MAGMAMAX NO. 1 GEOTHERMAL BRINE BULK SOLIDS PRECIPITATION PILOT PLANT

ENGINEERING DESIGN

FOR

U. S. BUREAU OF MINES
GEOTHERMAL MINERALS GROUP
RENO METALLURGY RESEARCH CENTER

HAZEN RESEARCH, INC.

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HRI Project 4049G-03
Copy No. 37

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for

U. S. Bureau of Mines
Geothermal Minerals Group
Reno Metallurgy Research Center
Contract No. J0265057

May 25, 1978

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Approved by:

F. M. Stephens, Jr.
Vice President

TABLE OF CONTENTS

INTRODUCTION AND BACKGROUND

In March of 1978, the U.S. Bureau of Mines authorized an extension to Contract No. JO265057, authorizing Hazen Research, Inc., to develop an engineering design package for the bulk precipitation of heavy metals contained in Magmamax No. 1 geothermal brine.

The subject report and engineering drawing package contained herein present the results of our work efforts and detail a pilot demonstration plant capable of processing 10-15 gpm (37 to 50 liters per min) of post-flash Magmamax No. 1 geothermal brine and precipitating the silica and heavy metals therefrom in bulk form.

The Bureau of Mines wishes to implement such a bulk precipitation pilot plant facility as rapidly as possible to provide a demonstration plant, which will verify that potential precipitable materials present in post-flash Magmamax No. 1 geothermal brine can be effectively removed prior to reinjection of the brine.

Removal of such precipitable heavy metals and silica from geothermal brines will allow spent brine reinjection back into the producing zone with lowered concern over potential plugging of the producing zone.

PROCESS DISCUSSION

Post-flash Magmamax No. 1 geothermal brine is delivered to the bulk precipitation pilot demonstration plant battery limits, utilizing existing pumping equipment at the San Diego Gas and Electric - DOE demonstration plant. The hot (200°F) brine is stored for use in an agitated, insulated tank equipped with level control to maintain an inventory of brine.

Hot Magmamax No. 1 post-flash brine is then pumped into a 4-stage reactor vessel for removal of part or perhaps all of the soluble silica contained therein. Flow control is achieved by a Masoneilan Camflex pneumatic actuated control valve and Taylor Instrument Co. magnetic flowmeter.

Using a combination of silica solids recycle, coupled with some pH adjustment of the incoming brine feed, most of the soluble silica can be precipitated from the feed brine.

Silica slurry is then thickened in an Enviroclear up-flow type of thickener to maximize liquid-solids contact and aid in relieving silica supersaturation.

The clarified, low-silica brine is then sent to the bulk heavy metals precipitation reactor, which comprises another 4-stage compartmentized stirred tank reactor train. Here the hot brine is adjusted to pH 8.5 using calcium hydroxide slurry. Provision has been made for introduction of an air sparge, if required, to assist in complete removal of heavy metals or to enhance the settling rate of the precipitated solids.

We have chosen the option of removing silica prior to the bulk heavy metals precipitation step to improve the quality of the bulk precipitate and also to demonstrate that selective removal of silica is possible. If this option is not desired by the Bureau of Mines, then the silica reactor train can be deleted. Alternatively, it could be operated in parallel with the bulk heavy metals precipitation reactor to increase the plant throughput capacity.

Following the clarification and thickening of the bulk heavy metals slurry, these solids are removed by filtration for disposal to a sanitary landfill.

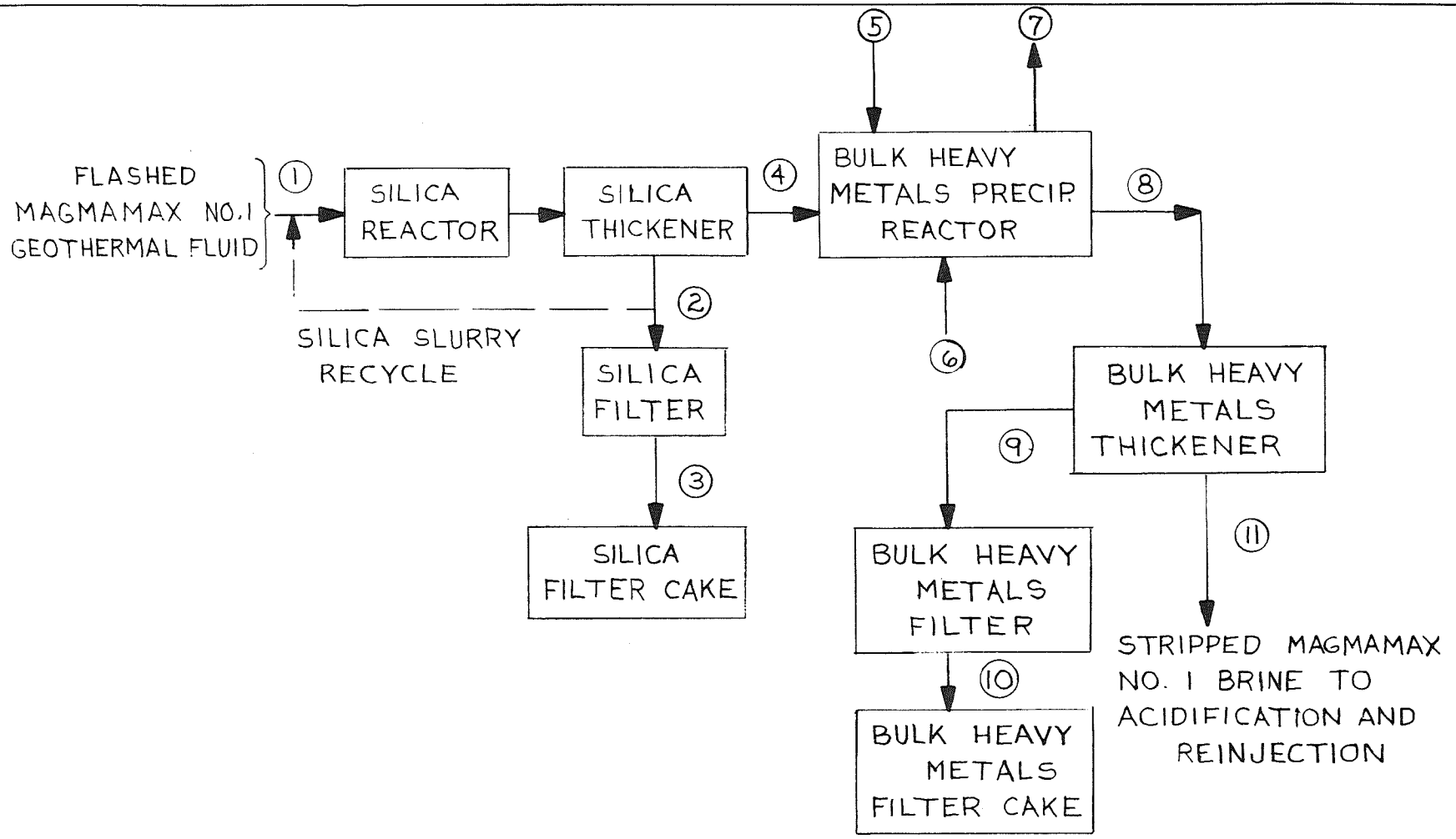
The ammonia gas evolved from the heavy metals precipitation reactor and thickener is scrubbed with water (either potable or ditch) and disposed of into an adjacent drainage ditch.

The heavy metals-free spent brine is pumped to an acidification absorber column where a CO_2-containing gas is used to lower the pH of the spent brine from 8.5 down to near 5.5 prior to reinjection of the brine.

The CO_2-containing gas stream is provided from a portion of the noncondensable gases presently vented from the San Diego Gas and Electric facility off-site.

PROCESS FLOW DIAGRAM AND MATERIAL BALANCES

Figure 1 presents a simplified block flow diagram of the Magmamax No. 1 bulk precipitation process together with a process heat and material balance. It should be noted that the calcium hydroxide slurry used for brine pH control is metered to process at 40% w/v to minimize dilution. If dilution of the brine flow with water is of little or no consequence, the use of 20% w/v lime slurry would make metering and control of the slurry somewhat easier.



PROCESS FLOW DIAGRAM AND MATERIAL BALANCE
BULK HEAVY METALS PRECIPITATION MAGMAMAX
NO. 1 BRINE

FIGURE 1

PROCESS DESIGN BASIS AND REQUIREMENTS

PROCESS EQUIPMENT DESIGN CONSIDERATIONS

An inventory of hot, post-flash Magmamax No. 1 will be required to ensure a uniform feed rate to the bulk heavy metals precipitation pilot plant. We have called out for an integrally insulated polyester-fiberglass storage tank, with agitator, to provide from 250 to 350 minutes of surge capacity (for 10 gpm to 15 gpm feed rate to plant) ahead of the precipitation reactors.

The design concept developed by Hazen Research provides for separate silica removal prior to the bulk heavy metals precipitation step. The rationale for this is:

1. Such a silica removal reactor would provide a demonstration of the feasibility of removing silica from geothermal brines by a combination of seeding-crystallization and pH control.
2. Removal of silica prior to the bulk heavy metals precipitation step will improve the purity of the bulk heavy metals, thereby perhaps making subsequent separation processing easier.

The heavy metals precipitation reactor design was based on batch tests carried out for 30 minutes. This 30-minute batch reaction time was sufficient to achieve about 98-99% removal of the various heavy metals present in the brine.

We have designed a 4-stage compartmentized reactor train for both the silica and the heavy metals precipitation steps as shown on the enclosed blueprint. Design basis for the reactor sizing is shown in Table 1.

Table 1

Reactor Design Basis

Basis: Batch Reaction Time, 30 min
Degree of Conversion, 95% ?
99%, 30 min

RTU (Relative Time Units Required, Figure 1):

95%	3
99%	4.4

∴ One Relative Time Unit = 6.82 min

Stages of Reactors	Conversion	
	95% RTU	99% RTU
2	7	18.0
3	5.1	11.0
4	4.3	8.9
5	4.0	7.1

Reactor Tank Sizing

	Input, 10 gpm				Input, 15 gpm			
	95% Conversion		99% Conversion		95% Conversion		99% Conversion	
No. of Stages	Time, min	Total Vol, gal	Time, min	Total Vol, gal	Time, min	Total Vol, gal	Time, min	Total Vol, gal
2	47.7	477	122.8	1842	47.7	715.5	122.8	1842
3	34.8	348	75.0	1125	34.8	522	75.0	1125
4	29.3	293	60.7	910	29.3	439.5	60.7	910.5
5	27.3	273	48.4	726	27.3	409.5	48.4	726

4-stage reactor train appears optimum.

Since the purpose of the bulk precipitation pilot plant will be to evaluate equipment and materials of construction, we have called out for standard commercially available pumps, thickeners, and filters to be used in the pilot plant.

Thickeners recommended for consideration in the bulk precipitation pilot plant are those made by Enviroclear and Eimco. A Lamella unit may also be considered if space is a factor, since these units require much less ground area than do standard thickener units.

Standard ductile iron centrifugal pumps with water sealed stuffing boxes, such as those made by Duriron Company, are recommended for all process uses and are so specified. Small water flowmeters or rotameters, such as made by Brooks and others, are needed on the pump seal water flow to control water inlet to process via this route.

In our experience, mechanical seal pumps used in such applications would also require a water purge for cooling and lubricating purposes. Additionally, mechanical sealed pumps are more costly and also require more care in installation and assembly.

Where possible, all pumps and thickeners are called out to be of carbon steel or ductile iron construction. This has been done to evaluate steel as the lowest potential cost material for this application.

Fiberglass-polyester and polypropylene have been specified for some tankage, reactor trains, scrubber columns, and for plates and frames on filter presses. All polyester resin used in fabrication of components for this pilot plant should be of Bisphenol A type, as recommended for maximum chemical resistance in high temperature service. Pertinent data and specifications governing fiberglass-polyester process equipment are presented following the Equipment and Instruments Specifications section.

PIPING AND VALVES DESIGN CONSIDERATIONS

Piping material for the front end of the plant can be either polyester-fiberglass (A. O. Smith Green Thread) in sizes of 1-inch and above, or Schedule 80 (heavy wall) carbon steel pipe.

Due to the combination of high temperature and high chloride levels, carbon steel may not have too long a life in the head end of the plant before any pH adjustment has taken place. Therefore, it is suggested that all brine piping be of polyester-fiberglass construction, using cemented joints.

All lime slurry lines should be of Schedule 80 carbon steel pipe, using threaded joints. The main lime slurry loop should be 1-inch NPT size, while feeder lines to reactor tanks will need to be reduced to 1/4-inch NPT size for flow control valving.

It is extremely important that all laterals or feeder lines off the main lime slurry loop be taken from the top of the slurry loop and be sloped to be free draining into the process vessel. Lime slurry control valves should be located as close to the lime slurry loop as possible to minimize stagnant sections of line, where solids settlement and plugging may occur.

Process valving can be of rubber sleeve valve type using high temperature butyl or chlorobutyl rubber sleeves. Alternatively, ductile iron plug valves such as manufactured by Duriron Company, Continental Tuf-Line, and others can be used for on-off service.

Process control valves for brine service should be of the butterfly or V-ball type. A Camflex type plug valve is suggested for use as the primary brine flow metering valve. Conventional single and double guided globe pattern control valves should not be considered due to solids accumulation around the guides and subsequent freezing-up of the valve.

Line slurry control valves should be soft gum rubber-sleeved valves of the Flexible Valve or Red Valve type. In order to ensure tight shut-off of these valves, actuating pressures of about 60 psig will be required. Therefore, amplifying or booster relays will be required to utilize the conventional 3-15 psig pneumatic controller output signal. Details on valving and booster relays, recycle lime slurry back pressure control valves, and rubber sleeve control valves are given in the Equipment Specifications section.

ELECTRICAL DESIGN CONSIDERATIONS

Substation

1. Power is available at battery limits of 33 Kv, 3 Ø, 60 Hz.
2. Due to high summertime ambients near 50°C (122°F), substation components should be designed and sized with this constraint in mind.
3. Total pilot plant connected load will approximate 100 Kva. Suggest designing substation for at least 200 Kva and preferably 250 Kva if any expansion of facilities is contemplated.
4. Suggest providing secondary side metering station (on 480 volt side) to supply pilot plant facility for reduced minimum electric rate schedule (check this with San Diego Gas and Electric Company billing schedules).

Electric Motors

Due to high summertime ambient temperatures of near 50°C (122°F), all electric motors have been called out to be:

65°C Ambient Rating

1.15 Service Factor

ODP or TEFC Housing (depends on amount of wash down or water flush to be done in area)

Field Wiring

In Conduit: Suggest that high temperature rating wire, type THHN (90°C maximum temperature rating) be used.

Control wiring such as stop-start station, field mounted to be No. 16 B&S gauge.

Load wiring to service be No. 14 B&S gauge minimum (up to 20 amp load) and No. 12 B&S gauge (up to 25 amp load) preferred, to allow for possible future expansion provisions.

In Tray or Raceway: Type THW (maximum temperature rating of 75°C) insulation may be easier to lay in cable trays or raceways as compared to THHN. Current rating of THW is somewhat lower than THHN for given wire size.

UTILITIES DESIGN CONSIDERATIONS

Compressed Air

Utility Air: 30 scfm at 100 psig with in line oil and water separation.

Instrument Air: 20 scfm at 100 psig delivered to instrument air dryer package. Pressure reduction station from 100 psig to 20 psig for instrument air supply.

Air Dryer: Kemp Oriad Dryer, size 25E or equivalent, using activated alumina dessicant pellets, thermal regeneration with automatic cycling.

Potable Water: Assume that potable water is available at battery limits at 50 psig pressure for use at pump glands, scrubber make-up water, general wash-down uses, and personnel drinking fountains.

Scrubber Waste Water: Effluent from scrubber column D-302 will contain up to 3-5% NH_3 in solution. We have assumed that this effluent can be disposed of via existing field drainage ditches in lieu of impoundment.

PILOT PLANT COST ESTIMATE

MAGMAMAX NO. 1 BULK HEAVY METALS
PRECIPITATION PILOT PLANT

Basis

1. Assume land is available near or adjacent to San Diego Gas and Electric Company geothermal power demonstration plant at Calipatria, California.

2. Assume potable and industrial water is available at plant battery limits at volume of 10-20 gpm each at 50 psig.

3. Assume sanitary facilities are available on site for tie-in to office trailer.

4. Assume three-phase power is available at site battery limits at 33 kv, 3 diameter, 60 HZ. Total connected load will approximate 100 kva. Design for 200 kva to allow for future expansion.

5. Assume existing Baker tank at battery limits will be available to receive spent brine from pilot plant for subsequent disposal.

6. Assume office, laboratory, motor control center trailer, size 10' wide x 60' long can be leased for duration of pilot plant operation.

Estimated Plant Cost

	Cost
Purchased equipment	$131,600
Equipment installation at 40% of purchase equipment costs	52,640
Concrete work, slab and foundations, 50 yds^3 at $\$150/yd^3$ formed and in place	7,500
Piping and valves	12,300
Instrumentation, material and installation	22,350
Electrical, material and installation	12,500
Substation, 33 kv →480 200 kva, and fenced slab	11,800
Installed cost	$250,690
Contractors fee at 7.5%	18,802
Total facility cost	$269,492
Say	$270,000

PILOT PLANT SITE LOCATION

Following visits to the field to tentatively locate a site for the Magmamax No. 1 pilot plant, the most accessible and available site appears to be the area north of the present brine effluent pond and west of the existing SDG&E plant.

The prevailing wind is predominantly from the north, so that this location will be free of wind-borne brine spray whenever the existing brine pond is used to receive flashing geothermal brine.

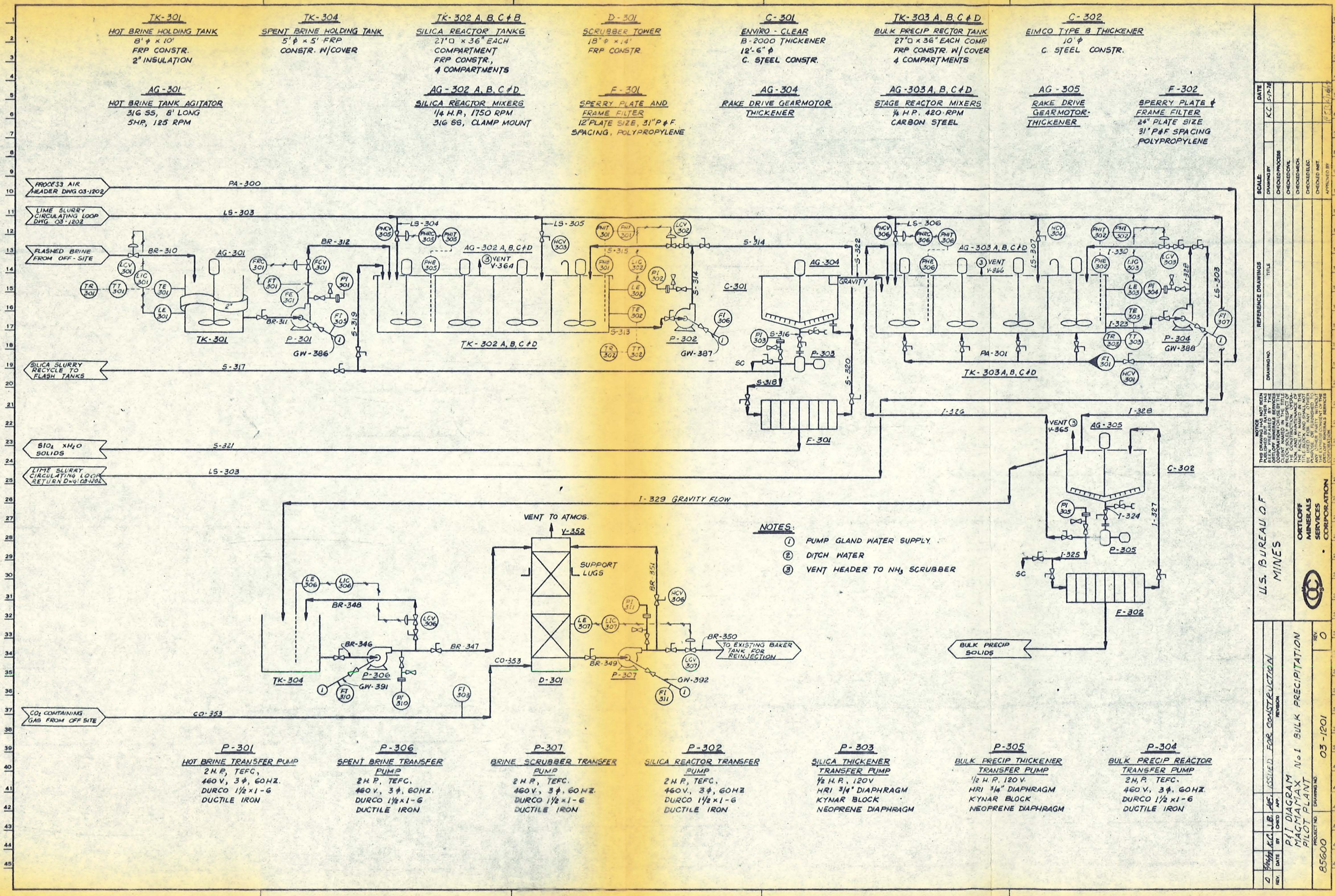
The following aerial photograph obtained through the courtesy of Mr. Art Ellis, Public Relations Supervisor of SDG&E, outlines the proposed site of the pilot plant.

Drawing List

Drawing No.	Description
-	Line schedule
03-1201	P & I diagram, Sheet 1
03-1202	P & I diagram, Sheet 2
03-5101	General arrangement, plan
03-5201	Piping arrangement, plan
03-5202	Piping arrangement, sections
03-5203	Piping arrangement, sections
03-2301	Concrete, foundation plan
03-2302	Concrete, sections and details
03-2401	Structural steel, platform plan
03-2402	Structural steel, details
03-7301	Electrical detail, sections and schedules
03-7302	Electrical, one line, MCC and trailer plan and lights
03-7303	Electrical, power and lighting layout

	1	2	3	4	5	6	7	8	9	10	11	12	
SiO_2	230 ppm Total 187 ppm Solid	1.6 lbs/hr 10.2 wt %	1.6 lbs/hr 60 wt %	43 ppm				43 ppm	0.18 lb/hr SOLIDS				
Fe	255 ppm			255 ppm				255 ppm TOTAL	3.96 lb/hr SOLIDS		13 ppm		
Zn	333 ppm			333 ppm				333 ppm	4.11 lb/hr SOLIDS		17 ppm		
Mn	775 ppm			775 ppm				775 ppm	10.06 lb/hr SOLIDS		39 ppm		
Pb	70 ppm			70 ppm				70 ppm	0.13 lb/hr SOLIDS		6 ppm		
Li	182 ppm			182 ppm				182 ppm			182 ppm		
Inerts	22.1 %			22.1 %				22.1 %			22.1 %		
H_2O	77.7 %			77.7 %			27 lbs/hr	77.7 %			77.8 %		
Specific Grav.	1.135	1.20		1.135	1.22			1.14	1.30	1.9	1.13		
Temp. ° C	93	93	93	93	25	29	90	90	90	90	90		
Temp. ° F	200	200	200	200	77	85	195	195	195	195	195		
flow, GPM	15	0.025		15	0.125			15	0.14		15		
flow, GPH	900	1.5		900	6.80			904	8.6		902		
flow, CFM	—	—				17.4	23.0						
flow, lbs/hr	8523	15.0	2.67	8520	69.5			8540	94	31.6	8515		
Specific Heat Btu/lb °F	0.85	0.78	0.46	0.85	0.77			0.85		0.48	0.85		
Heat BTU/hr	1.45×10^6	2340	2.46	1.45×10^6	13,130			1.41×10^6			1.41×10^6		
Density	9.47 lb/gal	9.99 lb/gal	≈50 lb/FT^3	9.47 lb/gal	10.2 lb/gal			9.45 lb/gal	10.9 lb/gal	15.8 lb/gal	9.44 lb/gal		
NH_3	352 ppm			352 ppm			3.0 lb/hr				35 ppm		
	POST FLASH MAGMAMAX NO. 1 BRINE INPUT	SiO_2 THICKENER UNDERFLOW @ 11 WT.% SOLIDS	SiO_2 FILTER CAKE	BRINE FEED TO BULK HEAVY METALS PRECIPITATION REACTOR	40% w/v $Ca(OH)_2$ SLURRY	AIR SPARGE TO IRON REACTOR	VENT GASES FROM HEAVY METALS PRECIPITATION REACTOR	BULK HEAVY METALS SLURRY TO THICKENER	BULK HEAVY METALS THICKENER UNDERFLOW @ 20 wt % SOLIDS	BULK HEAVY METALS FILTER CAKE	BULK HEAVY METALS THICKENER OVERFLOW		

REVISION	DATE	HAZEN RESEARCH, INC. 4601 INDIANA STREET • GOLDEN, COLORADO
		TITLE: PROCESS MATERIALS BALANCE BULK HEAVY METALS PRECIPITATION MAGMAMAX NO. 1 BRINE
		U.S. BUREAU OF MINES GEOTHERMAL MINERAL OFFICE
		SCALE: NONE DATE: 5/17/78
		DRAWN BY: D.A.I. PROJECT NO.: 4049G-03
		CHECKED BY: C.E.B. SHEET NO.: 1 OF 1
		APPROVED BY: C.E.B. DRWG. NO.:



TK-301
HOT BRINE HOLDING TANK
8' ϕ x 10'
FRP CONSTR.
2" INSULATION
TK-304
SPENT BRINE HOLDING TANK
5' ϕ x 5' FRP
CONSTR. W/COVER
TK-302 A, B, C & D
SILICA REACTOR TANKS
27"□ x 36" EACH
COMPARTMENT
FRP CONSTR.,
4 COMPARTMENTS
D-301
SCRUBBER TOWER
18" ϕ x 14'
FRP CONSTR.
C-301
ENVIRO - CLEAR
B-2000 THICKENER
12'-6" ϕ
C. STEEL CONSTR.
TK-303 A, B, C & D
BULK PRECIP RECTOR TANK
27"□ x 36" EACH COMP.
FRP CONSTR. W/ COVER
4 COMPARTMENTS
C-302
EIMCO TYPE B THICKENER
10' ϕ
C STEEL CONSTR.
AG-301
HOT BRINE TANK AGITATOR
316 SS, 8' LONG
5HP, 125 RPM
AG-302 A, B, C & D
SILICA REACTOR MIXERS
1/4 H.P., 1750 RPM
316 SS, CLAMP MOUNT
F-301
SPERRY PLATE AND
FRAME FILTER
12" PLATE SIZE, 31" P & F
SPACING, POLYPROPYLENE
AG-304
RAKE DRIVE GEARMOTOR
THICKENER
AG-303 A, B, C & D
STAGE REACTOR MIXERS
1/4 H.P., 420 RPM
CARBON STEEL
AG-305
RAKE DRIVE
GEARMOTOR-
THICKENER
F-302
SPERRY PLATE &
FRAME FILTER
24" PLATE SIZE
31" P & F SPACING
POLYPROPYLENE
PROCESS AIR HEADER DWG. 03-1202
PA-300
LIME SLURRY CIRCULATING LOOP DWG. 03-1202
LS-303
FLASHED BRINE FROM OFF-SITE
BR-310
BR-312
BR-311
SILICA SLURRY RECYCLE TO FLASH TANKS
S-317
S-314
S-315
S-313
S-316
S-318
S-319
S-320
S-322
GRAVITY
VENT V-364
VENT V-366
PA-301
I-326
I-328
I-330
I-323
VENT V-365
SiO2 xH2O SOLIDS
S-321
LIME SLURRY CIRCULATING LOOP RETURN DWG. 03-1202
LS-303
I-329 GRAVITY FLOW
I-324
I-325
I-327
SC
VENT TO ATMOS.
V-352
SUPPORT LUGS
BR-351
BR-348
BR-346
BR-347
BR-349
BR-350
TO EXISTING BAKER TANK FOR REINJECTION
CO-353
GW-386
GW-387
GW-388
GW-391
GW-392
CO2 CONTAINING GAS FROM OFF SITE
BULK PRECIP SOLIDS
NOTES:
1 PUMP GLAND WATER SUPPLY
2 DITCH WATER
3 VENT HEADER TO NH3 SCRUBBER
P-301
HOT BRINE TRANSFER PUMP
2 H.P., TEFC,
460 V, 3ϕ, 60HZ.
DURCO 1 1/2 x 1 - 6
DUCTILE IRON
P-306
SPENT BRINE TRANSFER PUMP
2 H.P., TEFC,
460 V., 3ϕ, 60HZ.
DURCO 1 1/2 x 1 - 6
DUCTILE IRON
P-307
BRINE SCRUBBER TRANSFER PUMP
2 H.P., TEFC,
460 V., 3ϕ, 60 HZ.
DURCO 1 1/2 x 1 - 6
DUCTILE IRON
P-302
SILICA REACTOR TRANSFER PUMP
2 H.P., TEFC,
460 V., 3ϕ, 60 HZ
DURCO 1 1/2 x 1 - 6
DUCTILE IRON
P-303
SILICA THICKENER TRANSFER PUMP
1/2 H.P., 120V
HRI 3/4" DIAPHRAGM
KYNAR BLOCK
NEOPRENE DIAPHRAGM
P-305
BULK PRECIP THICKENER TRANSFER PUMP
1/2 H.P. 120 V.
HRI 3/4" DIAPHRAGM
KYNAR BLOCK
NEOPRENE DIAPHRAGM
P-304
BULK PRECIP REACTOR TRANSFER PUMP
2 H.P. TEFC.
460 V., 3ϕ, 60HZ.
DURCO 1 1/2 x 1 - 6
DUCTILE IRON
U.S. BUREAU OF MINES
ORTLOFF MINERALS SERVICES CORPORATION
P & I DIAGRAM
MAGMAMAX No1 BULK PRECIPITATION
PILOT PLANT
85600
03-1201
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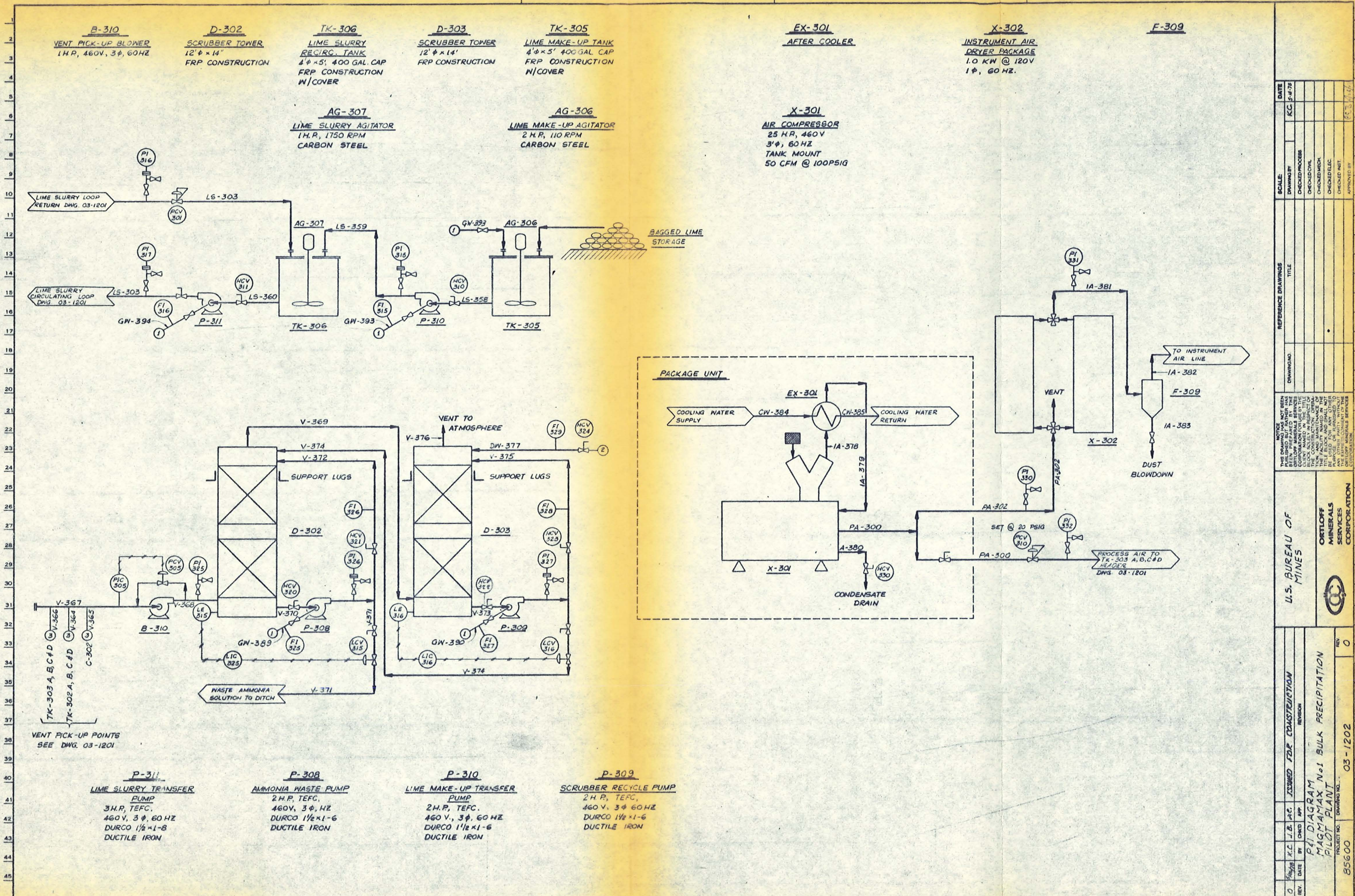
ISSUED FOR CONSTRUCTION


B-310
VENT PICK-UP BLOWER
1 H.P, 460V, 3ϕ, 60HZ
D-302
SCRUBBER TOWER
12'ϕ × 14'
FRP CONSTRUCTION
TK-306
LIME SLURRY RECIRC. TANK
4'ϕ × 5', 400 GAL. CAP
FRP CONSTRUCTION
W/COVER
D-303
SCRUBBER TOWER
12'ϕ × 14'
FRP CONSTRUCTION
TK-305
LIME MAKE-UP TANK
4'ϕ × 5' 400 GAL. CAP
FRP CONSTRUCTION
W/COVER
EX-301
AFTER COOLER
X-302
INSTRUMENT AIR DRYER PACKAGE
1.0 KW @ 120V
1ϕ, 60 HZ.
F-309
AG-307
LIME SLURRY AGITATOR
1 H.P, 1750 RPM
CARBON STEEL
AG-306
LIME MAKE-UP AGITATOR
2 H.P, 110 RPM
CARBON STEEL
X-301
AIR COMPRESSOR
25 HP, 460V
3ϕ, 60 HZ
TANK MOUNT
50 CFM @ 100PSIG
LIME SLURRY LOOP RETURN DWG. 03-1201
LIME SLURRY CIRCULATING LOOP DWG 03-1201
BAGGED LIME STORAGE
PACKAGE UNIT
COOLING WATER SUPPLY
COOLING WATER RETURN
CONDENSATE DRAIN
TO INSTRUMENT AIR LINE
DUST BLOWDOWN
VENT
SET @ 20 PSIG
PROCESS AIR TO TK-303 A,B,C & D HEADER DWG. 03-1201
VENT TO ATMOSPHERE
SUPPORT LUGS
WASTE AMMONIA SOLUTION TO DITCH
VENT PICK-UP POINTS SEE DWG. 03-1201
P-311
LIME SLURRY TRANSFER PUMP
3 H.P, TEFC,
460 V, 3ϕ, 60 HZ
DURCO 1½×1-8
DUCTILE IRON
P-308
AMMONIA WASTE PUMP
2 H.P, TEFC,
460V, 3ϕ, HZ
DURCO 1½×1-6
DUCTILE IRON
P-310
LIME MAKE-UP TRANSFER PUMP
2 H.P, TEFC.
460 V., 3ϕ, 60 HZ
DURCO 1½×1-6
DUCTILE IRON
P-309
SCRUBBER RECYCLE PUMP
2 H.P, TEFC,
460 V, 3ϕ 60 HZ
DURCO 1½×1-6
DUCTILE IRON
U.S. BUREAU OF MINES
ORTLOFF MINERALS SERVICES CORPORATION
P&I DIAGRAM MAGMAMAX No.1 BULK PRECIPITATION PILOT PLANT
0 K.C. J.B. A.C. ISSUED FOR CONSTRUCTION
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03-1202
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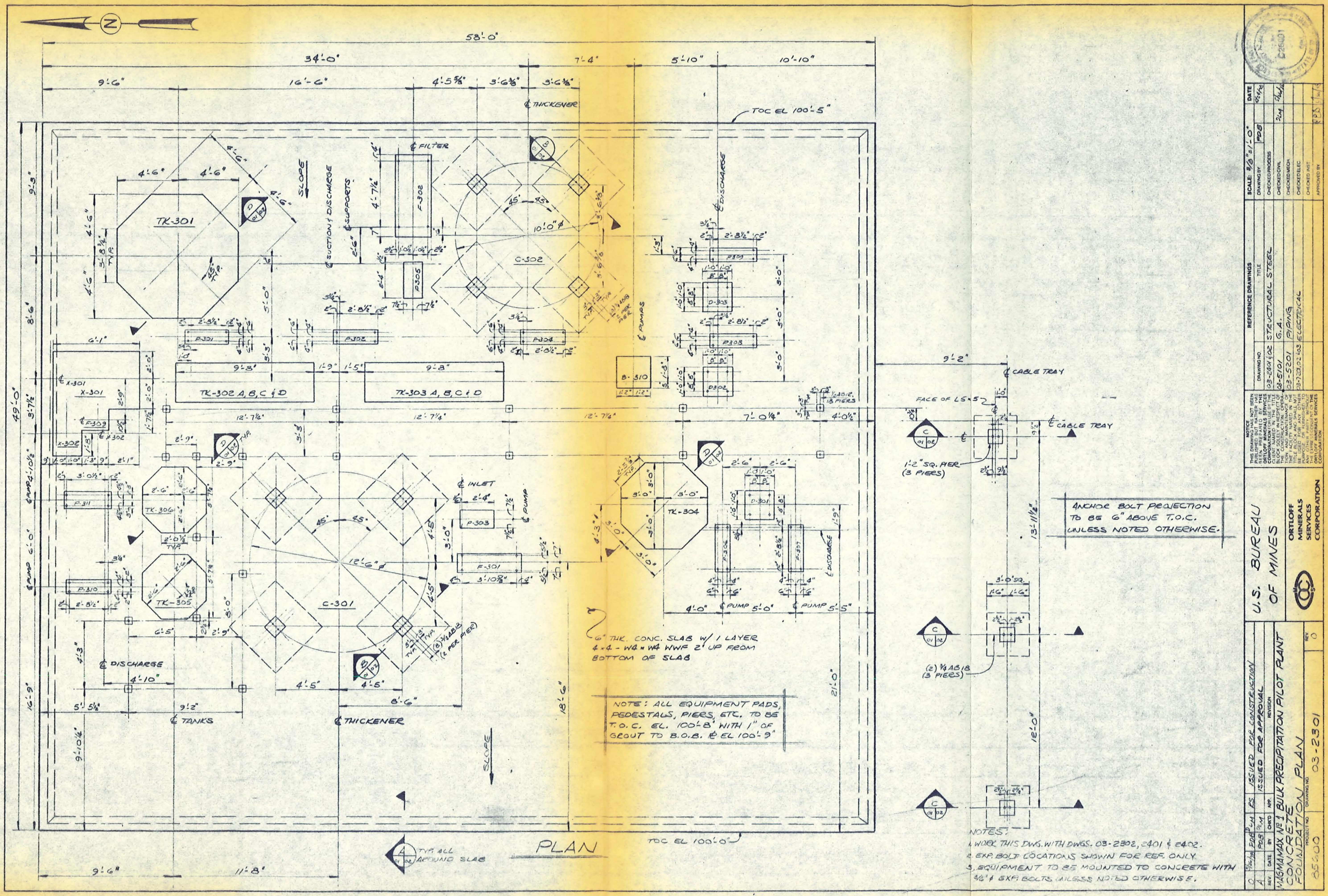
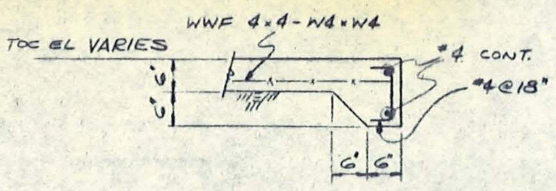
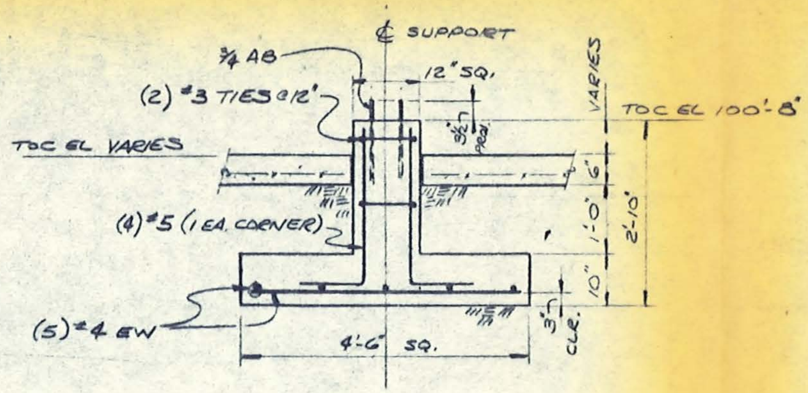

PLAN
NOTE: ALL EQUIPMENT PADS, PEDESTALS, PIERS, ETC. TO BE T.O.C. EL. 100'-8" WITH 1" OF GROUT TO B.O.B. @ EL 100'-9"
6" THK. CONC. SLAB W/ 1 LAYER 4×4 - W4 × W4 WWF 2" UP FROM BOTTOM OF SLAB
ANCHOR BOLT PROJECTION TO BE 6" ABOVE T.O.C. UNLESS NOTED OTHERWISE.
TOC EL 100'-5"
TOC EL 100'-0"
TK-301
TK-302 A, B, C & D
TK-303 A, B, C & D
TK-304
TK-305
TK-306
C-301
C-302
F-301
F-302
X-301
X-302
CABLE TRAY
NOTES:
1. WORK THIS DWG. WITH DWGS. 03-2302, 2401 & 2402.
2. EXP. BOLT LOCATIONS SHOWN FOR REF. ONLY.
3. EQUIPMENT TO BE MOUNTED TO CONCRETE WITH 3/4" ϕ EXP. BOLTS UNLESS NOTED OTHERWISE.
REFERENCE DRAWINGS
03-2301/02 STRUCTURAL STEEL
03-5101 G.A.
03-5201 PIPING
03-7231/02/03 ELECTRICAL
U.S. BUREAU OF MINES
ORTLOFF MINERALS SERVICES CORPORATION
0 ISSUED FOR CONSTRUCTION
A ISSUED FOR APPROVAL
MAGMAMAX No 1 BULK PRECIPITATION PILOT PLANT
CONCRETE FOUNDATION PLAN
PROJECT NO 85600
DRAWING NO 03-2301
REV 0

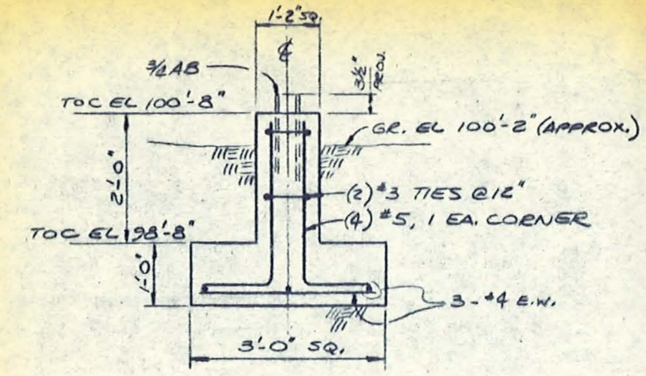
4



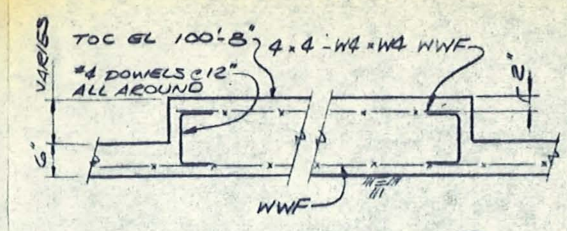
SECTION (A)
3/4"=1'-0"
TYP. ENTIRE PERIMETER



SECTION (B)
3/4"=1'-0"
4 REQ'D EA. THICKENER; 8 TOTAL



SECTION (C)
3/4"=1'-0"
3 REQUIRED



SECTION (D)
3/4"=1'-0"

NOTE: ALL EQUIPMENT, PLATFORMS, VESSELS TO BE PLACED ON 1" THICK GROUT PADS UP TO EL. 100'-9"

REV.	DATE	BY	CHK'D	APP.	REVISION
0	5/24/78	PDB	DLM	RS	ISSUED FOR CONSTRUCTION
A	5/24/78	PDB	DLM		ISSUED FOR APPROVAL

MAGMAMAX No 1 BULK PRECIPITATION PILOT PLANT
CONCRETE
SECTIONS & DETAILS

PROJECT NO. 35600 | DRAWING NO. 03-2302 | REV. 0

U.S. BUREAU OF MINES

ORTLOFF MINERALS SERVICES CORPORATION

NOTICE
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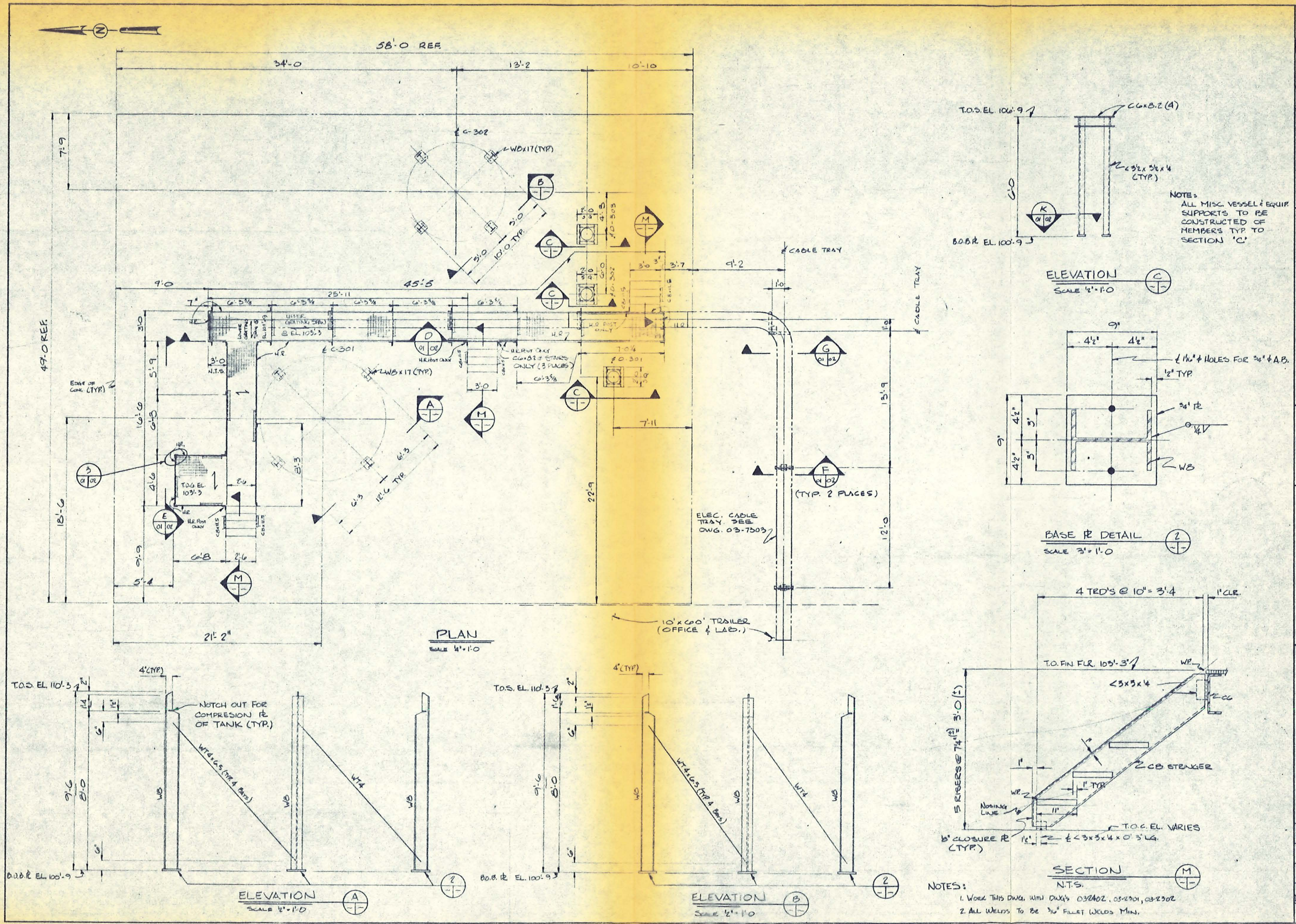
REFERENCE DRAWINGS	
DRAWING NO	TITLE
	SEE DWG. 03-2301

SCALE: AS NOTED		DATE
DRAWING BY	PDB	5/24/78
CHECKED PROCESS		
CHECKED CIVIL	DLM	5/24/78
CHECKED MECH.		
CHECKED ELEC.		
CHECKED INST.		
APPROVED BY	RS	[illegible]



