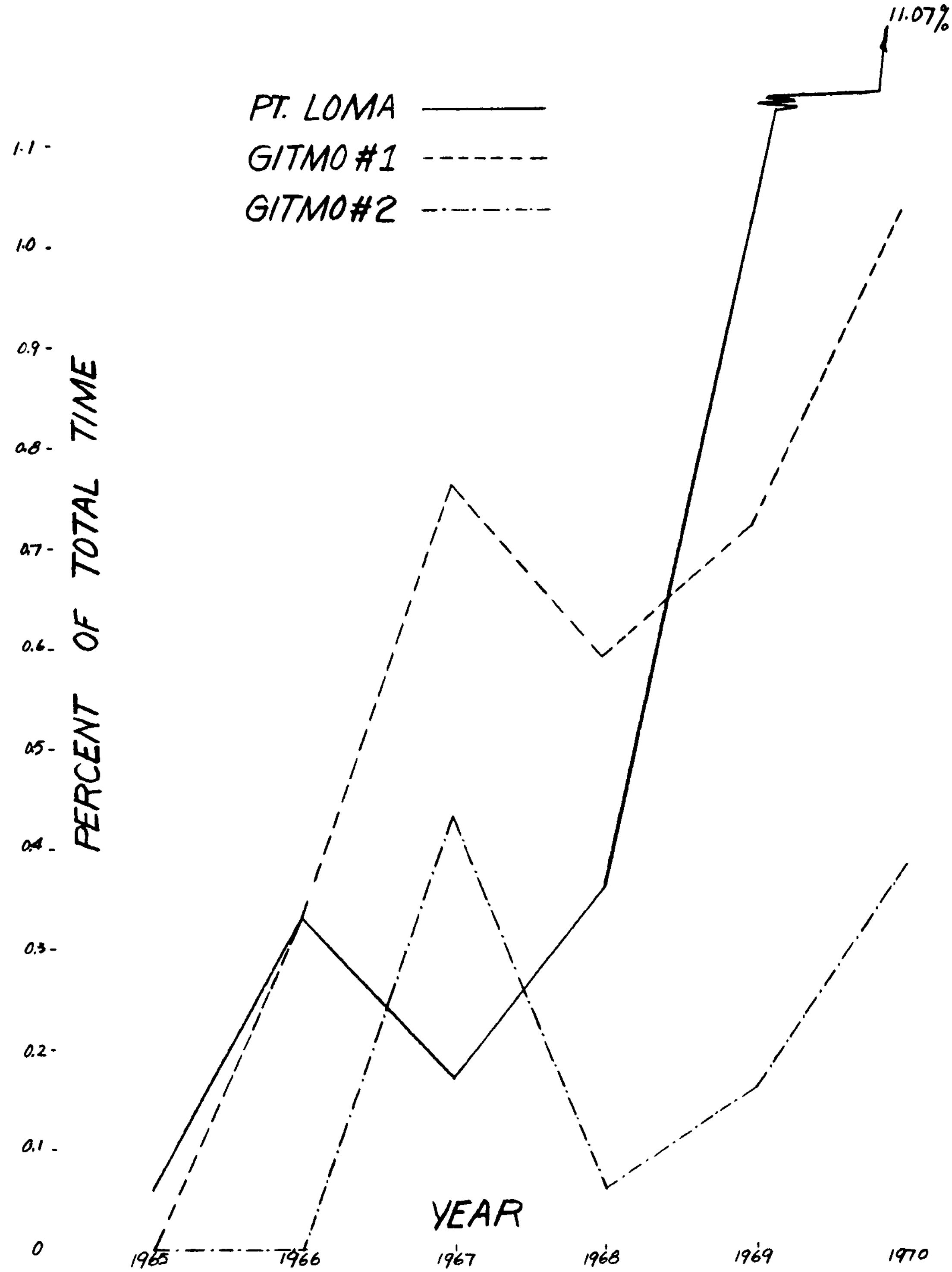


Figure 9-5

PERCENT OUTAGES FOR WATER BOXES LEAK

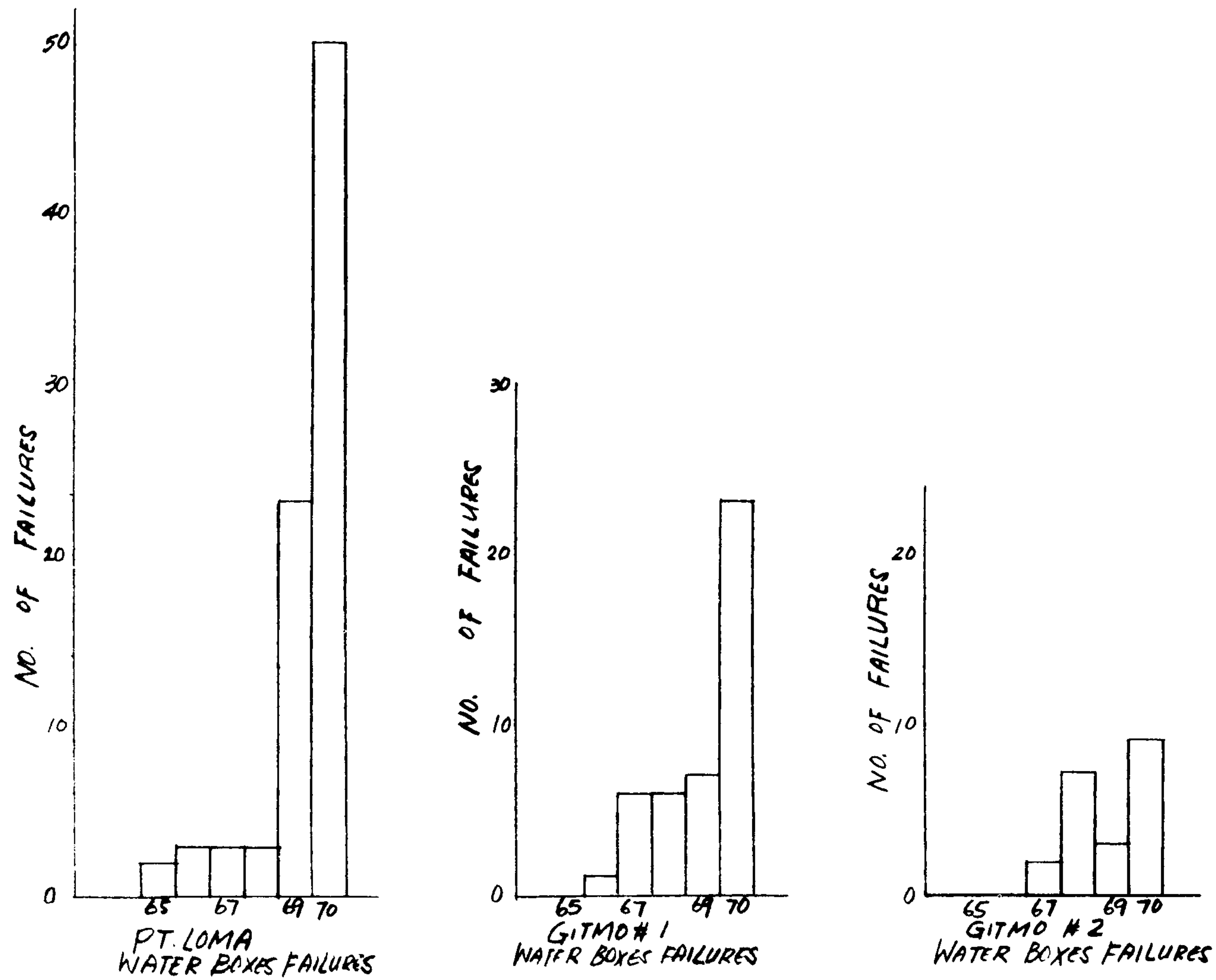
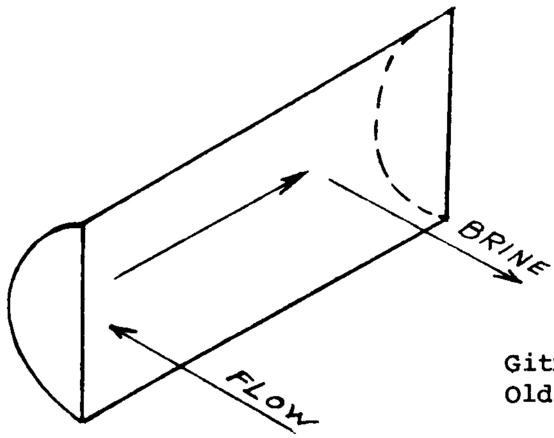
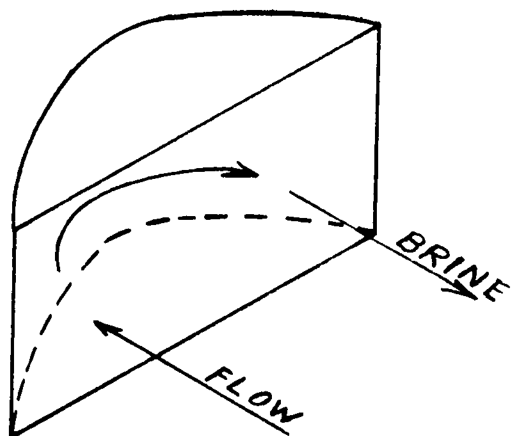

NO. OF FAILURES
50
40
30
20
10
0
65
67
69
70
PT. LOMA
WATER BOXES FAILURES
NO. OF FAILURES
30
20
10
0
65
67
69
70
GITMO # 1
WATER BOXES FAILURES
NO. OF FAILURES
20
10
0
65
67
69
70
GITMO # 2
WATER BOXES FAILURES

Figure 9-6



Gitmo #1 and #2
Old Design Water Box



Gitmo #1 and #2
New Design Water Box

Figure 9-7

9.3.3 Performance of Stainless Steel

Stainless steel water boxes have been in service a relatively short time in comparison with unlined or lined carbon steel water boxes at Guantanamo. The one failure of a stainless steel box through July 15, 1971 indicates favorable performance, but extended service is required before arriving at conclusions.

9.3.4 Comments and Recommendations

The Wisconsin Protective Coating Corp., "Plasite" 7155 appears to be a satisfactory coating for carbon steel in brine service at temperatures encountered in the Guantanamo evaporators. Continued observation of the performance of carbon steel Plasite lined, carbon steel stainless lined, and solid stainless water boxes is recommended.

9.4 Evaporator Piping and Fittings

9.4.1 Design Specifications[26]

The following tables list the materials of construction for the piping and fittings for each service used in the original installation. For a given service the specifications may change with pipe diameter.

9.4.1.1 Piping Materials

Service	Size	Material
Seawater (undeaerated and exposed)	≤3"	Standard weight wrought iron.
	≥4"	Standard weight seamless steel (cement mortar lined).
Deaerated Brine - High Pressure	≤2"	Sch40 wrought iron (zinc coated).
	≥2½"	Extra strong wrought iron or seamless steel (zinc coated).
Deaerated Brine - Low Pressure	≤2"	Sch40 wrought iron (zinc coated).
	≥2½"	Std. weight wrought iron or seamless steel (zinc coated).
Concentrated Sulfuric Acid	All sizes	Sch80 seamless steel.
Dilute Sulfuric Acid	1"	Sch80 austenitic stainless steel.
Hagevap and dilute NaOH solution	All sizes	Sch40 seamless steel.
Chlorine Gas or Liquid	All sizes	Sch80 wrought iron.
Vent Piping - Low Pressure	≤3"	Sch40 steel (zinc coated).
	≥4"	Std. weight wrought iron.
Condensate, Evaporator Distillate, Fresh Water Service	All sizes	Extra strong seamless steel.
Product Water	≤3"	Std. weight wrought iron (zinc coated).
	≥4"	Cast iron pipe (cement mortar lined when buried).
High Pressure Steam	All sizes	Sch40 or std. weight seamless steel.
Low Pressure Steam, Turbine Bleed Steam	All sizes	Std. weight seamless steel.
(except 20" extraction line from turbine)		Sch10 seamless steel.
Seawater (Concrete Pipe Buried)[27]	All sizes	Reinforced concrete.

9.4.1.2 Fittings

Service	Size	Material
Seawater (undeaerated and exposed)	≤3"	Malleable Iron.
	≥4"	Carbon steel (cement mortar lined).
Deaerated Brine - High Pressure	≤2"	Malleable Iron (zinc coated).
	≥2½"	Extra strong zinc coated wrought iron or extra strong carbon steel.
Deaerated Brine - Low Pressure	≤2"	Malleable Iron (zinc coated).
	≥2½"	Std. weight wrought iron (zinc coated). Std. weight Carbon steel.
Concentrated Sulfuric Acid	1/8",¼",3/8"	Forged steel.
	≥½"	Extra strong carbon steel.
Dilute Sulfuric Acid	All sizes	Austenitic stainless steel.
Hagevap and Dilute NaOH Solution	≤1½"	Forged steel.
	≥2"	Carbon steel.
Chlorine Gas or Liquid	All sizes	Malleable Iron.
Vent Piping - Low Pressure	≤3"	Malleable Iron (zinc coated).
	≥4"	Std. weight wrought iron.
Condensate, Evaporator Distillate, Fresh Water Service	≤2"	Forged steel.
	≥2½"	Extra strong steel.
Product Water	≤3"	Malleable Iron (zinc Coated)
	≥4"	Cast iron.
High Pressure Steam	≤2"	Forged Steel.
	≥2½"	Std. weight alloy steel.
Low Pressure Steam	≤2"	Forged steel.
	≥2½"	Std. weight carbon steel.

9.4.2 Performance History

The piping failures recorded [6] for each unit were classified under the following categories: seawater (undeaerated and exposed), deaerated brine, sulfuric acid, vent piping, product water. For each of these categories the number of failures that occurred in a year was plotted versus that year. The data is presented so that one may distinguish the contributions from the individual units (see legend Figure 9-10).

9.4.2.1 Seawater (Undeaerated and Exposed)

Figure 9-8 shows that failures experienced in the seawater (undeaerated and exposed) piping increased with each year from 1964 to 1968 and decreased in 1969 and 1970. About 50% of these failures were repaired by welding.

Seawater piping in sizes 4" or greater were cement lined, standard weight, seamless steel. Slightly over 80% of the reported failures occurred in this type of piping, and 80% of these were weld repaired.

Some repiping of this system took place in 1969. That, for which Hyle and Patterson was responsible, is indicated on Figure 9-9.

9.4.2.2 Deaerated Brine

Deaerated brine piping experienced the greatest number of failures in 1968 as can be seen on Figure 9-8. Fewer problems were encountered in 1969 and 1970, during which much of the recycle piping was replaced.

Point Loma accounted for 45 of the 70 deaerated brine piping failures recorded. Gitmo #1 accounted for 13. Gitmo #2 accounted for 12. Most of the Gitmo failures occurred in 1970.

