**BRAWLEY
10 MW GEOTHERMAL PLANT**

**SOUTHERN CALIFORNIA EDISON COMPANY
AND
UNION OIL COMPANY OF CALIFORNIA**

**PLANT MANUAL
SYSTEMS DESCRIPTIONS
VOLUME I**

ROGERS
Engineering • San Francisco

NOV 28 1980

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PLANT MANUAL

Volume I Systems Descriptions

Presents each system of the facility and discusses basic features. Brief discussion of each piece of major equipment in system and design conditions.

Volume II Systems Start-up and Operations

Each system within the facility is considered from an operation viewpoint. There are five subsegments within this operation's viewpoint. Prerequisite conditions, start-up, normal operating, emergency and shutdown.

Volume III Drawings and Diagrams

The plant design drawings and diagrams are presented. A list of all drawings and an index of drawings included in the book are in Section 1. The design drawings data in this book is for general plant understanding.

Volume IV Equipment Data

This volume has technical presentations on each piece of plant equipment. It also references manufacturer's instruction books and drawing lists.

Volume V Equipment Spare Parts

This volume presents the spare parts list for each piece of equipment and references the Material Requisition on which each piece of equipment was purchased.

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C.1 Station Site

C.1.1 Location and Description

The power plant site is located in the Imperial-Mexicali Valley of Southern California. It is located immediately west of State Highway 111 and south of Spruce Drain #3, approximately two miles north of Brawley, California. The project consists of the power plant and two cooling water make-up lines to supply the cooling tower with water either from the Spruce Lateral #3 due west of the plant or Stanley Lateral No. 1 as an alternate source of water. The power plant consists of the control building, the turbine-generator building which houses the turbine-generator equipment, a switchyard area for the electrical switchyard structures, the cooling tower and various piping runs. Access roads and employee parking are also provided.

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C.1.2 Utility Services by Others

Potable water for drinking is bottled supply and truck delivered.

Makeup cooling water for the cooling tower, fire water and water service in general is supplied thru a pipeline from either Spruce Lateral No. 3 or Stanley Lateral No. 1. This water is currently used for irrigation and is furnished by the Imperial Irrigation District (IID).

Electric power source for start-up operation, 34.4 kV, and also 12.5 kV for back-up power supply for critical equipment, are supplied by IID. The lead terminals are located at the north east portion of the plant off Highway 111.

Telephone services are supplied by Pacific Telephone and Telegraph Co.

C.1.3 Drainage, Paving and Sewage

To improve drainage, portions of the site are raised. A compacted fill about three feet high is provided for the control and turbine-generator building. The site is graded such that run-off water is to be drained towards the northeast corner of the plant and eventually spilled into Spruce Drain No. 3 located at the west side of Highway 111. Sewage coming from the control building is deposited in an underground septic tank. Effluent from the septic tank is

discharged into the sanitary sewer tile field located at the southeast corner of the plant. Paved access road and parking for employees are also provided. The plant perimeter is bounded by an 8 foot high cyclone wire fence.

C.1.4 Oily Waste Water and Silt Deposit Disposal

Wash down water from the turbine generator area and the main condenser are pumped into an underground oily water tank. The underground tank is pumped out and hauled by truck for disposal outside plant site.

The silt deposit from the cooling tower basin is removed and run in a sand filter tank. Silt is ultimately dumped into a backwash sump. The silt deposits from the backwash sump are pumped to Spruce Drainage Ditch.

C.1.5 Reference Drawing List

E-04-001 General Arrangement Battery Limit
E-80-001 Floor Plan Section and Elevations
E-80-002 Control House and T/G Building Schedules and Details
E-80-006 Miscellaneous Equipment Shelters
E-46-001 Paving Grading and Drainage Plan
E-46-002 Road Storm and Sanitary Sewer Sections and Details
E-46-004 Chain Link Fence
E-46-005 Cooling Water Makeup Lines Plans and Profiles
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C.2 Structural Design

C.2.1 Soil Investigation

Subsurface soil exploration and evaluation were performed by the firm of Harding-Lawson Associates. 16 test borings, varying in depth from five feet along the pipeline route to over 50 feet in the plant site were done. Samples were taken from these borings, and analyzed and tested. Compressional and shear wave velocities of the soil were determined. Based on the test results, obtained, a report was prepared with recommendations necessary for the design and construction of the proposed facilities.

C.2.2 Design Codes and Standards

Uniform Building Code (UBC) 1976 edition

American Concrete Institute (ACI) 1971 Code

American Institute of Steel Construction (AISC) 7th edition

American Welding Society (AWS) Specifications

Structural Engineers Association of California (SEAOC) Standard No. 1

C.2.3 Design Loadings

Roof live load = 20 psf (with reduction)

Floor live load:

Turbine-generator building = 400 psf or HS-20 truck loading

Control building = 200 psf

Cooling tower basin = six feet of water in basin

Wind loading (on vertical projection above ground level):

height above ground level is 0 to 30 feet = 15 psf

height above ground level is 30 to 100 feet = 20 psf

Seismic loading base shear is calculated using the method used in the SEAOC, Standard No. 1, with the importance factor (I) = 1.

Where psf = pounds per square foot.

C.2.4 Allowable Stresses

Structural steel allowable minimum yield stress (fy) =

36,000 psi

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Reinforced concrete minimum bearing stress (f_c') at 28 days =
3,000 psi

Reinforcing steel minimum yield stress (f_y') = 60,000 psi

Allowable soil bearing pressures (from Soil Engineers Report):

Dead load (DL) + live load (LL), sustained = 2500 psf

DL + LL + seismic or wind loading = 3750 psf

Passive soil pressure = 400 psf

Coefficient of friction = 0.40

Friction piers (neglect upper four feet of soil)

Friction force = 700 psf for DL + LL (Sustained loads)

= 1050 psf for DL + LL seismic or wind

Passive soil pressure = 200 psf (acting on twice the
pier diameter)

Where psi = pounds per square inch

Where psf = pounds per square foot

pcf = pounds per cubic foot

C.2.5 Reference Drawings

E-42-001 Pipe Support Structures (Sheet 1)

E-42-002 Equipment Support Structures

E-42-003 Pipe Support Structures (Sheet 2)

E-42-004 Electrical Switchyard Steel Structures

E-42-005 Miscellaneous Platform (Sheet 1)

E-42-006 Ladders and Miscellaneous Steel

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E-42-007 Pipe Support Structures (Sheet 3)
E-42-008 Miscellaneous Platform (Sheet 2)
E-45-001 Control House and T/G Building Foundation
E-45-002 Turbine and Generator Foundation
E-45-003 Main Condenser Foundation Including Pit
E-45-004 Miscellaneous Foundations Area 6, 7, 9 and 10
E-45-005 Cooling Tower Basin (Sheet 1)
E-45-006 Cooling Tower Basin (Sheet 2)
E-45-007 Electrical Switchyard Foundations
E-45-008 Miscellaneous Foundations Area 1, 7 and 8
E-45-010 Foundation Location Plan

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C.3 Station Structures

C.3.1 Turbine-Generator Foundation

The turbine-generator foundation is a block of concrete 10 feet wide x 40 feet long and 6 feet high that is located inside the turbine-generator building. The top of concrete is flush with the finish floor. The turbine and generator, which are assembled on a mounting skid made up of I steel beam framing, is set and anchored to the foundation by anchor bolts. Drip oil from the equipment is drained into the trench located around the foundation by drain pipes. In determining mass of foundation, the criteria used limits the resonant frequency of both equipment and foundation to less than half the operating frequency of the equipment. Maximum amplitude of vibration at resonance is less than .001 inch. Foundation is sufficiently stiffened to reduce differential settlement between turbine and generator.

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C.3.2 Switchyard

The switchyard area is located at the northeast corner of the plant site immediately north of the control and turbine-generator building. It is isolated with a fenced enclosure. Access gates are located at the south side of the switchyard fence. Six inches of rock surfacing make up the finish grade. The transformers are supported on reinforced concrete pads and tied down with cast-in-place anchor bolts. The disconnect switches, cross bus, line take-off and potential and current transformers are all supported on structural steel frames anchored to reinforced concrete round piers poured into holes drilled in the ground. All exposed structural steel surfaces are hot-dipped galvanized for durability. All structures are designed for gravity, and lateral loads (wind or earthquake).

C.3.3 Cooling Tower

The two unit cooling tower is located at the west end of the plant site. The basin is reinforced concrete 43 feet wide x 83 feet long and 6 feet high and stands 6 feet above finish grade. The water level in the basin under normal operating conditions is about 5 feet high. The basin floor which is 14 inches thick is designed as a rigid mat. The basin walls are 14 inches thick. The basin forebay located at the east side near the northeast corner is 9 feet wide x 23 feet long and 7 feet deep. Bottom of forebay is one foot lower

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than the basin. Removable stainless steel screen located at the forebay entrance prevents trash from entering the sump. The two main cooling water circulating pumps and an auxiliary cooling water circulating pump are located over the sump supported by steel grating on structural steel beams. A steel ladder at the east side provides access to the pumps. Membrane water proofing covers the entire basin inside surface in contact with the cooling water.

C.3.4 Miscellaneous Structures

The main condenser is supported by three reinforced concrete piers 18 inches thick by 8 feet wide and 7 feet high on a 24 inch thick by 8 feet wide and 34 feet long mat. The middle pier support is anchored to the main condenser and the two exterior piers (one on each side of the middle pier) are provided with teflon sliding plates to allow movement for the equipment thermal expansion. The pipe support structures are made of hot-dipped galvanized structural steel anchored to reinforced concrete drilled piers. The other miscellaneous equipments such as pumps, compressors, tanks, etc., are all supported by reinforced concrete pads and anchored with set in place anchor bolts or drilled in expansion bolts. The top of concrete is set at a minimum of 6 inches above finish grade.

C.3.5 Reference Drawings

E-42-001 Pipe Support Structures (Sheet 1)

E-42-002 Equipment Support Structures

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E-42-003 Pipe Support Structures (Sheet 2)
E-42-004 Electrical Switchyard Steel Structures
E-42-005 Miscellaneous Platform (Sheet 1)
E-42-006 Ladders and Miscellaneous Steel
E-42-007 Pipe Support Structures (Sheet 3)
E-42-008 Miscellaneous Platform (Sheet 2)
E-45-003 Main Condenser Foundation Including Pit
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C.4 Station Buildings

C.4.1 Control Building

The control building is located at the east side of the plant site south of the switchyard structures, and contiguous to the east side of the turbine-generator building. It is 30 feet wide by 70 feet long and 14 feet high. A small equipment shed building 11 feet wide by 25 feet long and 13 feet high is located along the north face of the control building. The control building superstructure is pre-fabricated, made of structural steel columns, roof beams, purlins to support the roofing and girts to support the siding. The column spacings along the length of the building are 24 feet and 20 feet. Each bent, consisting of columns and beams, is designed as a rigid frame, i.e., the column-beam common joint is fixed and able to take full movements. The super structure is supported and fastened with anchor bolts to the reinforced concrete beam on grade which is poured monolithic with the 6 inch slab on grade. Temperature rein-

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forcement consisting of electrically welded wire mesh help prevent large cracking in the slab. Vapor barrier and an 8 inch thick capillary rock barrier is placed below the slab on grade. Construction and expansion joints are placed at a maximum spacing of 20 feet. Cable trenches are provided below grade. The building finished floor is 3 feet 8 inches higher than the adjacent finish grade. The control building is air pressurized and fitted for air conditioning requirements.

