Rogers *IR*
Mark-up copy

MAGMA MAX POWER GENERATING PLANT

**FEASIBILITY STUDY
AND
PRELIMINARY DESIGN**

**For
MAGMA ENERGY, INC.**

**Prepared by
Rogers Engineering Co., Inc.
Engineers & Architects
San Francisco, California**

**Reco Ref. No. S-70018
July 23, 1970**

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Rogers

INDEX

SECTION NO.

TITLE

1.	INTRODUCTION
2.	PLANT PERSPECTIVE
3.	SUMMARY
4.	ISOBUTANE POWER CYCLE
5.	ELECTRICAL GENERATION
6.	HOT WELL WATER SYSTEM
7.	COOLING SYSTEM
8.	GENERAL FACILITIES
9.	DETAILED COST ESTIMATES

SECTION 1.

MAGMA ENERGY, INC.
631 SOUTH WITMER STREET
LOS ANGELES, CALIFORNIA 90017
—
TELEPHONE 483-2285

We would like to suggest that Mr. B. C. McCabe
write a letter 'To Whom It May Concern' with
respect to this Magma Max process and its meaning
to power generation for the future.

SECTION 2.

MAGMA MAX POWER PLANT
MAGMA ENERGY INC.

Rogers Engineefing Co., Inc.

San Francisco, California

[illegible]

SECTION 3.

SECTION 3.

SUMMARY

Rogers Engineering affirms that the isobutane power recovery cycle is a sound one from the standpoint of thermodynamic and engineering considerations.

Rogers Engineering feels that the cost estimate is realistic ^{no} within the contingency as indicated ^{is} The detailed designs and costs are developed in Section 9 (Detailed cost estimates).

either plus or minus.

Cost Estimate Summary

Direct Capital Costs

	<u>Total Installed</u>	<u>Thousands of Dollars</u>		<u>Budget Estimate</u>
		<u>Engineering</u>	<u>Contingency</u>	
Isobutane Power Plant	1,657	109	116	1,942
Hot Well Water System	496	12	51	560
* Cooling Water System (Base Case)	574	26	90	690
Site Costs				
Total	2,727	147	317	3,192
 * Alternate with Cooling Tower	 299	 18	 32	 349
 Alternate Case-Total	 2,452	 139	 259	 2,851

Discussion of Cost Estimate

The isobutane process estimate is based upon quoted equipment prices, and estimates based on previous experience for installation costs of similar equipment. Construction costs were estimated based upon labor and productivity in the Reno, Nevada area, including probable 1971 craft labor rate adjustments.

The costs for the shallow well pump system, the night stream cooling system and the hot water well system ^{are} based upon the requirements as defined by Mr. J. Hilbert Anderson. The installation costs have been estimated by Rogers Engineering based upon earthwork, construction costs prevailing in the plant site area, and well drilling costs as defined by Mr. B. C. McCabe.

~~Previous experience with a number of projects of this size and scope, indicates that at this stage of the development of the design, a cost estimate will contain a predictable deviation from the cost of the plant as eventually constructed.~~

~~A convenient method of expressing this deviation is to provide an allowance for contingency at this time as shown in the detailed estimate sheets in Sec. 9.~~

✓ mechanical In the isobutane process the design of exchangers follows standard chemical design to TEMA Standards, and the properties of isobutane are well known. Although the turbines are basically compressors used as expander-turbines, this technology is well known and operationally should present few problems. *Long tube ht ex still being designed promises reduced costs*

There are some unknown factors in the area concerning the hot wells, such as the flow per well on a sustained basis, the precise temperature of the hot water and the ability of the wells to sustain this temperature condition over long periods of time. However, there is fairly accurate test data to support ~~some of these~~ ^{the} assumptions.

The economic viability of this plant, however, can be evaluated from data in the estimate showing probable plant costs for the addition of wells and piping, or for variations of bottom well temperatures.

Although the cooling system concept is based upon a novel design as proposed by J. Hilbert Anderson, ~~the variants here may be in such areas as soil leakage and erosion.~~ It seems safe to say that enough weather-bureau data is available to reasonably predict the thermodynamics of the system on a year round basis.

In any event a conventional cooling tower system is included as an alternate to the estimate. *other locations could indicate*

SECTION 4.