Deaerated brine piping specifications differed depending on whether the service was high pressure (recycle) or low Pressure (flashing). Over 75% of the 70 reported failures occurred in the high pressure piping. Seventeen (17) low pressure piping failures were reported. Thirteen (13) of these occurred in piping immediately after or preceding the FRC valve.

Mitre joints in the high pressure deaerated brine piping (recycle) were replaced with long sweep elbows of wrought iron construction. This substitution was completed in 1971 with the intention of reducing erosion.

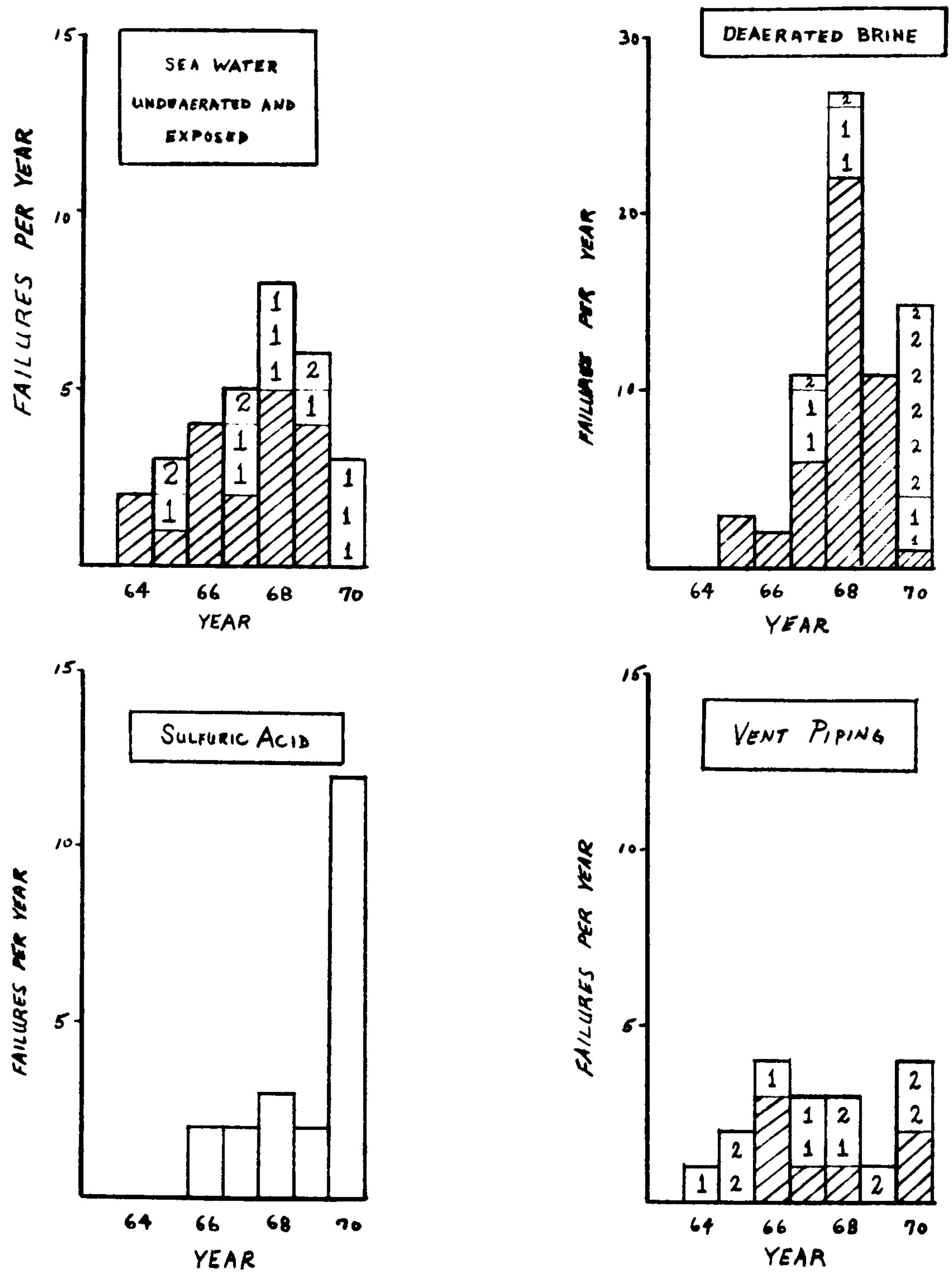


Figure 9-8
PIPING FAILURES PER YEAR
BY SERVICE

UNIT	SERVICE	REPLACEMENT	SIZE	AMOUNT REPLACED	MATERIAL OF CONSTRUCTION
Gitmo #1&#2 (ea)	H.P. Brine	Piping	20"	212'	Wrought Iron
"	L.P. Brine	"	36"	18'	" "
Point Loma	Recycle (H.P.)	"	16"	214'	" "
"	" "	Elbows	16"	51	" "
"	Make-up	Piping	12"	45'	Seamless Steel
"	" "	Elbows	12"	4	" "
"	" "	"	8"	6	" "
"	" "	Piping	8"	16'	Stainless Steel
---	Sulfuric Acid	"	½"	615'	Black Iron Sch80
---	" "	Tees	½"	50	" " "
---	" "	45°Elbows	½"	25	" " "

Figure 9-9

MODIFICATIONS BY HYLE AND PATTERSON

TO PLANT PIPING AND FITTINGS

9.4.2.3 Sulfuric Acid

Sulfuric acid piping (Figure 9-8) experienced a six-fold increase in reported failures in 1970 with four of the twelve reported failures occurring on the acid injection nozzles. In August of 1970 the acid was drained from the plant storage tank to allow repairs and modification of the tank and piping.

9.4.2.4 Vent Piping

Eighteen failures of Vent piping (Figure 9-8) were reported between 1964 and 1970. Point Loma accounted for seven of these, while Gitmo #1 and Gitmo #2 accounted for five and six respectively.

9.4.2.5 Product Water

Product Water piping (Figure 9-10) had far fewer failures than for brine piping. Ten failures were reported over the seven year period from 1964 to 1970, all of which were on Point Loma. No failures were reported for 1970, the year Point Loma's vessel to vessel Product Water piping was replaced.

9.4.2.6 Hagevap and Dilute NaOH

The only reported failure for this service occurred in 1970 when suction strainers were replaced.

9.4.2.7 Chlorine Gas or Liquid

Problems with this service were confined to the chlorine lines at the seawater intake. Six failures were reported. Three of these involved replacement of all or part of the seawater intake chlorine lines. The remaining three failures were able to be repaired.

9.4.2.8 Evaporator Distillate

Five failures were reported. Three of these called for pipe replacement. All five occurred in 1969 and 1970.

Two of the failures were on SJAE drain lines; one was on the product water pump gland, one was on a desuperheating water pipe and one was on a condensate line.

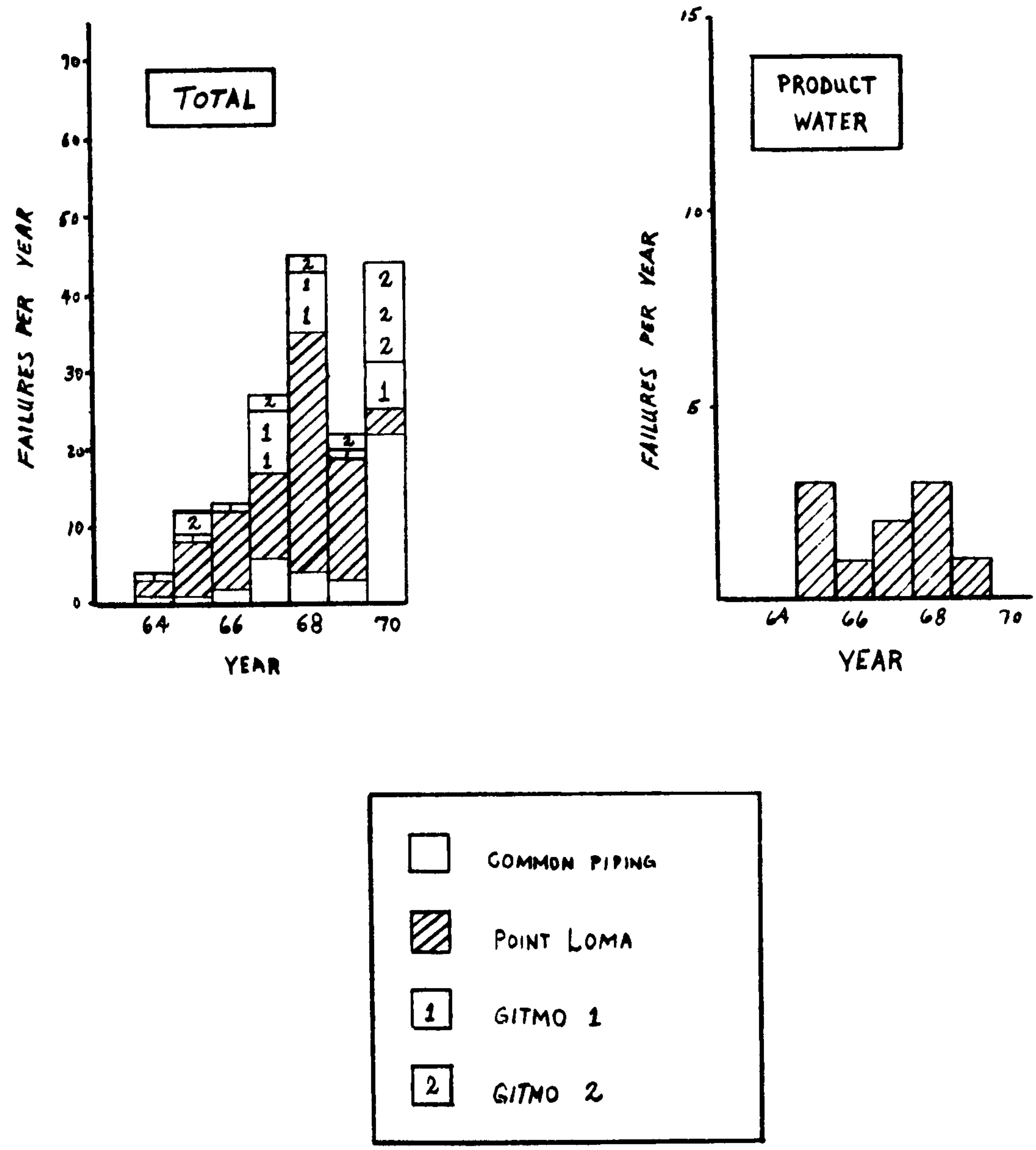


Figure 9-10

PIPING FAILURES PER YEAR
TOTAL & PRODUCT WATER SERVICE

9.4.2.9 Steam (High Pressure-Low Pressure)

There were two high pressure steam failures and four low pressure steam failures. One occurred in 1964 and another in 1967. The remaining four occurred in 1970.

9.4.2.10 Seawater (Concrete Pipe-Buried)

No failures for this service were recorded; however, 3" to 4" of sea growth was reported to be clinging to the walls of the 66" cement seawater intake.

9.4.2.11 General

The total number of reported piping failures for each year is plotted on Figure 9-10. A peak was reached in 1968 and again in 1970. Piping common to all three units accounted for 23.2% of the failures. Point Loma piping experienced 51.8% of the recorded failures. Gitmo #1 and Gitmo #2 had 16.7% and 12.5% of the failures, respectively. Weld repairs were used on 60% of the brine piping failures while only 12% of the failures in the remaining piping were corrected by this procedure.

Hyle and Patterson was contracted to replace piping, fittings, pumps, valves, etc. for the plant. Figure 9-9 summarizes their modifications to plant piping and fittings. Recycle piping was completely installed and hydro-tested by September, 1970.

9.4.2.12 Outage Time Due to Piping Failures

The hours of down time as a function of each year of operation is plotted on Figure 9-11 for the following services: Makeup piping, recycle piping, product piping and vent piping. Figure 9-12 is a plot of the total down time due to piping failures for each year of operation.

In comparing "failures versus year" with "outage time versus year" note the following points. Failures resulted in varying degrees of down time. Some resulted in no down time. Repiping of the various services accounted for much down time in 1969 and 1970. Repiping was not considered a failure. As was noted earlier, Point Loma was down far more than either of the other units.