REV	DATE	BY	CHK'D	APP.	REVISION
0	9/26/78	DLM	PDB	RS	ISSUED FOR CONSTRUCTION
A	9/1/78	DLM	PDB	RS	ISSUED FOR APPROVAL

MAGMAMAX #1 BULK PRECIPITATION PILOT PLANT
STRUCTURAL STEEL PLATFORM PLAN

PROJECT NO. 85600 · DRAWING NO. 03-2401 · REV 0

U.S. BUREAU OF MINES

ORTLOFF MINERALS SERVICES CORPORATION

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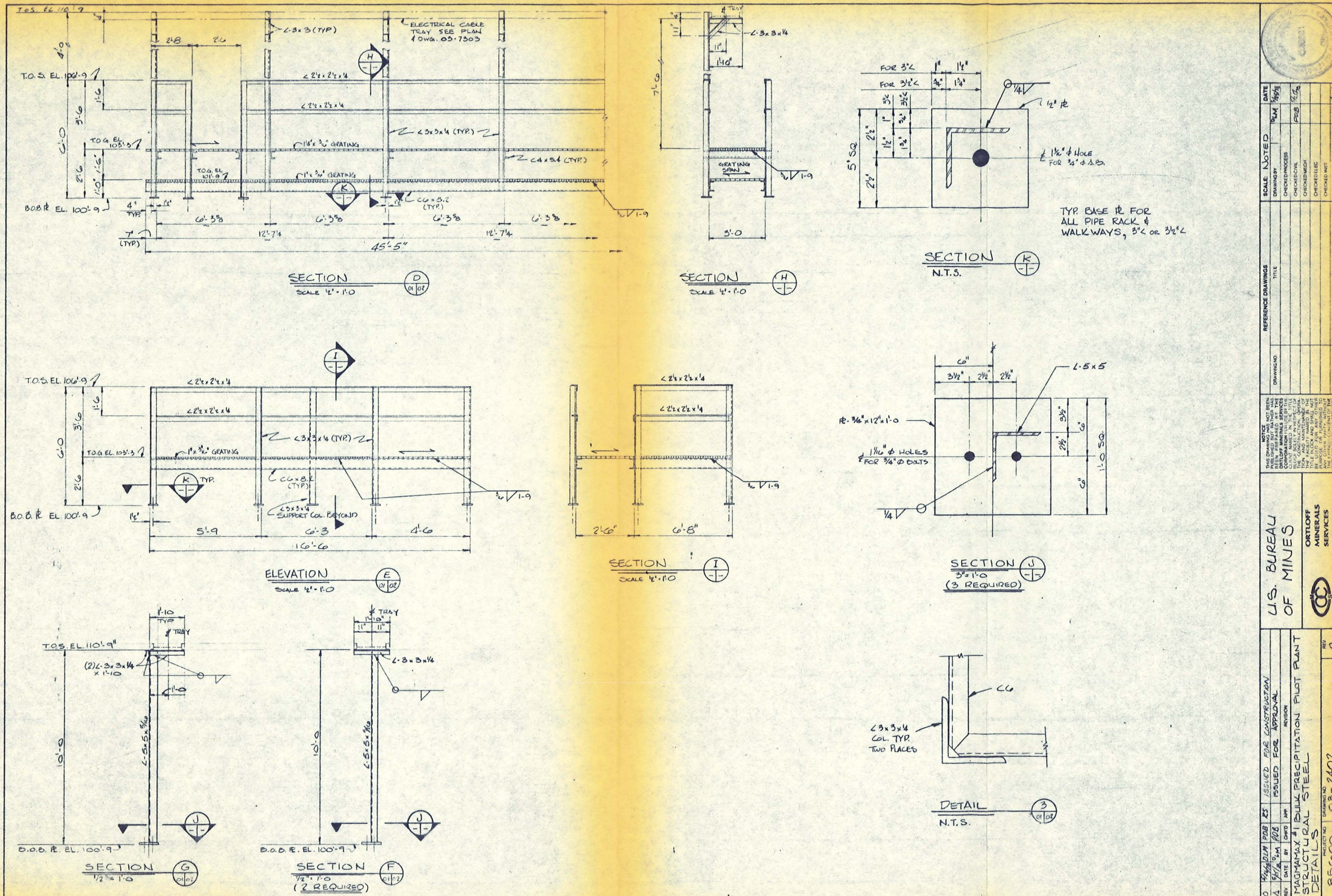
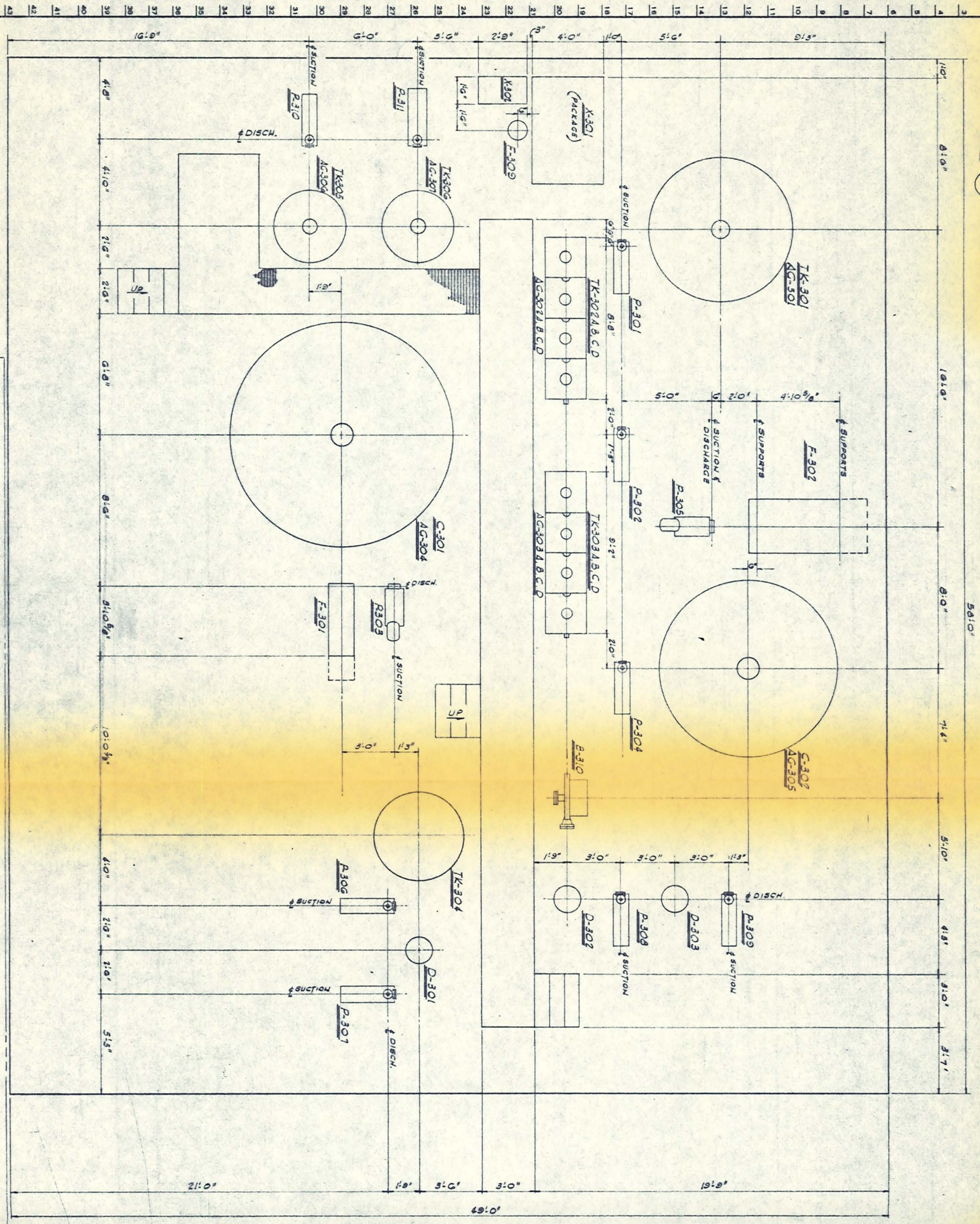
REFERENCE DRAWINGS	
DRAWING NO.	TITLE
03-5101	GENERAL ARRANGEMENT
03-5201	PIPING
03-2501 & 02	CONCRETE
03-7301, 02, 03	ELECTRICAL

SCALE: NOTED
DRAWING BY: DLM 7/26/78
CHECKED CIVIL: PDB 9/25/78

6



T.O.S. EL. 110'-9
L-3x3 (TYP)
ELECTRICAL CABLE TRAY SEE PLAN & DWG. 03-7303
T.O.S. EL. 106'-9
T.O.G. EL. 103'-3
T.O.G. EL. 101'-9
B.O.B. ℞ EL. 100'-9
L 2½x2½x¼
L 3x3x¼ (TYP.)
1¼"x¾" GRATING
1"x¾" GRATING
C4x5.4 (TYP.)
C6x8.2 (TYP.)
45'-5"
SECTION D
SCALE ½"=1'-0
L-3x3x¼
GRATING SPAN
3'-0
SECTION H
SCALE ½"=1'-0
FOR 3"L
FOR 3½"L
½" ℞
1⅛" ⌀ HOLE FOR ¾" ⌀ A.B.
5" SQ.
TYP. BASE ℞ FOR ALL PIPE RACK & WALKWAYS, 3"L OR 3½"L
SECTION K
N.T.S.
L 2½x2½x¼
L3x3x¼ (TYP.)
1"x¾" GRATING
C6x8.2 (TYP.)
L3x3x¼ SUPPORT COL. BEYOND
5'-9
6'-3
4'-6
16'-6
ELEVATION E
SCALE ½"=1'-0
2'-6"
6'-8"
SECTION I
SCALE ½"=1'-0
L-5x5
℞-⅜"x12"x1'-0
1⅛" ⌀ HOLES FOR ¾" ⌀ BOLTS
1'-0 SQ.
SECTION J
3"=1'-0
(3 REQUIRED)
T.O.S. EL. 110'-9"
(2) L-3x3x¼ x 1'-10
℄ TRAY
L-5x5x5/16
B.O.B. ℞. EL. 100'-9
SECTION G
½"=1'-0
L-3x3x¼
SECTION F
½"=1'-0
(2 REQUIRED)
C6
L3x3x¼ COL. TYP. TWO PLACES
DETAIL 3
N.T.S.
SCALE NOTED
U.S. BUREAU OF MINES
ORTLOFF MINERALS SERVICES CORPORATION
ISSUED FOR CONSTRUCTION
ISSUED FOR APPROVAL
MAGMAMAX #1 BULK PRECIPITATION PILOT PLANT
STRUCTURAL STEEL DETAILS
85600
03-2402



60'x10' TRAILER
(OFFICE & LAB)

REV.	DATE	BY	CHK'D	APP.	REVISION
0	9/24/79	BT	J.B	AE	ISSUED FOR CONSTRUCTION
A		BT			ISSUED FOR APPROVAL

MAGMAMAX PILOT PLANT Nº 1
GENERAL ARRANGEMENT
PLAN

PROJECT NO. 85600 | DRAWING NO. 03-5101 | REV. 0

U.S. BUREAU OF MINES

ORTLOFF MINERALS SERVICES CORPORATION

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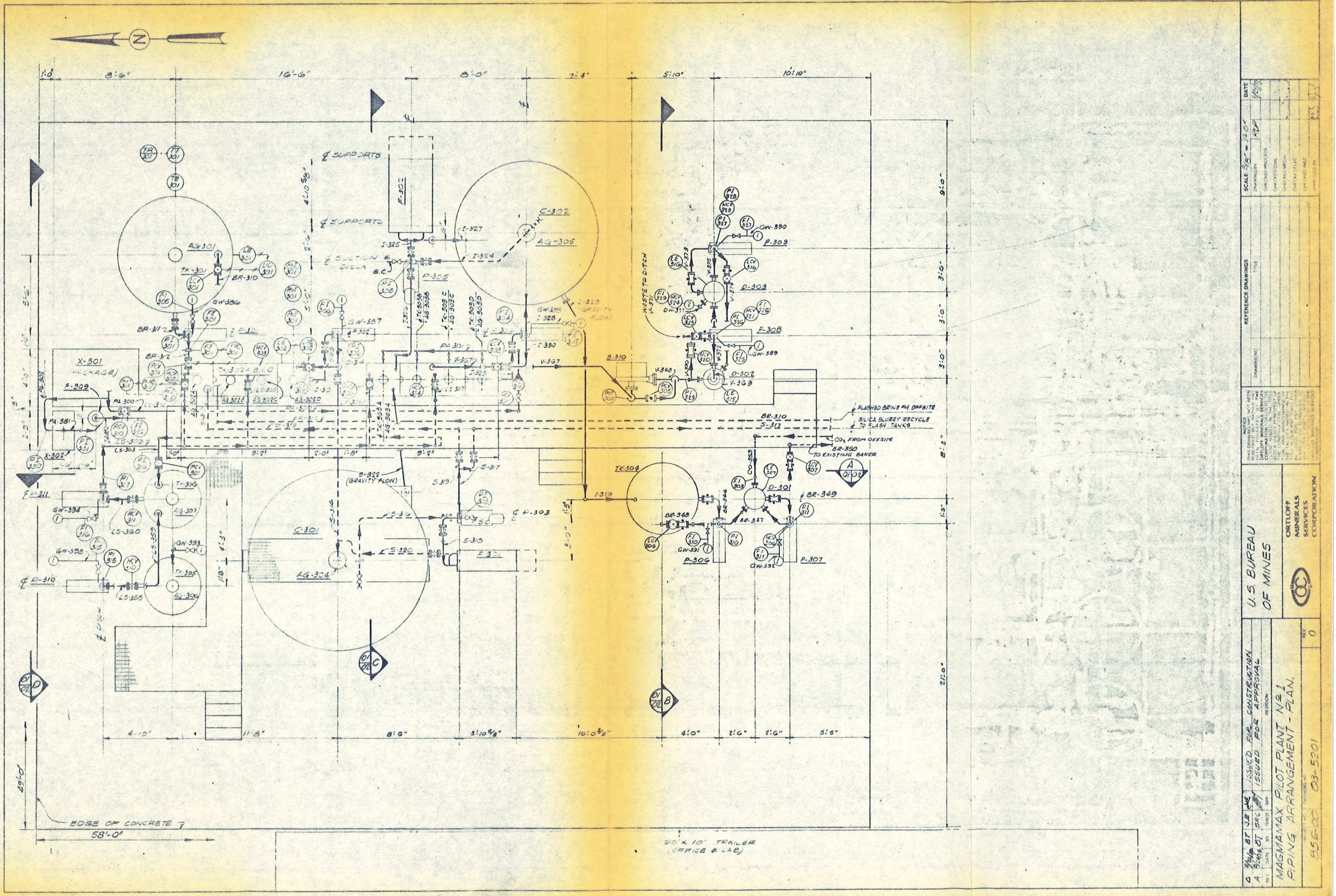
REFERENCE DRAWINGS

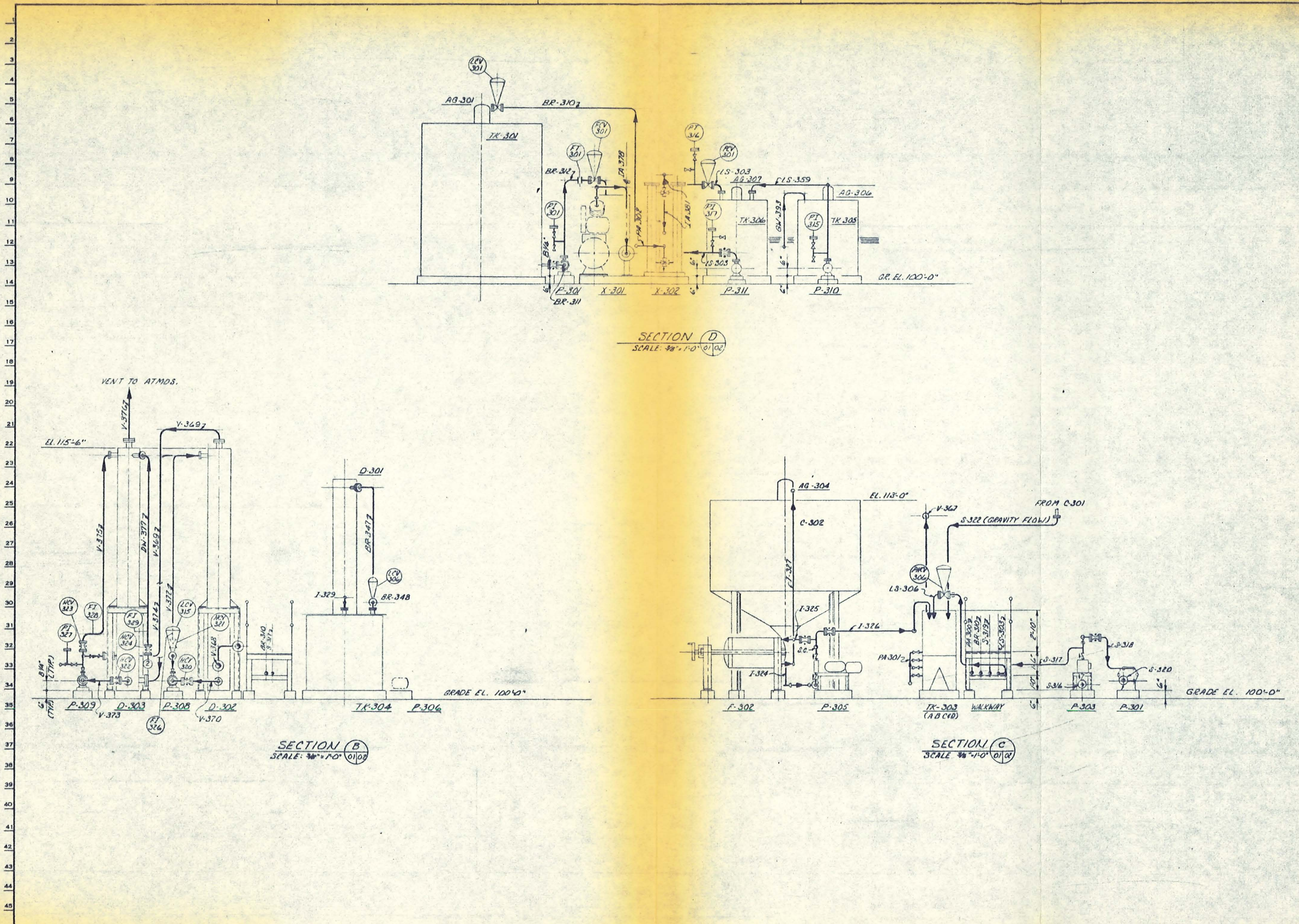
DRAWING NO.	TITLE
	•

SCALE: 3/8" = 1'-0"

		DATE
DRAWING BY	BT	5/24/79
CHECKED PROCESS		
CHECKED CIVIL		
CHECKED MECH.		
CHECKED ELEC.		
CHECKED INST.		
APPROVED BY		

8


N
¢ SUPPORTS
F-302
C-302
AG-305
AG-301
TK-301
X-301
(PACKAGE)
P-309
P-305
P-308
P-306
P-307
D-303
D-302
D-301
B-310
TK-304
TK-305
TK-306
AG-307
AG-306
C-301
AG-304
F-301
WASTE TO DITCH
FLASHED BRINE FM OFFSITE
SILICA SLURRY RECYCLE TO FLASH TANKS
CO₂ FROM OFFSITE
TO EXISTING BAKER
(GRAVITY FLOW)
EDGE OF CONCRETE
58'-0"
49'-0"
60' x 10' TRAILER (OFFICE & LAB)
REFERENCE DRAWINGS
U.S. BUREAU OF MINES
ORTLOFF MINERALS SERVICES CORPORATION
MAGMAMAX PILOT PLANT No 1
PIPING ARRANGEMENT - PLAN.
ISSUED FOR CONSTRUCTION
ISSUED FOR APPROVAL
856-00
03-5201



REV.	DATE	BY	CHK'D	APP.	REVISION
0	9/16/76	BT	J.B	CVE	ISSUED FOR CONSTRUCTION
A	7/14/76	BT	SEC		ISSUED FOR APPROVAL

MAGMAMAX PILOT PLANT N° 1
PIPING ARRANGEMENT - SECTIONS

PROJECT NO. 85600 | DRAWING NO. 03-5202 | REV. 0

U.S. BUREAU OF MINES

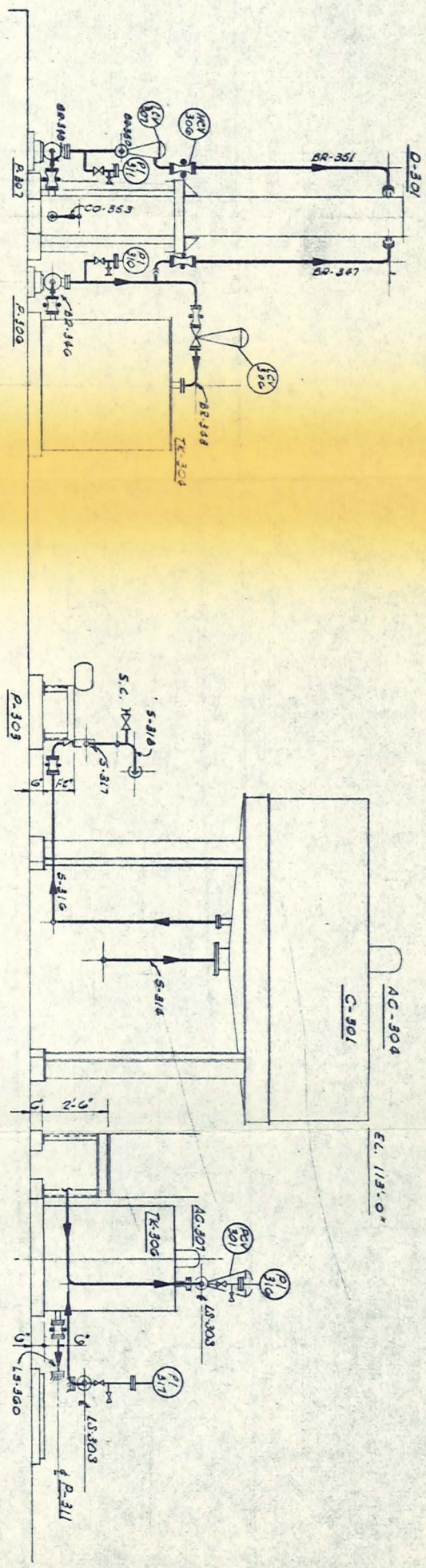
ORTLOFF MINERALS SERVICES CORPORATION

REFERENCE DRAWINGS

DRAWING NO.	TITLE

SCALE: 3/8" = 1'-0"

		DATE
DRAWN BY	J.B	3/24/76
CHECKED PROCESS		
CHECKED CIVIL		
CHECKED MECH.		
CHECKED ELEC.		
CHECKED INST.		
APPROVED BY	CEB	9/16/76



SECTION A
SCALE: 3/8"=1'-0"
DRG. NO. 03/02

REV.	DATE	BY	CHK'D	APP.	REVISION
0	5/24/78	BT	J.B		ISSUED FAR CONSTRUCTION
A	5/24/78	BT			ISSUED FOR CUSTOMER APPROVAL

MAGMAMAX PILOT PLANT №1
PIPING ARRANGEMENT
SECTIONS

PROJECT NO. 85600 | DRAWING NO. 03-5203 | REV.

U.S. BUREAU OF MINES

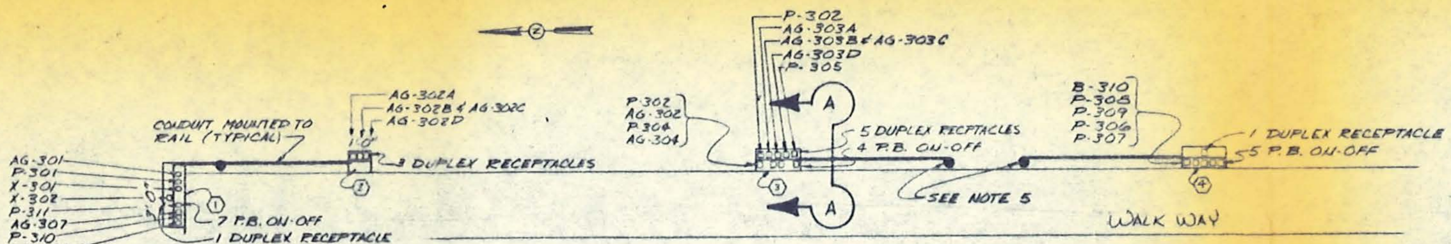
ORTLOFF MINERALS SERVICES CORPORATION

REFERENCE DRAWINGS

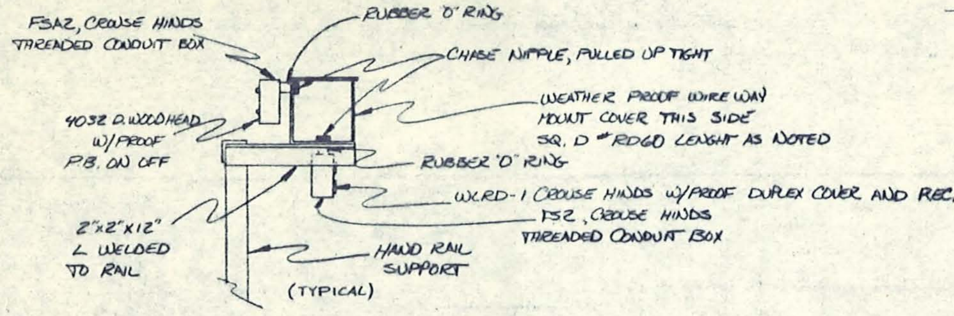
DRAWING NO.	TITLE

SCALE: 3/8"=1'-0"

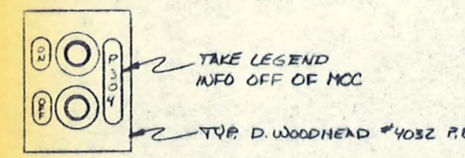
		DATE
DRAWING BY	BT	5/24/78
CHECKED PROCESS		
CHECKED CIVIL		
CHECKED MECH.		
CHECKED ELEC.		
CHECKED INST.		
APPROVED BY		



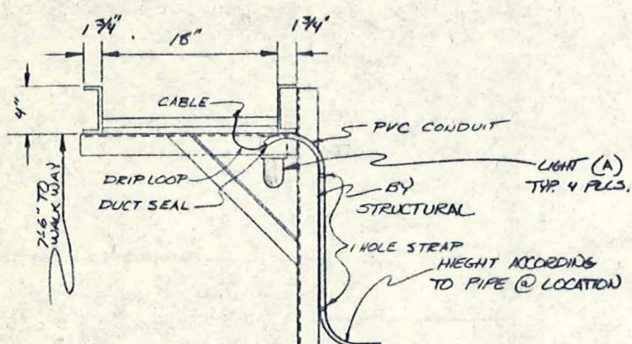
CONTROL PLAN DETAIL
NTS



SECTION – A A
NTS



PUSH BUTTON DETAIL
NTS



CABLE TRAY SUPPORTS
NTS

NOTES:

1. ALL CABLE LAYOUT TO FOLLOW AND TO BE SUPPORTED BY EXISTING PIPES & PIPE RACK AS REQD.
2. AG302A-D AND AG303A-D RESPECTIVELY, PLUG IN TO WEATHERPROOF DUPLEX OUTLETS MOUNTED ON THE HAND RAIL.
3. ALL ON OFF P.B. TO BE MOUNTED TO THE HAND RAIL AS SHOWN IN DIRECT SIGHT OF APPLICATION.
4. ALL DISCONNECTS TO BE LOCALLY MOUNTED AT MOTOR.
5. GROUP PVC CONDUIT GOING FROM CABLE TRAY TO HAND RAIL, ROUTED BY WAY OF TRAY SUPPORTS & ALONG RAIL ACCORDINGLY.
6. ALL MOTORS TO HAVE MIN. OF 2'-0" SEAL TIGHT FLEX CONDUIT @ MOTOR CONNECTION.
7. AT POINT OF ENTRY OF CABLE TRAY INTO TRAILER FEILD PROVIDE WEATHER PROOF FLAP.
8. WIRE SIZE PER MCC ONE LINE DIAGRAM CONDUIT SIZE SHOWN FOR RUNS, FROM TRAY TO MOTORS.
9. ALL CABLE USED TO BE SUITABLE FOR CABLE TRAY TYP TC OR EQUAL.