C.4.2 Turbine-Generator Building

The turbine-generator building is located contiguous to the west side of the control building and south of the switchyard structures. It measures 37 feet wide by 70 feet long and 37 feet high. It has a roof only except for an 18 foot high sun baffle at the west side. The super structure is pre-fabricated structural steel. The columns made of pipe, supports the roof beams and crane rail girders. The roofing is supported on purlins placed over the roof beams. The building frame is not rigid at the joints and overturning movement from the lateral force due to crane loading and wind or earthquake loading are resisted by the drilled reinforced concrete piers. The drilled piers are provided with a grout hole 16 inches in diameter and 6 feet deep for grouting-in of the pipe columns. The slab on grade is 8 inches thick and reinforced with No. 5C 12 inch reinforcement. An 8 inch thick capillary rock barrier is placed below the slab. Construction and expansion joints are placed at a maximum

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spacing of 20 feet. The turbine-generator foundation is located near the center of the building. A concrete trench used for drainage of oil spills and for installing piping associated with the turbine-generator is provided around the turbine-generator foundation. A 16 foot wide ramp at the west side south corner of the building is provided for vehicle access into the building. The finish floor is 3 feet 6 inches higher than the adjacent finish grade.

C.4.3 Miscellaneous Enclosures

A shed to house the air compressor equipment is located at approximately the central portion of the plant site west of the turbine-generator building. The superstructure is of prefabricated structural steel, with a metal roofing and open sides. The concrete floor slab is 8 inches thick and reinforced with No. 4 bars @ 12 inch centers each way. The finish floor is 4 inches above finish grade.

A shed to house the chemical storage tanks and equipment used for treating the cooling water is located adjacent to the south end east corner of the cooling tower basin. The superstructure is similar in make to the air compressor shed mentioned above. The concrete slab is 8 inches thick reinforced with No. 5 bars @ 12 inch centers. The finish floor is 4 inches above finish grade.

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A small air conditioned enclosure is provided for the fire pump controller, jockey pump starter and the control panel for the cooling tower water treatment system.

The machine shop building is located to the south of the turbine-generator contiguous to the power plant building. This building is provided with a wall type air conditioner.

C.4.4 Reference Drawing List

- E-45-001 Control House And T/G Foundation
- E-45-004 Miscellaneous Foundations Area 6, 7, 9 And 10
- E-45-005 Cooling Tower Basin (Sheet 1)
- E-45-006 Cooling Tower Basin (Sheet 2)
- E-45-010 Foundation Location Plan
- E-80-001 Floor Plan Section and Elevations
- E-80-002 Control House and T/G Building Schedules and
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M.1 Steam Supply System

M.1.1 Drawing List

- E-03-002 Steam System
- E-41-003 Steam Inlet Line Pipeway
- E-41-014 Steam Silencers & Relief Values
- E-20-001 Flow & Control Diagram

M.1.2 General Description

The purpose of the steam system is to supply saturated steam to drive the turbine-generator and auxiliary steam equipment in the power generation plant. Steam is supplied to this system by Union Geothermal's steam gathering system. The two systems interface at the main steam valve HV-902.

Steam enters the system from the gathering system at the main steam valve HV-902, which is a 20 inch motor operated WKM gate valve. The valve has a 2 inch bypass line and valve. Three 6 inch relief valves protect the steam separator from over pressure. The next major component in the system is the steam separator, which the steam passes through and receives a final moisture separation. After leaving the separator, the steam flows through a venturi flow element FE-100 and into the turbine inlet steam strainer supplied by M. H. I. The turbine has two inlets equipped with drain valves. The turbine control valves are also equipped with drains. Gland sealing steam is supplied directly from the twenty inch main steam line by a 1 inch take off line. The gland steam drains and turbine casing drains are piped to a stainless steel flash drain tank supplied by M. H. I.

A 6 inch auxiliary steam line branches from the main steam line to supply steam to the 1st and 2nd stage ejectors. The 6 inch line has two 1 1/2 inch take offs, one supplies steam to the flash drain tank eductor. The other line provides a positive flow through the vent gas system.

The main and auxiliary steam lines have traps and drains on low points in the system. The steam system controls and instrumentation consist of level controls, temperature and pressure recorders, thermometers and pressure gauges.

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M.1.3 Design Delivery Conditions

Steam is supplied at the plant limit as follows:

a.	Flow (max.)	209,000 lbs/hr. (approx.)
b.	Pressure	100 psig
c.	Temperature	338°F
d.	Enthalpy	1190 Btu/lb.
e.	Quality	99.75% dry
f.	Maximum	Chemical Composition
	1. TDS (max.)	50 ppm
	2. NCGas	2% wt.
	3. H ₂ S	.29% wt. of Noncondensable Gas

M.1.4 Steam Separator (Equipment No. 10-2)

The steam separator is designed to handle approximately 210,000 lb/hr of 99.5% inlet steam at 338°F and 115 psia. Its performance is such that 209,160 lbs/hr at 99.9% quality is delivered to the turbine. This separator will operate during all modes of operation in order to follow the turbine during load changes.

The water level in the steam separator (10-2) is controlled by a differential gap controller which opens the control valve below the separator on high water level and closes when the separator is at a low level. This cycle, under normal full load conditions, has a 300 gallon surge available and would take 15 minutes to fill the

tank. This water storage capacity on the line prevents a slug of water entering the turbine. An excessive water level in the separator trips the turbine and closes the motor operated steam valve at the plant boundary.

M.1.5 Emergency Steam Pressure Relief System

The purpose of this system is to vent steam if the steam supplier's pressure control and blow off system fails to respond during a turbine trip.

This system includes 3 relief valves with silencers. Each valve is designed to handle one half of the required capacity so that one valve may be taken out of service at anytime.

When this system operates steam is vented through silencers. The silencers will reduce the noise within 3 feet of the valves to no more than 90 dBA.

M.1.6 Main Steam Valve

The main steam valve HV-902 is a 20 inch WKM gate valve, actuated by a 460 volt Limitorque motor. The valve is located in the steam line paralleling the north access road near the Union Geothermal interface and is operated by pushbutton switches on the control panel, by pushbutton switches on the valve mounted controller or by a mechanical valve operator. The local pushbuttons allow setting the valve

in any intermediate position. The remote pushbuttons in the Control Room cause the valve to open or close fully (no intermediate position). A dial indicator indicates valve position aided by local and remote indicator lights to indicate full open and full closed positions.

A 2 inch bypass line and valve around HV-902 is used to warm up steam system piping.

M.1.7 Auxiliary Steam Line

The auxiliary steam line branches from the main steam line between the separator and the turbine control valves. This line supplies steam to the first stage ejector, the drain tank ejector and the second stage ejector in succession. Isolation valves are provided at each point of use.

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- E-03-002 Steam System
- E-02-001 Flow & Control Diagram
- E-03-009 Hydraulic Oil Piping Diagram
- E-03-010 Lube Oil Piping Diagram
- E-03-011 Steam & Drain Piping Diagram - Turbine Generator
- E-41-007 Turbine Generators & Condensers
- E-41-011 Turbine Generators & Condensers
- E-41-016 Turbine Generators & Condensers

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M.2.2 General Descriptions

The purpose of this section is to describe the turbine and the various mechanical components associated with the turbine. Some of these include the lube oil system, gland steam seal and drain system and turbine control system. The turbine receives steam from the steam supply system to be expanded in the turbine and passed on to the condenser under vacuum. The turbine has auxiliaries to keep the turbine lubricated and sealed and to control and monitor its performance during load changes.

M.2.3 Turbine (Equipment No. 18-2)

The turbine is a single pressure inlet, single steam flow type condensing turbine rated at 10,000 kw at the generator terminals. It has a single cylinder and five impulse stages. The rated speed is 3600 rpm with rated steam conditions at inlet flange of 95 psia. Design back pressure is 4 inch Hg a.

Steam from the steam separator flows first through the turbine steam strainer and then through two sets of stop valves and control valves in parallel. These valves will be discussed under section M.2.6.

The main steam strainer is a multi-holed Y type with a stainless steel temporary screen with 1/8 inch mesh (now removed) and a permanent stainless steel screen with 1/4 inch mesh. The main strainer

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mesh is designed for an area 4 times the cross sectional of the pipe to reduce pressure drop. Its main purpose is to filter particulate matter from the steam immediately prior to the turbine inlet. It is equipped with drain and traps system, which empties to the seal water separator.

The turning gear is provided to rotate the turbine rotor at a very slow speed (about 3 rpm) while the turbine is on standby. This is done so as to prevent distortion of the rotor due to uneven cooling or heating. Turning gear should be used continuously during startup or shutdown periods.

M.2.4 Lubricating Oil System

The control and lubrication of the main turbine and lubrication of the generator is provided by the main oil pump which is installed in the oil reservoir and is driven through a gear and an extension shaft.

The pressure and temperature of the lubricating oil is controlled by appropriate valving and the oil is sent through an oil strainer before entering each bearing pedestal. Drain oil off the bearings is then fed back to the oil reservoir. Lubricating oil is also lead to the turning gear.

Lubricating oil is introduced to the protective devices which trip the turbine when oil pressure is decreased below some established

limit. Two pressure switches are provided in the oil line to start either auxiliary or emergency oil pump when lubricating oil pressure decreases below the limit.

Auxiliary oil pump driven by ac electric motor and emergency oil pump driven by dc electric motor are installed at the oil reservoir. These pumps are attached to the main oil line and will be used during the start-up period or in an emergency.

a. Main Oil Pump:

The main oil pump is installed in the oil reservoir and driven by an extension of the generator shaft through a gearbox. The oil from this pump is sent to the governing and lubricating system.

During turbine start-up and shut-down, the pressure and flow rate of the main oil pump is not sufficient and part of the oil is supplied by the ac auxiliary oil pump. As rated speed is approached, the main oil pump starts to operate normally and the ac auxiliary oil pump is manually stopped and starts automatically on low oil pressure. See Plant Manual, Equipment Data, Volume IV, Section 18 for capacities of these pumps.

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b. Auxiliary Oil Pump (Motor Driven)

This pump is a motor driven vertical shaft centrifugal type driven by an ac motor which is used to supply bearing oil requirements during the starting and stopping periods of turbine operation.

c. DC Emergency Oil Pump

This pump is a centrifugal type driven by dc motor for use in case of the loss of power to the auxiliary oil pump. The construction of the pump is similar to the auxiliary oil pump and supplies lubricating oil only. If lubricating pressure decreases below an acceptable limit, the dc emergency oil pump starts. The pump is stopped by manual operation.

d. Centrifuge

The lube oil centrifuge is provided to maintain the quality of the turbine lube oil by continuously removing the moisture and other impurities that are introduced into the oil when it is circulated through the turbine bearings and hydraulic system. The centrifuge purifies the oil by separating the water and dirt from the oil by centrifugal action. The clean oil is delivered to the lube oil tank while the sludge is delivered to

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the oily waste water tank. An anti-syphon device is provided in the oil supply line to the centrifuge to prevent critical loss of oil in the event of pipeline rupture.

e. Oil Purifier

An oil purifier is provided to clean the turbine lube oil when the centrifuge is out of service. The purifier consists of a self contained pump and three stages of filtration as follows:

- a. A prefilter to remove large particles.
- b. A coalescing filter to remove moisture.
- c. A final polishing filter.