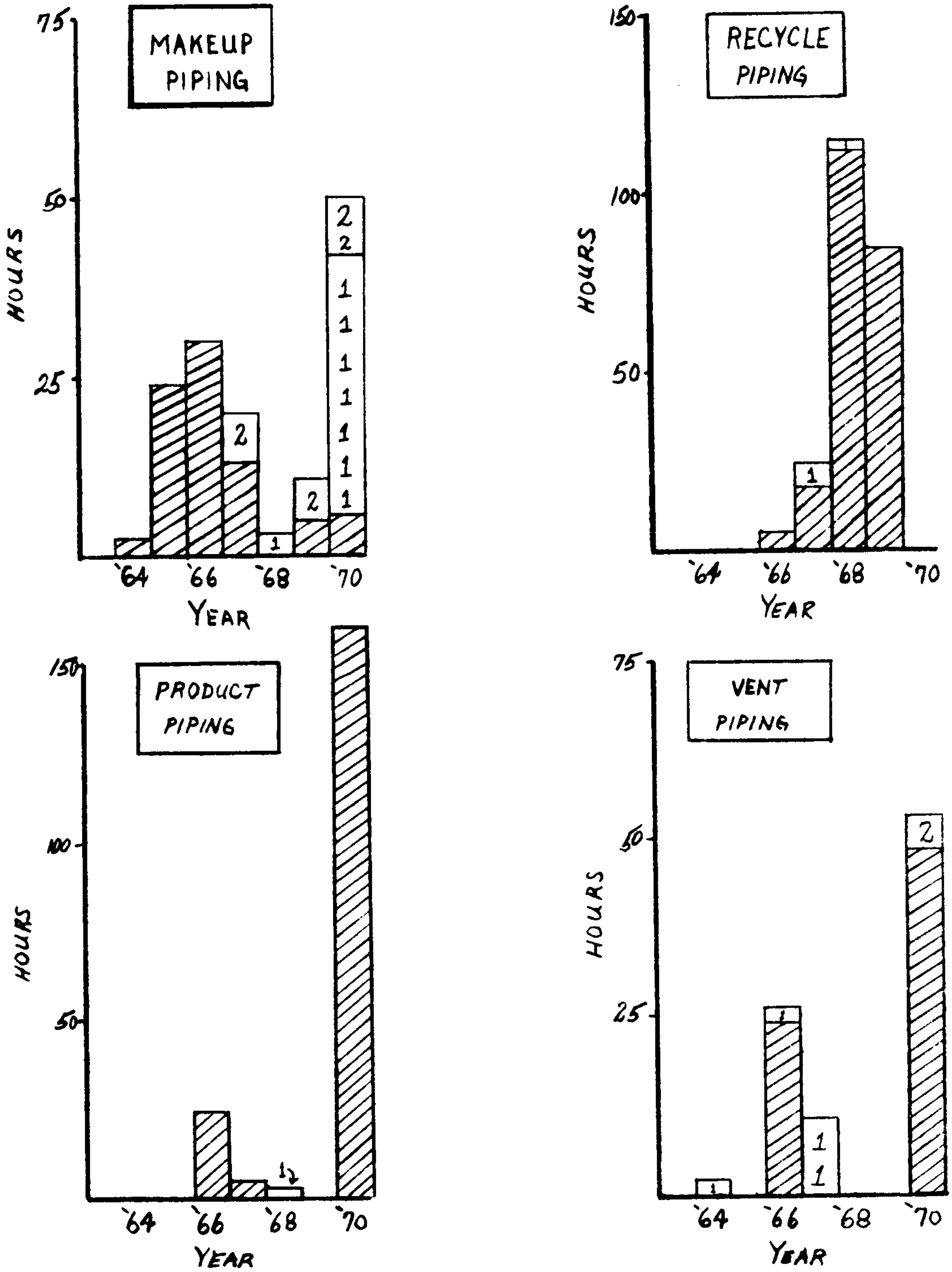


Figure 9-11

HOURS DOWNTIME BY SERVICE
PER YEAR

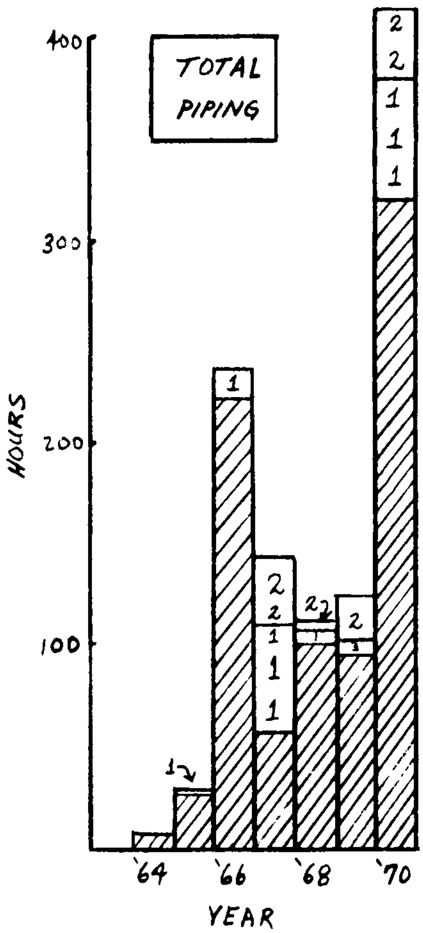


Figure 9-12

TOTAL OUTAGE TIME DUE TO PIPING FAILURES FOR EACH YEAR OF OPERATION

The high amount of down time in 1966 is due primarily to trouble with the SJAE, which accounted for 71% of the down time.

9.4.3 Comments and Recommendations

The source for the data used in the preceding section was the "Summary of Weekly Activities." All piping failures may not have been documented but a sufficient number have been recorded to give an indication of relative piping performance and general trends. In connection with evaporator piping design specifications, reference is made to Sections 8.5, 4.4.4.2, and 4.4.8.4.

9.5 Valves

9.5.1 Design Specifications [27]

The original installation materials of construction for the valves are contained in the tables of this section. Each table describes a different valve type (gate, globe, etc.). As with the piping, materials vary with service and size.

Since the body, disc, seat, plug and sleeve were considered the critical components of the valves, listed material specifications were limited to these items.

9.5.1.1 Gate Valves

Service	Size	Materials of Construction		
		Body	Disc	Seat
Seawater (undeaerated and exposed)	≤3"	Bronze	Bronze	Bronze
	≥4"	High grade iron (bronze trimmed)	Cast iron (bronze faced)	Bronze
Deaerated Brine - High Pressure	≤2"	Bronze	Bronze	410 stainless steel
	≥2½"	Bronze	Cast iron (bronze faced)	Bronze
Deaerated Brine - Low Pressure	≤2"	Bronze	Bronze	Bronze
	≥2½"	High grade iron (bronze trim)	Cast iron (bronze faced)	Bronze
Vent Piping	≤2½"	Bronze	Bronze	Bronze
	≥3"	High grade iron (bronze trimmed)	Cast iron (bronze faced)	Bronze
Condensate, Evaporator Distillate, Fresh Water Service	≤2"	Bronze	Bronze	Bronze
	≥2½"	High grade iron (bronze trim)	Cast iron (bronze faced)	Bronze
Product Water	≤3"	Bronze	Bronze	Bronze
	≥4"	High grade iron (bronze trimmed)	Cast iron (bronze faced)	Bronze
High Pressure Steam	≤2"	Alloy steel	Steel	Steel
	≥2½"	Cast alloy steel	Steel (stellite faced)	Steel (stellite faced)
Low Pressure Steam	≤2"	Forged steel	Steel	Steel
	≥2½"	Cast carbon steel (stainless trim)	Steel	Steel

9.5.1.2 Globe Valves

Service	Size	Materials of Construction		
		Body	Disc	Seat
Seawater (undeaerated and exposed)	≤3"	Bronze	S.S.	S.S.
	≥4"	Iron (bronze trim)	≤6" bronze >6" iron (Bronze Faced)	Bronze
Deaerated Brine - High Pressure	≤2"	Bronze	≤½" Monel >½" Nickel alloy	Exelloy
	≥2½"	Ferrosteel (bronze trim)	≤3" bronze >3" iron (Bronze Faced)	Bronze
Deaerated Brine - Low Pressure	≤2"	Bronze	S.S.	S.S.
	≥2½"	Iron (bronze trim)	≤6" bronze >6" iron (Bronze Faced)	Bronze
Chlorine Gas or Liquid	All sizes	Carbon forged steel	Teflon	Hastelloy "C"
Vent Piping - Low Pressure	≤2½"	Bronze	S.S.	S.S.
	≥3"	Iron (bronze trim)	<6" Bronze >6" Iron (Bronze Faced)	Bronze
Condensate, Evaporator Distillate, Fresh Water Service	≤2"	Bronze	S.S.	S.S.
	≥2½"	Iron (bronze trim)	≤6" Bronze >6" Iron (Bronze Faced)	Bronze
Product Water	≤3"	Bronze	S.S.	S.S.
	≥4"	Iron (bronze trim)	≤6" Bronze >6" Iron (Bronze Faced)	Bronze
High Pressure Steam	All sizes	Alloy steel	Alloy steel (StelliteFaced)	Alloy steel (Stellite Faced)
Low Pressure Steam	≤2"	Forged carbon steel	S.S. (Stell.Faced)	Exelloy (Stell.Faced)
	≥2½"	Cast carbon steel(SS trim)	No.4(Nickel Alloy)	Exelloy

9.5.1.3 Check Valves

Service	Type	Size	Materials of Construction: Body	Disc	Seat
Seawater (unde-aerated and exposed)	Swing	<3"	Bronze	Bronze	Integral
	Swing	≥4"	Ferrosteel (bronze trim)	≤3" bronze >3" iron (Bronze Faced)	Bronze
Deaerated Brine - High Pressure	Swing	≤2"	Bronze	Bronze	Bronze
	Swing	≥2½"	Ferrosteel (bronze trim)	≤3" bronze ≥4" iron (Bronze Faced)	Bronze
Deaerated Brine - Low Pressure	Swing	≤2"	Bronze	Bronze	Integral
	Swing	≥2½"	Ferrosteel (bronze trim)	≤3" bronze 3" iron (Bronze Faced)	Bronze
Vent Piping - Low Pressure	Swing	<2½"	Bronze	Bronze	Integral
	Swing	≥3"	Ferrosteel (bronze trim)	≤3" bronze ≥3" iron (Bronze Faced)	Bronze
Condensate, Evap. Distillate, Fresh Water Service	Swing	≤2"	Bronze	Bronze	Integral
	Swing	≥2½"	Ferrosteel (bronze trim	≤3" bronze ≥3" iron (Bronze Faced)	Bronze
Product Water	Swing	≤3"	Bronze	Bronze	Integral
	Swing	≥4"	Ferrosteel (bronze trim)	≤3" bronze ≥3" iron (Bronze Faced)	Bronze
High Pressure Steam	Lift	≤2"	Forged steel	Exelloy	Exelloy
	Swing	≥2½"	Cast carbon steel	≤8" Exelloy >10" Exelloy (Exelloy Faced)	Exelloy
Low Pressure Steam	Lift	≤2"	Forged steel	Exelloy	Exelloy
	Swing	≥2½"	Carbon steel (S.S. trim)	≤8" Exelloy ≥10" Carbon steel (Exelloy Faced)	Exelloy

9.5.1.4 Butterfly Valves

Service	Size	Materials of Construction		
		Body	Disc	Seat
Seawater (unde-aerated and exposed)	All Sizes	Bronze	Cu-Ni Alloy	Buna N*
Deaerated Brine - High Pressure	All Sizes	Cast Iron	Al Bronze	Buna N*
Deaerated Brine - Low Pressure	$\geq$4"	Cast Iron	Bronze or Al Bronze	Buna N*
Condensate, Evap. Distillate, Fresh Water Service	$\geq$4"	Cast Iron	Al Bronze	Buna N*
Low Pressure Steam	$\geq$4"	Cast Steel	Al Bronze	

*For throttling service no Buna N seat

9.5.1.5 Plug Type Valves

Service	Size	Materials of Construction		
		Body	Disc	Seat
Concentrated Sulfuric Acid	½"to6"	Ductile Iron	Ductile Iron	Teflon
Dilute Sulfuric Acid	All sizes	Durimet 20	Durimet 20	Teflon
Hagevap and Dilute NaOH Solution	½"to6"	Ductile Iron	Ductile Iron	Teflon

9.5.2 Valve Performance

Sixty-two instances involving the repair or replacement of a valve were reported[6] for the period 1964-1970. These instances will be called "failures" and are plotted versus the year in which they occurred. The contributions to these "failures" by the individual units are indicated on Figure 9-13.

Point Loma accounted for 57% of the failures; Gitmo #1 accounted for 24%; Gitmo #2 accounted for 8%, and valves servicing all three units contributed the remaining 11%.

A relatively large number of failures were experienced in the 1964-1965 period and again during 1969 and 1970. During the earlier period 40% of the reported failures took place, with 45% reported during the later period. Only 15% occurred during the intervening period (1966 to 1968).

Five failures were reported for the Loma makeup DRC valve. At least three of these were caused by missing tapered pins attaching the disc to the shaft.

In 1969 four acid system valves were reported to be defective. The cause was ruptured teflon bonnet gaskets (on plug valves).

Seven failures were reported for the FRC valves with three more on FRC by-pass valves and one more on the valve just down stream of the FRC valve. Failures on the FRC valves included: valve vibration due to worn key and shaft groove; leak on the bottom plug; a sheared shaft. The FRC by-pass valves were replaced in 1965 after they were discovered to have cracked bodies.

More than half the reported valve failures occurred on butterfly valves. On several occasions an inoperative disc was the problem. The usual cause of this was missing pins attaching the disc to the shaft.

Also plotted on Figure 9-13 is the unit outage time attributable to valves ("Down Time") versus the year of occurrance. Included in the hours of down time are outages for maintenance and contractor work. These are not necessarily associated with valve failures and tend to disrupt the correspondence of the two graphs on Figure 9-13. In addition, failures resulted in varying degrees of down time. In some cases failures were repaired during an unrelated forced outage.

Outages due to valves are further discussed in Sections 5.3.3 and 5.3.4.

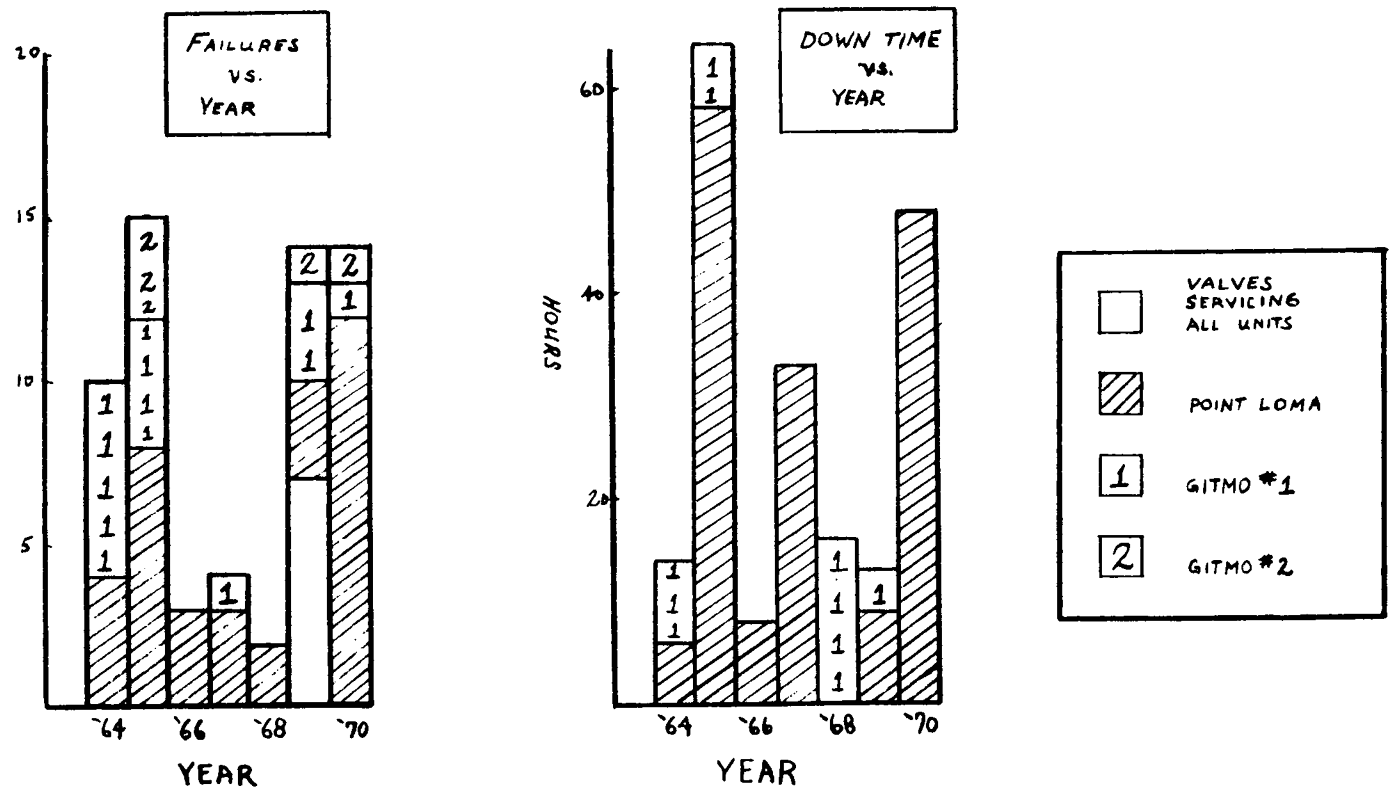


Figure 9-13

VALVE FAILURES AND DOWNTIMES
PER YEAR

9.5.3 Comments and Recommendations

In general the butterfly valves have performed satisfactorily, with the rubber seated valves performing well with flows of low velocity and low temperature.