FIXTURE SCHEDULE

MARK	MANUFACTURER	CAT. NO.	LAMPS	DESCRIPTION
A	HUBBELL	ADXF-1110	1-150W/A-23	CEILING MOUNT W/GUARD
B	WESTINGHOUSE	VR-440A	4-F40T12/CW	4 LAMP FLUORESCENT WP/RD WITH TWO END PLATES
C	WESTINGHOUSE	TIG-CNGE-3EA	1-250W/MV	MV ROADWAY COMPLETE 480V WITH BRACKET # W70-00-31

PANEL SCHEDULE

PANEL LP- 120/240 VAC/60 100 AMP – 1 PHASE 3 WIRE

CKT. NO.	BKR AMPS	POLE	DESCRIPTION	LOAD – KVA				DESCRIPTION	POLE	BKR AMPS	CKT. NO.
1	20	1	LIGHTS	1.4 / 1.0	A			LAB. RECEPTACLE	1	20	2
3	20	1	OFFICE RECEPTICALS			B	1.0 / 1.0	LAB. RECEPTACLE	1	20	4
5	20	1	INSTR AIR DRYER	1.5 / .7	A			RECEPTACLE AG-302A	1	20	6
7	20	1	(RECEPTACLE)			B	1.7 / 1.4	" AG-302B & C	1	20	8
9	20	1	(RECEPTACLE)	1.7 / .7	A			" AG 302D	1	20	10
11	20	1	P-303			B	1.7 / .7	" AG-303A	1	20	12
13	20	1	P-305	1.7 / 1.4	A			" AG-303B & C	1	20	14
15	20	1	SPARE			B	.7	" AG-303D	1	20	16
17	20	1	SPARE		A			SPARE	1	20	18
19	20	1	SPARE			B		SPARE	1	20	20
21	30	2	WATER HEATER	2.0	A			SPARE	1	20	22
23						B	2.0	SPARE	1	20	24
25	20	1	SPARE		A			SPARE	1	20	26
27	30	1	AIR CONDITIONER			B	2.5	SPARE	1	20	28
29	30	1	" "	2.5	A			SPARE	1	20	30
				14.6			12.7				

150 MAIN BUS 150/2 MAIN BREAKER LUGS FOR # 1/0 CU

120/240 VOLT 1 PHASE 3 WIRE TOP FEED 30 POLE

DESIGN LOAD 36 KVA TYPE: ______ 100 A MAIN BREAKER

CONNECTED LOAD 27.3 KVA

SPARES 8.7 KVA

REFERENCE DRAWINGS

DRAWING NO	TITLE
03-7302	ELEC. ONE-LINE, MCC & TRAILER PLAN
03-7303	ELECTRICAL POWER & LIGHTING LAYOUT

SCALE:	DATE
DRAWING BY	10-17-77
CHECKED PROCESS	
CHECKED CIVIL	
CHECKED MECH.	
CHECKED ELEC.	REW 5/25/78
CHECKED INST.	
APPROVED BY	

U.S. BUREAU OF MINES

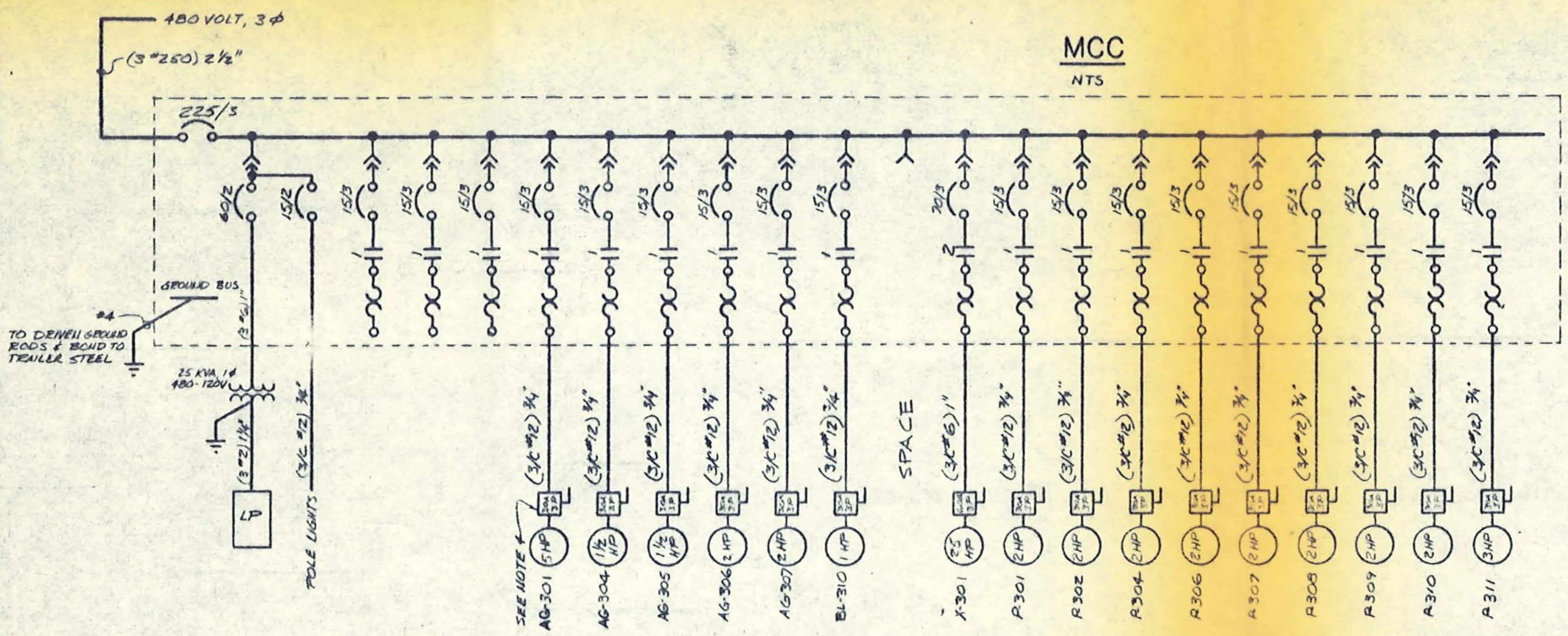
ORTLOFF MINERALS SERVICES CORPORATION

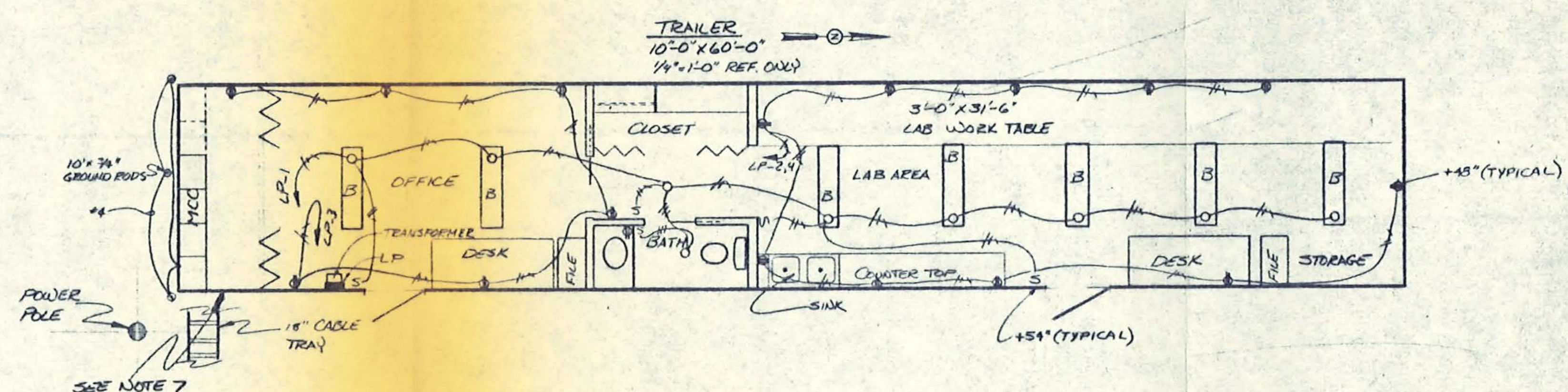
REV	DATE	BY	CHK'D	APP.	REVISION
0	6-2-78	DT	REW	REW	ISSUED FOR CONSTRUCTION
A		DT	REW		ISSUED FOR APPROVAL

MAGMAMAX PILOT PLANT No 1
ELECTRICAL
DETAILS, SECTIONS & SCHEDULES

PROJECT NO. 85600 DRAWING NO. 03-7301 REV. 0

12





MAIN BREAKER 225/3	AG-301 5 HP SIZE 1 15/3	SPACE	P306 2 HP SIZE 1 15/3
	AG-304 1½ HP SIZE 1 15/3		P307 2 HP SIZE 1 15/3
LP 60/2 / POLE LIGHTS 15/2	AG-305 1½ HP SIZE 1 15/3	X-301 25 HP SIZE 2 70/3	P308 2 HP SIZE 1 15/3
SPARE	AG-306 2 HP SIZE 1 15/3	P301 2 HP SIZE 1 15/3	P309 2 HP SIZE 1 15/3
SPARE	AG-307 2 HP SIZE 1 15/3	P302 2 HP SIZE 1 15/3	P310 2 HP SIZE 1 15/3
SPARE	BL-310 1 HP SIZE 1 15/3	P304 2 HP SIZE 1 15/3	P311 3 HP SIZE 1 15/3

MCC
NTS

REFERENCE DRAWINGS	
DRAWING NO.	TITLE
03-7301	ELECTRICAL DETAILS, SECTIONS & SCHEDULES
03-7303	ELECTRICAL POWER & LIGHTING LAYOUT

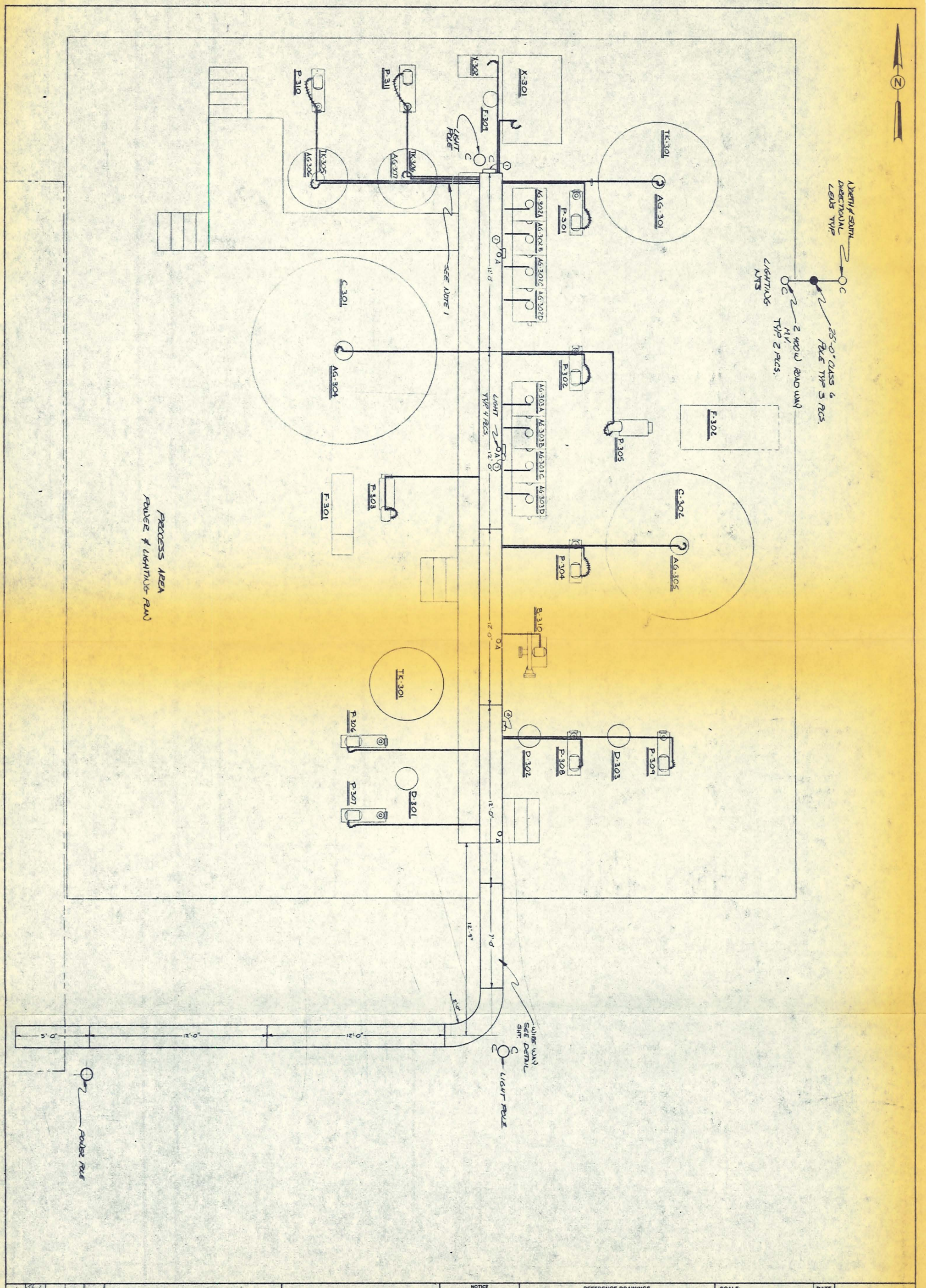
U.S. BUREAU OF MINES

ORTLOFF MINERALS SERVICES CORPORATION

REV	DATE	BY	CHK'D	APP	REVISION
0		DT	RCW		ISSUED FOR CONSTRUCTION
A		DT	RCW		ISSUED FOR APPROVAL

MAGMAMAX PILOT PLANT No 1
ELECTRICAL
ONE LINE / MCC & TRAILER PLAN & LIGHTS

PROJECT NO. 85600 DRAWING NO. 03-7302 REV. 0



PROCESS AREA
POWER & LIGHTING PLAN

REV.	DATE	BY	CHK'D	APP.	REVISION
0	9/14/78	DT	REW	REW	ISSUED FOR CONSTRUCTION
A		DT	REW		ISSUED FOR APPROVAL

MAGMAMAX PILOT PLANT № 1
ELECTRICAL
POWER & LIGHTING LAYOUT

PROJECT NO. 85600 | DRAWING NO. 03-7303 | REV. 0

U.S. BUREAU OF MINES

ORTLOFF MINERALS SERVICES CORPORATION

REFERENCE DRAWINGS	
DRAWING NO.	TITLE
03-7301	ELECTRICAL DETAILS, SECTIONS & DETAILS
03-7302	ELEC. ONE-LINE, MCC & TRAILER PLAN

SCALE:		DATE
DRAWING BY	FDC	10-17
CHECKED PROCESS		
CHECKED CIVIL		
CHECKED MECH.		
CHECKED ELEC.	REW	9/29/78
CHECKED INST.		
APPROVED BY	[illegible]	10/24/78

EQUIPMENT AND INSTRUMENT SPECIFICATIONS
AND MANUFACTURERS LITERATURE

Tankage List

Identification No.	Service	Capacity or Feed Rate, gpm	Size	Retention Time, min	Material of Construction	Comments	Approximate Cost
TK-301	Hot brine holding tank	10-15	8' diam x 10' high	350-250	Polyester-fiberglass	2" tank insulation integral with wall	$4,500
TK-302, B, C, D	Silica reactor tank	10-15	27" square x 36" high, 4 compartments	30-20	Polyester-fiberglass	Agitator side mount reinforce pads on tanks, lids provided	3,400
TK-303, B, C, D	Bulk precipitation reactor tank	10-15	27" square x 36" high, 4 compartments	30-20	Polyester-fiberglass	Agitator cross mount bracing on each section, lids with vent ports on each section	3,400
TK-306	Spent brine holding tank	10-15	5' diam x 5' high	60-40	Polyester-fiberglass	Slip-on cover	1,200
TK-307	Lime slurry makeup tank	400 gal	4' diam x 5' high	24-hour Lime slurry supply	Polyester-fiberglass	Agitator support strut and split cover	1,000
TK-308	Lime slurry holding tank	400 gal	4' diam x 5' high	24-hour Lime slurry supply	Polyester-fiberglass	Agitator support strut and split cover	1,000

Pump List

Identification No.	Service	Type	Flow Rate, gpm	Approximate Head-ft	Size	Driver hp	Comments	Approximate Cost
P-301	Raw brine transfer	Centrifugal	10-15	20-30	1-1/2 x 1-6	2 hp, TEFC 65°C ambient 1.15 S.F.	Ductile iron with stuffing box and water seal	$ 800
P-302	Silica reactor transfer	Centrifugal	10-15	20-30	1-1/2 x 1-6	2 hp, TEFC 65°C ambient 1.15 S.F.	Ductile iron with stuffing box and water seal	800
P-303	Silica thickener underflow	Diaphragm	0.1-1.0	30	3/4" HRI diaphragm	1/2 hp DC Vari-speed	Kynar body block neoprene diaphragm	2,300
P-304	Bulk precip reactor transfer	Centrifugal	10-15	20-30	1-1/2 x 1-6	2 hp, TEFC 65°C ambient 1.15 S.F.	Ductile iron with stuffing box and water seal	800
P-305	Bulk precip thickener	Diaphragm	0.1-1.0	30	3/4" HRI diaphragm	1/2 hp DC Vari-speed	Kynar body block neoprene diaphragm	2,300
P-306	Spent brine transfer	Centrifugal	10-15	20-30	1-1/2 x 1-6	2 hp, TEFC 65°C ambient 1.15 S.F.	Ductile iron with stuffing box and water seal	800
P-307	Brine scrubber transfer	Centrifugal	10-15	20-30	1-1/2 x 1-6	2 hp TEFC 65°C ambient 1.15 S.F.	Ductile iron with stuffing box and water seal	800
P-308	Ammonia scrubber transfer	Centrifugal	15-20	20-30	1-1/2 x 1-6	2 hp, TEFC 65°C ambient 1.15 S.F.	Ductile iron with stuffing box and water seal	800
P-309	Ammonia scrubber transfer and export	Centrifugal	15-20	20-30	1-1/2 x 1-6	2 hp, TEFC 65°C ambient 1.15 S.F.	Ductile iron with stuffing box and water seal	800
P-310	Lime slurry makeup transfer	Centrifugal	15-20	20	1-1/2 x 1-6	2 hp, TEFC 65°C ambient 1.15 S.F.	Ductile iron with stuffing box and water seal	800
P-311	Lime slurry loop circulation	Centrifugal	15	65	1-1/2 x 1-8	3 hp, TEFC 65°C ambient 1.15 S.F.	Ductile iron with stuffing box and water seal	900

Filter and Centrifuge List

Identification No.	Service	Type	Feed Rate, gpm	Filter Area, ft^2	Cake Volume, ft^3	Power, hp	Comments	Approximate Cost
F-101	Silica solids filter	Sperry 12" type RC-SFP	0.1-1.0	11	0.5	-	Polypropylene plates and frames, ratchet closure, bottom feed, wash type	$ 2,900
F-102	Bulk heavy metal solids filter	Sperry 24" type HHC-SFP	0.1-1.0	87	3.3	-	Polypropylene plates and frames, hydraulic closure, bottom feed, wash type	8,800

Clarifier-Thickener List

Identification No.	Service	Feed Rate, gpm	Settling Rate, ft/hr	Area Required, ft^2, 15 gpm Input	Available Area, ft^2	Driver, hp	Comments	Approximate Cost
C-301 AG-304	Silica slurry settling	10-15	Unknown	Unknown	122	1/2	Enviroclear B-2000, 12'6" diam, carbon steel	$ 40,000
C-302 AG-305	Bulk heavy metals slurry settling	10-15	4.3	30	78	1/2	Eimco type B 10' diam carbon steel	25,000

Agitator List

Identification No.	Service	Driver, hp	Output Shaft Speed, rpm	Impeller Diameter	Material of Construction	Approximate Cost
AG-301	Raw brine hold tank agitator	5.0	125	24" turbine fixed base	316 ss	$ 1,900
AG-302 B, C, D	Silica reactor agitators	1/4 each	1,725	4" propeller clamp mount	316 ss	300 (each unit)
AG-303 B, C, D	Bulk precipitation reactor agitators	1/4 each	420	12" turbine fixed base	316 ss	600 (each unit)
AG-306	Lime makeup tank agitator	2.0	110	24" turbine fixed base	Carbon steel	1,500
AG-307	Lime slurry loop tank agitator	2.0	110	24" turbine fixed base	Carbon steel	1,500

Miscellaneous Equipment

Identification No.	Service	Purpose	Size-Rating	Comments	Material of Construction	Approximate Cost
B-310	Vent gas blower	Maintain draft on TK 103, TK 104, C-103	200 scfm at 8" AP 1 hp, Spencer turbo blower	Feeds vent gases to scrubber tower D-102	Carbon steel	$ 1,600
D-301	Spent brine CO_2 absorber tower	Acidification of spent brine with CO_2 prior to reinjection	18" diam x 14' high, 10' packed height, 1" polypropylene saddles	Sizing based on air rate to tower	Polyester-fiberglass	4,000
D-302	Primary NH_3 scrubber tower	Absorbs NH_3 in water	18" diam x 14' high, 10' packed height, 1" polypropylene saddles	Sizing based on liquid rate to tower	Polyester-fiberglass	4,000
D-303	Secondary NH_3 scrubber tower	Final removal of NH_3 from vent gas stream	18" diam x 14' high, 10' packed height, 1" polypropylene saddles	Sizing based on air rate to tower	Polyester-fiberglass	4,000
X-301	Process and instrument air compressor	Supply process and instrument air	50 cfm at 100 psig, 25 hp, tank mount type with intercooler EX-101	-	-	4,000
X-302	Instrument air dryer package	Remove moisture from instrument air	Kemp 25E Oriad, 1 kw at 120 v. Dual column	25 cfm air capacity, manual cycle	-	2,000
F-309	Instrument air filter	Remove dust from instrument air supply	Dollinger GP-111-105	75 cfm at 100 psig rating	Carbon steel	400

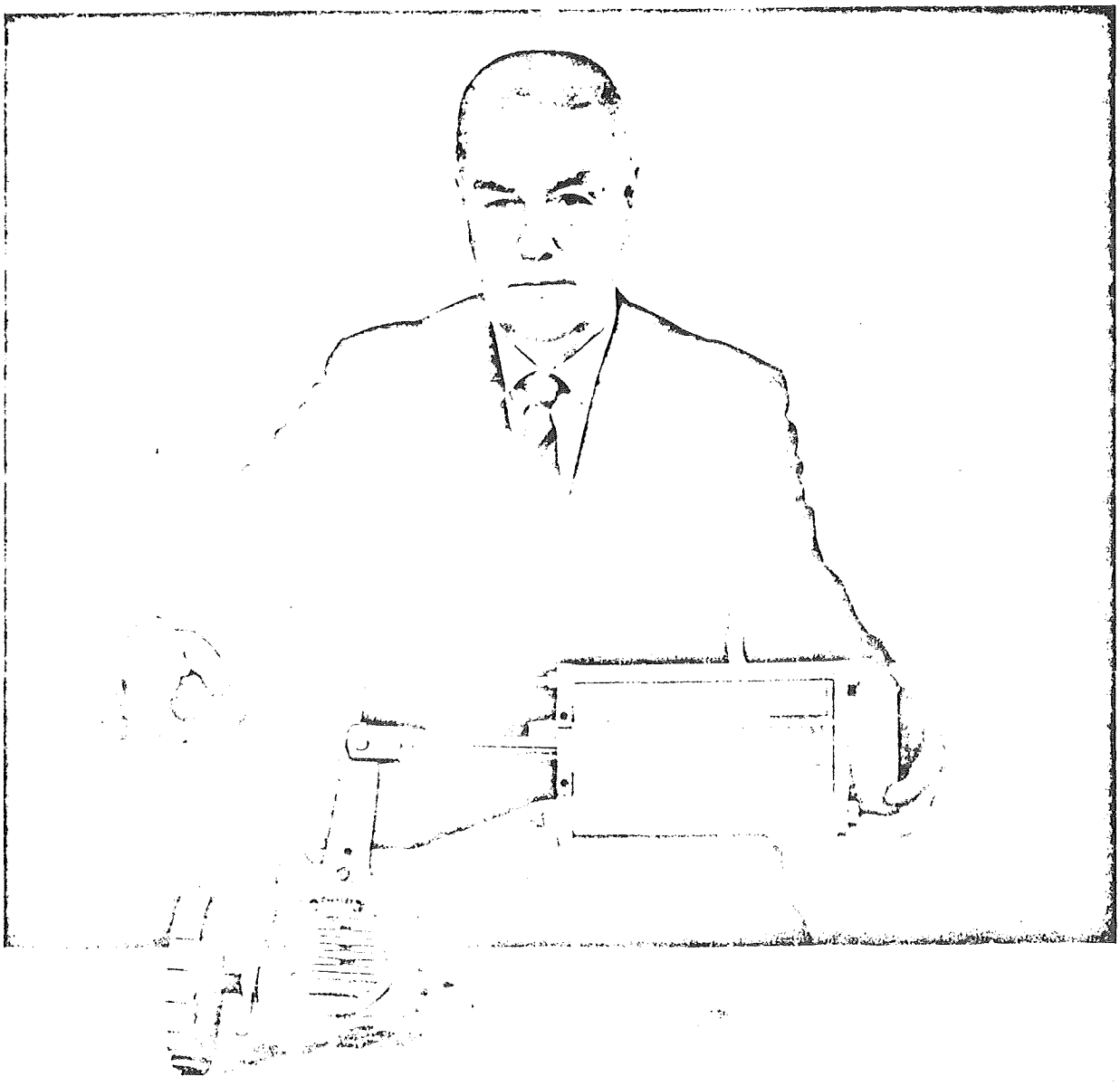
Instrumentation (1 of 2 pages)

Identification No.	Service	Description	Alarms	Range	Comments	Approximate Cost
LIC-301, 307, 315	Process vessel level indicator-controllers	Tank side mount differential pressure transmitter with pneumatic indicating controller	Hi-level on LIC-301	LIC-301, 0-100" H_2O LIC-307, 315, 316 0-30" H_2O		$ 900 (each unit)
LIC-302, 303	Reactor tanks level indicator-controllers	Bubble-tube level sensor with pneumatic indicating controller	Hi-level alarm	10-30" H_2O	Water purge on bubble tube, 5-50 cc/min with integral needle valve	800 (each unit)
pHRC-305, 306	Reactor tanks, pH recorder-controllers	Dip-probe pH sensor with pre-amplifier, remote transmitter with I/P converter and electronic recorder-controller	Hi-pH alarm	2-12 pH units	Gel-type reference electrode, standard glass electrode. Antimony electrode optional	3,000 (each unit)
pHI-301, 302	Reactor tanks final stage pH indicator	Dip-probe pH sensor with pre-amplifier and remote indicator	None	2-12 pH units	Gel-type reference electrode, standard glass electrode, antimony electrode optional	1,100 (each unit)
TR-301, 302, 303	Process temperature recorder	Multipoint temperature recorder adjustable 6 to 12-point, with thermocouples and lead wire	None	0-300°F all points	Type 8 thermocouple input	2,400
FRC-301	Flow control of raw brine to process	Magnetic flow recorder-controller with 1" IPS size sensing head with electronic transmitter and indicator and pneumatic recorder-controller	None	10-25 gpm	Teflon liner with titanium electrodes on sensing head calibrated to 0.25% accuracy on flow	5,400
PCV-301	Control back pressure on lime slurry loop	Pneumatic pressure indicating-controller 3-15 psi output with 4:1 multiplying relay	None	0-30 psig	External Moore 66 Bay, 4:1 multiplying relay required	700
FI-301	Air flow measurement to TK-303	Glass tube rotameter with ss float	None	0-25 cfm air at 3 psig	-	180
FI-303	CO_2 gas flow measurement to Tower D-101	Glass tube rotameter with ss float	None	0-30 scfm CO_2 gas	-	300
PIC-305	Draft control on vent points	Pneumatic draft indicator-controller	None	0-1" H_2O	-	1,100

Identification No.	Service	Description	Alarms	Range	Comments	Approximate Cost
Purge water and gland water flowmeters	Measure and control purge and pump gland water	Glass tube rotameters with integral needle valve	None	0-100 cc/min and 0.2-2.0 gpm	-	$ 1,000 (total for all required)
Pneumatic process control valves	Control brine and process reagent flows	Camflex brine control valve. Rubber sleeve valves for reagents	None	-	Moore 66 Bay 4:1 booster relay for rubber sleeve valves	2,000 (total for all required)
Pressure indicators	Measure process pump discharge pressures	Dial type gauge with diaphragm isolators	None	0-30 psig	Gauges to be glycerine filled for pulsation damping	1,200 (total for all required)

The Camflex Valve: the first all-purpose automatic control valve.