It is important that the final filter be of a 10 micron rating to prevent loss of additives from the oil.

f. Lube Oil Reservoir

The lube oil reservoir serves to collect, recondition and cool the lube oil that is returned from the turbine-generator bearings and control system. This vessel mounts the following equipment: auxiliary lube oil pump; emergency lube oil pump, oil filter, oil purifier; oil cooler; vent fan; oil heater; and oil level indicator.

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g. Vapor Extractor

The vapor extractor is an electric motor driven centrifugal type turbo-blower mounted on the oil reservoir and designed to extract combustible oil vapors from the reservoir, and to remove atmospheric moisture which would deteriorate the oil.

The vapor extractor is also used to maintain a slight vacuum in the bearing pedestal to prevent leakage of oil vapor outward to the shaft seals.

M.2.5 Gland Steam Seal System

The Gland Steam Seal System is used to minimize steam leakage or air ingress which may occur through the clearance between the rotor and turbine casing gland seals. Turbine gland seal steam is supplied from the main steam line and is controlled at almost constant pressure by the gland seal steam supply valve by manual adjustment.

At low load, the gland seal steam is supplied to both the fore and aft gland. At the high load where the internal steam pressure in the fore gland is high, gland seal steam for the fore gland is supplied by the leakage steam from inside of the casing.

The gland leakage steam from both the fore and aft gland is led to the flash and drain tank and exhausted directly into the condenser.

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a. Gland Seal Ejector (Equipment No. 15-4)

The drain ejector is provided to remove condensate which drains from the turbine and the gland seal system into the flash drain tank. The condensate enters the ejector by gravity flow from the bottom of the flash drain tank. The ejector transfers this condensate into the main condenser. The ejector is made of 316LSS and designed for a motive steam of 58 psia.

b. Flash Drain Tank

The flash drain tank design pressure is from full vacuum to 150 psia. Maximum operating pressure is 16.8 psig. It is made of 316LSS and is 3-1/2ft. in diameter by 6 1/2 ft. high.

Steam and condensate from the turbine steam chamber drains and the gland leakage drains are fed to the flash drain tank. Steam from the flash drain tank flows directly to the main condenser while condensate is pumped to the main condenser by the action of the drain ejector.

The flash drain tank is equipped with a gauge glass and two high level switches. If the level reaches the first switch an alarm is sounded in the Control Room. If the level continues to rise to the second switch the turbine is automatically tripped.

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M.2.6 Mechanical Hydraulic Control System

The control of the turbine speed and steam flow rate is governed by a speed droop type governor. Input to the speed governor is mechanical. The governor output is connected mechanically with linkage to the governing valve servomotors. The servomotors control the governing valve. The overspeed trip, lube oil trip, thrust bearing trip and vacuum trip control the servomotors to shut down the turbine.

a. Governing System

The governor supplied is the speed droop type, a Woodward Type UG 40.

The Woodward governor detects turbine speed through the governor driving mechanism. Mechanical output of Woodward governor is connected to the input shaft of the governing valve servomotor (hydraulic amplifier) through rods and links.

When the turbine speed increases, the output signal of the governor is given in such a direction that the rods are pulled upwards to close the governing valve. The above actions reverse if the turbine speed decreases.

A governing valve is installed in each of the two main steam inlet lines to the turbine. Governing valves are of the but-

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terfly type and are used to control flow. The pressure loss across the valve is low. The basic construction of the valve minimizes sticking problems. The valve body and disc are made of cast steel. The entire circumference of the valve disc is stellited and the portion of the valve body that comes in contact with the valve disc when the governing valve is fully closed is welded stainless steel.

b. Main Stop Valve and Controller

The main stop valve controller is of the manual type and can be operated by hand wheel. When the handwheel is operated in the open direction the spring support opens the main stop valve. When the turbine trips the trip servomotor is provided to close the main stop valve.

The main stop valve is of swing check type with a small pilot valve. This pilot valve is operated by the main stop valve controller. The valve body is made of cast steel and is designed for maximum steam pressure. The main valve is made of cast steel and the pilot is made of forged steel. The main valve seat is made of forged steel, pressed in and tightly fixed to the valve body, and is seal welded further to prevent steam leakage.

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c. Emergency Trip Mechanism

The turbine is provided with protective devices against various possible accidents that might cause damage to the unit. The emergency pilot valve works in all the cases of emergency trip. For the hand trip and overspeed trip, a latch is released mechanically and for the other cases, oil under the emergency pilot valve is drained and the same latch is disengaged.

The thrust bearing trip device is a safety device that shuts down the turbine to prevent the rotor from coming in contact with the casing. This may happen when the rotor moves axially beyond a predetermined limit because of thrust bearing wear.

The low vacuum tripping device is designed to shut down the turbine in case of a serious rise in exhaust pressure. A trip latch is provided to prevent tripping the unit during the starting period when the vacuum may be less than the trip setting of the vacuum trip.

When the lubricating oil pressure falls below a predetermined value for any reason while the turbine is in operation, a pressure switch is provided to detect the low oil pressure and energize an alarm. If the pressure continues to fall below another predetermined value the emergency trip device will trip the turbine.

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M.2.7 Electrical Controls

The electric control systems for the turbine are the following:

- a. Governor - speed/load adjusting motor on the turbine/generator can be operated either through a control switch on the turbine supervisory panel or main control panel or by a kilowatt controller on the main control panel. The kilowatt controller is used to operate the turbine so that the generator delivers to the IID system a set continuous output.
- b. Governor test system - Control switches, indicating lights, solenoid valves and limit switches are provided for a control system that permits exercising the governing valves and associated linkage (stem free test). Right hand and left hand valve operation are interlocked to avoid closing both valves at the same time.
- c. Automatic start - Auxiliary oil and emergency oil pumps will start on loss of turbine oil pressure. The auxiliary oil pump cuts in first. If it does not keep the oil pressure up the emergency oil pump cuts in.
- d. Turbine auxiliaries - Control switches and indicating lights are provided on a local control panel for monitoring operation

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of the oil purifier, vapor extractor, lubricating oil heater, turbine turning gear and auxiliary and emergency oil pumps.

- e. Alarms - Turbine is provided with the following alarms: bearing low oil pressure, governor low oil pressure, bearing oil high temperature, oil purifier failure, excess vibration, high flash tank level, turbine overspeed, emergency oil pump run, thrust bearing excessive wear, turbine protective device operate, oil reservoir level abnormal, turbine casing level and low vacuum. The alarms are indicated on the annunciator on the main control panel.

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M.3	<u>Condensate System</u>
M.3.1	Reference Drawings
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M.3.3	Main Condenser
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M.3.5	Condensate Pumps

M.3 Condensate System

M.3.1 Reference Drawings

E-03-003 Condensate System
E-02-001 Flow & Control Diagram
E-41-007 Piping Plan - Area 8
E-41-011 Piping Elevation - Area 8

M.3.2 General Description

The condensate system includes the gathering of all steam condensate from miscellaneous trap drains, vacuum system condensation and the main turbine exhaust condensation. All condensate is collected in

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the main condenser hot well and is returned via the condensate pumps to the steam supplier. This system and the following associated equipment will operate during all modes of operation.

M.3.3 Main Condenser (Equipment No. 12-2)

The main condenser receives turbine exhaust steam through the 66" stainless steel line and condenses this steam to provide the low pressure exhaust necessary for turbine efficiency.

This condenser condenses 98% of the steam exhausted from the main turbine.

The condenser is a Graham Manufacturing Co. horizontal single pass shell and three pass tube type heat exchanger located immediately west of the turbine generator. The condenser is designed to condense 190,000 lb/hr of steam by 12,600 gpm of water operating on a 28°F rise and 15.5 psi pressure drop. Steam flows in the top of the 304 stainless steel shell at 122°F and over the 3/4", 316 stainless steel tubes where cooling water condenses the steam. Condensate, now at 103°F, collects in the hotwell on the bottom of the condenser. The shell of the condenser is rated for pressure from full vacuum to 40 psig and for a temperature of 150°F.

Condensate from the intercondenser and vacuum compressor seal water enters the main condenser hotwell through 2" gate valves. The

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hotwell has a capacity such that the condensate pump can be run for 2 minutes before losing suction when all condensate input stops. Condensate pumps take suction through vortex breakers and 12" butterfly valves.

M.3.4 Intercondenser (Equipment No. 12-3)

The intercondenser provides the low pressure exhaust necessary to the operation of the first stage steam ejector. This heat exchanger is also a horizontal, cross-flow shell and tube unit built by Graham Manufacturing Co., located immediately beneath the first stage steam ejector just west of the main condenser. The condenser uses 1,667 square feet of heat transfer surface area to take 14,000 lb/hr of steam flow from 126°F to 120°F. Steam flows into the shell which is constructed of Incol[®] 800 and rated at a maximum working pressure range of full vacuum to 30 psig and a temperature of 300°F. Cooling water flows in 3/4" tubes constructed of Allegheny Ludlum 6X.

Condensate collects in a hotwell which drains through a vortex breaker and control valves to the main condenser hotwell. Draining should take 6 minutes. A 1" line penetrates the intercondenser hotwell to carry the condensate conductivity analyzer slip stream flow.

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M.3.5 Condensate Pumps (Equipment No. 14-4A,B)

Condensate from the main condenser hotwell is pumped to the holding pond by two vertical in-line centrifugal Worthington pumps located in the pit below the hotwell. A rated capacity of 500 gpm at 36 psi (53 ft.) allows either pump to carry the full 10 MW load while the other pump is normally in automatic standby. The pumps are of all 316 stainless steel construction. The thrust bearing is oil lubricated and external to the pump and motor.

Since the pumps are subject to vapor binding due to the 103°F temperature of the condensate, both pumps are fitted with 1" constant vent lines which vent back to the hotwell through 1" globe valves.

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M.4	<u>Condenser Noncondensable Gas Removal System</u>
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M.4.2	General Description
M.4.3	Vacuum Compressor
M.4.4	First Stage Ejector
M.4.5	Second Stage Ejector
M.4.6	Vent Gas Silencer
M.4.7	Seal Water Recirculation Pump
M.4.8	Seal Water Separator
M.4.9	Piping

M.4 Noncondensable Gas System

M.4.1 Drawing List

E-03-002 Steam System

E-03-005 Non Condensable Gas System

E-03-003 Condensate System

E-02-001 Flow & Control System

M.4.2 General Description

The noncondensable gas system collects the gas from the main condenser and the intercondenser and passes it on to the vacuum compressor. During normal operation the vacuum compressor discharges

the gas through the seal water separator prior to exhausting directly into the noncondensable gas vent stack. On each gas compression stage a gas recycle system is provided for control of low gas flow during either start-up or normal operation.

A steam supply is provided to the vent stack during compressor operation to purge noncondensable gas from the stack.

M.4.3 Vacuum Compressor (Equipment No. 15-3)

The vacuum compressor is a Nash model CL 4002, which takes a suction on the intercondenser and discharges to the seal water separator at a rate of 3,000 ACFM (Vacuum). The compressor body and rotor are cast iron with ceramic coating to prevent hydrogen sulfide corrosion and mechanical abrasion. The only moving part is the one piece rotor which is offset toward the bottom of the pump body. The rotor is shaped of vanes which are open at the top and bottom - paddle wheel fashion. The rotor is divided in half crosswise by a solid plate. On either end of the pump body surrounding the rotor shaft and protruding into the center of the rotor are cones with suction and discharge ports. As the rotor rotates, gas and water are drawn in the suction ports in the top of the cones and into the empty vanes. Air cannot escape due to the water seal on the outside which seals the outer edge of the vanes. Air is forced out the bottom ports of the cone by seal water filling the vanes of the rotor as it rotates through the bottom area of the pump body which has less clearance. The gases, along with some seal water, are discharged to

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the seal water separator through two pump discharge lines. The vacuum compressor cannot be run without seal water flow since it must have seal water to prevent surface to surface contact between the rotor and cones and the rotor and body. The vacuum pump is driven by a Louis Allis 460 V, 250 hp, 296 amp, 1,780 rpm motor, through a Falk reduction gear which drives the pump at 398 rpm. The vacuum pump assembly is located under the west side of the intercondenser. The suction valve on the vacuum pump opens when the vacuum pump is started and closes when it is shutdown. The vacuum pump has an anti-surge bypass line. The bypass is automatically controlled to maintain a set vacuum and prevent surging.