ISOBUTANE POWER CYCLE

STREAM NO.		1A	1B	1C	1D	1E	2A	2B	2C	2D	2E	2F	3A	3B	3C	4	5	6	7	8	9	10	11	12	13	14	15	16	
ALL FLOWS IN 1000#/HR.																										HEAT EXCHANGER			
FLOW RATE	GEOTH WATER	1,458	1,438	1,458	1,458	1,458																							
	CONDENSER WATER																												
	GASEOUS 150 BUTANE																												
	LIQUID 150 BUTANE						1,032	1,032	1,032	1,032		1,092	1,092		5,550	5,550	5,550												
																		598		1,092	497	535	60	65	125	457	470	125	32
																			TR										

HEAT EXCHANGER		SERVICE	DUTY
		150 BUTANE PREHEATER	152
		150 BUTANE VAPORIZER & SUPER HEATER	52
		150 BUTANE FIRST STAGE CONDENSER	74
		150 BUTANE SECOND STAGE CONDENSER	104

LEGEND

PIPING SYMBOLS		INSTRUMENT SYMBOLS	
	GATE VALVE		LOCAL MOUNTED
	GLOBE VALVE		PANEL MOUNTED
	BALL VALVE		COMBINATION SERVICES
	BUTTERFLY VALVE		PRESSURE LINE
	CHECK VALVE		THERMAL LINE
	CONTROL VALVE		HYDRAULIC LINE
	CONTROL VALVE ELECTRO-PNEUMATIC		TRANSMITTER
	CONTROL VALVE AC PRESSURE		PANEL MOUNTED TRANSMITTER OR PRESSURE SWITCH
	GATE VALVE (NORMALLY CLOSED)		LOCAL PANEL MOUNTED INSTRUMENT
	INSULATION (NOT)		CABLEWAY
	INSULATION (PERSONNEL PROTECTION)		ELECTRIC LINE
	SIGNAL SELECT		
	ELECTRICAL SELECT		

FOR COMPLETE LIST OF SYMBOLS SEE STD. OIL SYMBOLOGY SHOWN ABOVE ARE GENERAL OR EXCEPTION

NOTES:

1. P-12, -14, -16, -18 LOW LUBE OIL ALARM & SHUTDOWN
2. T-12, -14, -16, -18 HIGH LUBE OIL TEMP ALARM & SHUTDOWN

EQUIPMENT LIST	
10-101	LIQUID KNOCK OUT SEPARATOR
10-102	150 BUTANE SURGE DRUM
10-103	1 ST STAGE 150 BUTANE CONDENSATE SEAL DRUM
10-104	150 BUTANE STORAGE TANK
11-101-1	150 BUTANE PREHEATERS
11-101-2	
11-101-3	
11-101-4	
11-102-1	150 BUTANE VAPORIZERS
11-102-2	
11-103-1	150 BUTANE SUPERHEATERS
11-103-2	
11-104-1	2 ND STAGE 150 BUTANE CONDENSERS
11-104-2	
11-105-1	1 ST STAGE 150 BUTANE CONDENSERS
11-105-2

ROGERS ENGINEERING CO., INC. ENGINEERS - ARCHITECTS 10 BULL STREET, SAN FRANCISCO, CALIFORNIA 94104		MAGMA ENERGY INC. LOS ANGELES, CALIFORNIA		PLOT PLAN MAGMA MAX POWER PLANT	
SCALE 1/8" = 1'-0" DATE 7/17/70		APPROVALS		JOB NO. 5-10015-00	
ISSUED FOR STUDY REPORT		DATE		E-04-1001 0	
REVISION		DATE		E-04-1001 0	

SECTION 4.

Process Description

Referring to Process Flow Diagram E-02-1001.

The heat energy contained in the geothermal hot water is transferred by heat exchangers into the closed power fluid system.

Heat rejection from the power fluid system is provided by a separate recirculating water system arranged for heat transfer to the atmosphere from a falling film type cascade cooling pond section.

Power generation is accomplished via energy recovery in the gas expansion power turbines. Extraction gas from the power turbine is also used to drive the liquid isobutane power fluid feed pump. Isobutane is extracted from both turbine sections to obtain maximum turbine output.

Referring to the Power Fluid Cycle on the isobutane pressure enthalpy diagram, FIG. 1 attached, the power fluid cycle shown is typical of expected geothermal hot water and cold sink water temperature at the design conditions. The cycle reflects expected pressure drops which must be allowed in the heat exchangers required.

The state points shown on the isobutane pressure enthalpy diagram Fig. 1 have been used to prepare the process materials balance, the heat exchanger summary and performance curves, the pump summary and the cycle data following.