9.6 Evaporator Pumps

9.6.1 Design Specifications

The design specifications for the initially installed evaporator pumps are presented on Figure 9-14. The following pumps are considered: brine recycle pumps, brine extraction pumps, brine booster pumps, blowdown pumps, product pumps, brine heater condensate pumps, acid pumps and Hagevap pumps.

9.6.2 Installed Spares

To minimize "down time" caused by pump failures, some services are provided with more pumps than are necessary for normal service.

There are three 50% capacity brine extraction pumps on each Gitmo unit. Thus, only two are required for full flow.

Similarly, there are three 50% capacity brine booster pumps on each Gitmo unit.

There are two product pumps on each Gitmo unit, either one of which has sufficient capacity for rated water production. The Gitmo brine heater condensate pumps are installed in duplicate with capacity permitting either pump to maintain the unit at full capacity.

The Point Loma evaporator plant was initially constructed with the primary purpose being a test unit and the secondary purpose being production on a continuing basis. The plant therefore did not have installed spare pumps. The relatively inexpensive condensate pumps are not redundant since both must operate for full production due to the brine heater being divided for the "A" stream and "B" stream. However, to improve "on stream" time, a spare product pump was installed on Point Loma in September, 1968. A description of this pump is contained in Section 4.4.6.8.

PUMP	DESCRIPTION	MANUFACTURER	RATING	MATERIALS OF CONSTRUCTION			
				SHAFT	IMPELLER	BODY	BEARING-SHELL
POINT LOMA							
Recycle (2)	2 Stage,Vertical	Westinghouse	3800 GPM @ 210'TDH	316 Stainless Steel	316 Stainless	Cast Iron	Rubber-Bronze
Blowdown	Single Stage,Vertical	"	1000 GPM @ 56'TDH	"	"	"	"
Product	" " "	"	700 GPM @ 102'TDH	Monel	Ni-Resist	"	Bronze
GITMO #1 & #2							
Brine Extraction (6)	Single Stage,Vertical	"	3500 GPM @ 58'TDH	304 Stainless Steel	Stainless Steel	"	Rubber Cutlass
Brine Booster (6)	" " Horizontal	Ingersoll Rand	3150 GPM @ 200'TDH	304 Stainless Steel	" CF8 "	"	"
Distillate (4)	2 Stage, Vertical	" "	700 GPM @ 100'TDH	Stainless Steel		"	Bronze
POINT LOMA							
Brine Heater	Centrifugal	Westinghouse	55 GPM @ 145'TDH				
Condensate (2)	Horizontal						
GITMO #1 & #2							
Brine Heater	Centrifugal	Ingersoll Rand	120 GPM @ 150'TDH				
Cond. Trans. (4)	Horizontal						
ALL EVAPS.							
H_2SO_4 (2)	Control Volume Type	Reliance Electric	6.6 GPH-44.5 PSIG				
POINT LOMA							
Hagevap (2)	Control Vol.Piston Type	Milton Roy	3.8 GPH-50 PSIG				
GITMO #1 & #2							
Hagevap (2)	Control Volume	Milton Roy	11.5 GPH-50 PSIG				

Figure 9-14

PUMP DESIGN SPECIFICATIONS

9.6.3 Pump Wear and Maintenance

9.6.3.1 Brine Recycle Pumps

In February, 1966 the "B" brine recycle pump became inoperable with the main shaft sheared between the 1st and 2nd stage impeller and the casing wear ring cracked. A scrap monel shaft was used as a replacement. In addition, the 1st intermediate bearing and the 1st stage impeller key were replaced.

No other problems were reported until mid April, 1970 when the pump was disassembled revealing the following conditions:

(1) 1st stage casing wear ring broken
(2) 1st stage impeller wear ring sheared from its impeller
(3) 2nd stage casing wear ring completely deteriorated
(4) Pump drive shaft broken directly below and above the 1st stage impeller
(5) All cutlass bearings deteriorated beyond usage
(6) Diffusers from each stage corroded.

Bearings, shaft, impeller and wear rings were on hand and installed. The pump casings and diffusers were considered to be deteriorated beyond repair. The running life of the pump was then estimated at 9 months. The "B" brine recycle pump was replaced as part of Hyle and Patterson overhaul contract.

In April, 1970 gland nipples on the "A" recycle pumps were repaired. Late that same month the pump was removed from service due to excessive vibration and noise. The pump was found to be beyond repair. The diffuser which is cast as an integral part of the casing and supports the impeller bearing had completely deteriorated. This pump remained out of service until August when Hyle and Patterson installed a new one. Some difficulty was encountered in aligning this pump and it was not operating until late August. During the four months that "A" was inoperable, the Point Loma unit operated at reduced capacity.

9.6.3.2 Brine Extraction Pumps

No significant problems were recorded for the brine extraction pumps up to February, 1970 when a noisy "B" unit on Gitmo #1 was shut down.(6) Its shaft journals and cutlass bearings were "excessively worn". and the impeller wear ring to casing wear ring clearance was worn beyond design. The bearings were replaced and the shaft journals cleaned.

In September, 1969 the Gitmo #2 "C" brine extraction pump was overhauled.

In August, 1970 the capacities of the brine extraction pumps were reported[7] to be reduced as a result of years of operation without replacement parts. The three 50% load extraction pumps on both Gitmo units were required for full production.

In August, 1970 the coupling gap clearances on the "A" and "B" brine extraction pumps of Gitmo #1 were adjusted.

In October, 1970 the Gitmo #1 "C" brine extraction pump and motor were replaced. The new pump displayed a noise and seized shortly after being started. Hyle and Patterson accomplished the removal and overhaul of the remaining five brine extraction pumps and motors during 1970-71.

9.6.3.3 Brine Booster Pumps

In 1965 the Gitmo #1 "A" brine booster pump experienced vibrations which were corrected when the motor was replaced. In late December, 1968 emergency repairs were made on this pump. Its housing was eroded beyond use. The shaft sheared in February, 1970 and was replaced. The pump and motor were completely replaced in September, 1970.

The "B" brine booster pump on Gitmo #1 was removed from service in October, 1965 after a noise was heard coming from the motor. A bearing failure was apparently the problem.

The bearings and seals on the Gitmo #1 "C" brine booster pump required changing in December, 1968.

The bearings on the Gitmo #2 "A" booster pump failed in December, 1969.

The Gitmo #2 "B" booster pump was dismantled in March, 1968 revealing wear rings with excessive clearance and a deteriorated lower casing.

The motor on the Gitmo #2 "C" brine booster pump was repaired in July, 1965. The pump bearing on the coupling end was replaced in January, 1968. The pump was overhauled in September, 1969. A new pump and rebuilt motor were installed in July, 1970. After one week of operation, the pump failed due to misalignment or bearing failure. The failure was located on the pump coupling where all bolts sheared.

Six new brine booster pumps and motors were installed by Hyle and Patterson prior to June, 1971.

9.6.3.4 Blowdown Pump

The Point Loma blowdown pump experienced few problems. Aside from a "wobble" which was corrected in January, 1968, no other repairs were recorded. A new pump and motor has been installed by Hyle and Patterson. The old pump and motor will be overhauled and used as a spare.

9.6.3.5 Product Pump

The Point Loma product pump experienced vibrations in March, 1968. After investigation, the following were replaced: lower, intermediate and upper bearings; impeller; inlet and guide vanes.

In June, 1968, the Point Loma product pump was removed from service to allow the impeller wear ring to be welded to the impeller and the intermediate bearing to be replaced.

In January, 1969 an unusual noise prompted shutdown of the Point Loma product pump. A deteriorated impeller, loose wear ring and corroded diffuser were found. The wear ring was welded to the impeller and the unit placed back in service.

The Point Loma product pump was replaced in October, 1969.

The product pump was removed from service in January, 1970 due to a metallic noise on the pump end. The pump shaft bearings were found to be excessively worn and they were replaced. The propeller, shaft and wear rings were deteriorated.

The Point Loma product pump was inspected in August, 1970. The lower bearing was worn and was replaced.

In September, 1968 a backup product pump was installed on the Point Loma unit. In August, 1969 it developed bearing trouble on the motor end.

The only reported incidence of a failure on a Gitmo product pump occured in January, 1965 when a bearing replacement was required. In March, 1968 the Gitmo #2 "A" product pump was inspected and found in "good condition". The pump end was sound with no corrosion or erosion taking place. No excessive wear was found on the impeller or casing wear rings. This same pump was overhauled in 1969 and replaced by Hyle and Patterson in 1970.

The Point Loma product pump and motor and all four Gitmo product pumps and motors have been overhauled. This results in one spare for the Gitmo units and one spare for the Point Loma unit.

9.6.3.6 Brine Heater Condensate Pumps

In January, 1965 the Point Loma "A" brine heater condensate pump was removed from service because of worn parts. Point Loma's "B" pump needed repairs in March, 1966 and again in December, 1969. Both pumps have been replaced by Hyle and Patterson.

The Gitmo #2 "A" pump needed repairs in January, 1965. The "B" pump was removed from service in October, 1970 because of excessive bearing noise at the pump end.

The "A" and "B" brine heater condensate pumps on both Gitmo units were replaced by Hyle and Patterson in January, 1970.

9.6.3.7 Acid Pumps

Acid pump repairs were reported for May, 1965, February and November, 1968, March, 1969 and June, 1970.

One new sulfuric acid pump and motor was installed prior to June, 1971. Its rating is 13.2 gph and it replaces two 6.6 gph pumps.

9.6.3.8 Hagevap Pumps

In September, 1965 the Gitmo #1 and #2 Hagevap pumps were repaired. In December, 1965 they were both overhauled.

Hyle and Patterson replaced the Hagevap pumps on all three units in 1970. One of these pumps replaced two formerly needed on the Point Loma unit.

9.6.3.9 Pump Replacement and Overhaul

A summary of the pumps replaced and overhauled by Hyle and Patterson is contained on Figure 9-15. Similar data for the motors are also presented. The number of warehouse spares resulting from this work is listed in the last two columns.

9.6.4 Comments and Recommendations

Pumps are one of the more vulnerable components of the desalination plant, perhaps because pumps are the major plant component which

Service	Number Replaced		Pump Manufacturer	Specifications	Unit	No. Overhauled		Resulting Warehouse Spares	
	Pumps	Motors				Pumps	Motors	Pumps	Motors
Recycle	2	1	B&W	Same as Original	Loma	2	2	2	1
Brine Extraction	1	1		Same as Original	G-1	5	5	0	0
Brine Booster	6	6	Ingersoll Rand	Same as Original	G-1&2	0	3	0	3
Blowdown	1	1	B&W	Same as Original	Loma	1	1	1	1
Product	1	1	B&W	Same as Original	Loma	1	1	1	1
	1	1	Ingersoll Rand	Same as Original	G-2	4	4	1	1
Brine Heater Condensate	6	6	Ingersoll Rand	Same as Original	All 3	2	2	2	2
H_2SO_4	1	1	Milton Roy	Replaces Both Pumps Previously Installed	Loma	0	0	-	-
Hagevap	1	1	Milton Roy	Replaces Both Pumps Previously Installed	Loma	0	0	-	-
	2	2	Milton Roy	Same as Original	G-1&2	0	0	-	-

FIG. 9-15

HYLE AND PATTERSON CONTRACT
Replacement and Overhaul of Pumps and Motors

involve moving parts. Since pumping reliability is an important part of plant reliability, careful consideration should be given to pumping capacity redundancy and adequate warehouse spares.

Where pumping redundancy has been built into the Guantanamo desalination plant, production has been maintained that would not otherwise have been possible. Where pumping redundancy has not been built into the plant, pump failure has most often resulted in reduced production, but on occasion, shutdown of an evaporator has been necessary.

Since many of the pumps have required replacement after six to seven years service, a continuing search for better materials of construction appears to be worthwhile.

9.7 Seawater Pumps

9.7.1 Design Specifications

Listed on Figure 9-16 is a description of the original seawater circulating pumps and screen wash pumps.

9.7.2 Installed Spares

The circulating seawater pumps had no installed spares.

There are two screen wash pumps, either of which can be used to wash one or both of the traveling screens.

9.7.3 Pump Wear and Maintenance [6] [7]

9.7.3.1 Main Seawater Circulating Water Pumps

In February, 1968 the west main circulating pump was removed from service after developing a metallic noise on the pump end. The pump was dismantled revealing the following conditions: lower cutlass bearing 90% deteriorated; shaft scored at the lower bearing journal; clearance excessive between casing and impeller wear rings. The pump casing and impeller were removed for repairs. Within five days the pump was back in service parallel with the east pump.

In January, 1970 the west main circulating pump was removed from service and its pump to motor coupling clearance was checked. It was found to be approximately 1". Design clearance is .100". A spacer was manufactured and installed restoring the .100" clearance. Several days later the pump was removed from service to replace the propeller wear ring, machine the casing wear ring, replace the line bearings and

PUMP	DESCRIPTION	MANUFACTURER	RATING	MATERIALS OF CONSTRUCTION			
				SHAFT	IMPELLER	BODY	BEARING-SHELL
Sea Water Circulating Pumps (2)	Vertical	Westinghouse	14000 GPM @ 65TDH	304 Stainless Steel	CF8 Stainless Steel	Cast Iron	Rubber-Bronze
Screen Wash Pumps (2)	Vertical	"Peerless" (Food Mach. Corp.)	200 GPM @ 85PSIG	304 Stainless Steel	CF8 Stainless Steel	Cast Iron	Rubber

FIG. 9-16

PUMP DESIGN SPECIFICATIONS

packaging and to clean and paint the pump casing.

In June, 1970 a new west circulating pump was installed.

The east main circulating pump was cavitating in September, 1966 because of sea growth and shells restricting flow to the pump. In December, 1968 this pump was reported to be operating at reduced capacity because there were no spare parts available.

In January, 1970 the east main circulating pump displayed a metallic noise emanating from the pump end. The unit was removed from its foundation and disassembled revealing: excessive wear ring clearance; propeller periphery worn; cutlass bearings deteriorated. Three cutlass bearings were replaced, and the wear ring clearance was machined to .054". New propeller and suction casing wear rings (stainless steel) were installed. This pump had been operating for five years without repairs.

A new east main circulating pump and motor was installed late in 1970. The new motor was apparently damaged in shipment and the old motor was used to operate the pump.

9.7.3.2 Screen Wash Pumps

In September, 1966 the west screen wash pump was investigated revealing galvanic corrosion. The 1st stage casing and pump suction adapter need replacement. One year later this pump was removed from service and reported to be beyond repair.