Starting the vacuum pump energizes three solenoids which applies signal air to two Keystone pneumatic butterfly valves, PV-364 the 10" vacuum pump inlet valve and PV-362, the 3" automatic anti-surge valve. Closing of the inlet valve on loss of the pump prevents a loss of vacuum. Automatic anti-surge protection is required by Nash to protect the pump.

The anti-surge valve controls intercondenser pressure, which is sensed by a pressure transmitter, PT-362. PT-362 is a Foxboro transmitter model 11AM-HS2 located on the platform rail above the intercondenser outlet. The transmitter sends a 3-15 psig air signal to PIC-362 through a pressure relay (solenoid valve), PY-362 behind the control panel and energized by the vacuum pump controller. Pressure indicating control PIC-362 is a Foxboro model 130-N5-A with

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0-30 in. Hg absolute indicator, setpoint adjustment, and auto/manual station on the control panel front. PIC-362 will normally be set to control intercondenser pressure at 10 in. Hg absolute and has an internal pressure switch, PSH-362, set to close alarm contacts at 20 in. Hg absolute. PIC-362 outputs a proportional 3-15 psi air signal to the positioner of control valve PV-362.

M.4.4 First Stage Ejector (Equipment No. 15-1)

This ejector draws motive steam from the main steam line and is designed to extract non-condensable gases out of the main condenser and maintain a vacuum of 1.5 psia at an operating steam pressure of 80 psig and steam temperature of 324°F. It is constructed of 316LSS and requires 10,800 lbs/hr of motive steam.

The only control in the vent gas portion of the air ejector is the anti-surge valve. Anti-surge is necessary to stabilize operation when vacuum gets into the lower ranges and the ejector tries to draw more vacuum than it can hold. The anti-surge valve is a 6" (Durco) butterfly valve, HV-940, with pneumatic actuator located near the ejector. Control is from a Foxboro control panel hand indicator, HIC-940, which bypasses a small amount of flow around the ejector to break vacuum slightly and stabilize pressure. Over-pressure protection on the ejector and intercondenser is provided by a 6" Teledyne Farris pressure relief valve on the discharge of the air ejector set to lift at 10 psig.

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M.4.5 Second Stage Ejector (Equipment No. 15-2)

The second stage ejector is provided as a back up for the vacuum compressor. Should the vacuum compressor fail, the second stage ejector would take over the function of removing noncondensable gases from the intercondenser. The ejector is designed to operate at 80 psig of steam pressure and 324°F steam temperature. Motive steam requirements are 9000 lbs/hr.

The second stage ejector has a 2" anti-surge butterfly valve, HV-941, located on the platform alongside the ejector in the 3" anti-surge line. The valve is also controlled by a hand indicator, HIC-941, on the control panel. The 3" pressure safety relief valve, PSV-315, is set to lift at 80 psi.

M.4.6 Vent Gas Silencer (Equipment No. 20-1)

Gases from the seal water separator or the 2nd stage ejector which originate in the noncondensable gas sections of the main condenser and intercondenser are vented to the atmosphere through the vent gas silencer. This silencer is designed to handle 4560 lbs/hr of vapor and reduce noise to 90 dBA or less.

The power plant noncondensable gas, during normal operation, is vented from a small stack at the north side of the cooling tower. The vent stack extends above the level of the cooling tower decking. Because the quantity of H_2S vented is expected to be less than new

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point source standards, this vent should not contribute to ground level H_2S contamination.

M.4.7 Seal Water Recirculation Pump (Equipment No. 14-5)

This pump maintains proper flow through the seal water cooler to the vacuum compressor and transfers excess condensate to the main condenser. It is sized for 175 gpm at 60 feet of head. At the design point the efficiency is 62%. The electric drive motor is 5 hp, 1,800 rpm.

M.4.8 Seal Water Separator (Equipment No. 10-1)

This separator is sized to handle approximately 5000 lbs/hr of gases and 80,000 lbs/hr of water at 100°F. The gases are then released through the vent gas silencer and the water is returned to the seal water system recirculation pump suction. Excess water from the condensed steam is returned to the main condenser. Level is maintained by an automatic controller.

M.4.9 Piping

All piping in the system is stainless steel and all valves are rubber lined butterfly valves with stainless steel discs for service with highly corrosive H_2S .

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M.5.12	Vacuum Compressor Seal Water Cooler
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M.5 Cooling Water System

M.5.1 Drawing List

E-03-004	Cooling Water System
E-41-004	Cooling Tower Area (North half)
E-41-005	Cooling Water Recirculating Line Pipeway
E-41-008	Cooling Tower Area and Chemical Treatment (South)
E-41-013	Cooling Water Pumps

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M.5.2 General Description

The cooling water system is a closed system which provides cooling water to various heat exchangers; namely the main condenser, inter-condenser, lube oil cooler, generator air cooler, vacuum compressor seal water cooler, instrument air cooling system heat exchangers and the building air conditioner condenser.

The cooling water system includes the cooling tower, cooling water circulation system to all heat exchangers, cooling water circulating pumps, auxiliary cooling water pump, and the auxiliary facilities for cooling water treatment. The cooling water treatment facilities include storage tanks with metering pumps to provide controlled addition of sulfuric acid and corrosion inhibitor into the system. Microbiological control is achieved by manually controlled addition of dispersants and chlorine.

Controlled addition of sulfuric acid is accomplished by monitoring a sample from the cooling water circulation pumps discharge using a pH sensor. On high pH condition, acid is added to insure that calcium bicarbonate is changed to soluble calcium sulfate.

Likewise, a sample of the cooling water circulation pumps discharge is monitored using a conductivity sensor, and on high salt concentrations in the cooling water, a control valve will open to release blowdown water to the New River via the Spruce Drainage Ditch.

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M.5.3 Cooling Tower (Equipment No. 12-1)

The wet cooling tower is of the induced draft, counter flow type with two cells and serves the cooling duties of all the equipment listed in the General Description (M.5.2). Each cell has a 22 foot diameter fan. The tower is designed to cool water from 117°F to 89°F. Each fan is driven by a 75 hp motor at a fan speed of 175 rpm.

M.5.4 Cooling Water Circulation Pumps (Equipment No. 14-1A&B)

After the cooling water passes through the cooling tower, it is collected in the forebay and pumped back by the Cooling Water Circulation Pumps (14-1A & B) to the various heat exchangers as outlined in the general description.

Each pump is 60% nominal capacity and is designed for 8700 gpm and 83 feet of differential head. These pumps are vertical wet pit type operating at 1180 rpm and at the design point have an efficiency of 86%. The electric drive motors are each 250 hp.

M.5.5 Auxiliary Cooling Water Circulation Pump (Equipment No. 14-2)

The auxiliary cooling water pump is a vertical wet pit type designed for operation during start up of the plant in order to fill the cooling water system heat exchanger with water and to maintain water circulation to the turbine lube oil cooler following turbine trip

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and subsequent cool down and, as well, to the generator air cooler, compressed air cooling water heat exchanger and the building air conditioner condenser.

This pump is designed for 500 gpm at 85 feet of head and at the design point has an efficiency of 79%. The electric drive motor is 20 hp.

M.5.6 Acid Metering Pump (Equipment No. 14-9)

This pump supplies sulfuric acid to the cooling water system to control calcium carbonate by changing it into soluble calcium sulfate which permits concentration to increase. This pump takes suction from the sulfuric acid feed storage tank and can be adjusted during operation from 0 gal/hr to 2.62 gal/hr. The pump discharges the acid solution into the cooling tower basin.

M.5.7 Inhibitor Metering Pump (Equipment No. 14-10)

This pump supplies a corrosion stablizer to the cooling water system to control loss of iron from the water circulation piping caused by the aeration of the cooling water in passing through the cooling tower. The pump can be adjusted during operation from 0 to 2.62 gal/hr.

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M.5.8 Sulfuric Acid Day Tank (Equipment No. 10-4)

This non-code 40 gal (18" dia. x 36") tank is designed to hold 93% Sulfuric Acid (H_2SO_4) at 90°F for checking the acid metering pump feed rate.

M.5.9 Sulfuric Acid Feed Storage Tank (Equipment No. 11-2)

This 4,000 gal tank (9' dia. x 9' high) is designed to receive 3,000 gal. tank truck loads of 93% (Sulfuric Acid) (H_2SO_4) which is then intermittently transferred into the sulfuric day tank.

M.5.10 Corrosion Stabilizer Feed Storage Tank (Equipment No. 11-5)

This 900 gal tank (4' dia. x 10' high) is designed to store a corrosion stabilizer for the cooling water system. This tank is directly connected to the inhibitor metering pump which discharges into the cooling tower basin.

M.5.11 Chlorine System

The chlorine system includes two one-ton storage cylinders (one operating, one spare) and a handling system for microbiological control. Water from the cooling water circulation pump discharge is motive fluid for an eductor. The eductor takes chlorine gas from a cylinder mounted flowmeter and mixes it with the motive water and

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forces the mixture into the cooling water system in the forebay. When the residual chlorine level is below a predetermined value, the flowmeter is manually adjusted to provide a higher chlorine flow rate.

M.5.12 Vacuum Compressor Seal Water Cooler (Equipment No. 12-4)

This heat exchanger is used to cool the water from the seal water recirculation pump in order to maintain proper operation of the vacuum compressor.

Cooling water (102,000 lbs/hr) at 89°F cools 80,000 lbs/hr of geothermal steam condensate from 110°F to 94°F with about a 10 psi pressure drop on both sides of the cooler.

M.5.13 Piping

All piping for the cooling water system is Class 150 carbon steel. A new chemical water treatment may be needed at the time the source is changed in order to protect against possible increased corrosion from the aerated condensate.

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M.6.5	Backwash Sump Pump
M.6.6	Oily Waste Water Sump Pump

M.6 Make Up Water and Waste Water System

M.6.1 Reference Drawing List

E-03-004 Cooling Water System

E-03-008 Canal Water, Filtration and Fire Water System

M.6.2 General Description

The makeup water system supplies water to the cooling water system. This system replaces water that has been lost by evaporation, blow-down and drift from the cooling tower.

Presently the makeup water source is from the Spruce and Stanley laterals (irrigation ditches) of the IID distribution network. Two independent sources and pumps are provided in this design in case

one source is unavailable. The possible future use of condensate as makeup in a wet-dry cooling tower design will reduce the flow needed from the source.

The waste water system removes silt from the cooling tower basin. Cooling tower basin silt clean up includes a silt pocket pump removing dirty water from the cooling tower silt pockets and feeding into an automatic sand filter. Cleaned water recycles back into the cooling tower and filter backwash is dumped into the backwash sump. The sand filter is provided with an air blower which gives a scour action to insure that the sand bed is thoroughly cleaned on each filter cycle. The blower electric drive motor is 5 hp. The backwash sump is also used to accumulate wash down from cooling tower basin screen cleaning, safety shower drainage and maintenance wash down from the acid storage area. All streams flowing into the backwash sump are pumped via the backwash sump pump into the cooling tower blow down water line. All these flows and the cooling tower blow down are returned to the agriculture drainage system, Spruce Drain No. 3.