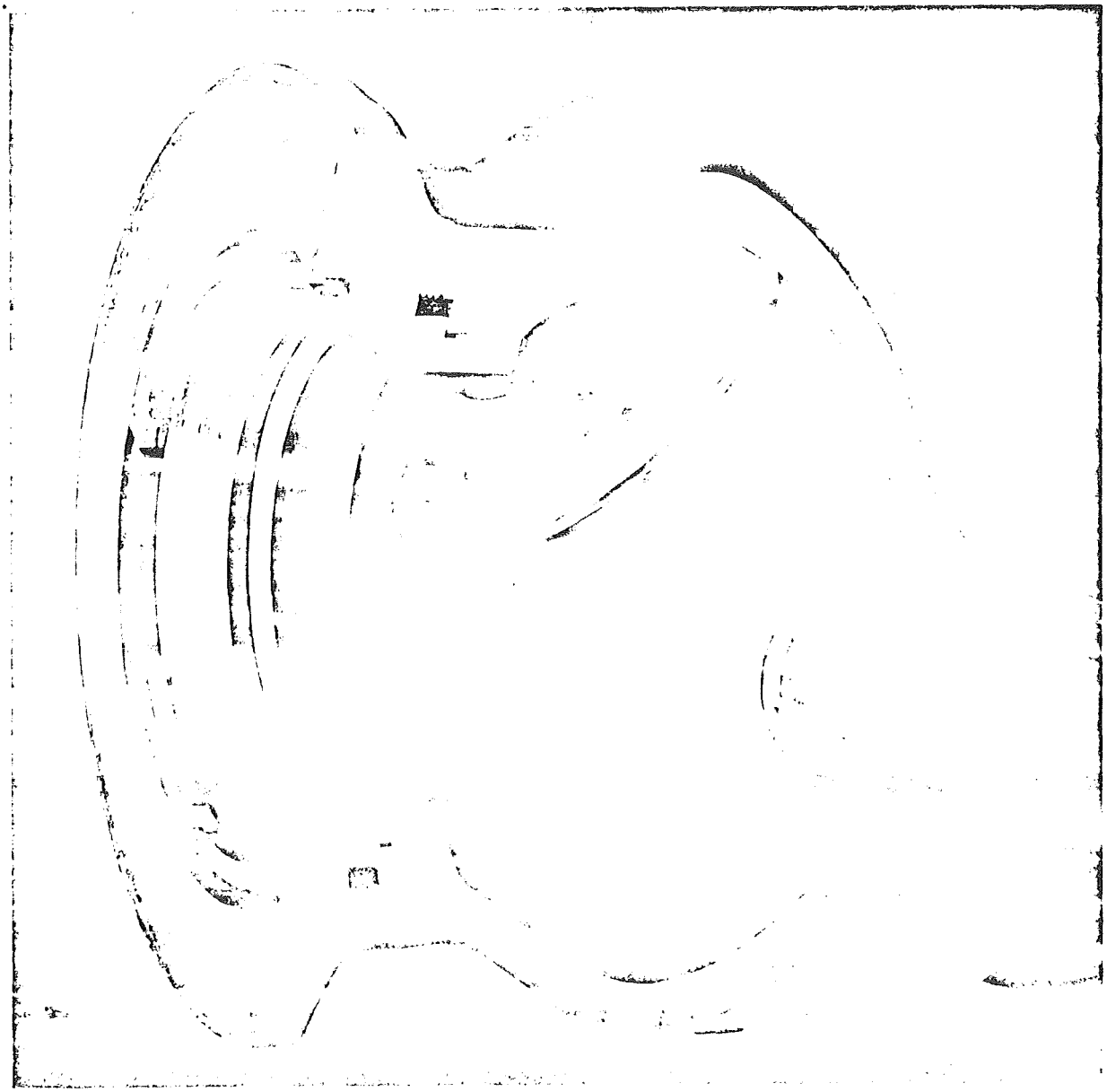
The Camflex Valve with plug.



Masoneilan

The Camflex valve eliminates sliding seal friction.

Self aligning plug rotates eccentrically into seat for tight shutoff.



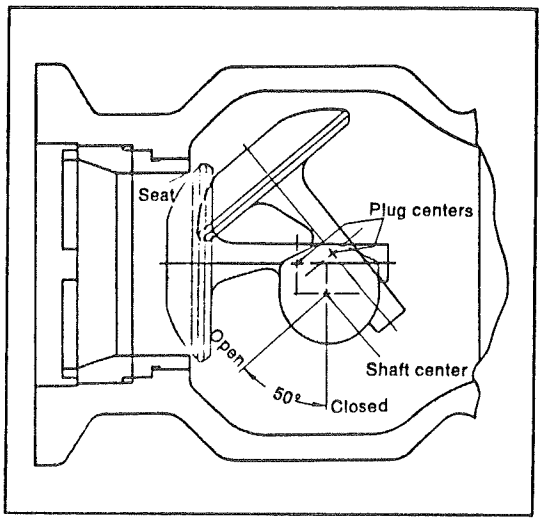
The Camflex valve plug eliminates the sliding seal friction associated with ball valves as well as the high seating forces required for tight shutoff in butterfly and globe valves.

Incorporated in a single casting is the plug seating surface joined by flexible arms to a hub which slides onto a rotating shaft. The seat portion of the plug has the form of a spherical segment and is rotated through a nominal 50 angle. The center of the spherical seating surface is offset from the shaft axis. The one piece shaft, which is connected to an actuating arm linked to the actuator piston rod, rotates the plug face which moves with an eccentric, cam-like motion, down and forward into the seat. By design, there are no parts inside the Camflex valve that can loosen and/or become disengaged to pass downstream during operation.

A positive seal between plug and seat is achieved by the elastic deformation of the plug arms; as the plug seats, the arms "flex" such that additional actuator thrust only forces the plug deeper into tighter contact with the seat. The shaft connection allows the plug to center itself along the shaft axis. The angle of contact between the plug and seat lets the plug wipe larger particles off the seating surfaces yet permits no rubbing, once contact is established.

A shouldered seat ring is clamped inside the valve body by a threaded retaining ring. The clamped design prevents seat ring distortion and ensures a positive seal between ring and body. Installation of reduced trim requires only a change in seat rings; the plug remains the same.

The advanced design of the Camflex makes possible a unique combination of desirable features in a standard valve: high capacity, tight shutoff, low unidirectional dynamic force and identical flow characteristics in either direction.



Center of the spherical plug seating surface is offset from shaft axis. When rotated through a 50° arc, plug moves down and forward to contact solidly against seat ring.

Comparison of Camflex with other control valves

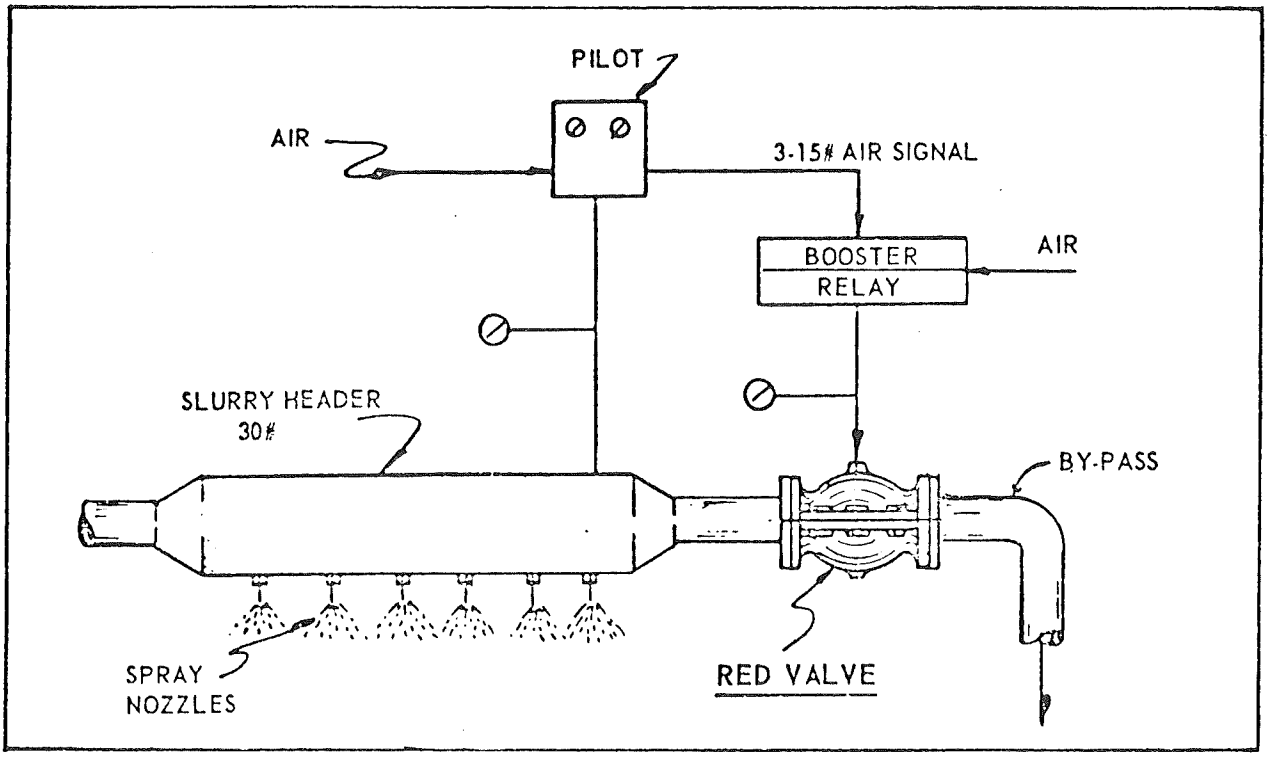
	Camflex	Single Seat Globe	Double Seat Globe	Ball	Butterfly
High capacity	■			■	■
Tight shutoff	■	■		■	■
Low static and dynamic force	■				
Low required actuator thrust	■				
Reduced trim	■	■			

RED VALVE COMPANY, INC.

Memo Engr. 6

500 Bell Avenue, Carnegie, Pa., Phone 923-2677

BACK PRESSURE REGULATOR



Red Valves are being used as back pressure regulators in the food, mining, pulp and paper and chemical industries.

The above application of Red Valves is in a brick factory. The valves are handling clay glaze which is being sprayed on the brick faces before baking.

The line pressure is 30#. The Red Valve is set to relieve at any pressure above 30#. Previously, they required a man, full time, to constantly adjust nozzles. The plugging up on one nozzle would upset flow in the other nozzle since the pressure in the line would build up.

With the installation of a Red Valve, as illustrated above, the excess pressure caused by plugging of one of the nozzles is relieved through the Red Valve, and the other spray nozzles maintain a constant, uniform spray.

The full-round port of a Red Valve gives an unobstructed flow pattern. The gum rubber sleeves withstand the abrasive cutting action of the clay and has given them long, satisfactory life.

Red Valves

"More Pinch to the Inch"

SERIES 2600

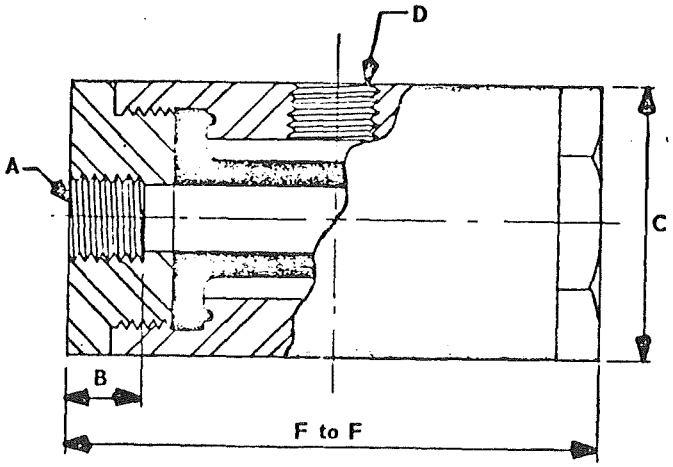
A SAMPLING VALVE FOR REAGENTS

The latest addition to the Red Valve line is a low cost sampling valve with threaded ends, Series 2600. This valve is designed to cycle within seconds and can be operated pneumatically or hydraulically.

This valve has all the advantages of the Red Valve line; simplified operation, unobstructed flow, large seating surface, one wearing part and absolute closure on entrapped solids.

The Series 2600 is an ideal valve for sampling, controlling or on-off service of acids, slurries, reagents, or catalysts in mining, pilot plants or chemical process operations.

The simple four-part construction requires little or no maintenance. The body consists of steel tube with two steel end connectors turned tightly down on a rubber or synthetic sleeve.

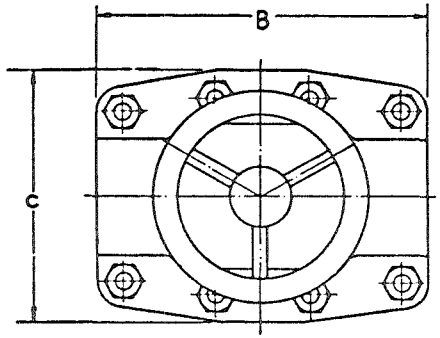


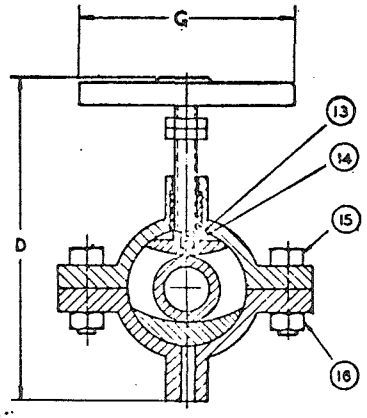
The body is available in stainless steel, the end connectors are available in stainless steel, brass or PVC.

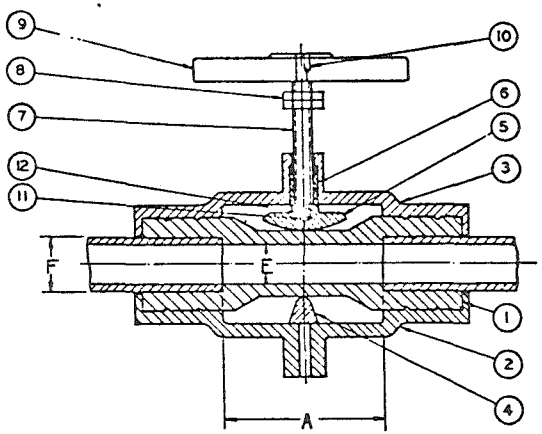
Molded sleeves are stocked in pure gum rubber, Neoprene, Butyl, Urethane and Silicone.

VALVE SIZE I.D.	LENGTH F to F	NPT A	B	C	NPT D	MAX. LINE PRESSURE
1/8" (.269)	3"	1/8"	1/2"	1-1/2"	1/4"	75 psi
1/4" (.364)	3"	1/4"	1/2"	1-1/2"	1/4"	75 psi
3/8" (.493)	3-1/2"	3/8"	1/2"	2-1/8"	1/4"	75 psi
1/2" (.622)	3-1/2"	1/2"	5/8"	2-1/8"	1/4"	75 psi
3/4" (.824)	4"	3/4"	5/8"	2-1/4"	1/4"	75 psi
1"	4-1/2"	1"	3/4"	2-1/2"	1/4"	75 psi

Red Valve Company, Inc. *500 Bell Ave., Carnegie, Pa. 15106 • Ph.: (412) 923-2677*







BILL OF MATERIALS

ITEM	DESCRIPTION	MATERIAL
1	Valve Body	Elastomer
2	Lower Casing	Aluminum
3	Upper Casing	Aluminum
4	Base	Malleable Iron
5	Shoe	Malleable Iron
6	Bushing	Bronze
7	Stem	Stainless Steel
8	Jamnut	Steel
9	Hand Wheel	Ductile Iron
10	Groove Pin	Steel
11	Thrust Washer	Case Hard Steel
12	Ball	Stainless Steel
13	Socket Screw	Steel
14	Hex Nut	Steel
15	Cap Screw	Steel Cad. Plated
16	Hex Nut	Steel Cad. Plated

Valve Size		1/2	3/4	1	1-1/4	1-1/2	2
Weight Lbs.		6	7	8	10	12	15
Press. High Press		125	125	100	75	50	50
PSIG Std.		75	75	50	35	35	35
DIMENSIONS	A	2	2	4	5	6	8
	B	5-1/4	6-1/4	7-1/4	8-1/4	11-1/4	13-1/4
	C	4-1/2	4-3/4	5-1/4	5-3/4	7	7-3/4
	D	5-1/2	6	6-3/8	8-3/8	10-1/4	11-7/8
	E	.622	.824	1.049	1-1/4	1-1/2	2
	F	.840	1.050	1.315	1.660	1.906	2.375
	G	3	3	3	3	5	5

VALVE NO.	
SIZE	
BODY MATERIAL	
VALVE WORKING TEMP.	
VALVE WORKING PRESS.	

CUSTOMER

ORDER NO. REQUESITION NO.

CERTIFIED FOR INSTALLATION

FLEXIBLE VALVE CORPORATION

South Hackensack, New Jersey 07606

TYPE 7600 DRAWING NO. FV-10199

INSTALLATION AND MAINTENANCE INSTRUCTIONS

TYPE 7600

GENERAL

1. Be certain that the materials, pressures and temperatures involved are those approved by the Flexible Valve Corporation. Any changes in service conditions should again be reviewed and accepted by this office.

2. Do not install valves near steam lines or where excessive temperatures would exist.

3. After the valve has been installed for a period of six months (this depends entirely upon the individual application) the valve body should be rotated approximately 90° from the original installed position. This is to prevent the body from taking a "semi-set." To further lengthen the life of the valve body, it can be reversed. The upstream would become the downstream, and vice versa.

4. For lubrication, use a heavy grease compound on the stem, preferably a compound such as silcone grease which is non-injurious to rubber.

5. Be sure all pipe lines are in line and are securely supported by hangers, hooks, etc.

TYPE 7600

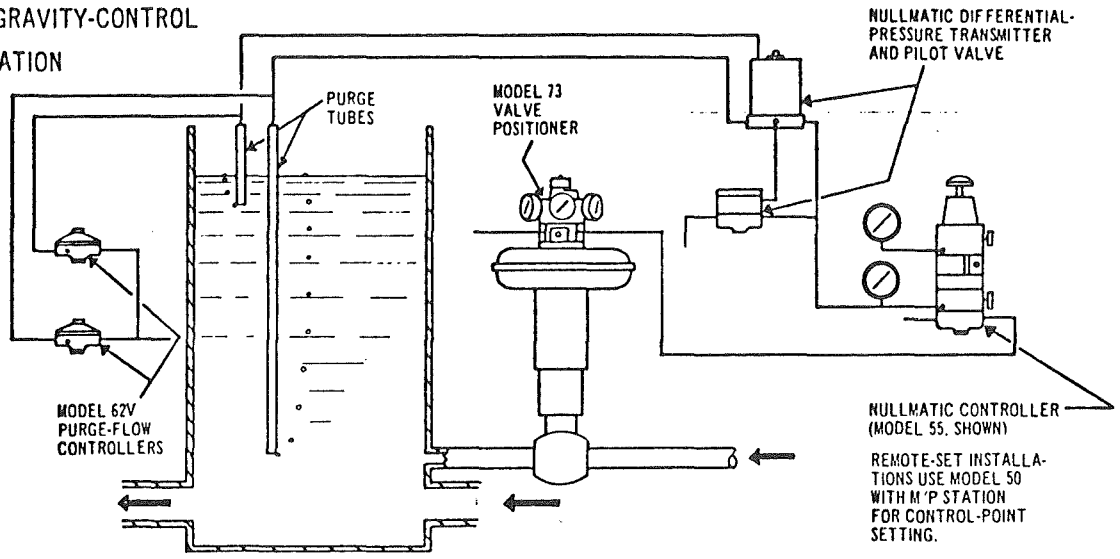
1. The ratio of the flexing area is four times the pipe size; therefore in cutting your pipe when installing a one inch Type 7600 valve, four inches of pipe should be cut out of the pipe line where the valve is to be installed.

2. The end of each pipe should be free from any burrs, pipe wrench marks, foreign matter, etc. A smooth surface should appear before inserting the pipe into the enlarged end, thus preventing any cutting of the rubber liner.

3. When inserting one end of the piping into the enlarged end of the valve body, be positively sure that the existing pipe butts up against the shoulder in the body. Slip on the body over the other section of piping and put the upper and lower casings into position for clamping. Tighten each of the end bolts first by hand. Middle bolts should then be tightened by hand. Wrench tighten end bolts first and then wrench tighten inside bolts until the mechanism is securely fastened to both ends of the pipe.

PURGE-FLOW CONTROL

SPECIFIC-GRAVITY-CONTROL APPLICATION



The diagram above shows a typical specific-gravity-control application, in which:

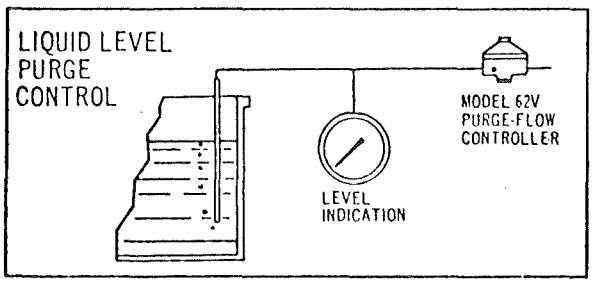
Two purge-flow controllers maintain a constant purging condition for the particular settings of their integral needle valves.

A Nullmatic differential-pressure transmitter measures the difference in pressures within the two dip tubes and transmits an air-pressure signal to a model 55 Nullmatic controller.

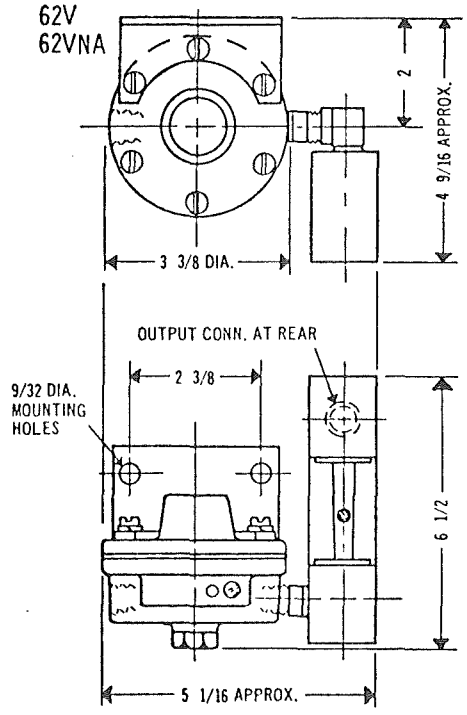
The controller, illustrated, contains its own control-point-setting regulator. In the diagram, a model 73 built-in valve positioner is being controlled by the output pressure of the Nullmatic controller.

The diagram below illustrates a typical liquid-level air-purge control application. Such applications are generally considered noncritical.

LIMITATIONS: These vented instruments were not designed for liquid-purge applications. For information on series 63 low-flow controllers (used for liquid purging), request GC-63.



MODELS
62V
62VNA

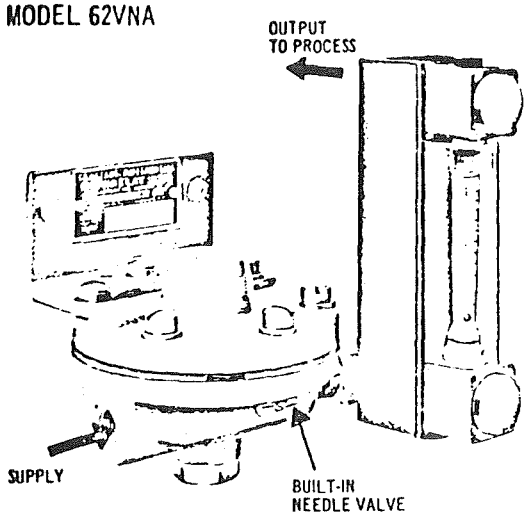


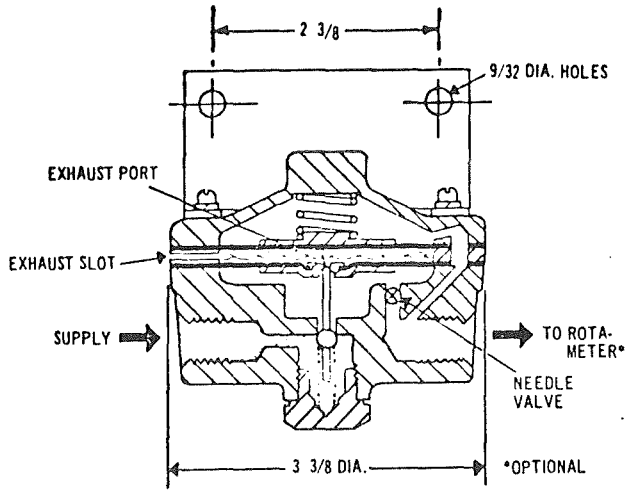
MOORE PRODUCTS CO.
Spring House, Pa.

Manufacturing Subsidiary: Moore Instrument Co., Ltd., Rexdale, Ont.

Constant-Differential Relays

MODEL 62VNA





ALL CONNECTIONS 1/4 NPT

These constant-differential relays serve as air-flow controllers, maintaining an essentially constant air purge for each setting of an integral needle valve.

By maintaining a constant differential-pressure drop across a built-in needle valve (for any flow setting up to about 1 cu. ft. of air per minute), each instrument insures an essentially constant volumetric rate of flow —regardless of variations in process or supply pressure.

The differential applied to the integral needle valve is determined by a spring-loaded diaphragm. This diaphragm controls the action of the supply-port plunger, automatically admitting supply air to the needle valve at the required rate. Excess purge air bleeds to the atmosphere, when necessary.

Series 62 constant differential relays are made entirely of brass, stainless steel and neoprene. These components are not affected by ordinary air-line impurities.

Note: Models 62VN and 62VNA permit flows of less than 0.9 scfh. It is therefore recommended that a flow indicator be used in the downstream line.