Parts were ordered for replacement of the deteriorated items. The casing was reported to be deteriorated and the drive shaft broken in November, 1967. Twice in 1968 and once more in 1969 there were reports of service required for this pump.

The weld between the upper casing and discharge piping on the east screen wash pump parted in 1967. More trouble (unspecified) was experienced in 1968.

A gasoline driven pump was installed in March, 1968 as a back up for the screen wash pumps. The ignition magneto on this pump failed four months later. There were no replacement parts and an electric driven pump was installed in its place. This pump failed three months later.

One new screen wash pump and motor has been provided on the Hyle and Patterson overhaul and repair contract.

Since November, 1970 when the traveling screens were removed from service (Section 9.8.2) the screen wash pumps have been out of service.

9.7.3.3 Pump Replacement and Overhaul

Figure 9-17 is a summary of the work on the seawater pumps accomplished by Hyle and Patterson. Pumps and motors that were replaced or overhauled are indicated. The number of warehouse spares resulting is also listed.

9.7.4 Comments and Recommendations

The west main circulating pump operated 3½ years without repairs and was replaced after 6 years. The east main circulating pump operated over 5 years without repairs and was replaced after 6 years. The replacement pump specifications were the same as the original specifications.

9.8 Seawater Traveling Screens (28)

Two traveling water screens, water spray cleaned, were installed, designed to pass 14,000 gpm, 2.1 ft/sec at a low water level of 6'6" through 100% clean screen cloth. The five-feet-wide chain and tray assemblies with ¼" mesh, .080 diameter wire cloth travel 10 ft/min over sprockets on 19 ft centers driven by a 1 HP motor.

9.8.1 Material Specifications

Tray frames, cloth, and fasteners are 304 SS. Chain side bars are 304 SS with pins, bushings and rollers 416 SS H.T. fitted with flush type, Alemite #1452 chain lub. fittings. Foot sprockets are 304 SS, foot shaft 316 SS in bronze bushed bearings. Head sprocket is steel with 410 SS removable tooth inserts, head shaft is 316 SS in cast steel bronze bushed head bearings.

Frame bolts, nuts, side plates, angles and channel cross bracing are mild carbon steel protected with one shop coat of bitumastic solution.

Splash housing and discharge chute are 12 gauge carbon steel protected with one shop coat of bitumastic solution.

9.8.2 Performance [6] [7]

The splash housings began to corrode through during the first year of operation and continued to deteriorate during the time the screens were

SERVICE	NUMBER REPLACED		SPECIFICATIONS	NUMBER OVERHAULED		RESULTING WAREHOUSE SPARES	
	Pumps	Motors		Pumps	Motors	Pumps	Motors
Main Sea Water Circulating Pumps	2	1	Same as original	1	2	1	1
Screen Wash	1	1	" " "	0	0	-	-

Figure 9-17

HYLE AND PATTERSON CONTRACT

Replacement and Overhaul of Pumps and Motors

(Sea Water)

used. The drive roller chains experienced wear and failures. During 1970 the structural frames of the screens experienced corrosion failures to the extent that the foot shaft bearings were not supported by the frames. By November, 1970 both traveling screens were out of service and replaced with temporary 3/8" mesh galvanized screen placed over the bar grates.

Three screen covered bar grates are available so that the two screens which are in service may be alternately removed for cleaning. The extra screen is placed in position prior to removing the screen to be cleaned.

9.8.3 Comments and Recommendations

The screen should be set in the intake structure with no openings for seawater to by-pass the screen and carry debris into the evaporators. Experience with the screens used at Guantanamo would indicate that consideration should be given to corrosion resistant materials for all parts of seawater traveling screens.

10.0 INSTRUMENTATION

10.1 Description and Control Philosophy

For any selected brine heater outlet temperature, the plant capacity is regulated by varying the recycle pump flow. Higher brine flow results directly in greater distillate production and steam demand.

Steam consumption is regulated by a temperature controller at the brine heater outlet. Higher recycle flow through the brine heater automatically results in a greater steam consumption.

As it accumulates, production is taken from the distillate trough of the final stage of the plant by level control. High conductivity alarms warn of contamination due to salt leaks or other causes and automatically divert the distillate from storage to waste.

Seawater makeup is on ratio control with the distillate production. Increasing the production automatically increases the seawater feed proportionally, and results in a fixed concentration factor for the blowdown. The blowdown rate is controlled by the brine level in the final stage, which in turn, depends on the makeup rate. A manual override is provided to furnish a fixed makeup rate when necessary.

Chemical additions are set manually, using controlled volume pumps, to agree with the makeup rate, which is reasonably constant during normal production because of the ratio control.

The instrumentation for each of the Gitmo units is a Hagen system and for the Pt. Loma unit, a Honeywell system. Since the Pt. Loma unit is operated with separate A and B streams, separate instrumentation and controls are supplied for each stream.

10.1.1 Field and Local Instruments

Local instrumentation provides for indication of all main stream flows including seawater flow to reject stages, make-up flow, recycle flow, blowdown flow, distillate flow, and brine heater condensate flow. Recorder indicators are provided for recording conductivity of brine heater condensate and conductivity of distillate. An integrating meter is installed for Pt. Loma brine heater and condensate return. Indicators are provided for steam temperature to the brine heaters and recycle brine pressure out of the brine heater. Gauge glasses are installed for indicating flashing brine level in each stage and for distillate level in the last stage. Additional miscellaneous pressure and temperature gauges are installed throughout the evaporator plants.

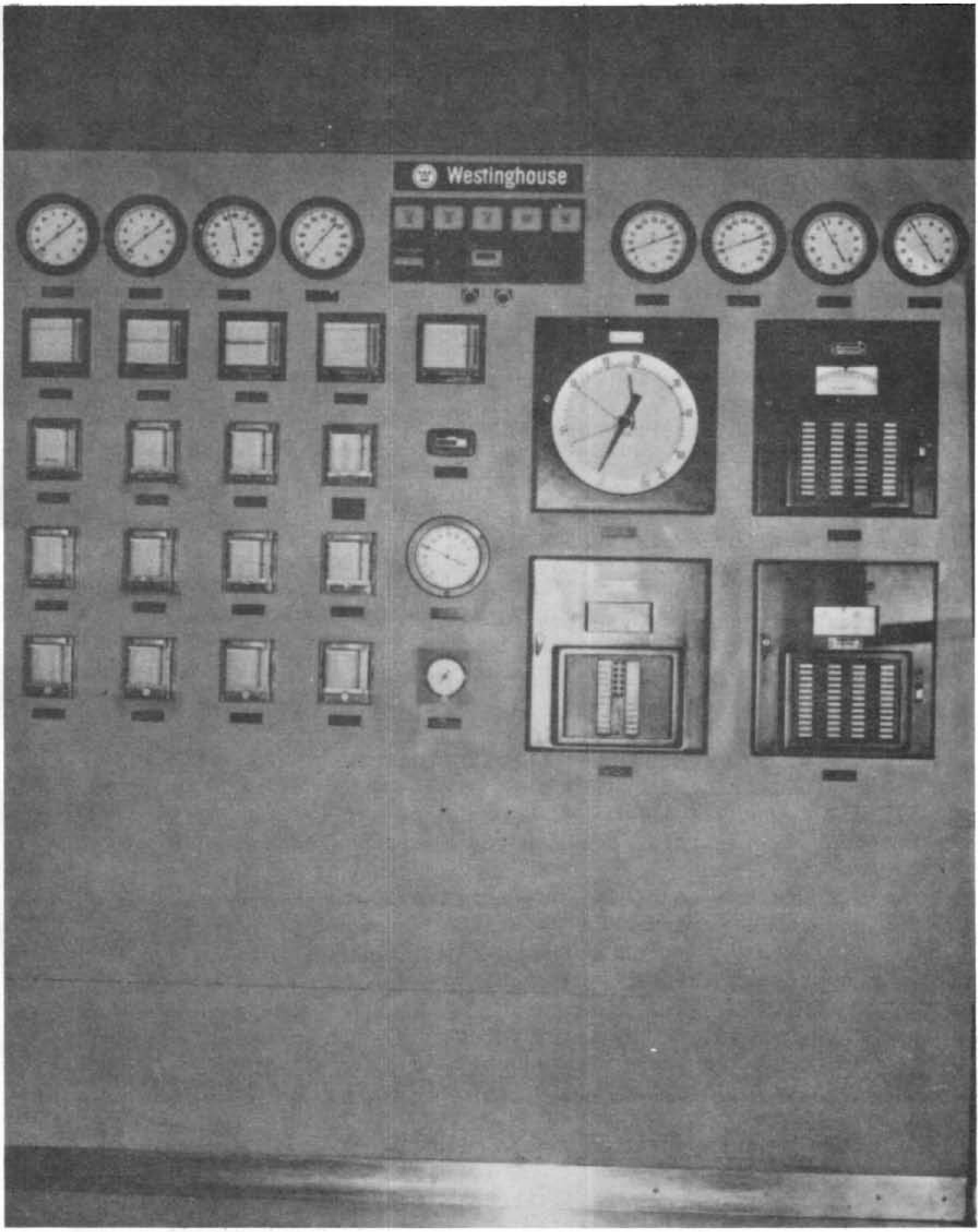


Figure 10-1

VIEW OF POINT LOMA EVAPORATOR CONTROL PANEL

10.1.2 Control Panels[2]

A Control Room on the operating floor of the power plant building contains several control panels and consoles, it is the nerve center of the power generation and seawater conversion facilities. Among these control panels there are three Evaporator Control Panels, one for each of the seawater conversion units.

10.1.2.1 Point Loma Evaporator Control Panel

This panel, which is shown pictorially in Figure 10-1, contains the following instruments and alarms:

a) Two vacuum gauges, one for the A-stream and one for the B-stream
b) One instrument air pressure gauge
c) One spare pressure gauge
d) An alarm circuit
e) Two recycle pressure gauges, one for the A-stream and one for the B-stream
f) Two brine heater shell pressure gauges
g) Five flow indicators for:
    1) Seawater flow to the evaporator
    2) Make-up flow (2)
    3) Seawater reject flow
    4) Product water flow
h) Four flow indicators for:
    1) Low pressure steam to the brine heater
    2) Recycle brine flow (2)
    3) One spare
i) Two density controls, one for the A-stream and one for the B-stream
j) Two temperature controls, one for the A-stream and one for the B-stream
k) One low pressure steam gauge
l) Four spare indicators
m) One conductivity recorder
n) Two minute-point temperature recorders, one for the A-stream and one for the B-stream
o) One four-station conductivity recorder

10.1.2.2 Gitmo Unit Evaporator Control Panels

One of these two identical panels is shown pictorially in Figure 10-2. Each such panel consists of the following instruments and alarms:

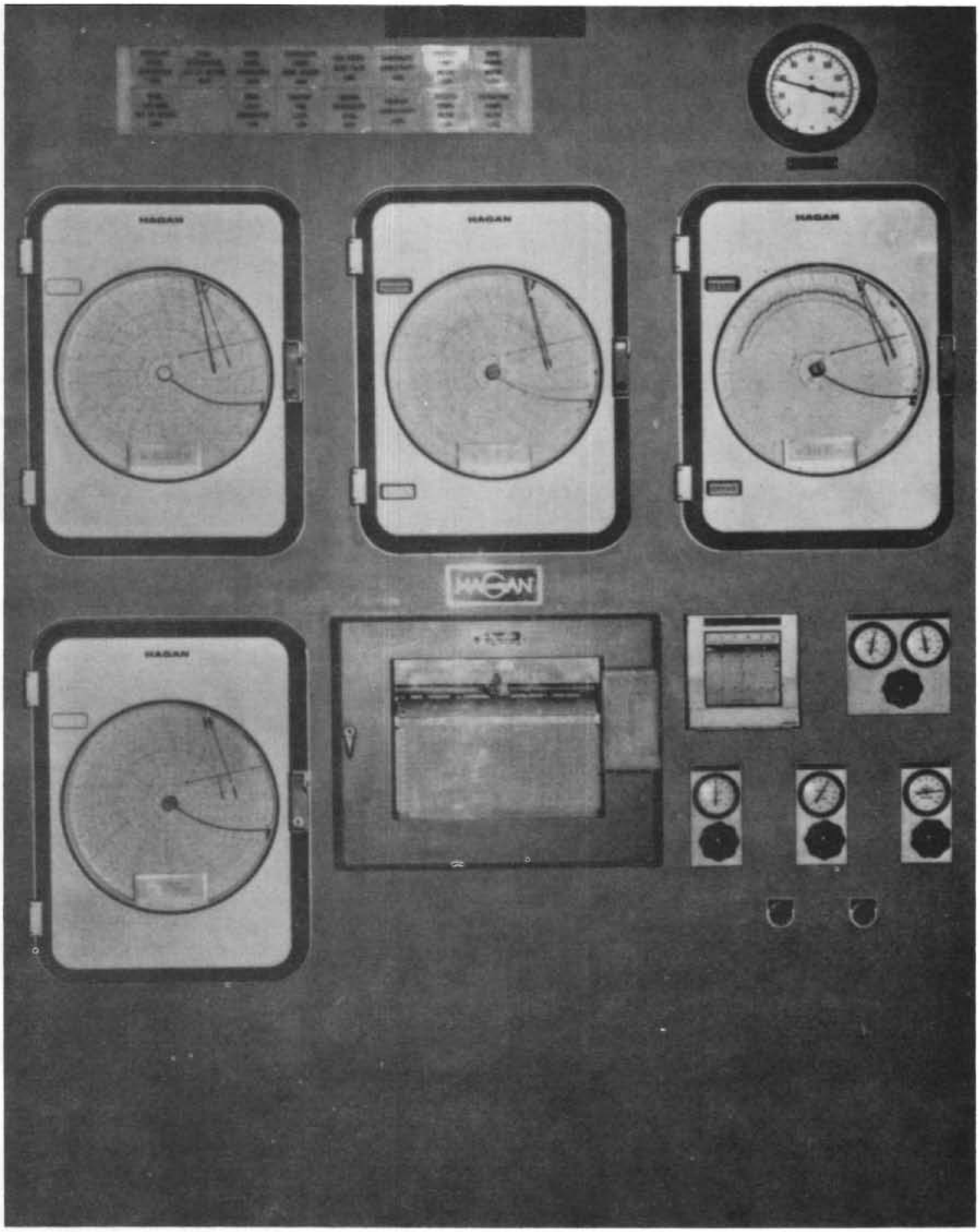


Figure 10-2

VIEW OF GITMO UNIT NO. 2 EVAPORATOR CONTROL PANEL

a) Two conductivity recorders
b) Two condensate high-conductivity alarm switches
c) One brine heater steam flow recorder
d) One distillate flow recorder and integrator
e) One seawater make-up flow recorder
f) One seawater inlet flow recorder
g) One brine flow recorder
h) One blowdown flow recorder
i) One seawater inlet low flow alarm switch
j) One brine heater high-pressure switch
k) One brine heater steam pressure recorder
l) Four seawater/distillate selector valves
m) One brine heater steam temperature recorder
n) One high-pressure brine temperature recorder
o) Eleven brine temperature recorders for stages 1, 3, 5, 7, 9, 11, 13, 15, 2, 4, and the brine line out of the brine heater
p) Twelve distillate temperature recorders for Stages No. 1, 3, 5, 7, 9, 11, 13, 15, 2, 4, and distillate line out of Stage No. 15, respectively.