M.6.3 Cooling Water Makeup Pumps (Equipment No. 14-7 and 14-8)

These pumps supply make up water to the cooling water system in order to replace water that has been lost through the cooling tower evaporation, drift and blowdown. Both of these pumps are 100% capacity and are of the vertical turbine wet pit type. Both of

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these pumps are rated at 645 gpm and operate independently from two different water sources.

Pump pressure is controlled by a manually operated bypass valve. Valve opening is preset.

These pumps draw water from two sources (Spruce lateral and Stanley lateral) in order to maintain make up water integrity if one source is unavailable. The pump drawing water from the Spruce lateral requires a 110 foot TDH and the Stanley lateral which is further away requires a 190 foot TDH. The electric drive motors are 30 and 50 hp respectively. This makeup water is not treated before injection into the cooling water system.

M.6.4 Silt Pocket Pump (Equipment No. 14-13)

This pump is a horizontal, end suction centrifugal type pump designed to pump 100 gpm of silt and water at 40 feet of head. The electric drive motor is 3 hp. This pump takes suction from the silt pockets in the cooling tower basin and discharges the silt to an automatic sand filter. The clean water is then sent back to the basin by gravity flow out of the sand filter.

M.6.5 Backwash Sump Pump (Equipment No. 14-14)

This is a self priming type pump which takes suction from the backwash sump after the sand filter has been backwashed and drained into

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this sump. This pump designed for 100 gpm at 70 feet of head. The electric drive motor is 7.5 hp. The backwash water is discharged along with the cooling water blowdown system into the Spruce Drain No. 3.

M.6.6 Oily Waste Water Sump Pump (Equipment No. 14-6)

This is a self priming type pump which takes suction from the oily waste water sump and transfers the waste water into the waste water holding tank. This pump is designed for 50 gpm at 50 feet of head. The electric drive motor is 3 hp. Material accumulated in the waste water holding tank will be removed periodically by a licensed contractor.

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M.7.3	Fire & Jockey Pumps
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M.7.5	Piping & Hydrant System
M.7.6	Water Source
M.7.7	Cooling Tower Wet Down System
M.7.8	Carbon Dioxide

M.7 Fire Protection System

M.7.1 Reference Drawing List

E-03-008 Fire Water Systems

M.7.2 General Description

The power plant receives fire protection from north and south fire mains complete with fire hydrants and hose reels which are pressurized by a fire pump and jockey pump with water from the cooling tower forebay. In addition, the generator is protected by an auto-

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matic CO₂ injection system, and dry chemical fire extinguishers are strategically located near the control room.

Fire protection water from the forebay is supplied to the fire mains by two parallel pumps. Normally, pressure is maintained by the jockey pump and hydro-pneumatic pressure tank. Fire fighting demand starts the fire pump. Both pump discharges enter a common manifold, which branches into the north fire main with 2 hydrants and 2 hose reels, the south fire main also with 2 hydrants and 2 hose reels, the cooling tower wet down system, and a test recirculation loop. All controls are located in the fire protection system control house. The power supply for the pumps is from the critical bus.

The generator is equipped with a CO₂ injection system activated by generator air temperature and consists of 2 CO₂ cylinders and a thermal valve. Portable dry chemical extinguishers are provided for protection in the turbine-generator lube oil and switchgear areas.

M.7.3 Fire Pump (Equipment No. 14-12) and Jockey Pump (Equipment No. 14-11) Pump

Both of these pumps are of the horizontal end suction centrifugal type. The jockey pump maintains a constant pressure on the system so fire water is instantaneously available. If a larger flow is required the fire pump with larger capacity will start under pres-

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sure control to supply the needed fire water. The jockey pump is sized for 115 gpm at a head of 190 feet. The fire pump is sized for 1000 gpm at a head of 190 feet. The electric drive motors are 15 and 75 hp respectively. The fire pump and starting controller are in accordance with standard underwriter requirements.

M.7.4 Hydropneumatic Tank

This tank is designed to act as a buffer so the jockey pump will not cause waterhammer when the pump starts. The lower part of the tank is filled with water and the upper part with air in order to accomplish this.

M.7.5 Piping & Hydrant System

The piping for the fire water system is all buried except for risers to the hydrants. This carbon steel piping is protected by a polymer coating and a cathodic protection system because of the corrosive nature of the soil. Hydrants are strategically located with hose stations to provide a limited fire control service.

M.7.6 Water Source

The normal water source for the fire protection system is the forebay of the cooling tower which is continuously filled from the cooling tower basin. A blind flange connection is provided to permit pumping from the adjacent drainage ditch or a tank wagon.

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M.7.7 Cooling Tower Wet Down System

Spray nozzles are provided under the deck of the cooling tower supplied with water from the fire main system. This system is used when the cooling tower is shutdown, to wet the wood and thus reduce fire hazard. Control for the wetting system is at ground level with local cell valves at deck level.

M.7.8 Carbon Dioxide

- A. The generator windings are protected by high pressure carbon dioxide supplied from two bottles, each 100 lb. capacity. The system is initiated by a thermostat inside the generator housing.
- B. The turbine-generator lube oil reservoir, switchgear room and control room are protected by portable dry chemical extinguishers.

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M.8.3	Inlet Air Filter
M.8.4	Instrument Air Compressors
M.8.5	Instrument Air Compressor Receiver
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M.8.7	Air Dryers
M.8.8	Air Compressor Cooling Water Pumps
M.8.9	Instrument Air Cooling System Heat Exchangers
M.8.10	Make Up Water Surge Tank

M.8 Compressed Air System

M.8.1 Reference Drawing List

E-03-006 Compressed Air and Air Compressor Cooling Water Systems

M.8.2 General Description

The compressed air system includes two identical parallel (100% spare) air compressors and air driers. Inlet air enters through a chemical filter to remove H_2S and is then compressed by a non-lubricated type

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compressor with after cooler and receiver. After compression the air is dried to an exit dew point of minus 40°F using dual automatic heatless type air dryers. The compressed and dried air passes into the instrument air receiver through two parallel (100% spare) after filters, and into the instrument air distribution system.

Instrument air is available to operate control valves, controllers, recorders and transmitters and to purge electrical panels.

The air compressor cooling water system is a closed system using treated water for cooling of the compressed air and the compressors. This system is isolated from the plant cooling water by two in parallel surface type heat exchangers. Circulating water pumps (100% spare each) respectively are provided.

M.8.3 Inlet Air Filter (Equipment No. 19-5A, 19-5B)

Each compressor inlet is provided with a chemical filter. These filters are designed to filter the incoming air at a rate of 80 cfm at a design inlet of 2 ppm H₂S with an outlet of 50 ppb H₂S.

M.8.4 Instrument Air Compressors (Equipment No. 16-1A, 16-1B)

Each compressor can provide 76 scfm using 25 hp electric motors at an operating speed of 494 rpm. By this compression process the air is heated to 405°F (maximum) prior to after-cooling.

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M.8.5 Instrument Air Compressor Receiver

After the air is compressed and cooled it flows through an air compressor receiver. Each tank is 5 cu. feet in size and is designed for 150 psig and is part of the air compressor assembly.

M.8.6 Instrument Air System Receiver (Equipment No. 10-3)

This tank is designed to prevent a surge of air out of the air dryers which might remove desiccant. The tank is 10 cu. feet and is designed for 180°F and 150 psig.

M.8.7 Air Dryers (Equipment No. 19-1A, 19-1B)

Each dryer is designed for inlet conditions of 76 scfm at 80 psig and a normal temperature of 106°F. Outlet conditions are minus 40°F dew point at the design operating pressure.

Driers are of the heatless type with two tanks filled with activated alumina. Air passes through one tank while the other tank is being regenerated. Air is automatically transferred from one tank to the other. One drier is spare.

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M.8.8 Air Compressor Cooling Water Pumps (Equipment No. 14-16A, B)

Each pump is a horizontal end suction type. The pumps circulate cooling water in the instrument air cooling system to remove the heat generated by compression of the air.

Each pump has a capacity of 14 gpm at 60 TDH in feet and is driven by a 1 1/2 hp electric motor. One pump is spare.

M.8.9 Instrument Air Cooling System Heat Exchangers (Equipment No. 12-5A,B)

These are plate type heat exchangers which transfer heat from the air compressor after coolers to the plant cooling water system.

On the hot side, the treated system cooling water has a flow rate of 1,850 lbs/hr at an inlet of 113°F and an outlet of 96°F. Pressure drop is 7 psi.

The cooling water side (cold side) flow rate is 10,000 lbs/hr with a 3°F rise and an inlet water temperature of 89°F. The pressure drop is 7 psi.

Design pressure is 100 psig and design temperature of 120°F.

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M.8.10 Make-up Water Surge Tank (Equipment No. 11-3)

This tank acts as a surge tank for the closed air compressor cooling water system and for adding and mixing chemicals to treat the water. The chemical used is sodium molybdate to maintain a concentration of 1,000 ppm. This water is treated in order to protect the compressor cylinder pockets and after cooler from corrosion. The tank capacity is 150 gal and is 3 ft. diameter by 3 ft. high.

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M.9	Vent Gas Dispersal System
M.9.1	Reference Drawing List
M.9.2	Vent Gas System
M.9.3	Steam Suppliers Vent Gas Dispersal
M.9.4	H ₂ S Monitoring

NOTE: The H₂S Monitoring System and the steam supplier vent stack are the only parts of this section that are installed.

M.9 Vent Gas Dispersal System

M.9.1 Drawing List

E-03-007	Piping and Instrument Diagram
E-42-030	Piping Support Plan, Sections and Details
E-40-002	H ₂ S Detector Location Plan
E-40-001	Main Control Panel
E-03-005	Noncondensable Gas System
E-41-030	Piping Plan
E-41-031	Piping Sections and Details
E-17-007	Electrical Plan and Details
B-08-004, Sh. Z-3	Elementary Diagram

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M.9.2 Vent Gas System

The facilities herein described are directed to handling the steam supplier's production noncondensable vent gas stream which contains much larger quantities of H_2S than that vented by the power plant. To control ground level emissions this vent gas is dispersed into the power plant fan exhaust wet air plume.

M.9.3 Steam Suppliers Vent Gas Dispersal

The facilities include piping and an automatic control system to send the vent gas to the cooling tower fan exhaust plume, or if the fans are not operating to vent the gas at an emergency vent stack* located on the steam gathering side of the fence. In addition, should atmospheric conditions result in plume downflow, an H_2S monitoring system is provided for air sampling at ten strategically located points. Any value in excess of 10 ppm will sound an alarm. Should values climb past 30 ppm the operator will call for a plant outage to abate the H_2S buildup.

This system consists of a piping network with remotely positioned control valves to send the steam supplying vent gas into an emergency vent stack or to either or both cooling tower fan exhaust wet air plumes. Normal flow will be to the cooling tower. If one fan is

*Vent stack and related piping installed within the steam suppliers area

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inoperative venting will be automatically stopped to that fan stack. If both fans stop then the vent gas is automatically routed to the emergency vent stack. To make the automatic valving sequence safe, limit switches will operate indicating lights to show that the emergency stack vent control valve is open prior to closing off the gas flow to the cooling tower fan wet air exhaust plume(s).