Model No.		Purge Rate cfh
62V		0.9 to 2.1
62VA	piped assembly†	0.9 to 2.1
62VN		0.06 to 1.8
62VNA	piped assembly†	0.06 to 1.8

† Includes indicating rotameter with 0.2 to 2.0 scfh scale range. To order rotameter for use with existing 62V or 62VN, specify part number 12431-3.

GENERAL SPECIFICATIONS

Materials of Construction	
Top & bottom forgings	Brass
Retaining nut	Brass
Diaphragm	Neoprene
Differential Spring	Stainless Steel
Valve Plunger	Stainless Steel
Plunger Spring	Stainless Steel
Ambient Temperature Limits	—40° to +180°F

Supply Pressure

100 psi max. (minimum supply pressure is 5 psi above highest output pressure required.)

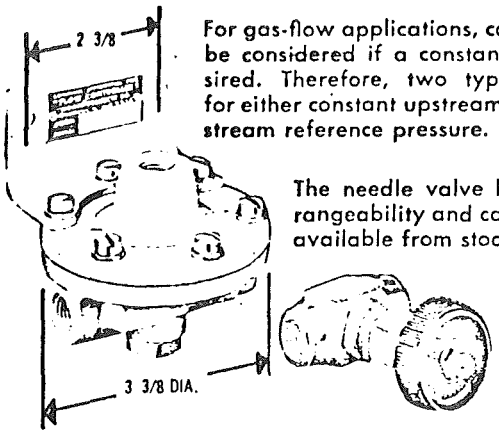
Moore constant-differential relays eliminate most of the problems encountered in conventional bubbling systems, because:

- Each relay holds the bubbling rate constant, maintaining high accuracy of measurement.
- The differential pressure which is maintained across the needle valve is approximately 1½ psi; allowing wider needle valve openings which are less subject to clogging.
- Full supply pressure (up to 100 psi) is connected to the purge system—resulting in a greater margin of safety.

In addition to the preceding advantages, the use of a constant-differential relay eliminates the need for a supply regulator. Models 62V and 62VA assure reasonable purge rates at all times. Another safety feature is the automatic exhaust, which bleeds off any excess air caused by the presence of foreign particles on the pilot seat of the supply-port plunger.

Flow Controllers

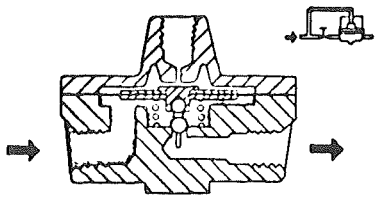
For liquid-flow applications, each of these instruments will provide a constant mass flow—independent of pressure changes.



For gas-flow applications, compressibility must be considered if a constant mass flow is desired. Therefore, two types are available, for either constant upstream or constant downstream reference pressure.

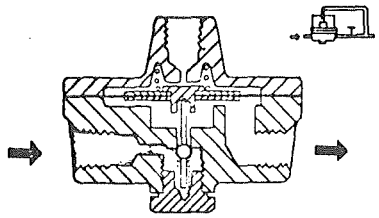
The needle valve helps to determine rangeability and capacity. Four valves available from stock.

ALL CONNECTIONS ARE 1/4 NPT
MOUNTING HOLES ARE 9/32 DIA.



MODEL 63BU

FOR GASES WITH CONSTANT UPSTREAM REFERENCE PRESSURE



MODEL 63BD

FOR GASES WITH CONSTANT DOWNSTREAM REFERENCE PRESSURE

These instruments are used in conjunction with an external needle valve to provide constant volume flow rates for either liquids or gases over a continuously adjustable flow range. With liquids—which are, of course, not compressible—the constant volume flow will also be a constant mass flow.

The ability to control at very low rates (in the order of one scc/min) and their wide rangeability (as high as 500:1 for the low-flow units) make these controllers useful in a wide variety of applications. One widespread use is in gas chromatography, in which the controller regulates the small (20-200 sccm) helium stream that carries the process sample. Other applications include: liquid purge and blending operations in process plants, a wide variety of precision flow controls in pilot plants, and many uses in laboratories.

MODEL SELECTION: The selection of a controller for gas- flow applications depends upon whether the upstream or the downstream pressure will remain constant. There are types for both conditions. Either type may be used for liquid flow (since compressibility is not a factor).

MODEL NO.	Brass Units	316 SS Units
For liquid-flow control independent of pressure or—		
for gas-flow control with constant downstream pressure	63BD	63SD
	63BD-L*	63SD-L*
	63BD3A†	—
	63BD4A‡	—
for gas-flow control with constant upstream pressure	63BU	63SU
	63BU-L*	63SU-L*

* with special valve plungers and ports to handle very low flow rates.
† piped assembly, including rotameter (scale 0.2-2.0 scfh, gas)
‡ piped assembly, including rotameter (scale 20-200 cc/min., H_2O)

GENERAL SPECIFICATIONS

►MATERIALS		Brass Units	316 SS
Body		Brass	316 SS
Diaphragm		Neoprene	PTFE*
Differential Spring		18-8 SS	316 SS
Valve Plunger & Seat		303 SS	316 SS
Plunger Spring (used in "D" models only)	63BD	316 SS	316 SS
	63BD-L	Phos. Br.	316 SS
►RATINGS			
Temperature		180°F	250°F
Pressure		250 psi	500 psi

* Polytetrofluoroethylene.

PRINCIPLE OF OPERATION

Moore Low-Flow Controllers maintain a constant differential in the pressures across an external needle valve or other restriction, making the flow a function of the needle valve opening only.

On gas applications (where compressibility is a factor), the type of controller used is determined by the pressure conditions. For applications with constant pressure upstream, the type and circuit shown in the upper schematic is used. The constant pressure serves as a reference on the top of the controller diaphragm, and the loading spring exerts a constant force which results in an output which is always 3 psi less than the reference pressure. On the second type, used with constant pressure downstream, the directions of loading spring force and pilot-valve operation are reversed.

Printed in U.S.A. March 1967

	Higher Range Models 63BD and 63SD; 63BU and 63SU	Low Flow Models 63BD-L and 63SD-L; 63BU-L and 63SU-L
GAS FLOW-CAPACITY		
Maximum at less than critical flow	$SCCM = 4000 \sqrt{\frac{\Delta P}{SG} \times Pd \times \frac{530}{T}}$	$SCCM = 400 \sqrt{\frac{\Delta P}{SG} \times Pd \times \frac{530}{T}}$
Maximum at critical flow	$SCCM = 2000\ Pu \sqrt{\frac{1}{SG} \times \frac{530}{T}}$	$SCCM = 200\ Pu \sqrt{\frac{1}{SG} \times \frac{530}{T}}$
Minimum controllable flow	Approximately 1/200 of maximum	$SCCM = 8\ \frac{\Delta P\ (Pu + Pd)}{Rv\ T}$
LIQUID FLOW-CAPACITY		
Maximum	$CCM = 470 \sqrt{\frac{\Delta P}{SG}}$	$CCM = 47 \sqrt{\frac{\Delta P}{SG}}$
Minimum	Approximately 1/200 of maximum	$CCM = .06\ \frac{\Delta P}{Rv}$
NEEDLE VALVE SIZING (With 3 psi drop across valve)		
For any liquid	$Kn = \frac{CCM}{6550 \sqrt{\frac{1}{SG}}}$	
For any gas	$Kn = \frac{SCCM}{49000 \sqrt{\frac{1}{SG} \times Pn \times \frac{530}{T}}}$	

SCCM = Cubic centimeters per minute of gas at standard conditions (70°F, 14.7 psia). Note: 1 SCF = 28,317 SCC.

ΔP = psi pressure drop across the controller valve = total drop minus 3 psi.

Pu = psia pressure at inlet of controller (allow 3 psi for drop across the needle valve, if it is installed upstream).

Pd = psia pressure at outlet of controller (allow 3 psi for drop across the needle valve, if it is installed downstream).

Pn = psia pressure at outlet of needle valve.

SG = Specific gravity of the gas referred to air, or specific gravity of the liquid referred to water at 4°C.

T = Absolute temperature of the gas = degrees F + 460.

Rv = Ratio of viscosities of gas referred to air; or Ratio of viscosities of liquid at operating temperature to water at 4°C.

Kn = Flow constant of needle valve.

Rangeability and minimum controllable flow of each size depend upon the needle valve used, the specific gravity of the fluid, the operating pressures, and other factors.

The formulas permit calculation of maximum flows for both the low-flow and higher-range models. Because minimum flows occur in a laminar pattern with the low-flow models, a separate formula is furnished. Rangeability is considerably higher on gases than on liquids.

FLOW-RANGE EXAMPLES

Conditions:
15 psig (29.7 pisa) at inlet of controller
10 psi drop across controller (not including 3 psi needle-valve drop)
70° F. process temperature

	Max. Flow	Min. Flow
Higher-range units (Series 63)		
On air	56,000 scc/min	280 scc/min
On water	1,500 cc/min	7.5 cc/min
Low-range units (Series 63-L)		
On air	5,600 scc/min	7 scc/min
On water	149 cc/min	0.6 cc/min

NEEDLE VALVES: Rangeability and capacities (especially minimum flows) are also determined by the needle-valve design and characteristics. Four valves are offered, covering many conventional application requirements. (The last two listed are often used with the low-flow models.)

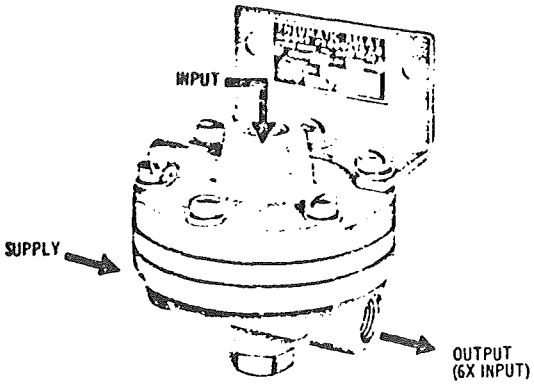
Part No.	Body	Needle	Kn*	Range-ability
3036	SS	SS	0.37	100:1
3034	SS	SS	0.15	350:1
10846	Brass	SS	0.09	500:1
10847	SS	SS	0.09	500:1

* Flow factor in Moore formulas.

MOORE PRODUCTS CO.
Spring House, Pa.
Manufacturing Subsidiary: Moore Instrument Co., Ltd., Rexdale, Ont.

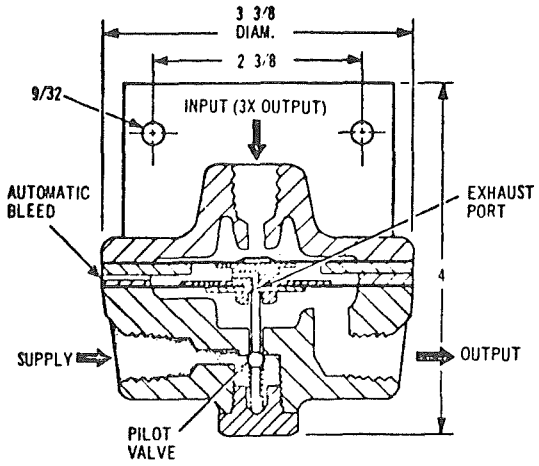
AMPLIFYING & REDUCING RELAYS

AMPLIFYING



MODEL 66BA6

REDUCING



MODEL 66BR3

ALL CONNECTIONS ARE 1/4" IPS.

These pneumatic relays are used to amplify or to reduce control-circuit pressure signals. For example: A 3-15 psi control signal can be amplified to operate a 6-30 psi control valve; or the 3-15 psi signal can be reduced to operate a low-pressure device.

AMPLIFYING		REDUCING	
Model No.	Input-to-Output Ratio	Model No.	Input-to-Output Ratio
66BA2	1:2	66BR2	2:1
66BA3	1:3	66BR3	3:1
66BA4	1:4	66BR4	4:1
66BA6	1:6	66BR6	6:1

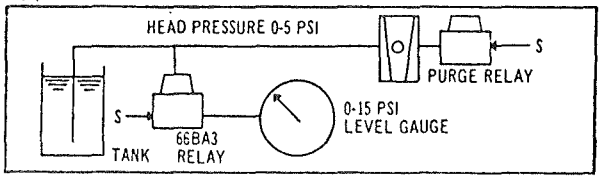
The operation of these rugged relays is simple and reliable. The input pressure, acting upon the effective area of the top diaphragm, produces a force which is balanced by the force produced by the output pressure, applied over the effective area of the lower diaphragm. Any unbalance in these opposing forces will operate the plunger; increasing or decreasing air supply to the output chamber. (The amplifying or reducing ratio is fixed by the ratio of input-to-output diaphragm areas.)

An increase in input opens the pilot valve to admit supply air directly to the output. A decrease in input opens the exhaust port to exhaust air from the output.

An amplifying relay may be easily changed to a different ratio—or into a reducing relay—by changing diaphragm-assembly parts. Detailed information appears in the instructions supplied with each relay.

Amplifying Low-Pressure-Measurement Signals

The problem: How to amplify low-pressure-measurement signals (with about 1% accuracy) for non-critical applications.



The solution: A model 66BA3 amplifying relay, used in conjunction with a purge relay. In this case, the model 66 relay serves a dual role: It amplifies the low-pressure-measurement signal and provides faster response, especially with long transmission lines.

Materials of Construction

Brass, stainless steel, and neoprene.

OPERATING CHARACTERISTICS

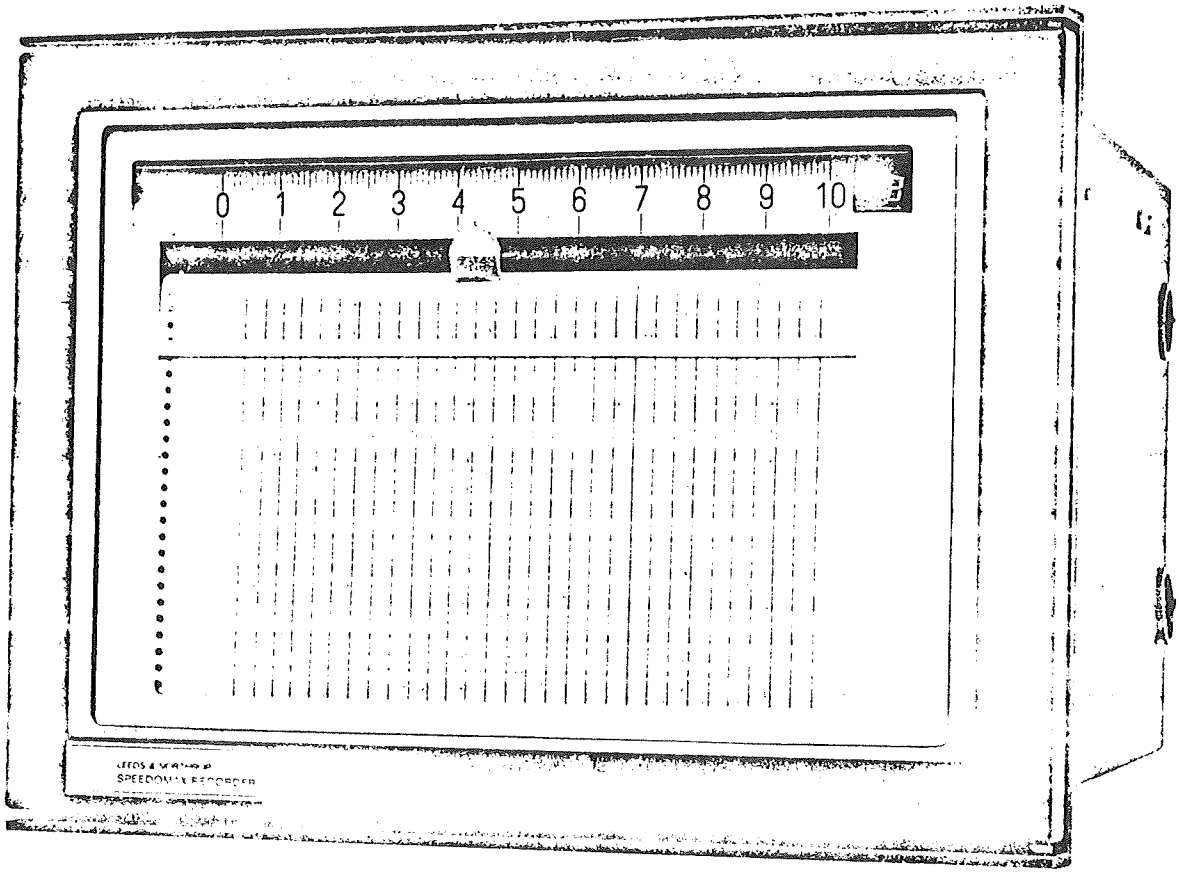
Supply pressure—	
Normal:	20 psi
Maximum:	60 psi
Minimum:	3 psi above maximum output
Maximum operating pressure:	50 psi for input and output
Maximum overload pressure:	100 psi at any connection
Minimum output pressure:	0.1 psi with 25 psi supply
Response level:	0.02 psi
Reproducibility of results:	within 0.5% of full scale
Ambient-temperature limits:	−40° to +180°F
Air consumption:	0.15 scfm, maximum at 20 psi supply
Accuracy of amplifying or reducing ratio:	within 1%
Flow capacity (25 psi supply; 9 psi output)	2.2 scfm
Zero adjustment	none†

† i.e.—The output of a 2:1 reducing relay is 1½—7½ psi for a 3-15 psi input

Printed in U.S.A., 11/70

Introducing a new generation of electronic chart recorders

SPEEDOMAX® 165 & 250 SERIES MULTIPOINT RECORDERS



- Two sizes available. Wide-scale, wide-chart Speedomax 250 has 250 mm calibrated chart width; intermediate size Speedomax 165 has 165 mm calibrated chart.
- 25% greater point handling capacity. Up to 30 points with the Model 250 as compared to the usual 24; up to 15 points with the Model 165, rather than 12.
- Unique programming panel for recording flexibility. Enables operator to select a variety of formats.
- Thermal chart marking system for better legibility, increased reliability. Thermal print head and thermal paper provide distinct advantages over ink systems.
- Illuminated display of point being measured. Large, bright LED readout of point number can be easily seen from a distance.
- Multiple circuits allow up to three preamplifiers—each with its own range card—to be mounted in the recorder for multi-range capability.
- Separate chart motor for each speed desired allows custom combinations of chart speeds.

LEEDS & NORTHRUP

Specifications

Speedomax 165 and 250 Series Multipoint specifications meet or exceed performance requirements of ANSI C39.4-1966 and safety requirements of ANSI C39.5-1974.

Models ..... Speedomax 165 Series Multipoint Recorder available from 2 to 15 points.
Speedomax 250 Series Multipoint Recorder available from 2 to 30 points.

Type..... Automatic null balancing recorder. Uses solid state electronics and dc servo motor system to effect balance.

Measuring Circuit..... DC potentiometer. Gain and damping is automatic for all spans and response time regardless of source resistance changes.

Measuring Circuit Current Source ..... Supplied by ac line, rectified and regulated by Zener diode circuit.

Ranges.....

Inputs	Minimum Span	Maximum Span
DC millivolts	1 mV	1000 mV
DC volts (by divider)	1V	100 V
Thermocouple	Ranges available for standard ISA thermocouple types. Reference junction compensation is automatic.	
Resistance thermometers	Spans from 2 to 500 ohms using a constant current measuring technique.	

Indicating Scale..... 165 Series: 165 mm (6-1/2" nominal) calibrated length.
250 Series: 250 mm (9-7/8" nominal) calibrated length.

Impedance..... Maximum Source: 1.0% preamp 2,500 Ω
0.25% preamp 10,000 Ω

Minimum Input at Maximum Unbalance:

Input Type	Instantaneous	100 msec	200 msec
1.0% preamp	2700 Ω	25,000 Ω	250,000 Ω
0.25% preamp	2700 Ω	25,000 Ω	5 MΩ

Accuracy ..... ±0.25% of span ±3.0 μV for total recorder (except those with the ±1.0% preamp circuit which have a ±1.0% overall accuracy) with a suppression ratio of 2 or less.
±0.25% + 0.1 (SR-2)% of span for suppression ratio greater than 2.
Thermocouple Circuits: add additional ±1/6°C (±1/3°F)
Thermohm Circuits: add additional ±0.1%

Dead Band ..... 0.1% of span.

Span Step-Response-Time Rating..... 5 seconds nominal full scale standard. 1 or 10 seconds available.

Time Per Point..... 5 seconds per point standard. Optional printing speeds are 1, 3, 10, 30 seconds or 1, 2, 3 minutes per point.

Chart..... Thermal sensitive, available in Metric or English time lines, printed in red.
165 Series: 165 mm (6-1/2" nominal) calibrated width; 219.8 mm (8.7" nominal) overall. Length is 36.5 meters (40 yd).
250 Series: 250 mm (9-7/8" nominal) calibrated width; 305 mm (12" nominal) overall. Length is 36.5 meters (40 yd).

Chart Drive ..... 165 Series: 1, 2, 3 or 4 speeds
250 Series: 1, 2, 3, 4 or 5 speeds

Chart Speeds..... From 1/4" per hour to 480 inches per hour or 3 cm per hour to 1200 cm per hour.

Ambient Temperature Limits RATED OPERATING: 15 C to 40 C (59 F to 104 F).
EXTREME OPERATING: –9 C to 50 C (15.8 F to 122 F).

Relative Humidity..... 10% to 90%.

Common Mode Rejection.... At power line frequency, 80 dB or 100 volts, whichever is less.

Normal Mode Rejection ..... Equal to or greater than 60 dB at power line frequency and above.

Power Requirements..... 120, 220, 240 volts, 50 or 60 Hz. Consumption, 40 VA.

Case ..... 165 Series: 13-1/2" (343 mm) W x 12-7/32" (310.4 mm) H x 14-3/4" (374.7 mm) D.
250 Series: 16-27/32" (427.8 mm) W x 12-7/32" (310.4 mm) H x 14-3/4" (374.7 mm) D.

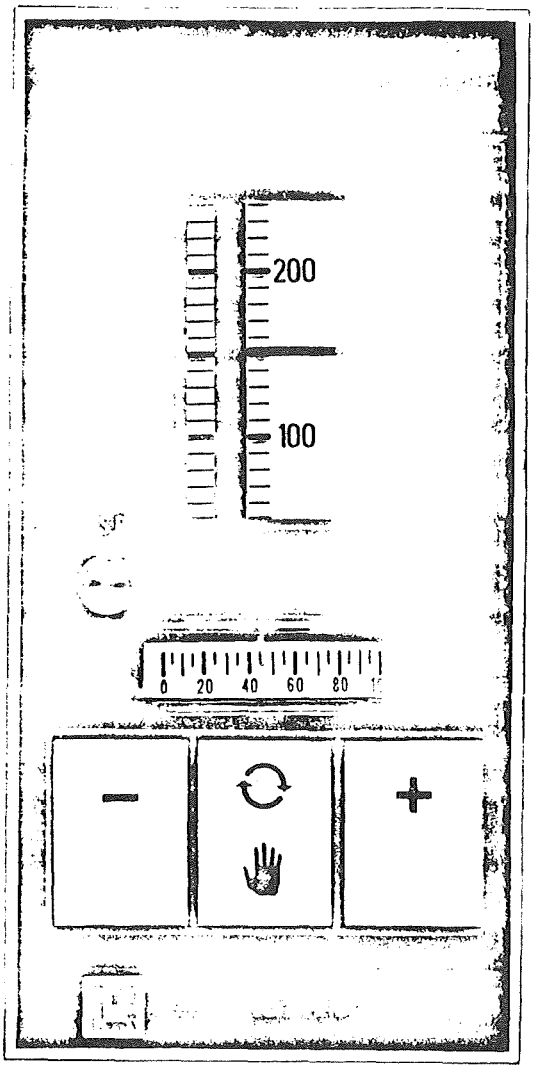
Weight..... 165 Series, approximately 42 lb (19 kg).
250 Series, approximately 50 lb (22.6 kg).

Case Color ..... Black

LEEDS & NORTHRUP *North Wales, Pa. 19454*

CENTRY® 440 and 441 Process Controllers with Expanded-Scale Set Point and LED Display

- **High-resolution 9-inch (229 mm) set-point tape, with solid-state LED indication of deviation and process variable**
- **4-20 mA and 1-5 V d-c inputs standard; direct thermocouple and millivolt inputs optional**
- **Current or triac-switching (P.A.T.) output**
- **Balanceless, bumpless transfer, automatic/manual control through full-size, illuminated pushbuttons**
- **Proportional action with manual or automatic reset, with options for rate, approach and lag adjustments**
- **Dedicated output meter reads drive-unit position for P.A.T., and with reversing switch, provides direct correlation between meter reading and valve position on current-output controllers**
- **Optional integral high and low deviation or process-variable alarms and signal lights**
- **Local terminal boards or cord sets**
- **24 V d-c or 120 V a-c power supply**
- **Single or multiple-unit panel mounting with gasketed dust-proof construction**
- **Manual "hold" receptacle provided as standard, for use with current-output controller**



To meet the need for reliable, economic electronic process control L&N's new Centry expanded-scale controller offers a choice of current or triac-switching (position-adjusting type) output.

The current-output controller holds a process variable at set point by adjusting its 4-20 mA control signal to meet demand: applied to a current/pneumatic converter, the signal will position a pneumatic actuator or valve; in electric heating applications, it will regulate electric power to a load through a suitable power package.

The triac-output controller holds a process variable on set point by switching "raise" or "lower" triacs as required, accurately positioning an electric drive unit, or a motor/pneumatic transducer, to open or close a valve in response to an error signal . . . offers inherent failsafe operation, since the valve is held in last position on power failure.

Designed for maximum operator convenience as well as high-density mounting, the controller features an expanded 9-inch set-point tape for excellent resolution. Deviation from set-point, in direction and magnitude, is instantly signalled by LED (light-emitting diode) lights above and below the green-index line, also readable against the tape as process-variable value.

A wide selection of control modes, alarms, signal lights and other integral options are available to meet the requirements of virtually every process-control application.

LEEDS & NORTHRUP

SPECIFICATIONS

PROCESS-VARIABLE INPUT SIGNAL

Standard: 1-5 V d-c into 1 megohm input impedance. Using external shunt resistor, 4-20 mA d-c into 250-ohm input impedance (other current-input ranges can be accommodated). Applies also to remote set-point signal or wild-variable signal (for ratio controller).

Optional: (a) Direct thermocouple non-isolated input, Type J, K, T, R, S, E or B. Span 10 mVmin., 100 mV max. Maximum suppression: negative, −10 mV; positive, 50% of span. Upscale failsafe is standard (field-convertible to downscale). (b) Direct millivolt non-isolated input. Span, 10 mV min., 100 mV max. Maximum suppression, ±25 mV. Thermocouple or millivolt input must be ungrounded.