CYCLE DATA

GEOHERMAL HOT WATER

Flow LB/HR	1,438,000
Temperature °F	
In	325
Out	179
Heat to power fluid MMBTU/HR	214

ISOBUTANE POWER FLUID

Flow LB/HR	
Total	1,032,000
Extraction	125,000
First Stage Outlet	437,000
Second Stage Outlet	470,000
Temperature °F	
Into preheater	77
Out of vaporizer (saturation @ 509 psia)	273
Out of superheater	290
Pressure, PSIA	
Into power turbine	496
Out at extraction	260
Out to first stage condenser	70
Out to second stage condenser	55

Isobutane Enthalpy per Fig. 1 (CANJAR DATA) BTU/LB

Into preheater	-798
Into vaporizer	-641
Out of vaporizer	-617
Out of superheater	-591
Out at extraction (85% turbine eff.)	-599.5
Out at first stage	-620.4
Out at second stage	-624.1

CONDENSING WATER

Flow LB/HR	5,555,000
Temperature °F	
Into first stage	40
Into second stage	58.6
Out of second stage	72
Pressure, PSIA	
Into first stage	65
Into second stage	40
Out of second stage	15

EQUIVALENT KWH VALUES

Turbine power to generation	8,660
Gear loss 2%	170
Generator loss 3%	260
Gross at generator terminals	8,230
Isobutane booster pump	38
Cooling water circulation pumps	388
Cooling water deep well make up pumps	116
Geothermal water deep well pumps	262
Geothermal water booster pump	107
Misc. auxiliary loads	11
Sub Total to station	922
Net generation to line	7,308

RATIOS

Geothermal water/KWH	
LB/Gross at generator terminals	175
LB/Net to line	197
Condensing water/KWH	
LB/Gross at generator terminals	675
LB/Net to line	760

Process Control

Referring to the Process Flow Sheet.

Normal Operation

The most important consideration during normal operation is the maintenance of safe equipment conditions. The synchronous electric generator will pick up or shed load over a broad range, in direct relation to the energy obtained from the power fluid gas expansion turbine.

Should the exchangers foul or geothermal hot water or cooling water fail, the system will first shed load and then can be set to shutdown to a low speed (or load).

The isobutane power fluid feed pump is driven by the gas extracted from the power fluid turbine and is controlled to maintain a constant isobutane pressure at throttle inlet to the power turbine. Gas superheat temperature is maintained by control of the geothermal water flow. ~~All deep well pumps, geothermal water booster pump, isobutane turbine and gear, generator drive turbine, reduction gear and generator~~ are provided with suitable vibration detection, alarming and shutdown controls.

Vital ~~and~~ rotating equipment

START UP

Correct X

The most important consideration during start up is "boot strapping" the isobutane feed pump gas expansion turbine 16-102. This is accomplished by using the isobutane booster pump to fill through the heat exchangers to a desired level in the K. O. Drum, 10-101 and then by applying hot water flow. The vapor formed is pressure controlled around the main turbine to start up the feed pump. After feed pump start up, the feed pump and main turbine flows are maintained in energy balance by by-passing extraction gas around the feed pump and/or main turbine to condensers. Main turbine speed is brought up by hand or automatic control to the point of synchronous speed before being placed into the power grid.

SHUTDOWN

Separate controls are supplied to allow an orderly shutdown on the following:

- (1) All equipment with vibration problems.
- (2) Lube oil high temperatures, generator, turbine and speed reducers.
- (3) Over speed on main turbine or boiler feed pump turbine.
- (4) Geothermal hot water failure
- (5) Minimum load output
- (6) Low level in isobutane condensers.

MAGMA MAX POWER PLANT
 FIGURE 1
 POWER FLUID CYCLE

JOB NO.
 S-70018

DATE
 7/15/70 BF

HEAT EXCHANGER SUMMARY

TABLE NO.
SHEET NO.