M.9.4 H₂S Monitoring

The H₂S monitoring equipment is supplied by Rexnord (formerly Dictaphone). Each scanning, readout and alarm module handles four channels. Field located sensors are two matched resistors, one of which changes value in the presence of H₂S. Field signal transmission requires a three wire shielded cable to each sensor.

Three scanning, readout and alarm modules are provided to obtain air sampling from ten locations (with two spares).

The scan and readout modules show the location and amount of H₂S present. This will allow the operator to apply proper judgment if values build to the point where a power plant outage should be scheduled to abate the H₂S fumes.

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M.10.2	General Description
M.10.3	Heating Design
M.10.4	Air Conditioning Design
M.10.5	Fire Safety Design
M.10.6	Fire Pump House

M.10 Air Conditioning System

M.10.1 Drawing List

E-80-003 Plan Plumbing and HVAC

E-41-007 Piping Plan - Area 8

M.10.2 General Description

The heating, ventilating and air conditioning system for the building is designed to hold the interior of building under a slight positive pressure relative to the building exterior. The incoming makeup air passes through a chemical filter to remove H₂S gas. A booster fan on the input of the filter provides the positive pressure.

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M.10.3 Heating Design

- a. Ambient temperature = 30°F dry bulb
- b. Inside temperature = 70°F dry bulb
- c. Occupants = 6 people
- d. Heater = electric

M.10.4 Air Conditioning Design

- a. Ambient temperature = 110°F dry and 79°F wet bulb
- b. Inside temperature = 78°F dry
- c. Inside relative humidity = 50% approximately
- d. Inside pressure = 0.05 inches water positive (min.)
- e. Chiller Type: = DX Type - water cooled condenser
- f. Cooling water source = plant cooling water system
- g. Cooling water temperature = 89°F
- h. Air filter sizing = to handle all makeup air
- i. Air filter type = Purafil (high capacity chemical/
fiberglass) - 2 stages in series
- j. H₂S concentrations in-makeup
air = 2 ppm maximum, 1 ppm Normal
- k. H₂S concentration in distri-
bution discharge air = less than 26 ppb

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M.10.5 Fire Safety Design

Fire dampers are installed in the supply duct where it passes thru into the control room and laboratory.

M.10.6 Fire Pump House

A wall type air conditioner is installed in the fire pump house to keep the ambient air temperature below 40°C in order to protect the electrical equipment.

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- E.1 Electrical Design
- E.1.1 General Scope
- E.1.2 Design Features
- E.1.3 Reference Drawing List

E.1 Electrical Design

E.1.1 General Scope

The electrical section of Plant Manual - Systems Descriptions contains pertinent engineering data on the electrical systems of the geothermal plant at Brawley. Electrical features associated with the generator, turbine, transformers, auxiliary power systems, switchyard and electrical control systems are described. Specific details concerning pieces of equipment are located in the Plant Manual - Equipment Data as well as references to manufacturer's instruction books. Operating conditions are described; however, start up procedures are included in the Plant Manual - Systems Startup and operations.

E.1.2 Station Design Features

The power plant consists of a 10 MW (gross) electric generator with an estimated net plant output of 9.6 MW. The plant includes a generator, two auxiliary power systems (4160 and 480 volts), and a

substation with the station service transformer, a step-up transformer and with two transmission line terminals. The 480-volt auxiliary power system has a normal load section and a critical load section. The critical load section can be energized by the station or an auxiliary power supply from IID's 12-kV distribution system. The cooling water make-up lines have electric motor driven pumps which are located outside of the station. These motors are served independently from the IID local distribution system.

A 4160-volt feeder serving the Union Oil Co.'s steam gathering system which comes from the station's 4160-volt station service bus is separately metered. This power is added to that metered on the 34.5-kV side of the stepup transformer to obtain the net generation from the station. The substation metering keeps track of watt hours and var hours delivered to the 34.5-kV bus and taken from the 34.5-kV bus.

Station startup power is supplied from the 34.5-kV substation bus.

E.1.3 Reference Drawing List

<u>Drawing No.</u>	<u>Title</u>
E-08-001	Electrical Single Line Diagram
E-08-002	Electrical Single Line Meter And Relay Diagram
E-17-001	Electrical Site Plan

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E.2	<u>Generator</u>
E.2.1	Reference Drawing List
E.2.2	General Description
E.2.3	Generator Connections (4.16 kV bus)
E.2.4	Generator Excitation
E.2.5	Generator Voltage Regulator
E.2.6	Generator Protection
E.2.7	Generator Controls and Metering

E.2 Generator

E.2.1 Reference Drawing List

<u>Drawing No.</u>	<u>Title</u>
E-08-001	Electrical Single Line Diagram
E-08-002	Electrical Single Line Meter and Relay Diagram
E-08-003	Logic Diagram Power Plant Protective System
E-17-002	Power Plan Turbine Generator & Control Buildings
E-17-009	Electrical Details
E-40-001	Control Panel
A-40-002	Instrument & Pushbutton Identification Legend
E-80-005	Electrical Grounding & Embedded Raceways Turbine Generator & Control Buildings

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E.2.2 General Description

The generator and all the immediately connected auxiliary devices are discussed as a part of the system description. Additional data about each item can be obtained from the equipment data volume book under Equipment Number 18-1. The generator rating follows:

Capacity:	10,000 kw at 0.85 power factor 11,765 kw at 1.0 power factor
Voltage:	4160 volts, three phase, wye
Speed:	3600 rpm
Rotation:	clockwise (viewed at exciter)
Cooling:	A pressurized totally enclosed air system with water coolers

E.2.3 Generator Connections

The generator is connected to the station 4160 volt switchgear through the generator circuit breaker. The connection is by underground raceway with seven cables per phase. The neutral is grounded at the generator through a potential transformer.

E.2.4 Generator Excitation

The generator field is supplied from a brushless exciter which consists of a shaft mounted ac generator and rectifying diodes. See

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Equipment Data Book IV Equip. 18-1 Vendor Print No. 18-101-12-2 for ratings.

The field of the exciter is controlled by the voltage regulator.

E.2.5 Generator Voltage Regulator

The power for the voltage regulator comes from a permanent magnet generator on the shaft of the main generator. This a.c. permanent magnet output is converted to dc by solid state elements for input to regulator. The regulator has two modes of operation: an automatic and a manual. The reference signal for automatic operation is from a potential and current transformer connection to the generator output.

E.2.6 Generator Protection

The single line meter and relay diagram specifically shows the various schemes of protection which are summarized below. Reference to the logic diagram for plant protection will aid in understanding the protective system design. The generator is provided with the following protection:

- a. generator bearing over temperature relay
- b. voltage restraint overcurrent relay (51V)
- c. negative sequence phase current balance relay to protect the generator from overheating (46)

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- d. reverse power relay to prevent motoring (32)
- e. field failure relay to prevent motoring and pulling out of step (40)
- f. generator neutral overvoltage relay to protect against single phase to ground faults (59G)
- g. generator ground fault sensor for sensitive internal ground fault protection (50G)
- h. generator differential relay for fault detection within the machine, main circuit breaker, and connecting cable (87G)
- i. generator, transformer, and 4160 volt bus differential for fault protection within the generator, transformer and interconnections
- j. generator surge protection equipment consisting of a .6 kv arrester and a 0.3 microfarad capacitor to protect against overvoltages.

E.2.7 Generator Controls and Metering

The electrical controls for the generator consist of voltage regulator control switches, synchronizing check relay, synchronizing switch, generator circuit breaker control switch, governor control switch and load and power factor control potentiometers. The voltage regulator control switches determine the generator terminal voltage before synchronism and power factor after synchronism. The synchronizing check relay determines, within limits, if the generator voltage and frequency are the same as the power system before the generator is connected to the power system. Either the governor

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control switch or a kilowatt controller through the load control potentiometer determines permissible generator loading. The latter device permits loading the generator to a constant output irrespective of IID's system conditions.

The power factor potentiometer through the voltage regulator sets a constant generator power factor.

The meters provided are the minimum required for plant operation. The meters consist of a three phase wattmeter, a three phase varmeter, a single phase ammeter with a selector switch, a single phase voltmeter and a frequency meter.

The generator output is metered by a 3 phase 2 wire watthour meter which includes a pulse device to transmit generator output to IID's control center. In addition a watt transducer transmits generator kilowatt output to a recorder at the IID's control center.

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E.3	<u>34.5 kV System</u>
E.3.1	Drawing List
E.3.2	General Description
E.3.3	Oil Circuit Reclosers
E.3.4	Disconnect Switches
E.3.5	Ground Switch
E.3.6	Step Up Transformer
E.3.7	Protection
E.3.8	Grounding System
E.3.9	Revenue Metering
E.3.10	Annunciator and Alarms

E.3 34.5 kV System

E.3.1 Drawing List

Dwg. No.

Title

E-08-001	Electrical Single Line Diagram
E-08-002	Electrical Single Line Meter & Relay Diagram
E-08-003	Logic Diagram Power Plant Protective System
E-17-001	Electrical Site Plan
E-17-002	Power Plan Turbine Generator & Control Building
E-17-004	34.5 kV Switchyard Arrangement Plan

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E-17-005	34.5 kV Switchyard Elevations & Details
E-80-005	Electrical Grounding & Embedded Raceways
E-40-001	Control Panel
E-40-002	Instrument & Push-Button Identification
E-40-003	Annunciator Engraving Schedule
B-08-004	Elementary Diagram Annunciator, Sheets A-1 thru A-7

E.3.2 General Description

The 34.5-kV system consists of the main transformer, and recloser, two 34-kV transmission line terminals, Line 1, Rio Vista Substation to Brawley and Line 2, Calpatria Substation to Brawley, and their oil circuit reclosers.

E.3.3 Oil Circuit Reclosers

The oil circuit reclosers are used in place of oil circuit breakers. The basic rating is 560 amperes maximum continuous at 34.5 kV and a 16,000 amperes symmetrical fault interrupting rating. The recloser has 125 volt DC trip and close coils and a 230 volt AC spring charging motor. Bushing type current transformers are provided.

Two oil circuit reclosers are used to terminate the two 34.5 kV IID transmission lines. These reclosers are equipped with surge arresters. The third recloser connects the power plant step-up transformer to the 34.5 kV bus.

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For further information or details see the Equipment Data Book, Section 17-4.

E.3.4 Disconnect Switches

Six 3-pole manual gang operated disconnect switches are provided. One is placed on each side of each oil circuit recloser for isolation. Switch ratings are: 38 kV maximum, 600 amperes continuous, 40,000 ampere momentary and 200 kV BIL. See also Equipment Data Book, Section 17-8.

E.3.5 Ground Switch

A 3-pole manual gang-operated ground switch is provided on each of the transmission lines into the switchyard on the line side of the first disconnect switch. These switches are to ground the line when it is de-energized. The ratings are: 38 kV maximum, 600 ampere, and 40,000 ampere momentary. See Equipment Data Book, Section 17-9.

E.3.6 Step-up Transformer

The step-up transformer is a 3-phase with high side taps and bushing current transformers. Voltage rating is 34,400 Y/19860-4160. The high voltage side is grounded wye the low voltage side delta. The maximum kVA rating is 14,000 kVA. Fans are provided for cooling. See Equipment Data Book, Section 17-1.