OUTPUT

Current-Output Control: Parallel outputs, 4-20 mA d-c into 0-600 ohms load, and 1-5 V d-c into 1200 ohms (minimum) load. High and low output-current limits are adjustable, 12-21 mA and 0-12 mA.

Triac-Output Control: Solid-state output switching for drive-unit positioning through a pair of triacs rated at 5 mA to 1.0 A at 120 V, 60 Hz. (Controller provides 15 V d-c output for 1000-ohm drive-unit slidewire, to generate 0-15 V feedback signal.)

Output Reversal: Two-position switch on chassis selects direct or reverse control action.

Output Meter: Horizontal meter with 1⅝" (41 mm) scale, graduated 0-100% to indicate current output or drive-unit position. Current controller has output-meter reversing switch.

SET POINT

Setter: Set point is indicated and set by a movable calibrated tape, 229 mm long by 22 mm wide (9" × ⅞"), positioned by a knob on the front panel in reference to a green index line. Deviation is indicated by 8 LED lights (4 above and 4 below the index line) at precisely ±1%, ±2%, ±4% and ±8% of electrical span. Position of light also reads on the tape as the value of the process variable.

Calibrated Accuracy: ±0.5% F.S. at reference conditions (25 C, 40% R.H.).

Potentiometer Resolution: 0.15% F.S.

Temperature Coefficient: ±0.25% F.S. for 40 C (72 F) change from reference conditions.

Optional Ramp Adjustment: 0.4 to 4 hours for full-scale set-point change for slow ramp; 3 to 30 seconds for fast ramp. Ramp circuit may be field-disabled.

THERMOCOUPLE AND MILLIVOLT INPUT

Low-Level Amplifier: Converts mV input signal to 0-4 V process-variable signal. Linearity: ±0.1% F.S. Temperature Shift: 5 μV/°C maximum, referred to input (process-variable signal shifts ±1.25% maximum for ±25 C change from 25 C reference for 10 mV span, ±0.13% for 100 mV span). Normal Mode Interference: 60-Hz noise equal to 100% of input span between input leads will shift process-variable signal less than 1%.

Reference Junction Compensation: Thermocouple compensated within ±0.25°/°C (plus thermocouple non-linearity) for ±25 C change from 25 C reference.

CONTROL MODES

(a) Proportional plus Manual Reset, or
(b) Proportional plus Automatic Reset plus Lag, or
(c) Proportional plus Automatic Reset plus Rate.
Automatic Approach, to minimize overshoot above set point in process start-up or batch processes, is also optional.

CONTROL MODE RANGE ADJUSTMENTS

Proportional Gain: 0.05 to 10 (10 to 2000% P.B.), continuously adjustable. With Gain/Reset Switch on "Gain X10", range is 0.5 to 100 (1.0 to 200% P.B.).

Automatic Reset (Integral): 0.02 to 10.0 repeats per minute, 12-position switch. With Gain/Reset Switch on "Reset X10", range is 0.2 to 100 repeats per minute.

Manual Reset: 0 to 100% of output, continuously adjustable, for proportional gain of 1. (Proportional Gain, 0.5 to 100, with no Gain/Reset Switch).

Rate (Derivative): 0 to 8 minutes, continuously adjustable. Field convertible to 0-48 seconds lag adjustment.

Lag (Inverse Rate): 0 to 35 seconds, continuously adjustable.

Approach: 0 to 25% below set point, continuously adjustable. 0-100 dial. 0 to 250% on "Reset × 10".

Drive-Unit Sensitivity (Triac-Output Controller): Eliminates drive-unit hunting without loss of reset sensitivity.

AUTO/MANUAL TRANSFER

Auto-Manual Rocker Switch: Full-size switch provides bumpless, balanceless transfer in both directions; switch is illuminated in "Auto" mode.

Current-Output Manual Control: Provided by two 2-speed "−" and "+" pushbuttons (6 or 50 seconds for full-scale change). Manual output stability, 0.1% per hour maximum drift at reference conditions (25 C, 40% R.H.).

Triac-Output Manual Control: Provided by two "−" and "+" pushbuttons. Manual output is directly from a-c line, independent of triacs. (On automatic control, pushbutton lights when corresponding triac is energized.)

OPERATING LIMITS

Temperature Limits: 0 to 60 C (32 to 140 F).

Relative Humidity Limits: 90% maximum at temperatures up to 40 C (104 F).

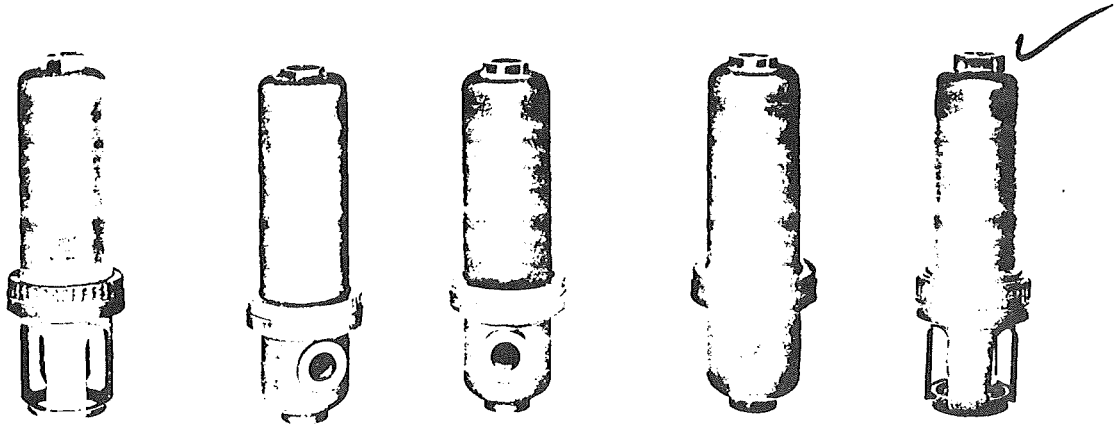
Vibration Limits: 0.2 g maximum at 0 to 60 cps per ANSI C39.4.

SERVICE FEATURES

Test-Point Terminals: Readily accessible for

7773 Multi-purpose Electrode And Transmitter Mountings For Industrial pH and Redox Measurements

D2.1119-DS



- **Corrosion-resistant universal mounting**
- **Low cost—high accuracy and reliability**
- **Minimum maintenance**
- **Versatile and flexible**
- **Non-hazardous in pressurized applications**
- **Stable, reliable preamplifier system**
- **Factory-Mutual approved for Class I, Groups C and D, Division 1 when used with 7073-21 or -23 Receiver**
- **Factory-Mutual approved for Class I, Groups C and D, Division 2 when used with 7073-11 or -13 Receiver**
- **Usable at 100% relative humidity**
- **Operates at high pressure and temperature**
- **Optional lightning protection**
- **Optional ultrasonic electrode cleaning**

These are only some of the advantages of L&N's 7773 Multi-purpose Mountings, available with plastic- or glass-body fouling-resistant reference electrodes and pH or redox electrodes, or a Meredian™ combination pH measuring/reference electrode, an automatic temperature compensator (if required) and a transmitter (preamplifier). Designed to measure industrial pH, Redox (ORP) or specific-ion concentrations in just about any type of flow or immersion application, this mounting is made of either 316 stainless steel, glass-fiber reinforced polypropylene or Ryton*, for use in even very corrosive solutions at pressures up to 150 psig and temperatures up to 266 F (130 C). The 7773 is available in seven configurations; change from flow- to immersion-type mounting or vice versa requires substitutions of only one part.

**Tradename of Phillips Petroleum Co. for new polyphenylene sulfide resin.*

The 7773 Mounting is available with transmitter, electrodes and automatic temperature compensator options (see "Ordering Instructions" for details). When supplied with a transmitter, the mounting can be used with a 7073, 7075 or 7076 Receiver or Speedomax® H or W Recorders (circuit 155) or Speedomax M Recorder (circuit 17). When supplied without a transmitter, the mounting can be used with 7070 Series pH and Redox Monitors or with Speedomax H or W Recorders (circuit 992).

The transmitter is an environmentally sealed (encapsulated), high-impedance preamplifier which, when specified, is mounted within the 7773 Mounting. The measuring and reference electrodes and optional automatic temperature compensator are directly connected to the preamplifier. A unique guarded circuit protects the input and provides a thousand-fold decrease in sensitivity to electrical leakage currents. The "guarded" transmitter conditions and amplifies the electrode signal locally. The elevated low-impedance signal can then be sent over ordinary unshielded wire to L&N's 7073, 7075 or 7076 Receiver or Speedomax H, M or W recorder. The preamplifier assures stability and reliability. The use of ordinary unshielded lead-wire provides low installation cost and reduced maintenance.

With this preamplifier, signals can be transmitted in excess of three miles with no decrease in accuracy when manual temperature compensation is used. For applications requiring automatic temperature compensation, signals can be transmitted over distances of 1000 feet or more.

System 95% response is 0.5 second or 3 time constants and is independent of distance. The transmitter system has high immunity to ground loop noise and spurious RF signals. Grounded or ungrounded solutions can be measured and no solution ground is required. Where the housing is in a location subject to a high incidence of lightning strikes, an option is available which provides maximum protection to the transmitter by dissipating surge currents through the electrodes.

Speedomax* M Mark III Recorder

C0.6213-DS

The Speedomax M Mark III Recorder is a d-c servo-potentiometer type of miniature instrument offered by L&N to continuously indicate and record the value of a measured variable. Equipped with a 4-inch calibrated scale providing horizontal indication, it is available for one-, two- or three-channel recording, and can be used in conjunction with a variety of transmitters having current or voltage outputs. The Mark III M can measure current spans from 100 microamperes to 100 milliamperes, and voltage spans from 50 mV to 5 volts. A unique feature is the ability to field change to any voltage span between these limits. Spans up to 200 Volts d-c can be furnished through the use of a voltage divider.

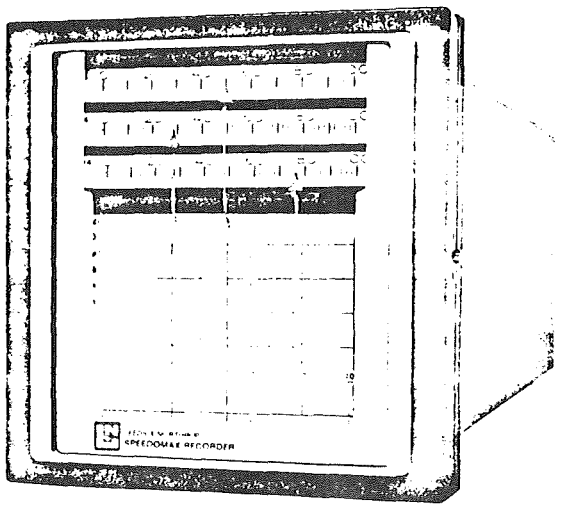
The 4-inch calibrated strip-chart is rectilinear and vertically driven at a standard chart speed of ½, 1, 2, 3, 6, 15, 30, 60, 120, 240 or 360 inches per hour. It feeds from a 60-foot supply roll, sufficient for 30 days of operation at a chart speed of 1 inch per hour. Distance to end of chart is continuously indicated on each roll for the last 6 feet (3 days) of operation. One of several faster speeds is optionally available as a second speed on a two-speed chart-drive.

AVAILABLE MILLIVOLT SPANS—Available standard circuits provide the Speedomax M Mark III with one, two or three low-level preamplifiers, adding millivolt capability to the recorder. With these circuits, the Mark III will accept temperature-compensated thermocouple inputs or direct millivolt inputs with spans from 1 to 100 millivolts.

The preamplifier(s) bring added flexibility to the recorder, permitting combinations of both high-level and millivolt channels on one compact instrument.

DIRECT pH AND CONDUCTIVITY MEASUREMENTS—The Speedomax M Mark III Recorder can be provided for the measurement of pH, using an L&N 7773- or 7779- series pH electrode mounting with an integral transmitter-amplifier. (For details, see Data Sheet C2.1021-DS). The recorder is also available for direct measurement of electrolytic conductivity, with range spans from 1 to 1000 μmhos (cell constants from 0.01 to 10). For maximum versatility, these circuits can be combined with other high-level, low-level or additional pH or conductivity circuits on two- and three-pen instruments.

ALARM CONTACTS—Either one, two, three or four SPDT (or SPST) contacts, rated at 1 ampere on 120 V a-c and adjustable over 100% of the recorder span can be provided on each channel.



Features

Mark III design features have been developed to provide many user benefits and advantages.

1. Application versatility is one of the outstanding features of this recorder—a wide choice of current and voltage input spans gives great freedom in using transmitted current and voltage signals, and/or direct millivolt signals (when used with optional preamplifier).

2. All channels are completely independent, allowing the specification of any combination of standard circuits and ranges.

3. Zero and span adjustments facilitate its use as a trend recorder. Overlapping records can be separated on a chart to display distinct trends of two or three different variables.

4. Recorder design has the latest state-of-the-art electronic circuits, solid-state components, and conductive plastic slidewire, assuring long in-service dependability and high accuracy.

5. Simplified chart replacement and large ink supply combine to reduce service time and frequency.

6. Combining pen, pointer and slidewire contactor into an integral unit assures perfect alignment and accurate recording of measured variables.

7. Simple and easy maintenance results from minimized stock of spare parts, because units such as the amplifier cards, balancing motors, pen assembly and reservoirs are interchangeable.

Application Versatility

The Mark III Recorder is the ideal instrument for measuring and recording a multitude of variables in research labs and pilot plants, in electric power generation, and in numerous processing industries, such as chemical, cement, metals, plastics, etc. The compact Mark III is especially advantageous in applications where panel space is at a premium and where minimum capital outlay is essential, at no sacrifice of performance.

Some of the variables which can be measured and recorded (and controlled if desired) include temperature, volts, millivolts, current, pressure, flow, pH, redox, percent oxygen, wind direction and velocity, etc.

Additional flexibility is made possible since the recorder can be provided with one-, two-, or three-pen recording of input signals from the same or different types of primary elements over the same or different ranges. Contact an L&N representative to help you select the optimum combination to suit your particular needs.

SPECIFICATIONS

Specifications meet or exceed the requirements of ANSI Spec. C39.4.

Type	Single-channel (one-pen), two-channel (two-pen) or three-channel (three-pen) recorders with individual scales for each pen. Continuous line record.	
Recording Channel	**HIGH-LEVEL CHANNEL**	**OPTIONAL MILLIVOLT CHANNEL**
Measuring Circuit	D-c potentiometer. Current is supplied from a-c line, reference voltage is Zener-regulated.	D-c potentiometer. Input filter, a-c amplifier and demodulator are on plug-in circuit cards. Preamplifier has fixed gain of 50.
Input Current	0 to 4 milliamperes 1 to 5 milliamperes 0 to 16 milliamperes 4 to 20 milliamperes 0 to 40 milliamperes 10 to 50 milliamperes −20 to 0 to 20 milliamperes Any specified span between 0.1 mA and 100 mA.	
Input Voltage	Spans between 0.05 and 5 volts. Any specified voltage over 5 volts, up to 200 volts.	Spans between 1 and 100 millivolts. Thermocouple spans include automatic reference junction compensation. Upscale or downscale thermocouple break protection provided.
Zero Adjustment	Continually adjustable over ±100% of selected span.	
Accuracy	±0.5% of span within ambient temperature limits of 60 to 105 F.	±0.5% or 10μV, whichever is greater, plus an additional 1μV/°C for ambient conditions other than 25 C.
Dead Band	0.25% of span at 60 to 105 F.	
Scale	4 inches long, calibrated in terms of variable.	
Chart	4-inch calibrated width; rectilinear coordinates; 60 feet long.	
Chart Speed	½, 1, 2, 3, 6, 15, 30, 60, 120, 240, 360 inches per hour. Dual speeds using ½, 1, 2, 3 or 6 inches per hour (slow speed) and 6, 15, 30, 60, 120, 240, 360 inches per hour also available.	
Span Step-Response-Time Rating	Less than 1 second for 4 inch pen travel.	
Power Supply	120 volts, 50/60 Hz, for rated accuracy.	
Power Consumption	4.5 volt-amperes for chart drive; 7.5 volt-amperes per channel maximum.	
Input Impedance	Greater than 5 megohms for spans less than or equal to 5 Volts; 1 megohm for spans greater than 5 Volts.	Greater than 500,000 ohms.
External-Circuit Resistance Rating	up to 25,000 ohms	up to 5,000 ohms
Physical Dimensions	Metal case 6" wide x 6" high (152 x 152 mm) with a front flange 7" wide x 7" high (178 x 178 mm). For 1-pen recorder, case is 13" (330 mm) long. For 2-pen recorder, 17" (432 mm) long (add 2" when low level or conductivity circuits are required). For 3-pen, 19" (483 mm) long (add 4" when low level or conductivity circuits are required).	
Optional Features	24-hour reroll feature; air purge; special door and bezel color; legend behind glass in door; identification labels at front and rear of case; customer-specified voltage or current inputs; "Load Dispatcher's" scale; angle mounting; alarm contacts; carrying handle; feet and line cord; fiber tip pens; event markers.	

L&N 8784-Series Compacted-Ceramic Insulated Thermocouples

D1.1118-DS

8784 Assembly with Miniature Head

- **Small size, fast response**
- **Long life, with minimum long-term calibration drift**
- **Excellent high-temperature insulation**
- **Single or dual elements**
- **Choice of thermocouples — E, J, K, T or S — with exposed, grounded or ungrounded junctions**
- **Wide variety of sheath materials and sizes**
- **Choice of miniature or Universal terminal heads, Quick-Disconnect terminals or integral leadwire extensions**
- **Ordering complete assemblies and replacement elements simplified by catalog numbering**

Compacted-ceramic thermocouple assemblies consist of single- or dual-element thermocouple wires, "hard-packed" magnesium-oxide insulation and an Inconel or stainless-steel sheath in one rigid, compact unit. They offer the advantages of small size, fast response and longer life than wire-type thermocouples. For a given wire size, the time/temperature effect on thermal/emf stability is less for compacted-ceramic insulated thermocouples than for standard wire-type elements.

These assemblies can be used at a maximum external pressure of 50,000 psi at temperatures up to 1200 F; can be bent on an inside radius equal to the sheath diameter, without rupture or loss of insulation; can be supplied in integral lengths as long as 40 feet. (Horizontally-mounted assemblies longer than 36" should be supported.)

The time constant (the time required for an element to respond to 63.2% of a step-change in temperature) is a function of wire size, and the values listed below are for a grounded junction.

Sheath Diameter	Wire Size	Time Constant
1/16"	30 AWG	0.25 sec.
1/8"	24 AWG	0.50 sec.
3/16"	20 AWG	1.00 sec.
1/4"	18 AWG	1.70 sec.
5/16"	16 AWG	2.00 sec.

THERMOCOUPLE TYPES

Type J (iron-constantan) thermocouples are specified for general use up to 1400 F. Featuring high and fairly uniform sensitivity in millivolts/degree change, and excellent service life, Type J is the most widely used of all industrial thermocouples.

Type K (nickel, chromium-nickel, aluminum) is most commonly used over the high-temperature range of 1400 to 2300 F (limited to 2100 F by the sheath materials available).

Type E (nickel, chromium-constantan) provides the highest millivolt/degree output, for maximum sensitivity — makes this thermocouple especially useful (up to 1600 F) for short ranges or differential-temperature measurements. (As an option, Type E elements can be supplied with "premium-grade accuracy" — see "Limits of Error", below.)

Type T (copper-constantan) is applicable below 600 F, and is highly stable at sub-zero temperatures, with a high conformity to published calibration data.

Type S (platinum, 10% rhodium-platinum), IPTS 68 calibration, is used for high-accuracy, high-temperature applications, here limited by the 2100 F restriction on the 3/16" OD Inconel 600 sheath.

LIMITS OF ERROR

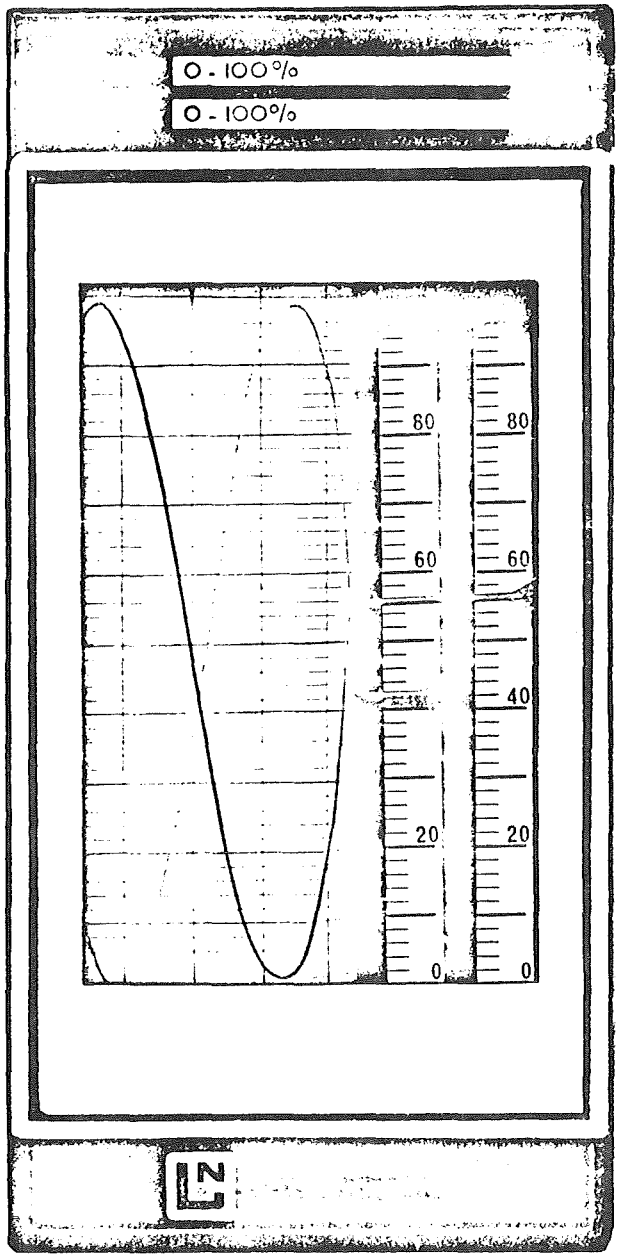
8784-Series Thermocouples are supplied to meet the following limits of error, referenced to IPTS 68.

ANSI	Thermocouple Type	Temperature Range*	Limits of Error	
			Standard	Premium Grade**
J	Iron-Constantan	−100 to +800 F 800 to 1400 F	±4 F ±½%	— —
K	Nickel, Chromium-Nickel, Aluminum	32 to 530 F 530 to 2100 F	±4 F ±¾%	— —
E	Nickel, Chromium-Constantan	32 to 600 F 600 to 1600 F	±3 F ±½%	±2 F ±⅜%
T	Copper-Constantan	−150 to −75 F −75 to +200 F 200 to 700 F	±2% ±1½ F ±¾%	— — —
S	Platinum, 10% Rhodium-Platinum	0 to 1000 F 1000 to 2100 F	±2.5 F ±0.25%	— —

*Upper limit for Types K and S is restricted by sheath material available.
**Type E can be specified for "premium-grade accuracy", see "Suffix H: Options" in the ordering instructions
When expressed as a percentage, the limit of error is a percentage of the temperature reading, not of the range.

Speedomax® 430-Series One, Two and Three-pen Trend Recorder

C0.6241-DS



Recorder shown full size; one-, two- and three-pen versions available.

- One-, two- or three-channel recording of +1 to +5 V dc input signals or any standard current span
- Null-balance potentiometer circuits, all-solid-state
- Vertical scale for each channel, 100 mm (nominal 4") length, calibrated as specified
- Strip chart with rectilinear coordinates, 100 mm (nominal 4") calibrated width, 16 m (52') per roll
- Continuous-line records from nylon-tip pens, with long-life ink cartridges—600 m (2000') of inked record
- Four-speed mechanical changer with speeds of 2, 12 cm/hr and 2, 12 cm/min.
- 50 mm (2") of past record visible on one-pen recorder; 35 mm (1-1/2") on two-pen; 23 mm (1") on three-pen. Additional 150 mm (6") is exposed by partially withdrawing chassis from case
- Zero adjustment, ±50% of span, permits displacement of overlapping multi-pen records
- Accuracy, ±0.5% of span; deadband, 0.2% of span; span step-response time, 3 seconds
- Operates on 120, 220 or 240 Volts a-c, 50 or 60 Hz or −15 to +15 V dc standby power

The 430-series trend recorder is a servo-potentiometer type of miniature panel-mounted instrument which continuously indicates and records the value of a measured variable. It is designed to complement the Electromax® III & IV range of universal controllers (Models 434, 435, 436) or conform to DIN dimensions for panel cutout (Models 431, 432, 433). Equipped with 100 mm (nominal 4") calibrated scale providing vertical indication, it is available for one-, two-, or three-pen recording and can be used in conjunction with a variety of transmitters having compatible current or voltage outputs—with current spans of 4-50 milliamperes or spans of 4 volts.

The 100 mm (4") calibrated strip chart is rectilinear and horizontally driven. It feeds from a 16 m (52') supply roll sufficient for 33 days of operation at a chart speed of 2 cm per hour. The distance to the end of the chart is continuously indicated on each roll for the last 1.5 m (5') of operation.

A four-speed gear box with an integral mechanical speed change dial provides speeds of 2, 12 cm per hour and 2, 12 cm per minute. This feature is particularly useful in optimizing control settings in fast acting loops such as flow.

The scale range and channel identity appears on the plastic strip housed in the door above the window.

Features

1. Operational versatility is one of the outstanding features of this recorder. As well as operating from ac power sources, the measuring circuit will also operate from an external 15-0-15 volts dc stand-by power supply. Under the latter, however, the standard a-c chart motor becomes inactive.

   In addition, the recorder can be ordered for operation on 24 V. dc power. When this feature is specified, both measuring circuit and chart drive are powered by built-in inverters.