NUMBER			12-101-1,2,3,4,5,6		12-102-1,2		12-103-1,2		
SERVICE			PREHEATER		VAPORIZER		SUPERHEATER		
HOT SIDE	MATERIAL AND MW		Geoth H ₂ O 18		Geoth H ₂ O 18		Geoth H ₂ O 18		
	QUANTITY	LB/HR	1,438,000		1,438,000		1,438,000		
	STREAM NO.		IN	OUT	IN	OUT	IN	OUT	
	TEMPERATURE	°F	290	179	307	290	325	307	
	ENTHALPY	BTU/LB*	259.31	146.90	276.77	259.31	295.49	276.77	
	PRESSURE	PSIA	205	180	180	155	155	130	
	VAPORIZATION	WT. %	0	0	0	0	0	0	
	VISCOSITY								
COLD SIDE	MATERIAL AND MW		Isobutane 58		Isobutane 58		Isobutane 58		
	QUANTITY	LB/HR	1,032,000		1,032,000		1,032,000		
	STREAM NO.		IN	OUT	IN	OUT	IN	OUT	
	TEMPERATURE	°F	77	273	273	273	273	290	
	ENTHALPY	BTU/LB*	-798	-641	-641	-617	-617	-591	
	PRESSURE	PSIA	530	520	520	509	509	500	
	VAPORIZATION	WT. %	0	0	0	100	100	100	
	VISCOSITY								
DUTY		M BTU/HR		162,000		25,000		27,000	
LMTD		°F		47		24.5		34.4	
NUMBER			12-105-1,2		12-104-1,2				
SERVICE			1st Stage Condenser		2nd Stage Condenser				
HOT SIDE	MATERIAL AND MW		Isobutane 58		Isobutane 58				
	QUANTITY	LB/HR	437,000		627,000				
	STREAM NO.		IN	OUT	IN	OUT	IN	OUT	
	TEMPERATURE	°F	166	93	153	77			
	ENTHALPY	BTU/LB*	-620	-789	-624	-798			
	PRESSURE	PSIA	69.8	64.8	55.3	50.3			
	VAPORIZATION	WT. %	100	0	100	0			
	VISCOSITY								
COLD SIDE	MATERIAL AND MW		Water 18		Water 18				
	QUANTITY	LB/HR	5,555,000		5,555,000				
	STREAM NO.		IN	OUT	IN	OUT	IN	OUT	
	TEMPERATURE	°F	58.6	72	40	58.6			
	ENTHALPY	BTU/LB*	26.67	40.04	8.05	26.67			
	PRESSURE	PSIA	65	40	40	15			
	VAPORIZATION	WT. %	0	0	0	0			
	VISCOSITY								
DUTY Desuper/Cond		M BTU/HR		13,200/60,700		18,100/85,400			
LMTD " "		°F		53.5/30.8		53.7/31.8			

EUGENE DIETZGEN CO.
MADE IN U. S. A.
NO. 340-20 DIETZGEN GRAPH PAPER
20 X 20 PER INCH

FIGURE IV

MAGMA MAX POWER PLANT
 FIRST STAGE
 ISOBUTANE CONDENSING
 PERFORMANCE CURVE

JOB NO.
 S-70018 7/15/70 BF

EUGENE DIETZGEN CO.
MADE IN U. S. A.

NO. 340-20 DIETZGEN GRAPH PAPER
20 X 20 PER INCH

PUMP SUMMARY

<u>Pump No.</u>	<u>Service</u>	<u>Liquid Pumped</u>	<u>gpm</u>	<u>ΔH,psi</u>	<u>Eff %</u>	<u>BHP</u>	<u>KWH (96%)</u>
14-101-1,2,3	(Geothermal Water Deep Well Pump	Hot Geothermal Water	3,200 (1,070 ea)	145	80	338	262
14-102	(Geothermal Water Booster Pump	Hot Geothermal Water	3,200	60	81	138	107
14-103	Not Assigned						
14-104	(Isobutane Feed Pump	Isobutane	3,700	462	81	1230 (Gas Turbine)	
14-105	Not Assigned						
14-106	(Isobutane Booster Pump	Isobutane	3,700	18	80	49	38
-1,2	(Cooling Pond Recycle	Cold Water	11,200 (5,600 ea)	65	85	500	388
-1, thru 10	(Cooling Pond Shallow Well Makeup	Cold Water	6,000 (600 ea)	34	80	150	116

MAGMA MAX POWER PLANT

FIGURE VI

PUMP SUMMARY

JOB NO.

S-70018

7/20/70

BF

Process Controls

Start up isobutane vapor pressure created by the circulating hot water is trapped between the isobutane booster pump and the valves controlling feed pump and main turbine bypass. The closed main turbine overspeed trip valve and throttle valve and extraction line check valves isolate the main turbine.

The feed pump is brought up to speed manually using SIC-2. Pump inlet pressure is controlled by PIC-2 which acts to close PIC-2VB and open PIC-2VA which are adjusted to open and close inversely.

The feed pump and hot water will create desired throttle pressure which will be relieved, if exceeded, by PIC-1.

The main turbine is brought up to speed manually, or automatically, by an acceleration-controlling ramp generator.

As the main turbine is brought up to speed, loop PIC-2 maintains desired extraction pressure by manipulating PIC-2VA and -2VB.

Bearing temperatures are monitored continuously by thermocouple high temperature alarm and shutdown trips and can be indicated through a selector switch on a self balancing indicating potentiometer.

Bearing lubrication oil high temperatures and low pressures are monitored continuously and an alarm sounded if unsafe limits are approached and the equipment is shutdown if those limits are exceeded.

Extremely low head loss venturi flow elements are provided (but only spool pieces are installed) by which overall turbine efficiency can be established. Second stage flow rates are determined by differences between total flow and extraction flows.

The usual electrical variables are indicated.

In the event the boiler feed pump or hot water flow produces excessive pressure at the main throttle inlet the control signal from PIC-1 acts to bleed excess pressure through PIC-1V and/or close SC-2V.