10.2 Brine Heater Control

The temperature of the brine at the brine heater outlet is sensed by a temperature transmitter, which generates a pneumatic signal proportional to the temperature.

This signal is compared to a set point generated by the set point station. The controller produces a proportional plus reset signal which moves the temperature control valve, so as to bring the error between the controlled variable and set point to zero. A maximum temperature limit is provided in the form of a pressure switch in the pneumatic temperature signal line, which trips at some pre-determined maximum temperature. On trip, the pressure switch actuates a solenoid valve, in the signal line to the temperature control valve, to close the control valve and bring the temperature of the brine down to normal operating limits.

10.3 Brine Recycle Control

An orifice plate in the brine recycle line produces a differential pressure that is a function of the flow. The differential pressure is sensed by the brine flow transmitter. This generates a pneumatic signal, linear to the actual flow. The signal is transmitted to the brine recycle flow controller and compared to an adjustable set point signal generated by the set point station. The flow controller response moves the brine recycle flow control valve so as to bring the error between the set point and brine recycle flow to zero. The set point can be manually adjusted from the control room and constitutes the prime parameter for governing the water production of the plant.

10.4 Blowdown Control

The Brine level in the last stage of the evaporator is sensed by a float type level transmitter, which generates a pneumatic signal proportional to the level. This signal positions the brine level control valve, to maintain the level in the final stage of the evaporator. For every value of the transmitter output, the valve takes a specific position. Suppression and proportional band are adjustable in the transmitter. Because of the level control, the blowdown rate is automatically governed by the seawater make-up rate.

10.5 Seawater Make-up Rate Control

The seawater make-up rate is sensed by an orifice plate which produces a differential that is a quadratic function of flow. The seawater make-up flow transmitter extracts the square root and furnishes a pneumatic signal linear to the flow. This signal, along with a similar signal from the distillate flow transmitter is furnished to a ratio flow controller. The seawater make-up set point, or flow demand signal is furnished by the distillate flow transmitter and is adjusted on a ratio basis in the ratio relay. This relay can be manually adjusted over a range of 1.2:1 to 16:1 for the ratio of seawater make-up to water production. The normal setting of 3:1 results in 2 parts of blowdown per part of product water, and a concentration factor of 1.5.

10.5.1 Brine Heater Drain Temperature

A higher than normal condensate temperature from the brine heater indicates the need for acid cleaning the brine heater tubes. See also Sections 6.2.3, 6.2.4, and 6.5.1.3.

10.6 Maintenance

Most instruments were calibrated or installed during scheduled or unscheduled outages. At times when instrument spare parts were not available, repair was necessary instead of replacement.

10.6.1 Instrument Maintenance Costs

Cost of instrument spare parts inventory on hand as of July 19, 1971 was $5,068.00. The total cost of instrument maintenance is a fraction of a cent per thousand gallons of water.

10.7 Comments and Recommendations

Consideration might be given to continuous pH indication and/or control instrumentation for acid additions, particularly if acid pretreatment is to be used extensively at any time in the future.

11.0 M & O STAFFING

11.1 Organization

The Contractor Maintenance and Operation staffing organization as of December 31, 1970 is shown in Figure 11-1. As of July 1, 1971, the position of Diesel Operator for each of the three shifts is not applicable for contractor M & O Staff. Following startup by M & O personnel, Diesel operators are provided by the Base Public Works Center within one hour after startup.

Staffing as of January 1, 1969 included one additional Auxiliary Operator per shift, but those duties were later reassigned and the position abolished. The maintenance crew as of Decmeber 31, 1969 was nine, one less than as of December 30, 1970. The added position is that of Electrician-Instrument Mechanic Helper.

11.2 Operator Duties

Evaporator operator duties include:

1) Under the direction of Shift Engineer line up all pumps, air ejectors, valves, etc. and place evaporator in service from cold startup, and also be able to properly secure any of the evaporator units without supervision.

2) Log hourly readings from the three evaporator units in the evaporator log, understand what the readings mean and when a reading indicates a problem area be able to correct the condition.

3) Make all adjustments on evaporator control board equipment.

4) Keep a close check on all operating machines for noisy or hot bearings, hot packing glands, etc.

5) Run all evaporator chemical tests, pH, Chlorides, flouride and chlorine residue.

6) Add the proper amounts of chemicals to feed system, and notify control room operator.

7) Within 1/2 hour after shift engineer change-over, and every two house thereafter, take the following readings and call them in to control:

(a) brine outlet temperatures
(b) chlorides
(c) combined chlorides
(d) densities

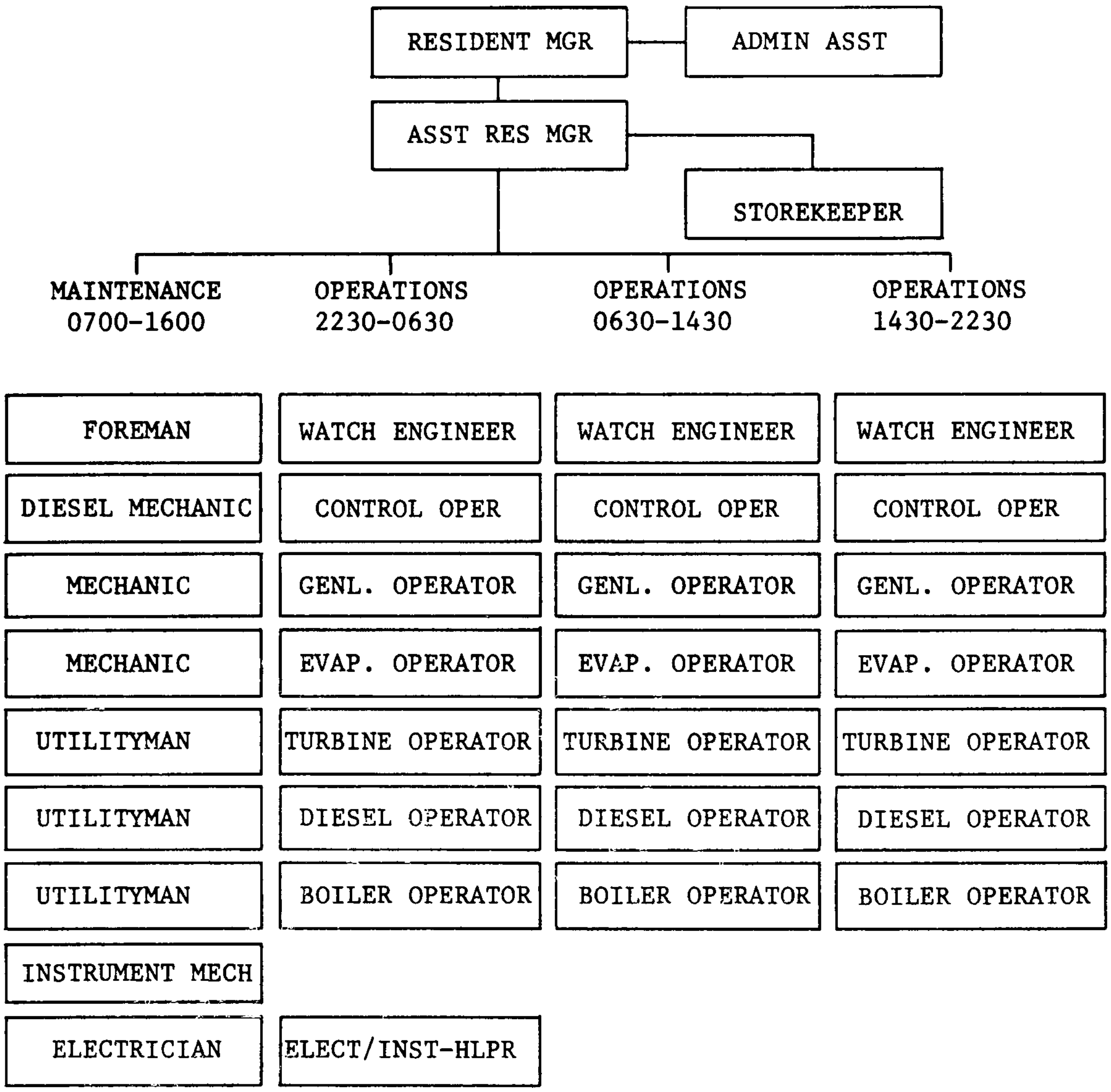


FIG. 11-1

DESALINIZATION & POWER GENERATION PLANT NO. 4

8) Pass on information and existing conditions of the vessels to your relief.

9) Maintain good housekeeping at all times. Each shift will go over their assigned cleaning stations.

10) Vent the vessels by opening the water box drains at least once each shift.

11) Upon securing acid cleaning, the following will be done:

(a) using compressed air, blow through the acid lines
(b) sound acid tank and report to control
(c) correct the density of the vessel

12) Immediately after securing or dumping a vessel, make necessary adjustments to the product line pressure, wet well level and chemical injection.

13) Keep closed all doors and covers of teletalks, level controls, instruments, motor control centers and chemical buildings.

During down periods operational personnel may be utilized during regularly scheduled shift hours for maintenance work.

11.3 Responsibilities

The "Operation and Maintenance Supervisor" (Resident Manager) and the "Assistant Operation and Maintenance Supervisor" (Ass't Resident Manager) are in responsible charge of the entire operation, maintenance and repair of the plant and are on duty at the plant during normal working hours. Either the supervisor or assistant supervisor are on board the base at all times except under the most unusual of emergencies.

11.3.1 Safety

In order to provide safety controls for protection of the life and health of employees and other persons; for prevention of damage to property, materials, supplies, and equipment; and for avoidance to work interruptions, the M & O staff complies with all pertinent provisions of "General Safety Requirements" EM 385-1-1, Corps of Engineers, U.S. Army (48).

The operation and Maintenance Supervisor schedules a monthly safety meeting with all supervisory and maintenance personnel in attendance. The purpose of the meeting is to promote safety, including condition of tools, working practices, condition of operating equipment and use of safety equipment.

11.3.2 Emergencies

In the event of warnings of winds of gale force or stronger, every precaution is taken by the M & O staff to minimize danger to persons, plant and property. Precautions include closing all openings, removal of loose materials, tools, and equipment from exposed locations and removing and securing scaffolding and other temporary work. Operating personnel are familiarized with the "Base Hurricane Bill".

In the event a turbo generator trips out and the electrical load at the time of the casualty is 9.3 MW or below, the plant Diesels are started and loaded as much as possible. Base Diesels are placed in standby position.

In the event a boiler fails during "Two Boiler" operation, the control room operator secures all low pressure steam to evaporators and instructs the evaporator operator (after he has completed securing steam to evaporators) secure the evaporator pumps at the motor control centers.

In the event a boiler fails during "Three-Boiler" operation, the control room operator keeps the two remaining boilers on "Auto". The two boilers should take the load with no problem. In the event any problem is experienced in maintaining steam pressure or flow, the steam flow to evaporators is decreased until the steam generating rate can be "leveled out" at which time the evaporators are again brought up to full load.

11.4 Maintenance Organization

The plant is maintained on a single shift basis Monday through Saturday with staffing shown on Figure 11-1. If maintenance work can be more effectively accomplished on Sunday or outside the normal shift time, plans are made to deviate from the normal schedule.

11.4.1 Categories and Duties

Job categories in the maintenance organization are shown on Figure 11-1. One of the Maintenance Mechanic positions is filled by a qualified welder. Duties include the repair and maintenance of the power and water plant within the area represented by the respective discipline of each mechanic.

11.5 Comments and Recommendations

Laboratory services are not included in the M & O contractor staffing. The Navy Public Works provides laboratory services and tests required to insure uniform quality control of evaporator product water and boiler water.

11.5.1 Effect of Automation on Number of Operators

Many routing manual jobs are necessary for operation of the present plant including:

1) Hagevap and antifoam solution mixing, setting feed rates, also cleaning and flushing tanks and lines.

2) Fluoride feeding

3) Chlorine drum changing and cleaning

4) Hexametaphosphate feeding

5) Lime feeding

6) Reject stage back flushing

7) Acid handling and acid cleaning

8) Tank sounding

9) Fuel oil pumping

10) Lub oil filtering

11) Strainer cleaning

12) Boiler tube blowing

13) Boiler blowdown

14) Boiler water analysis

15) Boiler make-up supply selection

16) Main condenser back flushing

Automation or further mechanization of a number of the above operations would likely be required in order to reduce the operating crew by one or more men per shift. Increased equipment and instrumentation would likely increase maintenance requirements.

12.0 COST ANALYSIS

Total costs of operating the Gitmo 1, Gitmo 2, and Point Loma Plants have been reported on a monthly [7] basis for 1969 and 1970. Costs included are contractual labor, fuel, chemicals, supplies, and maintenance.

From these records monthly costs have been computed for generation of electric power using the steam turbine generator plant, for electric power using the diesel generators, and for water. There is no breakdown for the individual costs of water production from Gitmo 1, Gitmo 2 and Point Loma. The costs reported do not include taxes, amortization of the capital equipment, insurance, major rehabilitation, or other costs normally incorporated into fixed charges. The reported costs also do not include charges for electric power used in the water plant.

The data available from the operation of the Guantanamo desalting plants does not lend itself to presentation in the format suggested in "Guidelines for Uniform Presentation of Desalting Cost Estimates"[16] and the cost breakdowns and analyses presented here do not follow these guidelines.

12.1 Water Costs Breakdown

12.1.1 Fuel

Fuel costs are reported in the monthly summary reports.[7] In turn, these are based on daily[6] records. The daily fuel measurements taken include metered fuel and tank soundings. Cost figures are based on billing cost. The cost of fuel remained constant at 5.93¢ per gallon from 1968 through October, 1970, when the price increased to 6.83¢ per gallon. The fuel cost represented 57% of the total annual reported operating cost in 1970 or $.66/1,000 gal. The increase in unit fuel cost for the last three months of 1970 caused a slight increase in overall percent of reported operating cost attributable to fuel. The large increase in water costs began in March, 1970. The cost of fuel was not a major factor in causing this increase. The major factor contributing to this cost increase was the decrease in production of water which started in March, 1970. The major rehabilitation of the Point Loma unit began at this time, and the amount of water produced by this unit has been much lower during these repairs.