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E.3.7 Protection

a. 34 kV Transmission Line Protection

Line No. 1 to the Rio Vista Substation is protected by pilot wire relays with directional phase overcurrent relays for back-up and a directional ground overcurrent relay. Line No. 2 to Calpatría Substation is protected by three zone distance relays and a directional ground overcurrent relay.

b. Step-up Transformer Protection

Protective devices associated with the transformer consist of a winding temperature relay, fault pressure relay, phase overcurrent and ground connection overcurrent relays. The transformer is also protected by a differential relay with a zone from the 34.5 kV side of the transformer recloser to the neutral side of the generator. This includes the 4 kV bus. The above relays operate a transformer lockout relay, opens the transformer recloser and generator circuit breaker. The lock out of relay must be reset before the transformer can be reenergized.

c. 34.5 kV Bus Protection

Protection for the 34.5 kV bus is minimal. The only protection provided is from the distance relays at IID's Rio Vista and

Calipatria substations and the overcurrent relays on the transformer oil circuit recloser.

E.3.8 Grounding System

The switchyard has an underground ground grid. Each piece of equipment and structure is connected to the ground grid.

E.3.9 Revenue Metering

The revenue metering is furnished by IID and consists of two sets of watthour and varhour meters. Both directions of flow are measured on the 34.5 kV bus side of the transformer oil circuit recloser. Watthour meters have a 15 minute demand register. No recording meters are installed.

E.3.10 Annunciator and Alarms

The plant has only one annunciator panel which is located in the control room on the main control board. The 34.5 kV switchyard has The following drops on the annunciator: 34.5 kV Line 1, 34.5 kV Line 2, and step-up transformer recloser trip, transformer fault pressure and transformer winding overtemperature. See the drawings for more details.

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E.4.1	Drawing List
E.4.2	General Description
E.4.3	4,160 Volt Power System
E.4.4	480 Volt Power System
E.4.5	Imperial Irrigation District Electric Connections

E.4 Auxiliary Power System

E.4.1 Drawing List

Drawing No.

Title

E-08-002	Electrical Single Line Meter & Relay Diagram
B-08-004	Elementary Diagrams
E-17-001	Electrical Site Plan
E-17-002	Power Plan Turbine Generator & Control Building
E-17-004	34.5 kV Switchyard Arrangement Plan
E-17-006	Electrical Plan & Details Utility Area
E-80-005	Electrical Grounding & Embedded Conduit

E.4.2 General Description

The auxiliary power system includes the power supplies to all power plant equipment and controls. IID provides power directly to the two off site locations where the cooling water makeup pumps are located. The on-site auxiliary power system is supplied from the

4,160 volt power plant switchgear with an auxiliary power supply connection to IID for critical 480 volt load backup.

In addition, the steam gathering system is provided with one 4,160 volt metered service from the power plant 4 kV bus and one 480 volt metered service from the IDD distribution system. These are IID services and are not part of the auxiliary power system.

E.4.3 4,160 Volt Power System

The 4,160 volt auxiliary power system is an extension of the 4,160 volt generation bus switchgear. The auxiliary power system at the 4,160 voltage level serves two 250 hp cooling water pumps, IID service to the steam gathering system, the grounding transformer and the 4,160-480 volt auxiliary power transformer for other plant auxiliary power requirements.

The 4,160 volt switchgear is a combination of metal-clad indoor drawout circuit breakers, motor starters and fused disconnect switches. The circuit breaker is rated 2,000 ampere continuous rating and an interrupting capacity of 250,000 kVA. The motor starters are rated 400 amperes continuous and 400 MVA interrupting. The fused switch is rated 600 amperes continuous and 400 MVA interrupting.

The 4,160 volt system is 3-phase, 3-wire high resistance grounded through a grounding transformer.

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The 4,160 volt motor controls are indicated on Drawing B-08-004, Sheet M-1, Elementary Diagram Cooling Water Circulating Pumps. The 4,160 volt IID service to the gathering system is shown on Drawing B-08-004, Sheet P-1. The 4,160-480 volt station service is shown on Drawing B-08-004, Sheet P-2. The grounding transformer is shown on Drawing B-08-004, Sheet B-1.

For plant operation the 4,160 volt bus must be energized. During startup power flows from the 34.5 kV system through the main transformer to supply the 4,160 volt bus in order to operate the cooling water pumps and the steam gathering system reinjection pumps. Reinjection pump operation is necessary in order to obtain steam.

E.4.4 480 Volt Power System

The 480 volt system includes two interconnected motor control centers. All low voltage loads - motors and panel boards - are supplied from these centers. The loads have been segregated into normal load and critical load.

The power supply to the motor control center is from the 4,160-480 volt station service transformer. The normal load motor control center is rated 480 volt, 1,200 ampere bus with a 22,000 kiloampere minimum interrupting rating. The critical load motor control center is a 480 volt, 600 ampere, bus with a 22,000 kiloampere interrupting rating. The 480 volt bus is 3-phase, 3-wire, ungrounded. Both buses are provided with ground detector indicating lights and alarms.

The 4,160 volt motor controls are indicated on Drawing B-08-004, Sheet M-1, Elementary Diagram Cooling Water Circulating Pumps. The 4,160 volt IID service to the gathering system is shown on Drawing B-08-004, Sheet P-1. The 4,160-480 volt station service is shown on Drawing B-08-004, Sheet P-2. The grounding transformer is shown on Drawing B-08-004, Sheet B-1.

For plant operation the 4,160 volt bus must be energized. During startup power flows from the 34.5 kV system through the main transformer to supply the 4,160 volt bus in order to operate the cooling water pumps and the steam gathering system reinjection pumps. Reinjection pump operation is necessary in order to obtain steam.

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The 480 volt system includes two interconnected motor control centers. All low voltage loads - motors and panel boards - are supplied from these centers. The loads have been segregated into normal load and critical load.

The power supply to the motor control center is from the 4,160-480 volt station service transformer. The normal load motor control center is rated 480 volt, 1,200 ampere bus with a 22,000 kiloampere minimum interrupting rating. The critical load motor control center is a 480 volt, 600 ampere, bus with a 22,000 kiloampere interrupting rating. The 480 volt bus is 3-phase, 3-wire, ungrounded. Both buses are provided with ground detector indicating lights and alarms.

The 4,160 volt motor controls are indicated on Drawing B-08-004, Sheet M-1, Elementary Diagram Cooling Water Circulating Pumps. The 4,160 volt IID service to the gathering system is shown on Drawing B-08-004, Sheet P-1. The 4,160-480 volt station service is shown on Drawing B-08-004, Sheet P-2. The grounding transformer is shown on Drawing B-08-004, Sheet B-1.

For plant operation the 4,160 volt bus must be energized. During startup power flows from the 34.5 kV system through the main transformer to supply the 4,160 volt bus in order to operate the cooling water pumps and the steam gathering system reinjection pumps. Reinjection pump operation is necessary in order to obtain steam.

E.4.4 480 Volt Power System

The 480 volt system includes two interconnected motor control centers. All low voltage loads - motors and panel boards - are supplied from these centers. The loads have been segregated into normal load and critical load.

The power supply to the motor control center is from the 4,160-480 volt station service transformer. The normal load motor control center is rated 480 volt, 1,200 ampere bus with a 22,000 kiloampere minimum interrupting rating. The critical load motor control center is a 480 volt, 600 ampere, bus with a 22,000 kiloampere interrupting rating. The 480 volt bus is 3-phase, 3-wire, ungrounded. Both buses are provided with ground detector indicating lights and alarms.

Elementary diagram drawings are provided in the Plant Manual Volume III for each motor starter or contactor. These show all the controls, indicating lights and alarms.

The interconnection between the normal and critical load sections is provided by an automatic transfer switch. When there is no potential on the normal bus, the critical bus is automatically disconnected from the normal bus and connected to an underground 480 volt feeder from the auxiliary transformer on the IID distribution line outside of the power plant. A circuit breaker and meter are installed at the riser for this feeder.

All the critical electric systems are supplied from the 480 volt critical load bus. These include but are not limited to air conditioning, turbine turning gear, fire pumps, 125 volt direct current battery charger, and lighting circuits.

Welding outlets are supplied from the 480 volt normal bus. Outlets are located in the building, machine shop, adjacent to the turbine-generator, adjacent to the fire pumps house and at the cooling tower forebay.

E.4.5 Imperial Irrigation District Electric Connections

The principal connection with the IID system is from the Rio Vista-Calpatricia 34.5 kV line which is looped through the plant switchyard. A watthour meter with a 15 minute demand attachment and varhour

meter for metering in and out watt- and varhours are provided for revenue metering.

A standby 480 volt 3-phase power supply is available from a pole-mounted 500 kVA transformer bank located in front of the power plant. The supply is connected to the motor control center critical bus. The service is metered.

Two separate 240 volt 3-phase services are provided at Spruce and Stanley laterals for the cooling water make-up pumps. These are metered.

The transformers for the standby and cooling water make-up pump supplies are connected to a common 12 kV distribution circuit.

The 500 kVA transformer bank in front of the power plant also supplies a standby 480 volt service to the motor control center in the steam gathering system office building. The 480 volt circuit is routed through the power plant's underground duct system.

SECTION INDEX

E.5	<u>125 Volt Direct Current System</u>
E.5.1	Reference Drawing List
E.5.2	General Description
E.5.3	Panel Board D
E.5.4	Battery
E.5.5	Battery Charger

E.5 125 Volt Direct Current System

E.5.1 Reference Drawings

<u>Drawing No.</u>	Title
E-08-001	Electrical Single Line
B-08-005	D. C. Single Line Diagram
E-17-003	Power Details Turbine-Generator & Control Building

E.5.2 General Description

The direct current system provides control power for many critical pieces of equipment and functions. The system includes a battery charger and set of batteries to maintain continuous direct current availability.

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E.5.3 Panel Board D (125V DC)

This panel board has a 225 ampere bus with a main breaker and eight feeder breakers. The pieces of equipment and systems using DC are: Turbine controls, 34.5 kV reclosers, generator controls, generator exciter, station annunciator, 4.16 kV switchgear controls, and an emergency oil pump.

E.5.4 Battery

The battery is of the nickel-cadmium type, 96 cells and rated 49 ampere-hour 125 volt nominal. The battery is connected to the battery charger and main DC circuit breaker.

E.5.5 Battery Charger

The battery charger is supplied by a circuit from AC panel board "LB". This charger continuously maintains the charge on the battery. The charger includes alarms for loss of AC, DC low voltage and DC ground fault.

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SECTION INDEX

E.6	<u>Alternating Current Low Voltage System</u>
E.6.1	Reference Drawing List
E.6.2	General Description
E.6.3	Panel "LA"
E.6.4	Panel "LB"
E.6.5	Panel "LC"
E.6.6	Panel "LF"

E.6 Alternating Current Low Voltage System

E.6.1 Drawing List

<u>Drawing No.</u>	<u>Description</u>
E-08-001	Electrical Single Line
E-17-003	Power Details Turbine-Generator & Control Building
B-08-004	34.5 kV Circuit Reclosers (Sheets H1, H2, H3, H4)
B-08-004	Instrumentation (Sheets J1 through J5)
B-08-004	Water Treatment (Sheet K-7)
B-08-004	460 Volt Motor Space Heaters (Sheet Z1)
B-08-004	4,000 Volt Motor Space Heaters (Sheet Z2)

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E.6.2 General Description

The low voltage (below 480V) alternating current system is used for lighting and miscellaneous controls. It is supplied from the 480 volt critical load motor control center through a 45 kVA 480-208/120V step down transformer.

The motor starters are an exception since each has a control power transformer as part of the starter.