If the throttle pressure decreases the increasing signal from PIC-1 acts through comparator Y-4 to open TIC-1V, and/or through Y-2A to increase feed pump speed.

If TIC-1 temperature approaches a low limit, below which two-phase flow might injure the main turbine, a TIC-1 low temperature stop prevents a lower temperature. If this low limit is exceeded a TCL shuts down the plant.

Appropriate thermal and overpressure relief valves are provided.

Related alarmed points, in the 35 window system, will be grouped in first-out groups to pinpoint the cause, or causes, of shutdown.

If the turbine generator load is lost, due to causes not under control of this system, the throttle valve will drop back to an approximately 10% load to provide energy for all services at the station ready to go back on line when main line is ready.

SECTION 5.

SECTION 5.

ELECTRICAL GENERATION

The electrical system will consist of a 10.2 megawatt generator, associated station service facilities and a utility owned tie transformer for connecting the plant to the utility system.

The tie transformer will permit the flow of power into the power plant for plant start-up. The generator will be brought up to speed, synchronized with the utility system across the generator main breaker. After synchronizing, the load on the generator will be brought to the desired level by means of the governor control, until full output is reached at which time, the governor valve will be wide open and the power to the network will be determined by the turbine loading from the process system.

Provision for synchronizing across the tie transformer has been provided to permit re-synchronizing of the two systems in the event the systems become separated due to utility system disturbances.

Maximum protection for the equipment has been provided with "first-in" annunciation, to give the operator the opportunity of trouble correction prior to plant shutdown.

Circuit breaker tripping power, emergency lighting power and process instrumentation power will be provided by a 125 VDC station battery.

Service to the well pumps will be by means of 5 kv overhead line with transformer banks mounted at the individual pumps of 150 or less horsepower. Motors above 150 HP will be rated for 4160 volts.

~ LEGEND ~

- AIR CIRCUIT BREAKER, 5KV, 850 MVA INTERRUPT CAP.
- AIR CIRCUIT BREAKER, 600- VOLT
- FUSE, RATING AS REQUIRED. - CL = CURRENT LIMITING.
- FUSED CUTOFF, 5KV CLASS, POLE-MOUNTED.
- POTENTIAL TRANSFORMER, 4160-120 VOLTS.
- CURRENT TRANSFORMER, WYE-CONNECTED OR SINGLE
- CURRENT TRANSFORMER, DELTA-CONNECTED.
- POWER TRANSFORMER, DELTA-CONNECTED.
- POWER TRANSFORMER WINDING, WYE-CONNECTED
- 5KV, FULL VOLTAGE STARTER, NEMA 3 ENCLOSURE.
- 480 VOLT FULL VOLTAGE MOTOR STARTER COMBINATION TYPE, WP INDICATES NEMA 3, S IS STARTER SIZE.
- GENERATOR WITH A DIRECT-CONNECTED BRUSH-LESS EXCITER, FULL WAVE RECTIFIER.
- MOTOR, HORSEPOWER RATING PER NUMBER.
- LIGHTNING ARRESTER, 6KV CLASS.
- Surge Protection Equipment
- ET GROUNDING & ISOLATING SWITCH OR TEST AND BYPASS SWITCH. (EXTERNAL TO METER OR RELAY.)
- GROUNDING CONNECTION
- TERMINAL BLOCKS PROVIDED BY OEM. MANUFACTURER FOR CUSTOMER'S EXTERNAL CONTROL, METER, ETC. WIRING.
- VOLTAGE REGULATOR
- POWER WIRING OR BUS FEEDER
- RELAY, CONTROL, OR METER WIRING.
- CONTROL OR ALARM WIRING. (FUTURE WHEN NOTED.)
- ANNUNCIATOR ALARM AS INDICATED. - T- BREAKER TRIPPED; OL- CURRENT OVERLOAD; GF- GROUND FAULT; UV- UNDERVOLTAGE
- CONTROL OR INSTRUMENT SWITCH AS INDICATED. - AS - AMMETER TRANSFER VS - VOLTMETER TRANSFER CS - CIRCUIT BREAKER CONTROL GS - GOVERNOR CONTROL SS - SYNCHRONIZING PS - PERMISSIVE SW. "REMOTE LOCK-TRIP-CLOSE" TS - CIRCUIT BREAKER TRIP
- SELECTOR SWITCH, FUNCTION AS NOTED.
- PRESSURE SWITCH
- PILOT LIGHT, OF COLOR INDICATED BY LETTER.
- VIBRATION SENSING DEVICE
- PUSH-BUTTON STATIONS - STOP, START-STOP, START-STOP-PILOT - IN GENERAL PURPOSE ENCLOSURES, UNLESS OTHERWISE INDICATED. SPECIAL FEATURES DESIGNATED BY FOLLOWING SUBSCRIPTS: - LOS - LOCK-OUT STOP EP - EXPLOSION PROOF WP - WEATHER PROOF
- WINDOW TYPE CURRENT TRANSFORMER ENCOMPASSING ALL THREE LEADS
- 5KV CABLE TERMINATOR

PANY
RNIA

SINGLE LINE METERING & RELAYING
DIAGRAM
MAGMA MAX POWER PLANT

E-17-3001 ()

REFERENCE DRAWINGS

REVISION

SECTION 6.