Figure 12-1 shows the reported monthly water cost from 1966 through 1970. The projected water cost of $1.00 per 1,000 gallons[17] is also plotted in Figure 12-1. As can be seen, the overall picture indicates production of water at less than $1.00/1,000 gal until the increase which began in 1970. There were months (particularly, December,

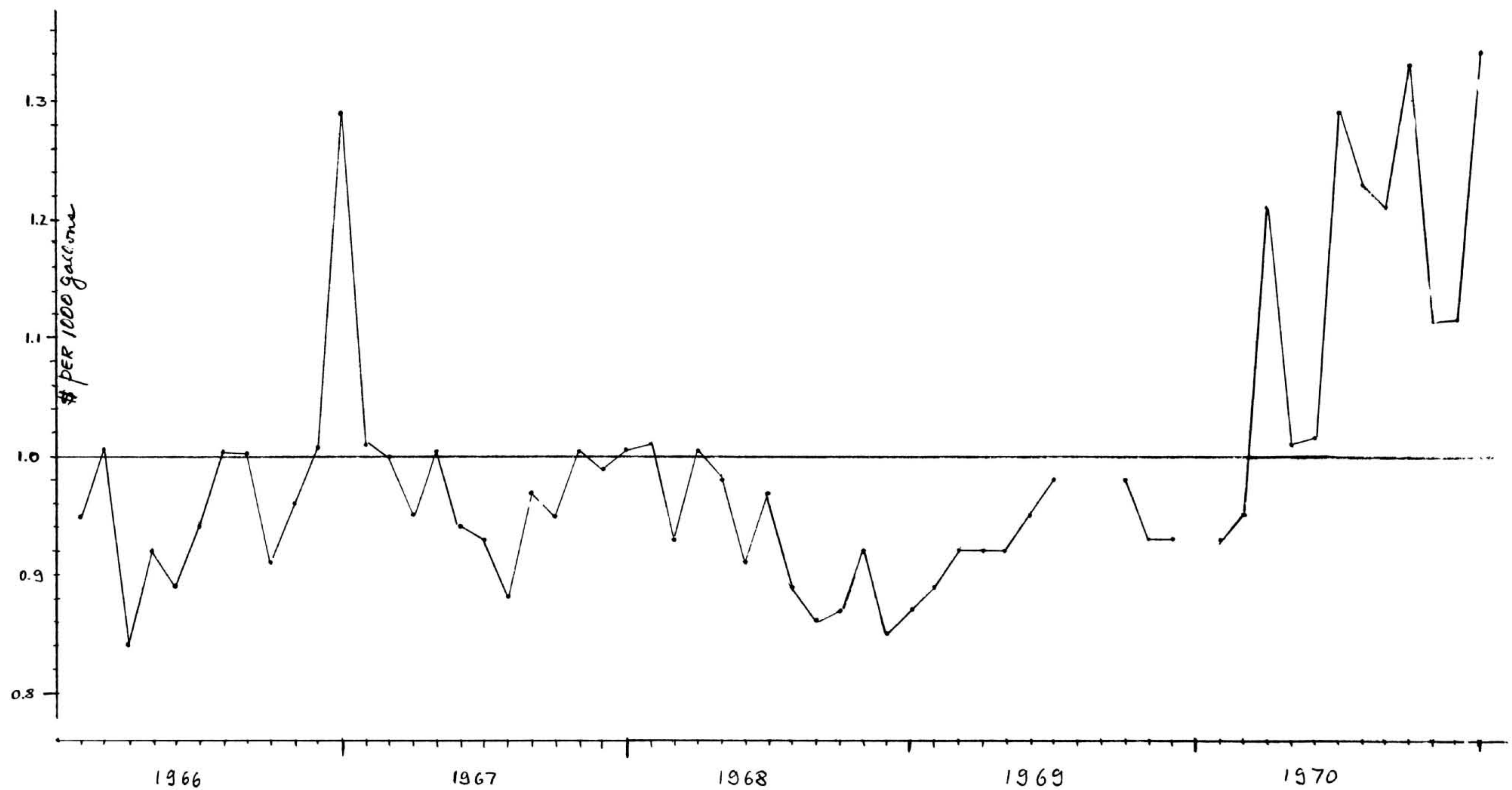


Figure 12-1

REPORTED MONTHLY COSTS FOR 1000 GAL. WATER;
PROJECTED COSTS $1.00 / 1000 GAL.

FORM SR 5002-2

1966) where cost of production exceeded the projection, but the general pattern was water costs below $1.00/1,000 gal.

The fuel used for the total plant did not change appreciably.

Fuel costs were by far the largest percentage of the cost of producing water, after proportioning the cost of fuel between the electric generating plant and desalting plant (see section No. 12.3).

12.1.2 Maintenance and Operations

The cost breakdown reports are in the following categories: (a) Contractual, which represents total labor cost for operation and routine maintenance of the electric generating plant and the water plant; (b) Fuel, which is the total cost of fuel for the water and electric generating plants; (c) Evaporators, which includes both chemicals and repair parts for the water plant; (d) Steam which includes repair parts for the steam plant; (e) Electricity, including parts for the electrical equipment, switchgear, etc.; (f) Miscellaneous items purchased for plant maintenance and housekeeping; and (g) Shop support costs.

The weekly reports [6] give summaries of the repair and maintenance projects undertaken on a daily basis but do not break the projects down so that the labor costs for maintenance can be separated from those for plant operation. Thus, the contractual labor costs include operation and routine maintenance. The allocation of labor costs, as well as fuel costs, to the water plant, as opposed to the electric generating part of the plant, are discussed in Section 12.3.

The labor cost amounted to 37% of the reported water cost in 1970.

12.1.3 Chemicals

Chemicals are included in the monthly [7] breakdown under evaporators and steam, but are listed separately in the monthly reports. Chemicals for the evaporator section averaged $2,790 per month (excluding cost of limestone for post-treatment) during 1970. The total yearly cost of evaporator chemicals is $33,500 out of a total desalting plant reported operating cost of approximately $747,000. This represents approximately 4% of the total reported cost or 5.2¢/1,000 gal. Thus, the cost of chemicals is only a small part of the total reported water production cost ($1.16/1,000 gal in 1970).

12.1.4 Supplies and Shop Support

Miscellaneous supplies and shop support costs for the water plant amounted to approximately $2,600 in 1970, representing less than 1% of the reported water cost.

12.1.5 Spare Parts

Steam plant spare parts charged to the water plant [7] and spare parts for the evaporator plant in 1970 cost approximately $6,900 in 1970, or approximately 1% of the reported water cost.

12.2 Indirect Costs

12.2.1 Amortization and Overhead

Cost data furnished does not include any charges for amortization of capital equipment. Since the installation includes 3 separate plants, including the Point Loma unit which was moved to Guantanamo, the cost of the three smaller plants would exceed a single plant of the same total capacity. It was therefore decided to estimate the cost of a single desalination plant with a total capacity of 2,200,000 gallons per day. The plant costs were computed using the methods recommended in "Desalting Cost Calculating Procedures". [18]

For public ownership an interest rate of 4-7/8% is recommended. [18] Actually, an interest rate of 4.93% was used, resulting in a capital recovery rate of 6.46%. With a replacement rate of 0.29% and insurance of 0.25% this resulted in a fixed charge rate of 7%. See report on Universal Plant. [19] The cost of a steam generator was included in the capital costs. This cost was estimated from "Desalting Cost Calculation Procedures" [18], Figure 20 at $330,000. Land requirement for the steam generator was taken as two acres from Figure 19 [18] and charged at $10,000 per acre. The cost of the plant intake system was estimated separately. This time the estimate was made using the Universal Plant Report, Vol. II, Part 1, Page II-44 [19]. The cost of the plant intake system, including auxiliaries, is $79,500. The steam generator cost was included in the capital costs even though these are dual plants for the following reasons. The Universal Plant Report [19] points out that the high pressure plant needed for dual-purpose [20] [21] applications require better and more expensive insulation, piping, instrumentation and water treatment. The extraction required for the water plant also adds to the turbine plant. With these increases the capital costs are roughly equal. Since the cost of steam is apportioned based on test data, no attempt to estimate the change in steam costs because of the operation of a dual-purpose plant was necessary.

The results of these analyses are a total capital investment of \$3,829,500, with an annual amortized cost for 30-year plant life of \$268,065 for a publicly financed plant. Based upon an annual water production of 718,000,000 gallons, as determined from production records, (See section 5.2.1) this comes to 37.3¢/1,000 gal for the publicly financed plant. If we were to use the design capacity of 2,250,000 gal/day with a 95% (See section 5.2.2) use factor, these costs would change to 36.3¢/1,000 gal.

No attempt was made to charge the cost of the major overhaul contract now under way against either the operating costs or the capital investment. Standard methods of retubing after 15 years are included in the capital cost.

12.2.2 Contract Labor

Contract labor costs were determined from the monthly reports.[7] Each individual working on the plant and his job function was reported monthly. The contract labor costs were used to give a monthly dollar amount. Several methods were considered as alternates to determine the percentage of the total cost that should be charged against the water plant. These alternate methods are discussed in detail in Section 12.3.

12.2.3 Pumping Costs

The cost of power to operate the pumps is not included in the water costs reported for the plant.

The total nameplate Horsepower for the three plants is 2,865 H.P. This does not include the horsepower for those pumps installed as standby units, but includes the seawater intake pumps.

The cost of operating the pumps was calculated, assuming the motors were loaded at 90% of the rated horsepower and that the plant operates 24 hours per day-365 days per year with a 95% on-stream time. Power was charged at the calculated average cost of 7.67 mils/kwh. (See Figure 12-2)

From this analysis the electric power cost for operating the pumps comes to \$122,808 per year, or 17.1¢/1,000 gal of water produced. This is in addition to the \$1.16 average cost reported and the amortization of the physical plant equipment.

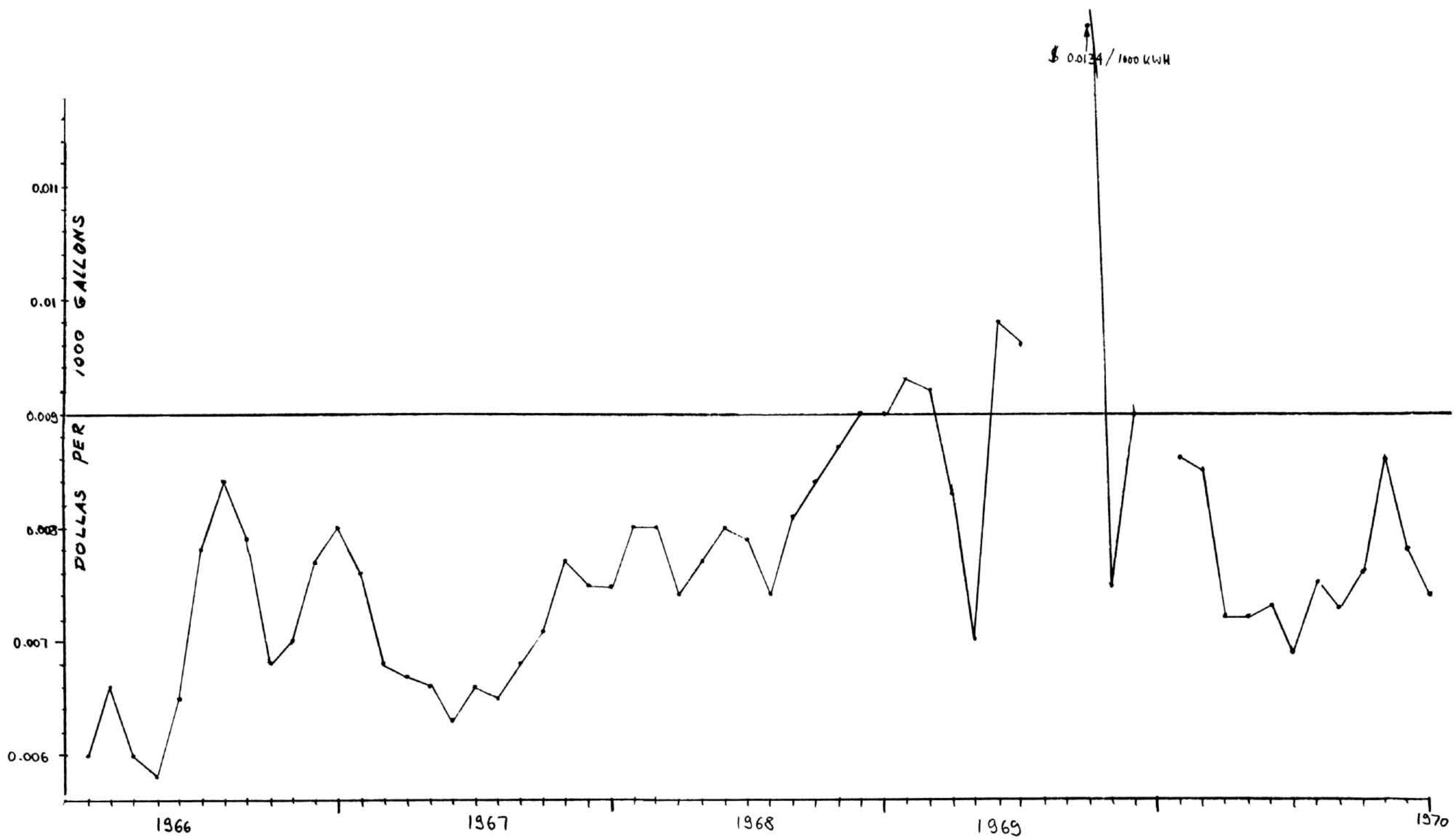


Figure 12-2
REPORTED MONTHLY COSTS FOR 1 KWH; PROJECTED
COSTS $0.009/ KWH.

12.3 Discussion and Comments

12.3.1 Power versus Evaporator Fuel Cost

In preparing the monthly operating costs and production costs for power and water the resident manager apportioned costs between these two plant functions on an energy basis. The energy to the evaporators is calculated by the product of the measured flow during the test period times the enthalpy which is based upon the measured pressure and temperature. The input energy to the turbine generator is used as the energy input to the combined power and water plant. This is calculated by the product of the measured steam flow to the turbine and the enthalpy at the inlet.

The ratio of energy input to the evaporator to the energy input to the turbines is used to apportion fuel, labor, and parts used for both functions. Chemicals for the evaporator plant and parts for the electrical plant are charged to these functions directly.

Since contract labor and fuel represent 94% of the total operating costs, the apportionment of these two costs has the major effect on the reported water and power costs.

In an effort to see whether other logical schemes for apportioning costs could change the results appreciably, two other methods were investigated. The manpower records were analyzed and those personnel who were clearly working on either the power plant exclusively or the desalting plant exclusively were identified. Personnel who shared their time between the two plant functions were also identified and their time apportioned between power and water. The resultant labor splitup was used for dividing fuel costs too.

Another standard practice used in dividing the cost between water and power is to apportion costs on the basis of available energy. In this method, it is assumed that the power plant could develop the theoretical work per pound of steam computed by assuming isentropic expansion from turbine inlet conditions to condenser pressure. The work done from turbine inlet conditions to extraction pressure for the evaporator plant is also calculated. The ratio of these work terms is taken as the percent cost to allocate to the power plant, and the rest is charged against the desalination process.