E.6.3 Panel "LA"

This panel is the main low voltage panel used for lighting and receptacles. The circuits can be seen in the panel board schedule. This panel is rated 208Y/120 volt, 3-phase, 4-wire.

E.6.4 Panel "LB"

This panel provides power for the miscellaneous control system, principally instrumentation, vent gas disposal system, transformer fans and reclosers and motor space heaters. Panel LB is rated 208Y/120 volt, 3-phase, 4-wire.

E.6.5 Panel "LC"

This panel provides power for the machine shop for tools and a 480-208/120V step down transformer in the shop. Panel is rated 480V, 3-phase.

E.6.6 Panel "LF"

This panel supplies 120V for interior lighting and tools in the machine shop. Panel is rated 208Y/120v, 3-phase.

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SECTION INDEX

- E.7 Lighting System
- E.7.1 Reference Drawing List
- E.7.2 General Description
- E.7.3 Outdoor Lighting System
- E.7.4 Indoor Lighting System

E.7 Lighting System

E.7.1 Reference Drawings

Drawing No.

Title

E-08-001	Electric Single Line
E-17-001	Electrical Site Plan
E-17-003	Power Details Turbine-Generator & Control Building
E-80-004	Electric Plan Turbine-Generator & Control Building

E.7.2 General Description

The lighting provided consists of an outdoor 480 volt system which is actuated by a photocell and an indoor 120 volt system within the control building and turbine-generator building.

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E.7.3 Outdoor Lighting System

The outdoor system has different lighting levels dependent upon the specific area. The outdoor areas are: switchyard, parking area, parameter road and equipment areas. High pressure sodium vapor floodlighting is provided. Individual circuit control is at Lighting Panel "LH".

The switchyard includes perimeter lighting as well as lighting at each recloser control mechanism or switch operator.

In the parking area the lights can be switched in pairs. This area is general area lighting.

In the perimeter road area, lighting is provided for general area lighting levels.

In the equipment areas lighting is provided for safety at major equipment locations and general area lighting.

E.7.4 Indoor Lighting System

The lighting level is provided based upon the space usage. Panel board "LA" supplies all the lighting except the machine shop. Control is individual local wall switches mounted on the area walls.

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SECTION INDEX

E.8	<u>Cathodic Protection System</u>
E.8.1	Reference Drawings
E.8.2	General Description
E.8.3	Protection System

E.8 Cathodic Protection System

E.8.1 Reference Drawings

E-17-028 - Plan

E-17-029 - Details

E.8.2 General Description

Cathodic protection is provided for approximately 900 ft. of coated steel pipe varying in diameter from 3 1/2-in. to 6 5/8-in. and 40 ft. of 14-inch diameter wrapped steel pipe. Soil resistivity ranges from 580 to 720 ohm-cm and is considered very corrosive.

E.8.3 Protection System

The protection provided is of the sacrificial anode type and consists of nine 32-lb. prepackaged magnesium anodes connected to the

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underground system at various points in the underground piping. All underground piping is isolated from structures by insulating flanges.

Test stations are provided at each anode to monitor current.

Design pipe to soil potential is 0.85 volts negative using a copper to copper-sulfate half cell for measurement.

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SECTION INDEX

E.9	<u>Main Control Panel</u>
E.9.1	Reference Drawing List
E.9.2	General Description
E.9.3	Clock
E.9.4	Annunciator
E.9.5	Bus and Electric Feeder Schematic
E.9.6	Switchyard Controls
E.9.7	Electric Output Indicators and Controllers
E.9.8	Graphic Flow Diagram Electrical and Pneumatic Indicators, Recorders, Controllers and Totalizers
E.9.9	Main Control Panel, Interior Equipment

E.9	<u>Main Control Panel</u>
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E.9.1	Drawing List
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<u>Drawing No.</u>	<u>Title</u>
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E-40-001	Control Panel
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A-40-002	Instrument and Pushbutton Legend
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A-40-003	Annunciator Engraving Schedule
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A-40-008	Pneumatic Instrument Engraving Schedule
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E.9.2 General Description

The Main Control Panel includes the electric and pneumatic indicators, controllers and control stations for monitoring and control of the power plant from a central location.

The panel includes the following major components:

E.9.3 Clock

12 inch synchronous electric clock

E.9.4 Annunciator

The annunciator includes drops of the first out type for turbine and generator trip indication and standard drops for non-tripping alarms.

When a turbine trip occurs the condition causing the trip will cause the appropriate drop to light intermittently with a fast flash. All subsequent trip alarms will flash fast but will not be intermittent. When acknowledged the first out drop will continue to flash but other trip alarms will go to steady light.

When a non-trip alarm occurs the appropriate drop will flash and will switch to steady on when acknowledged.

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Pushbuttons N36 through N39 provide: Acknowledge, first out reset, horn silence, test and horn cutout respectively.

E.9.5 A Bus and Electric Feeder Graphic Diagram

This schematic allows the operator to follow the operating sequence during start-up and shutdown of the power plant.

E.9.6 Switchyard Controls

Following controls are provided for 34.5 kV switchyard reclosure:

N13	34.5 kV Recloser, Line No. 1 Control Switch and Indicating Lights.
N14	34.5 kV Recloser, Line No. 2 Control Switch and Indicating Lights.
N15	34.5 kV Recloser, Transformer Control Switch and Indicating Lights.

E.9.7 Electric Output Indicators and Controllers

These items include:

N1	Synchroscope and Indicating Lights
N2	Bus Volts

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N3	Generator Watts
N4	Generator Volts
N5	Exciter Volts
N6	Exciter Amperes
N7	Generator Frequency
N8	Turbine Speed
N9	Generator Vars
N10	Generator Amperes
N11	Generator Winding Temperature
N12	Exciter Balance Meter
N16	Bus Volt Selector Switch
N17	Synchronizing Switch
N18	Generator Circuit Breaker and Position Indicating Lights
N19	Governor Control Switch
N20	Generator Volts Selection Switch
N21	Ammeter Selector Switch
N22	Automatic Voltage Regulator Control Switch
N23	Manual Voltage Regulator Control Switch
N24	Field Circuit Breaker Control Switch and Indicating Lights
N25	kW Controller Transfer Switch and Indicating Lights
N26	kW Controller Set Point Adjuster
N27	Voltage Regulator Manual-Automatic Transfer Switch and Indicating Lights
N28	PF-Controller Enable Switch
N29	Exciter Ground Fault Test
	Power Factor Controller Set Point Adjuster

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E.9.8 Graphic Flow Diagram, Electrical and Pneumatic Indicators, Recorders, Controllers and Totalizers

The graphic flow diagram illustrates the flow of steam, condensate, water and noncondensable gas in the power plant.

a) Indicators as follows:

A1	FI-100 Steam Flow
A3	PI-304 Steam Pressure
B8	FI-120 Cooling Water Flow
B9	PI-350 Makeup Water Pump Pressure
C1	FI/FQ-110 Condensate Flow
C4	PI-360 Intercondenser Pressure
D4	PI-355 Cooling Water Pressure
N32	TI-501 Temperature Indicator
N33	HJS-501 10 Point Temperature Indicator Selector Switch
N34	Turbine Reset
N54	Turbine Control Valve A Position Indicator
N55	Turbine Control Valve B Position Indicator
	Steam Conductivity Meter and Recorder

Lights - Plant Main Steam Block Valve - Open - Closed

Vacuum Compressor - Run

Seal Water Recirculation Pump Run

Cooling Water Makeup Pump A - Run

Cooling Water Makeup Pump B - Run

b) Controllers as follows:

A4	LIC-710 Main Condenser Level
B1	HIC-940 First Stage Ejector Bypass
B2	HIC-901 First Stage Ejector Steam Valve
B3	HIC-941 Second Stage Ejector Bypass
C3	HIC-923 Main Condenser Cooling Water Valve
D1	PIC-362 Intercondenser Pressure
D2	LIC-720 Intercondenser Level
D3	HIC-924 Intercondenser Cooling Water Valve
D9	LIC-730 Cooling Tower Forebay Level
N35	Turbine Emergency Trip
N36	Acknowledge
N37	Horn Silence
N38	Test
N39	Horn Cutout
N40	Condensate Pump A Start - Stop
N41	Selector Switch Pump A - Pump B
N42	Condensate Pump B Start - Stop
N44	Ejector and Gland Steam Supply Reset
N45	Cooling Water Pump A Start - Stop

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N46	Cooling Water Pump B
	Start - Stop
	Cooling Tower Fan No. 1
	Start - Stop
	Cooling Tower Fan No. 2
	Start - Stop
N47	Auxiliary Cooling Water Pump
	Start - Stop
N48A	HS-931A Cooling Water Makeup Pump A
	Start - Stop
N48B	HS-931B Cooling Water Makeup Pump B
	Start - Stop
N49	HS-902 Main Steam Valve
	Open - Close
N54	Turbine Control Valve A
	Open - Closed
N55	Turbine Control Valve B
	Open - Closed

c) Recorders as follows:

B7	FR-121/122 Cooling Tower Makeup Water Flow/Blowdown Water Flow
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TJR-535 Multipoint Temperature Recorder

1. Main Condenser Cooling Water - IN
2. Main Condenser Cooling Water - OUT
3. Cooling Tower Forebay
4. Cooling Tower Return
5. Four Spares

N30 XR-1 Vibration Recorder

e) Totalizers as follows:

FQ-100 Total Steam Flow
FQ-121 Total Cooling Water Makeup Flow
FQ-122 Total Cooling Water Blowdown Flow

E.9.9 Main Control Panel, Interior Equipment

Annunciator Logic Cards and Power Supply

Cooling Water Make-up Pump Control and Air Manifold and Regulator

RTD Alarm Units

Watt Transducers

Relays

Low Air Pressure Switch

Instrument Air Dew Point Meter

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SECTION INDEX

E.10	<u>Communication System</u>
E.10.1	Drawing List
E.10.2	General Description
E.10.3	Pacific Telephone & Telegraph Co. Service
E.10.4	Plant Intercommunication

E.10 Communication System

E.10.1 Drawing List

<u>Drawing No.</u>	<u>Title</u>
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B-17-027	Plant Intercom and Paging System
E-17-002	Power Plan, Turbine Generator & Control Building
E-17-006	Electrical Plan and Details Utility Area
E-80-004	Electric Plan Turbine-Generator & Control Building
E-80-005	Electrical Grounding & Embedded Conduit

E.10.2 General Description

Two communication systems are provided for the power plant: commercial telephone service by Pacific Telephone & Telegraph Co. and a private plant intercommunication system.

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E.10.3 Pacific Telephone and Telegraph Service

Pacific Telephone and Telegraph Co.'s service is limited to outlets in the office, receptionist area, control room, laboratory and maintenance area. In addition dedicated circuits from the plant for voice communication with IID dispatcher and telemetering to the IDD control center in El Centro and for the remote control of the cooling water makeup pumps at the Stanley and Spruce laterals are being provided.

E.10.4 Plant Intercommunication

The private plant communication system consists of a telephone stations and paging speakers at the following locations:

Power Plant Control Room

Power Plant Switchgear Room

Power Plant Lobby

Turbine-Generator Room

Cooling Tower Forebay

Instrument Air Shed

Union Oil Steam Gathering System - Office

Union Oil Steam Gathering System - Injection Pump Area

Union Oil Steam Gathering System - Paging Speaker Only

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Each telephone station has a push to talk switch in the handset to permit paging and a fire line selector switch. Up to five independent conversations may be held at anytime.

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