MAGMA - MAX POWER PLANT
FOR
MAGMA ENERGY, INC.

PLOT PLAN
HOTWELLS & PROPOSED
POWER PLANT LOCATION

ROGERS ENGINEERING CO., INC. JOB 5-70018

SCALE: 1" = 1000 FT. DATE: 7/24/70 APPR. *RCB*

SECTION 7.

J. HILBERT ANDERSON, CONSULTING ENGINEER, 1615 HILLOCK LANE, YORK, PA. 17403 / 717-843-8594

July 19, 1970

Mr. R. G. Brindle
Rogers Engineering Co., Inc.
16 Beale Street
San Francisco, California 94105

MAGMAMAX - S-70018

Dear Jerry:

As requested by phone on Friday night I am passing on to you a diagrammatic layout of the proposed night stream cooling system for this plant. This is designed to cool 12,400 gpm. average flow from 70F to 38F at mean October weather conditions.

As you know we have assumed 40F to 72F cooling water conditions at 12,400 gpm. for computing condenser performance. This heat rate was also based on subcooling the liquid. The actual present requirement for condensers should be a little less than 11,330 gpm., with the latest condensing arrangement. This should provide an ample factor of safety in cooling system design.

The cooling stream is designed for 55.2 cu. ft. per second flow at a mean velocity of 0.6 ft. per sec. and a mean depth of 0.1 ft. The mean slope of the stream is 0.30 ft. per 100 ft.

The streams must be divided into multiple channels, and since the channels are necessarily different lengths each channel will have a different velocity and depth so that outlet water temperatures will all be the same. The flow into each channel must be controlled by dividers just downstream of the gate. These dividers must be adjusted experimentally, because the outlet velocity from the gate will probably not be uniform across the width.

The gate is a 40 ft. length of 42" pipe, which can be opened by rolling it up ramps at the ends. The opening is accomplished by cables wrapped around the pipe and pulled by two slow speed 1/3 HP gear motors. The maximum opening under the gate needs to be approximately three inches. The gate should seat on a concrete apron, with a rubber hose seal in the top of the apron. The end seals can be rubber hoses set in grooves in semicircular steel plates set in concrete piers, strong enough to take total pipe force.

RECEIVED
JUL 21 1970

Rogers Engineering Co., Inc.
SAN FRANCISCO

Mr. R. G. Brindle
July 19, 1970
Page 2

A simple cam controller, operated by a time clock, can operate a set of limit switches to program the gate opening.

We have investigated Bascule gates and Fabridams. The pipe gate appears to be by far the lowest in cost, and also appears to have the best operating characteristics.

There is much flexibility in the shape of the system. We can also design for a longer, narrower shape by increasing stream velocity. Once the site is chosen we can optimize the shape of the stream and location and shape of the ponds to insure lowest cost of construction. While I have shown a loop system to keep ponds close together, it is quite possible to locate them at opposite ends. This would require more water piping.

I have shown the individual streams to be 100 ft. wide. I rather expect they should be narrower than this for two reasons:

1. The accuracy of grading across the stream is not as critical in a narrow stream.

2. Cross wind effects will not be as critical in a narrow stream.

1.2" ± .24" The stream depth must be shallow to permit shortest possible stream emptying time. I believe that the 0.1 ft. depth should be maintained across each stream within plus or minus 0.02 ft. The accuracy of the slope does not need to be this good. If this accuracy turns out to be unreasonably difficult for grading, then we will probably need to use a deeper channel, but I hope this is not necessary. It would increase emptying time and also increase pond size.

I have assumed shallow well makeup pumps of sufficient capacity so that special sealing of the stream bed should not be necessary. However, we may elect to apply some sort of sealing, either chemical treatment, Bentonite, butyl rubber or plastic. I would be concerned about anchoring plastic or rubber lining on the stream bed, but it should be feasible in the ponds.

The pump inlet tower needs to be designed as diagrammatically shown on drg. 13-B-43, with a top and a bottom inlet, and a ring valve to select flow from either inlet. The inlets must be screened, and large enough in diameter to insure no mixing from top to bottom inlet. We are working on this design, but it is not completed.

Mr. R. G. Brindle
July 19, 1970
Page 3

The enclosed partial estimate is our most recent one. I have left out all estimates of civil engineering work.