The results of these three analyses are:

(1) As reported in the monthly reports on an energy basis, electric 49.4%, water 50.6%, averaged over 1969 and 1970.

(2) On a manpower basis, the power plant required roughly 54% against 46% for water.

(3) On an available energy basis, the water plant accounts for 54% against 46% for the power.

(4) On an energy basis, the cost of water for 1970 is $1.16/1,000 gal; on a manpower basis, $1.04; and on an available energy basis, $1.22. Thus, the water cost is affected by the apportionment procedure.

The energy basis is the most accurate, since it involves daily measurements, does not involve estimating manpower allocation, nor does it require the assumption of isentropic expansion through the turbine.

12.3.2 Effect on Costs of Performance Ratio Loss Due to Sludge Buildup

Tests made and reported in Burns and Roe, Inc. report [8] indicate that sludge buildup has a substantial effect on the performance of a desalting plant. Accumulated brine heater deposits over a period of 2-2½ years result in pressure drops 3-3½ times the calculated clean friction pressure drop. Acid cleaning had a small effect on measured pressure drop but substantially increased brine heater heat transfer. The effects of these changes on water costs are difficult to evaluate on the basis of the data available. The heat transfer and friction pressure drops are time dependent functions and affected by the time between acid cleanings, by the total time that the plant has been in service, by the temperature of the seawater feed, by the operating temperature of the brine heater. Because of these many variables, placing a cost per 1,000 gallons on water production is extremely difficlut. The best one can do is to estimate the effect on heat transfer coefficient and pressure drop during design stages, to change the capital costs and pumping costs, establish an acid cleaning schedule to minimize water cost increases due to sludge buildup.

12.3.3 Water Cost Summary

Water costs discussed in Sections 12.1 and 12.2 are recapitulated as follows:

		Cost per 1,000 Gallons	
		Public Ownership	
		Amt.	% of Tot.
Fuel		$ .66	39
Maintenance & Operation		.43	25
Chemicals		.05	2
Supplies and Shop Support		.01	1
Spare Parts		.01	1
	Sub Total	1.16	68
Fixed Costs		.37	22
Power (.00767/kwh)		.17	10
	Total	$1.70	100

13.0 BIBLIOGRAPHY

(1) Westinghouse "Instruction and Operating Book Salt Water Conversion and Electrical Power Generation Plant, Guantanamo Bay, Cuba" for Bureau of Yards and Docks, Contract NBy 53175, FE-20119.

(2) Burns and Roe Construction Corp. "Operation and Maintenance Manual, Vol.1, System Function and Description, Guantanamo Bay Power Plant and Seawater Conversion Facilities" for Department of the Navy, Naval Facilities Engineering Command, Caribbean Division

(3) Burns and Roe, Inc. "Annual Report Saline Water Conversion Demonstration Plant Number 2, San Diego, California, July 1, 1963 through February 26, 1964", for United States Department of Interior, Office of Saline Water, Washington, 25, D. C.

(4) Department of Navy, Bureau of Yards and Docks Public Works Center, Guantanamo Bay, Cuba PWC Dwg. No. 10 DS-150-0465 "Flow Diagram of Desalinization Plant".

(5) Singmaster & Breyer "Feasibility Study for Providing Separate and Combined Power and Water Plants, U.S. Naval Vase, Guantanamo Bay, Cuba, Department of the Navy, Bureau of Yards and Docks, Area Public Works Office, Caribbean, San Jaun, P.R.", August 22, 1960 Navy Contract NBy 18013

(6) Burns and Roe Western Hemisphere Corporation, Guantanamo Bay, Cuba, Supervisor, Maintenance and Operations Weekly "Summary of Activities" Water Conversion and Power Generation Plant, for period August 3, 1964 to December 31, 1970.

(7) Burns and Roe Western Hemisphere Corporation, Guantanamo Bay, Cuba, Supervisor, Maintenance and Operations Monthly "Summary of Activities" Water Conversion and Power Generation Plant for period July, 1964 to December 31, 1970.

(8) Burns and Roe, Inc. Report "Effect of Adherent Sludge Deposits on Recycle Brine, Tube Friction on a Multi-Stage Flash Evaporator - GITMO No. 2 Evaporator, Guantanamo Bay, Cuba" dated August, 1967 for Department of the Interior, Office of Saline Water, Washington, D. C., OSW Contract No. 14-01-0001-955.

(9) "A Brief on the Combined Seawater Desalinization and Electric Power Plant, U.S. Naval Base, Guantanamo Bay, Cuba", prepared by the Public Works Center, U.S. Naval Base, Guantanamo Bay, Cuba, May, 1971.

(10) Report on Plant Performance Tests, Water Conversion and Electric Power Plant, Guantanamo Bay, Cuba, May 3, 1965 by D. H. Riley, Manager, Plant Test and Operations, Burns and Roe, Inc.

(11) Operational Data and Laboratory Analyses Letter Reports giving Flow Data and Chemical Analyses of Composite Samples for 12 Different Days approximately one week apart from April 15, 1968 to August 4, 1968 from R. R. Grove of Burns and Roe Western Hemisphere Corporation to U. S. Department of the Interior, Office of Saline Water, Washington, D. C.

(12) Burns and Roe Construction Corporation, "Operations Manual, Vol. II, System Operating Procedures, Guantanamo Bay Power Plant and Seawater Conversion Facilities," for Department of the Navy, Naval Facilities Engineering Command, Caribbean Division.

(13) Burns and Roe Western Hemisphere Corporation, Guantanamo Bay, Cuba, Supervisor, Maintenance and Operations Letter, Subject: Operational Data, to commanding Officer, U. S. Navy Public Works Center, Box 37, F.P.O., N.Y. 09593.

(14) Burns and Roe, Inc. Letter, Subject: Contract NBy 53175. Water Conversion and Electrical Power Generation Plant, Guantanamo Bay, Cuba, to Commander Lynn M. Cavendish, ROICC-Gitmo, P.O. Box Navy No. 115, Box 37, F.P.O., N. Y. 09593 dated September 10, 1964.

(15) Fisherman's Point Plant Monthly Feeder Report "Chemicals used by Evaps:", attached to Monthly Reports (7).

(16) United States Department of the Interior, Office of Saline Water, Research and Development Progress Report No. 264, "Guideline for Uniform Presentation of Desalting Cost Estimates".

(17) Attachment "A" to January, 1969 Monthly Report (7)

(18) United States Department of the Interior, Office of Saline Water, Research and Development Progress Report No. 555, "Desalting Cost Calculating Procedures".

(19) Burns and Roe, Inc. Report "Design of a 2.5 Million Gallon per Day Universal Desalting Plant" dated June, 1967 for Department of the Interior, Office of Saline Water, Washington, D. C., OSW Contract No. 14-01-0001-955.

(20) "Desalting" by S. Baron, Burns and Roe, Inc., Nuclear News, March, 1965.

(21) "Economics of Reactors for Power and Desalination" by S. Baron, Burns and Roe, Inc., Nucleonics, April, 1964.

(22) Burns and Roe Western Hemisphere Corporation. Daily Operators Evaporator Performance Data issued infrequently and usually attached to Monthly Summary of Activities (7).

(23) Burns and Roe Western Hemisphere Corporation Evaporator Temperature Profile, usually attached to (22) but sometimes separately attached to letter to U. S. Navy Public Works Center, U. S. Navy Base.

(24) Burns and Roe Western Hemisphere Corporation, Water Conversion and Power Generation Plant, Guantanamo Bay, Cuba daily "Midnight-to-Midnight OPERATION PERFORMANCE DATA" attached to Weekly Reports (6).

(25) Burns and Roe Western Hemisphere Corporation, Water Conversion and Power Generation Plant, Guantanamo Bay, Cuba, "SJAE Performance Data" attached to Weekly Reports (6).

(26) Burns and Roe, Inc., Specification S-2315-46, "Combined Saline Water Conversion - Steam Electric Plant" "Piping and Valve Material Specification".

(27) Burns and Roe, Inc., Specification S-2315-46, "Combined Saline Water Conversion - Steam Electric Plant" Concrete Pipe".

(28) Link-Belt Company drawing No. JK 6657-1, "General Arrangement - Model 45 A Water Screen 5'0" Wide Trays 19'0" centers", Rev. A. dated May 7, 1964.

(29) Burns and Roe Western Hemisphere Corporation, Guantanamo Bay, Cuba, Supervisor, Maintenance and Operations Letter to Utilities Foreman, Subject "Contract NBy 63395 -Operation and Maintenance of Water Conversion and Power Generation Plant - Point Loma Unit Data at 211^{o}F Brine Heater Outlet Temperature", dated April 5, 1967.

(30) Burns and Roe Western Hemisphere Corporation, Guantanamo Bay, Cuba, Supervisor, Maintenance and Operations Letter to Burns and Roe Construction Corporation, Subject, "U.S. Naval Base, Guantanamo Bay, Cuba - W.O. 1284, Point Loma High Temperature Test", dated April 5, 1969.

(31) Burns and Roe Western Hemisphere Corporation, Guantanamo Bay, Cuba, Supervisor, Maintenance and Operations Memo to Head Utilities Department, Subject "Contract NBy 63395 - Operations and Maintenance of Water Conversion and Power Generation Plant, Actual Costs of Scale Control Chemicals", dated March 28, 1968.

(32) Records, Laboratory, Utilities Department, PWC (code 601) Naval Base Guantanamo Bay, Cuba, J. M. Murray, Chemist.

(33) Record Book No. 1, 1/24/68, J. M. Murray, Chemist (GS-11) Laboratory, Utilities Department, PWC (Code 601) Naval Base, Guantanamo Bay, Cuba.

(34) "Daily Boiler and Product Water Analysis and Daily Corrosion Report", 10 ND PWCEN 11330/3, Water Conversion and Power Generation Plant, Guantanamo Bay, Cuba.

(35) "Summary, Weekly Report on Lime Bed, Surge Tank, Deaerators #1 and #2, Gitmo #1 and #2 and Point Loma Evaporators with Recycle Brine Pumps", Laboratory, Utilities Department, PWC (code 601) Form 10 ND PWCEN 11330/16 (7-68).

(36) Lt. J. R. Jacobsen Letter PWC:601:21A:op of 13 June 1966.

(37) Betz Laboratories Corrosion Test Data, Re Guantanamo Bay Project, Product Water Quality Control, dated April 4, 1966.

(38) Betz Laboratories Corrosion Study, Re Guantanamo Bay Project, Product Water Quality Control, dated September 10, 1965.

(39) Laboratory, Utilities Dept., PWC (Code 601) memo to Code 600, subject: "Lime Bed Material:Coral or Limestone Feasibility" dated 12 November 1969.

(40) Laboratory, Utilities Dept., PWC, Chemist memo to Mr. N. Hansen, Subject: "Coral Pilot Scale Test, Report #2" dated 13 January 1969.

(41) Laboratory, Utilities Dept., PWC, Chemist memo to Mr. N. Hansen, Subject: "Coral Pilot Scale Test, Report #3", dated 21 January 1969.

(42) Laboratory, Utilities Dept., PWC, Chemist memo to Mr. N. Hansen, Subject: "Coral Pilot Scale Test, Report #4", dated 27 January 1969.

(43) Laboratory, Utilities Dept., PWC, Chemist memo to Mr. N. Hansen, Subject: "Coral Pilot Scale Test, Report #5", dated 4 February 1969.

(44) Laboratory, Utilities Dept., PWC, Chemist memo to Mr. N. Hansen, Subject: "Coral Pilot Scale Test, Report #6", dated 7 February 1969.

(45) Anaconda American Brass Company, Report No. 1, Subject: "Burns and Roe, Inc., Failed 5/8" OD X 20 BWG 90-10 Copper-Nickel Tube Removed from Unit #1 Evaporator at Guantanamo Bay, Cuba; dated March 27, 1967.

(46) United States Department of the Interior, Office of Saline Water, letter from R. H. Jebens, Technical Advisor to the Assistant Director, PM & PE to Burns and Roe, Inc., dated January 22, 1969.

(47) United States Department of the Interior, Office of Saline Water, Specification Documents, Conditions, Detail Specifications and Small Drawings for a 1,000,000 Gallon Per Day Multistage Flash Distillation Sea Water Conversion Plant at San Diego, California; Specifications No. 198, dated October 18, 1960.

(48) "General Safety Requirements" EM 385-1-1 prepared by the Department of the Army, Corps of Engineers, U. S. Army, published by the U. S. Government Printing Office.

(49) Burns and Roe Construction Corp., Operation and Maintenance Manual, Vol. III, System and Equipment Maintenance, Guantanamo Bay Power Plant and Seawater Conversion Facilities for Department of the Navy, Naval Facilities Engineering Command, Caribbean Division.

14.0 LIST OF ABBREVIATIONS

AE	Air Ejector
BH, B/H	Brine Heater
btu	British Thermal Units
Btu/hr	British Thermal Units per hour
BWG	Birmingham Wire Gauge
cfm	Cubic feet per minute
CON	Condenser
Cu-Ni	Copper Nickel
D	Diameter
DRC Valve	Density Recorder Control Valve
ea	Each
eff	Effluent
ft/sec	Feet per second
FRC Va	Flow Recorder Control Valve
Gal., gal	Gallon
GE	General Electric
GM	General Motors
GPD, gpd	Gallon per day
GPM, gpm	Gallon per minutes
Hg	Mercury
H.P.	High Pressure
HP, hp	Horse Power
HX	Heat Exchanger
ID	Inside Diameter
Inf.	Influent
INST	Instrumentation
KW	Kilowatt
KWH	Kilowatt Hour
L.B.	Lime Bed

LB/Day, lb/day, lb/da	pound per day
LB/Hr, #/hr	pound per hour
lb/Mbtu, LB/Mbtu, #/1000 Btu	pound per thousand British Thermal Units
L.I.	Langellier Index
L.P.	Low Pressure
Mbtu	Thousand British Thermal Units
MGD, mgd	Million Gallon per day
MGPY	Million Gallon per year
M&O	Maintenance & Operation
Mos	Months
MSF	Multistage Flash
MW	Megawatt
NSD	Naval Supply Depot
OD	Outside Diameter
PD8	Hagevap L.P.
PPM	Parts per Million
PSIA	Pound per Square Inch Absolute
PSIG, psig	Pound per Square Inch Gauge
PSI	Pound per Square Inch
RPM, rpm	Revolution per Minute
SJAE	Steam Jet Air Ejector
SQ. Ft., sq. ft.	Square Feet
SS	Stainless Steel
TDH	Total Dynamic Head
TDS	Total Dissolve Solids
TG	Turbine Generator
MMC/day	Micro-Micro Curie per day, 10-12 Curie per day
V	Volt
W.P.	Water Plant
W.W.II	World War Two

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