Please pass along copies of the diagram to Mr. McCabe and Alf Hansen. I had no copy facilities available over the weekend.

In your C. N. No. 9 I note two discrepancies.

I thought we had agreed on 304 stainless heat exchanger tubes for the initial cost estimate.

In paragraph 8.4 the fouling factor should be expressed as a water side fouling factor, not an "overall" fouling factor.

Sincerely yours,

J. Hilbert Anderson

JHA:e
encl.

cc: Mr. B. C. McCabe
Mr. Alf Hansen

PRELIMINARY LAYOUT OF NIGHT STREAM
COOLING SYSTEM FOR MAGMA MAX PLANT

J. HILBERT ANDERSON
7-18-70

RECEIVED
JUL 21 1970

Rogers Engineering Co., Inc.
SAN FRANCISCO

ESTIMATED COST OF COOLING SYSTEM

42" PIPE 40' LONG	\$ 890.00
STEEL WORK FOR END SUPPORTS	2000.00
GATE OPERATING GEAR MOTORS	963.00
CABLES & FITTINGS	400.00
CONCRETE APRON & END PIERS 35 CU.YD.	—
CIRCULATING PUMP & MOTOR	
12,400 GPM @ 86 FT. HEAD	14,000.00
PUMP INLET TOWER, 32 FT. HIGH.	—
(3) MAKEUP WATER SHALLOW WELL	
PUMPS - 1700 GPM @ 30 FT. HEAD	—
(3) SHALLOW WELLS 40' DEEP	—
UPPER POND, EXCAVATION & WALLS	
3850 CU. YDS.	—
LOWER POND, EXCAVATION & WALLS	
19,350 CU. YDS.	—
STREAM BED GRADING 77 ACRES	—
STREAM DIVIDERS, EARTH DYKES	
OR STEEL STRIPS,	—

RECEIVED
JUL 21 1970

Rogers Engineering Co., Inc.
SAN FRANCISCO

80
7-19
P.7

SECTION 8.

SECTION 8.

GENERAL FACILITIES

This consists primarily of the building and its associated facilities.

The building will house the generator in a separate room. Ventilation for the generator will be provided by louvers, on the side of the building, with the generator fan discharging through the roof. Because of the non-sparking exciter provided, this room can meet Class I, Group D, Division II electrical area classification. The temperature in this room will be controlled in the winter months by recycling some of the hot air into the generator room.

The balance of the building area will be provided for the control room, change room and electrical switchgear. Because of its close proximity to the hazardous area this portion of the building will be pressurized to exclude explosive vapors. This pressurizing air will be carbon filtered, to remove trace H_2S which could create corrosion problems with electrical equipment, particularly contacts.

The control room will house all process controls and the necessary electrical controls under the surveillance of the operator. It will be air-conditioned for personnel comfort.

Septic tanks, sewers and a potable water system is included in General Facilities.

The building will also house the instrument air and governor oil systems.

SECTION 9.

MAGMA MAX ISOBUTANE POWER PLANT

<u>Category No.</u>	<u>Description</u>	<u>Equipment Costs F.O.B. Job Site</u>	<u>Field Materials</u>	<u>Labor</u>	<u>Contractor's Overhead Profit, Taxes, and Insurance</u>	<u>Installed Cost</u>
10	<u>Columns and Vessels</u> K.O. Drum; Isobutane Cond. Receiver; 1st Stage Cond. Int. Receiver	\$75,600	--	\$ 11,200	\$13,200	\$100,000
11	<u>Storage Tanks</u> Isobutane Storage Tank	15,000	--	900	1,600	17,500
12	<u>Exchangers</u> Isobutane Preheaters, Isobutane Vaporizers; Isobutane Superheaters; 2nd stage Isobutane Condensers; and 1st stage Isobutane Condensers	393,000	--	12,900	33,100	439,000
13	<u>Flare Stack</u>	2,000	--	300	400	2,700
14	<u>Pumps and Drivers (Except Isobutane Feed Pump Driver)</u> Isobutane Feed Pump and Isobutane Booster Pump	21,000	--	1,300	2,100	24,400
16	<u>Turbine Drivers</u> Generator Drive Turbine; Isobutane Feed Pump Turbine; Main Turb. Red. Gear; Isobutane Feed Pump Red. Gear	250,000	--	16,000	27,000	293,000
17	<u>Electrical (Equipment)</u> Generator	191,800	--	20,900	18,700	231,400
19	<u>Package Units</u> Inst. Air Compressor and Dryer; Governor Hydraulic Oil Pkg. Unit	5,000	\$ 1,250	2,100	2,050	10,400
40	<u>Instrumentation</u> I - Lot Process Controls; Governor Controls	66,600	8,500	10,700	12,100	97,900
41	<u>Piping Materials</u>	--	94,200	85,000	59,000	238,200
42	<u>Structures</u>	--	3,400	4,500	3,400	11,300
43	<u>Insulation</u>	--	17,000	9,000	8,000	34,000
44	<u>Electrical (Materials)</u>	--	18,300	20,100	11,400	49,800
45	<u>Foundations</u>	--	9,000	9,000	7,500	25,500
46	<u>Site Improvements</u>	--	10,000	14,000	10,000	34,000
48	<u>Expendables</u> Isobutane Charge; Lube Oil	--	2,000	N.A.	N.A.	2,000
80	<u>Power Plant Buildings</u>	--	15,000	18,000	12,900	45,900
Total Installed Engineering Contingency @ 10% Budget Estimate						\$1,657,000 109,000 176,000 \$1,942,000

MAGMA MAX HOT WELL WATER SYSTEM

Category No.	Description	Equipment Costs F.O.B. Job Site	Field Materials	Labor	Contractor's Overhead Profit, Taxes and Insurance	Installed Cost	Pwr Plt at Wells
14	<u>Pumps and Drivers:</u>	\$70,000	--	\$ 7,000	\$ 9,100	\$ 86,100 ✓	86,100
	Geothermal Well Pumps and Booster Pump						
--	<u>Wells Complete</u>	--	\$100,000	Inc.	Inc.	100,000 ✓	100,000
17	<u>Electrical Equipment</u>	19,400	--	4,400	2,900	26,700 ✓	22,600
40	<u>Instruments</u>	3,100	500	1,800	1,300	6,700 ✓	6,700
41	<u>Piping Materials</u>	--	72,400	62,000	43,000	177,400 140,000	86,000
43	<u>Insulation</u>	--	19,700	12,000	8,000	39,700 47,300	14,000
44	<u>Electrical</u>	--	24,900	24,300	10,700	59,900	30,000
	(Bulk Materials)						
Total Installed						\$496,500	345,400
Engineering						\$ 12,500	
Contingency @ 10%						\$ 51,700	
Budget Estimate						\$560,000	

MAGMA MAX COOLING WATER BASE CASE

<u>Category No.</u>	<u>Description</u>	<u>Equipment Costs F.O.B. Job Site</u>	<u>Field Materials</u>	<u>Labor</u>	<u>Contractor's Overhead Profit, Taxes and Insurance</u>	<u>Installed Cost</u>	
14	<u>Pumps and Drivers</u> Circulating pumps and shallow well pumps	\$19,000	\$ --	\$ 1,860	\$ 2,540	\$ 23,400	✓
17	<u>Electrical Equipment</u>	15,600	--	2,100	1,900	19,600	✓
18	<u>Special Equipment</u> , Upper Pond Gate	4,250	--	2,300	1,950	8,500	X
20	<u>Piping Equipment</u> Special Dividers		4,000	7,000	5,000	16,000	X
41	<u>Piping Materials</u> To and from ponds, and make-up water piping Assumes 1,500 ft. 12" Pipe @ 500/ft	--	37,000	28,500	19,500	85,000	
44	<u>Electrical</u> (Materials)	--	13,600	12,700	7,800	34,100	
46	Foundations Site Grading & Stabilization, Plastic		387,400	Inc.	Inc.	387,400	

Total Installed	\$574,000
Engineering	\$ 26,000
Contingency @ 15%	\$ 90,000
Budget Estimate Cost	\$690,000

Pur Pit @ Wells
Cooling Tur @ ✓

<u>Category No.</u>	<u>Description</u>	<u>Equipment Costs F.O.B. Job Site</u>	<u>Field Materials</u>	<u>Labor</u>	<u>Contractor's Overhead Profit, Taxes, and Insurance</u>	<u>Installed Cost</u>
12	<u>Exchangers</u>	\$ 150,000	Inc.	Inc.	Inc.	\$150,000
	Cooling Tower					
14	<u>Pumps and Drivers</u>	10,500	--	\$ 1,230	\$ 1,570	13,300
	C.W. Circ. Pumps and Make-up Pumps					
17	<u>Electrical Equipment</u>	25,100	--	1,200	2,100	28,400
41	<u>Piping (Materials)</u>	--	\$ 22,000	15,500	10,500	48,000
44	<u>Electrical (Materials)</u>	--	17,400	10,400	6,600	34,400
45	<u>Foundations</u>	--	10,000	9,000	6,000	25,000
	Elec Control Ctr Bldg					
	Total Installation					\$299,100
	Engineering					\$ 17,900
	Contingency @ 10%					\$ 32,000
	Budget Estimate					\$349,000