2. As many as three separate high-level circuits can be provided, permitting one-, two- or three-pen recording of signals from the same or different types of primary elements or transmitters over the same or different ranges. However, when instruments operate from dc stand-by supplies they do not have isolation between channels, as a common dc power supply is used.
3. On a single-pen instrument the right-hand scale is used and the position of the chart roller is moved to assure that the maximum amount of chart is visible from the front of the instrument, i.e. 50 mm (2"). For the two-pen recorder, visible chart is 35 mm (1-1/2") and for the three-pen recorder, 23 mm (1"). Approximately 150 mm (6") of past record is visible by partially withdrawing the chassis.
4. The zero adjustment permits the separation of multi-pen records which would otherwise overlap.
5. Recorder design has the latest state-of-the-art electronic circuits and solid-state components.
6. Chart and ink replacement is simplified by separate swing-out servo-pen frames for each channel. Ink supplies for each recording pen are of the disposable cartridge type with a capacity of approximately 600 m (2000') of continuous record. Colors are red, blue and green. Pen tips are of porous nylon and can be easily replaced. A common "freeze" switch prevents pen and chart activity when changing ink or paper supplies.
7. Combining pen, pointer and slidewire contact into an integral unit provides permanent alignment and assures accurate recording of measured variables.
8. The recorder can be mounted at an inclined angle with the rear of the case down 45° from the horizontal.
9. Parts such as the amplifier cards, balancing motors, scales and ink reservoirs are interchangeable. This simplifies maintenance and results in minimum stocks of spare parts.

SPECIFICATIONS

Type—Single-channel (one-pen), two-channel (two-pen) or three-channel (three-pen) recorders. Continuous line record.

Measuring Circuit—DC Potentiometer. Current is supplied from a-c line, reference voltage is Zener-regulated. Complete signal isolation between channels when on a-c power supply. When the stand-by power feature is supplied, the negative side of all inputs are commoned.

Input Current	0–4 mA dc into 1000 ohms
	1–5 mA dc into 1000 ohms
	0–16 mA dc into 250 ohms
	4–20 mA dc into 250 ohms
	0–40 mA dc into 100 ohms
	10–50 mA dc into 100 ohms
	-20–+20 mA dc into 100 ohms
Input Voltage	1–5 V dc into 500,000 ohms
	0–4 V dc into 500,000 ohms
	-2–+2 V dc into 500,000 ohms

Zero Adjustment—±50% of span.

Accuracy—±0.5% of span.

Dead Band—0.2% of span.

Input Impedance—500 K ohms.

Operating Temperature—Nominal: 15 to 40 C (59 to 120 F) Extreme: –9 to 50 C (15 to 125 F)

Normal Mode Rejection—40 dB.

Common Mode Rejection—80 dB.

Scale—Vertical, 100 mm (nominal 4").

Chart—100 mm (nominal 4") rectilinear coordinates, length 16 m (52').

Chart Display—1 pen, 50 mm (2"), 2-pen, 35 mm (1-1/2"), 3-pen, 23 mm (1"). Additional 150 mm (6") of past record is visible by partially withdrawing chassis.

Chart Speed—Four-speed changer—2, 12 cm/hr and 2, 12 cm/min. Single speeds of 2, 3, 6 or 12 cm per hour are available on special order.

Span Step-Response-Time Rating—3 seconds nominal.

Power Supply—AC: 110/120/220/240 volts ±10%, 50 or 60 Hz. DC: -15–0–+15 volts, measuring circuit only. Also available for 24 volt dc operation of complete recorder.

Power Consumption—Single-pen + chart motor, 14 volt-amperes, Two-pen + chart motor, 17 volt-amperes. Three-pen + chart motor, 22 volt-amperes. 15-0-15 volts dc (chart motor inoperative), 3 watts per channel. Center tap current, 120 mA. AC chart motor, 3 volt amperes.

External-Circuit Resistance Rating—1000 ohm.

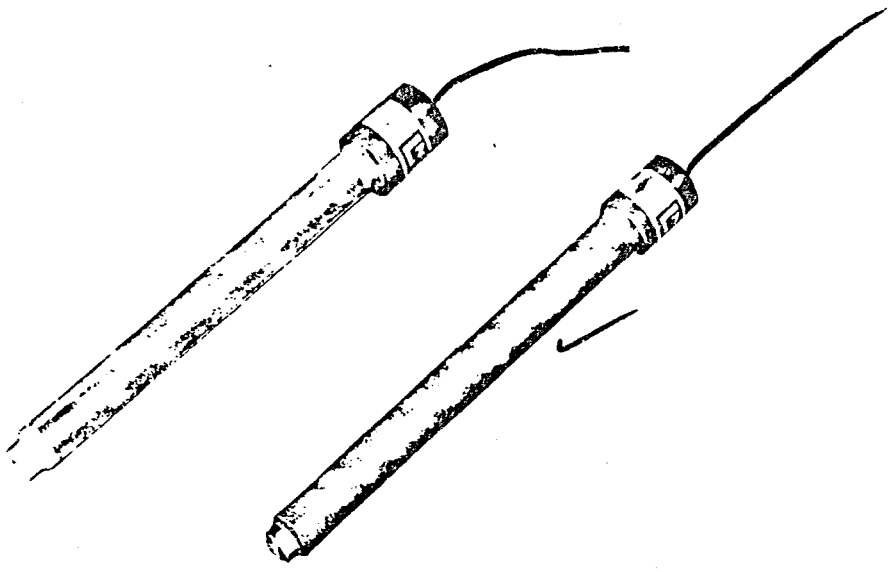
Mounting Position—Case horizontal or rear lowered – 45° max.

Physical Dimensions—Electromax Style Case: Sheet metal case and die cast door. Panel cut-out 76 mm wide x 165 mm high (3" x 6-1/2"). Front flange 89 mm wide x 178 mm high x 19 mm deep (3-1/2" x 7" x 3/4"). Length from rear of mounting face is 502 mm (19-3/4").

DIN Case:—Sheet metal DIN case and die cast door. Panel cutout 92 mm. wide x 138 mm. high (3-5/8" x 5-7/16"). Front flange 96 mm. wide x 144 mm. high x 14 mm. deep (3-13/16" x 5-11/16" x 9/16"). Length from rear of mounting face is 502 mm (19-3/4").

L&N Gel-Filled pH Reference Electrodes

D2.1118-IN



- **Extended operating life**
- **Reduced maintenance**
- **Can be left dry for extended periods**
- **Non-fouling diffusion-type junction**
- **Resists diffusion of heavy-metal ions**
- **Wide pressure and temperature application**
- **Epoxy-bodied or sterilizable glass construction**
- **Low cost**

These new fouling-resistant pH reference electrodes are permanently filled with a viscous gel which eliminates electrolyte maintenance for the life of the electrode

While applicable to general-purpose use, they are particularly advantageous in batch processes where the electrodes may be left dry for long periods, where high pressure and/or temperature cycling occurs, or where resistance to contamination by heavy-metal ions is required.

The plastic-bodied electrodes are virtually unbreakable, with an easily replaced porous-plug junction The glass-bodied electrodes, with a porous plug sealed into the tube, are resistant to solvents A sterilizable model, useable to 130 C (266 F), can be employed in fermenters and other processes involving periodic or sustained high temperatures.

The tables list (a) the specifications of the reference electrodes for use in 7773 and 7779 Mountings or 7758 Mountings, and (b) the electrode-option suffixes permitting these gel-filled reference electrodes to be ordered with new Mountings For a description of the 7773 Mountings, see Data Sheet D2.1119-DS; 7779, Data Sheet D2.1118-DS, 7758, Data Sheet D2.1121-DS.

LEEDS & NORTHRUP

GEL-FILLED FOULING-RESISTANT REFERENCE ELECTRODES

Used in Mounting	7773 and 7779		7758	
Electrode Part Number	117481	117484	117482	117483
Electrode Body	Epoxy	Glass	Epoxy	Glass
Electrode Tip	Replaceable Ceramic Plug	Non-Replaceable Ceramic Junction	Replaceable Ceramic Plug	Non-Replaceable Ceramic Junction
Temperature Limits	−5 to 110 C (23 to 230 F)	−5 to 130 C (23 to 266 F)*	−5 to 110 C (23 to 230 F)	−5 to 130 C (23 to 266 F)**
Process Pressure, Maximum	50 psig (3.5 kg/cm²) at 230 F (110 C); 150 psig (10.5 kg/cm²) at 140 F (60 C)	100 psig (7.03 kg/cm²) at 230 F (110 C); 150 psig (10.5 kg/cm²) at 176 F (80 C)	50 psig (3.5 kg/cm²) at 230 F (110 C); 150 psig (10.5 kg/cm²) at 140 F (60 C)	50 psig (3.5 kg/cm² at 266 F (130 C); 100 psig (7.03 kg/cm²) at 212 F (100 C)
Cable Length and Connection	7" (18 cm) Spade Lug	2' (61 cm) Spade Lug	12' (366 cm)	

Internal Element Ag-AgCl.
Electrolyte KCl gel.
Resistance 300 ohms, nominal.
Electrode Cap Plastic.
Electrode Dimensions $^{15}/_{32}$" O.D. by 5½" long (12 mm × 14 cm).

*Limited to a maximum temperature of 110 C (230 F) when used in a 7773 or 7779 Mounting.
**For use with a sterilizable pH electrode in a 7758 Pipeline Mounting; see Data Sheet D2.1122-DS.

ELECTRODE-OPTION SUFFIX FOR 7758, 7773, OR 7779 MOUNTING

Suffix Number†		Measuring Electrode
Epoxy	Glass	
21	31	Glass pH Measuring Electrode, −5 to 40 C
22	32	Glass pH Measuring Electrode, 10 to 80 C
23	33	Glass pH Measuring Electrode, 40 to 110 C
24	34	Gold Redox Electrode
25	35	Silver Redox Electrode
26	36	Platinum Redox Electrode
27	37	Antimony pH Electrode††
—	39†††	Sterilizable Glass pH Measuring Electrode, 20 to 130 C

†Specifies a combination of an epoxy-body or glass-body gel-filled reference electrode with the listed measuring electrode.
††For details, see Data Sheet D2.1120-DS
†††For 7758 Pipeline Mounting only; includes sterilizable glass-body reference electrode (117483). For details, see Data Sheet D2.1122-DS.

Sb Electrode interchangable w/ glass elect.

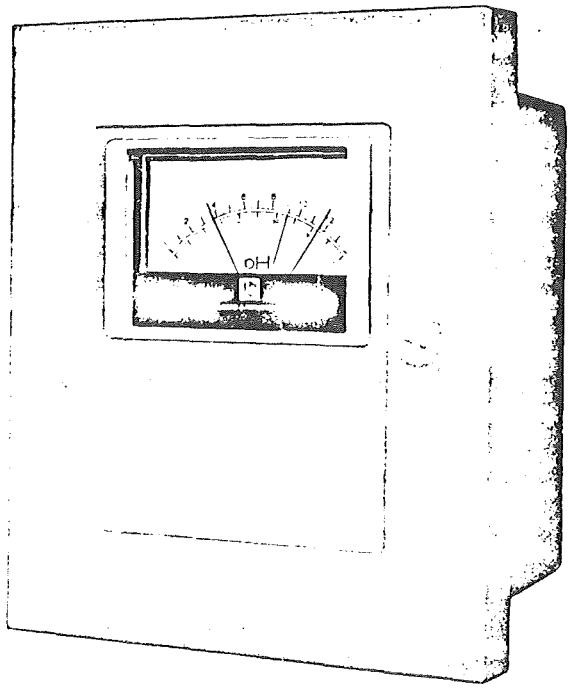
LEEDS & NORTHRUP North Wales, Pa. 19454

D2.1118-N 80 974

PRINTED IN U.S.A.

7073 Industrial pH and Redox Receiver

C2.1119-DS



- **Guarded electrode circuitry.**
- **Plug-in cards for isolated current or voltage outputs for grounded devices (true input-output isolation).**
- **Plug-in card with relay for alarms/controls.**
- **NEMA 4 case (can be mounted outdoors).**
- **Designed to meet OSHA (Occupational Safety and Health Act of 1970) requirements.**
- **Factory Mutual ⟨FM⟩ approved to meet Class I, Group C, Division 2 requirements; also available as FM-approved intrinsically safe Receiver when connected to L&N Electrode Mountings located in a Class I, Group C or D, Division 1 area.**

The 7073 Industrial pH/Redox Receiver is designed to measure and indicate acidity or alkalinity of a liquid or oxidation-reduction potential. Used with L&N's 7758, 7773, 7776 or 7758 Electrode Mounting equipped with a transmitter (preamplifier), this Receiver consists basically of a measuring circuit, voltage output circuit, and a 4-inch long scale for indicating measured pH or ORP. A "mother" board at the rear of the Receiver carries all the circuitry required to accommodate the input signal. Isolated Outputs and Alarms/Controls are available as separate plug-in options.

The 7073-11 and 7073-13 Receivers and an L&N Electrode Mounting with Transmitter are available for non-hazardous or Class I, Group C, Division 2 locations. The 7073-21 and 7073-23 Receivers are intrinsically safe when connected to L&N Electrode Mountings located in a Class I, Group C or D, Division 1 area (see next page).

The Transmitter—an environmentally sealed, high-impedance preamplifier—is located in (or adjacent to) the Electrode Mounting along with the measuring and reference electrodes and optional automatic temperature compensator. Electrodes and compensator are directly connected to the preamplifier. A unique guarded circuit protects the input and provides a thousandfold decrease in sensitivity to leakage currents. The "guarded" transmitter conditions and amplifies the electrode signal locally and transmits the elevated low-impedance signal to the Receiver over ordinary unshielded wire. Signals can be transmitted in excess of three miles with no decrease in accuracy when manual temperature compensation is used. For applications requiring automatic temperature compensation, signals can be transmitted over distances of 1,000 feet or more.

The transmitter-receiver system has high immunity to ground loop noise and spurious RF signals. Grounded or ungrounded solutions can be measured and no solution ground is required. The Receiver receives and measures the transmitted signal . . . indicates the measurement on the 4-inch scale . . . and if desired, will relay the measured signal to a recorder, controller or remote meter.

The Receiver is housed in a NEMA 4 case for use outdoors or in areas which are very wet or which are hosed down regularly.

SPECIFICATIONS

Catalog Number 7073-A-B-C-D-E-F-G; see Suffix List under "Ordering Instructions."

Ranges *pH:* 0 to 10, 0 to 14, 2 to 12, 4 to 14 (pH ranges are field selectable; only scale change is necessary). *Redox:* −500 to +500 mV, 0 to 1000 mV. Other ranges are available at an additional charge; for a complete list, see "Ordering Instructions."

Meter Scale 4 inches long with dual scale, black markings on yellow background. Upper scale has range markings to match range ordered; lower scale has 0 to 100 uniform divisions for Alarm/Control settings. Red pointers on meter face can be positioned to indicate limits.

Response Time 1 second for 99% of step change for typical system regardless of distance between receiver and transmitter.

Input Impedance Greater than 10^{13} ohms.

Stability *pH:* Less than 0.001 pH unit per week change (typical). *Redox:* Less than 0.06 mV per week change (typical).

Limit of Error *Output:* 0.1% of range (recorder and current outputs). *Meter:* 2% of range.

Input Bias Current Less than 10^{-12} amperes at 25°C (changes 10% per °C).

Temperature Coefficient *pH:* 0.001 pH unit per °C (typical). *Redox:* 0.06 mV per °C (typical).

Humidity Effect Negligible at relative humidity of 100%.

Ambient Temperature −40 to 140°F (−40 to 60°C).

Line Voltage Effect 0.001% per 1% change in line voltage.

Controls *Standardize:* marked −50 to 0 to +50 (range ±4 pH). *Temperature:* marked 0 to 100°C (pH only). *Measure Standby:* switch.

Temperature Compensation *Manual:* 0 to 100°C, supplied on all models, not useable on Redox instruments. *Automatic:* As specified per appropriate suffix for 7758, 7773, 7776 or 7779 Electrode Mounting for pH measurements only.

Case and Door Cast aluminum with a green, chemical resistant finish.

Case Dimensions *7073-11 and -13:* overall, 9⅛" (w) x 10¾" (h) x 7⅛" (d) (231 x 273 x 181 mm); behind front surface of a panel, 7⅛" (w) x 9¾" (h) x 5⅞" (d) (181 x 248 x 149 mm). *7073-21 and -23:* Same, except overall depth is 10¼" (260 mm), and depth behind front surface of panel is 9" (229 mm).

Weight *7073-11 and -13:* 13.5 lb (6.0 kg); *7073-21 and -23:* 21 lb (9.5 kg). Includes alarm and output options.

Mounting Hardware furnished to panel-, surface- or pipe-mount the Receiver.

Enclosure Classification NEMA 4, water tight, can be mounted outdoors.

Electrical Classification *7073-11 and -13:* For non-hazardous or Class I, Group C, Division 2 location. *7073-21 and -23:* Intrinsically safe; Receiver can be located in Class I, Group C, Division 2 location with pH or Redox Electrode Mountings in a Divison 1 area. Power Supply 100 to 132 V, 50-60 Hz, for all models. 200 to 240 V, or 220 to 264 V, 50-60 Hz, for 7073-11 or 7073-13 only.

Outputs *Recorder Output:* 0-1 volt standard regardless of output option selected. *Auxiliary Output:* Use for remote meter or up to 5 volts maximum, depending on drop resistor specified. *Isolated Output:* Optional plug-in card; circuit provides input-output electrical isolation permitting external connections to grounded circuits; all standard current outputs up to 50 mA can be provided on a single card. All ranges are field selectable; no field calibration is necessary. Ranges are 0 to 16, 4-20, 0 to 20, 5 to 25, 0-40 and 10 to 50 mA. Isolated voltages are also available between 0.16 and 10 V for external circuits that require up to 50 mA.

Not Isolated			
At Recorder Terminal	At Auxiliary Terminal		
	Voltage*	Resistor (0.1% Tol.)	
0-1 V	0 to 2 V 0-5 mV 0-10 mV	2500 ohms 5 ohms 10 ohms	
Isolated			
Current (mA)	Max. Load (Ohms)	Voltage**	Resistor (0.1% Tol.)
0-16 4-20 0-20 5-25 0-40 10-50	1000 800 800 640 300 240	0-1 V 0-2 V 0-5 V 0-10 V	52.5 ohms 115 ohms 303 ohms 615 ohms

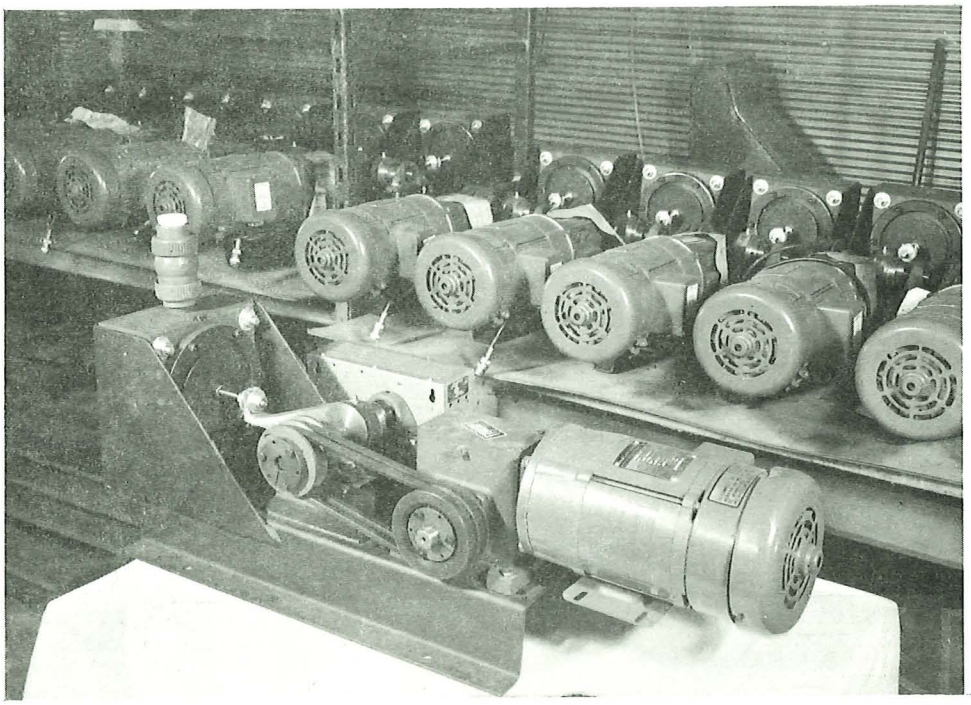
**Typical voltages with appropriate resistors based on $R = E10^4/10\text{-}E$ where E is desired full scale voltage.*

***Specify 0-16 mA isolated output (Suffix E—see "Ordering Instructions"). Typical voltages with appropriate resistances based on $R = E - 0.16/0.016$ where E is desired full scale voltage.*

Alarms and Controls Optional plug-in cards. Uses a plug-in relay connected in "fail-safe" mode with SPDT contacts rated at 120 V a-c, 3 amperes inductive, or 240 V a-c, 1.5 amperes inductive. The hysteresis (dead band) can be switched to 1, 3 or 5% of meter scale. The single card can be field-selected for "High" or "Low" operation, and two cards can be installed to give "High" and "Low", two "Highs" or two "Lows", connected in failsafe mode to close upon power failure. The set-point control is mounted on the plug-in card. Dial is calibrated 0 to 100 (50 divisions). For Class I, Group C, Div. 2 requirements, hermetically sealed relays are supplied.

3/4" HRI DIAPHRAGM PUMP
Suction-Pressure Type

Bulletin HRI P-001



APPLICATIONS

Positive displacement pump for metering up to 4 gpm of liquids and slurries in mineral, chemical and other industrial type pilot plants and small commercial installations. In general, handles slurries that will flow by gravity. Offers combined suction and pressure discharge characteristics to 30' TDH.

Ideal for metering thickener or hydroclassifier underflows, slurries, or liquids from agitated storage vessels, etc.

Corrosive or non-corrosive applications.

ADVANTAGES

1. Rugged. Designed to physically withstand unbalanced loads imposed during normal conditions of service.
2. Capacity adjustable over full range thru manual stroke adjustment and speed adjustable with optional D.C. variable speed motor drive (recommended for fluctuating conditions).
3. Meters slurries as well as liquids.
4. Standard for most applications with long wearing life ceramic ball valves, and replaceable Neoprene valve seats.
5. Available in variety of materials of construction to handle neutral or corrosive conditions.
6. Designed for minimum maintenance with easy access to all parts.
7. Many parts available from local supply houses.

(Dimensions and specifications on reverse side.)

HAZEN RESEARCH, INC. 4601 INDIANA STREET ▪ GOLDEN, COLORADO 80401 ▪ 303/279-4501
P. O. BOX 17928 ▪ TUCSON, ARIZONA 85731 ▪ 602/886-5545

THE DURIRON COMPANY, INC.

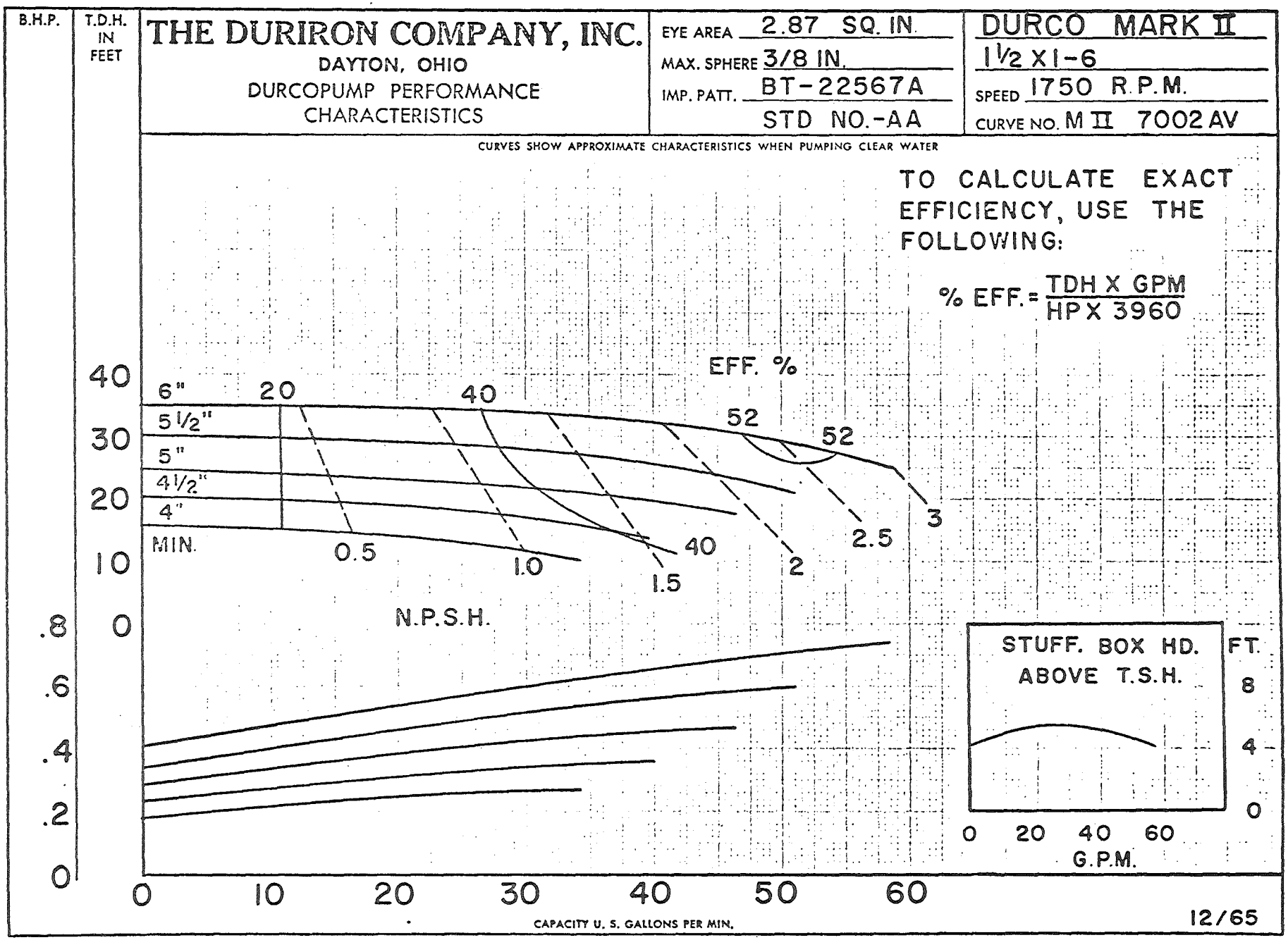
DAYTON, OHIO

DURCOPUMP PERFORMANCE CHARACTERISTICS

EYE AREA 2.87 SQ. IN.
MAX. SPHERE 3/8 IN.
IMP. PATT. BT-22567A
STD NO.-AA

DURCO MARK II
1½ X 1-6
SPEED 1750 R.P.M.
CURVE NO. M II 7002AV

CURVES SHOW APPROXIMATE CHARACTERISTICS WHEN PUMPING CLEAR WATER



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Form No. 62-2561

THE DURIRON COMPANY, INC.

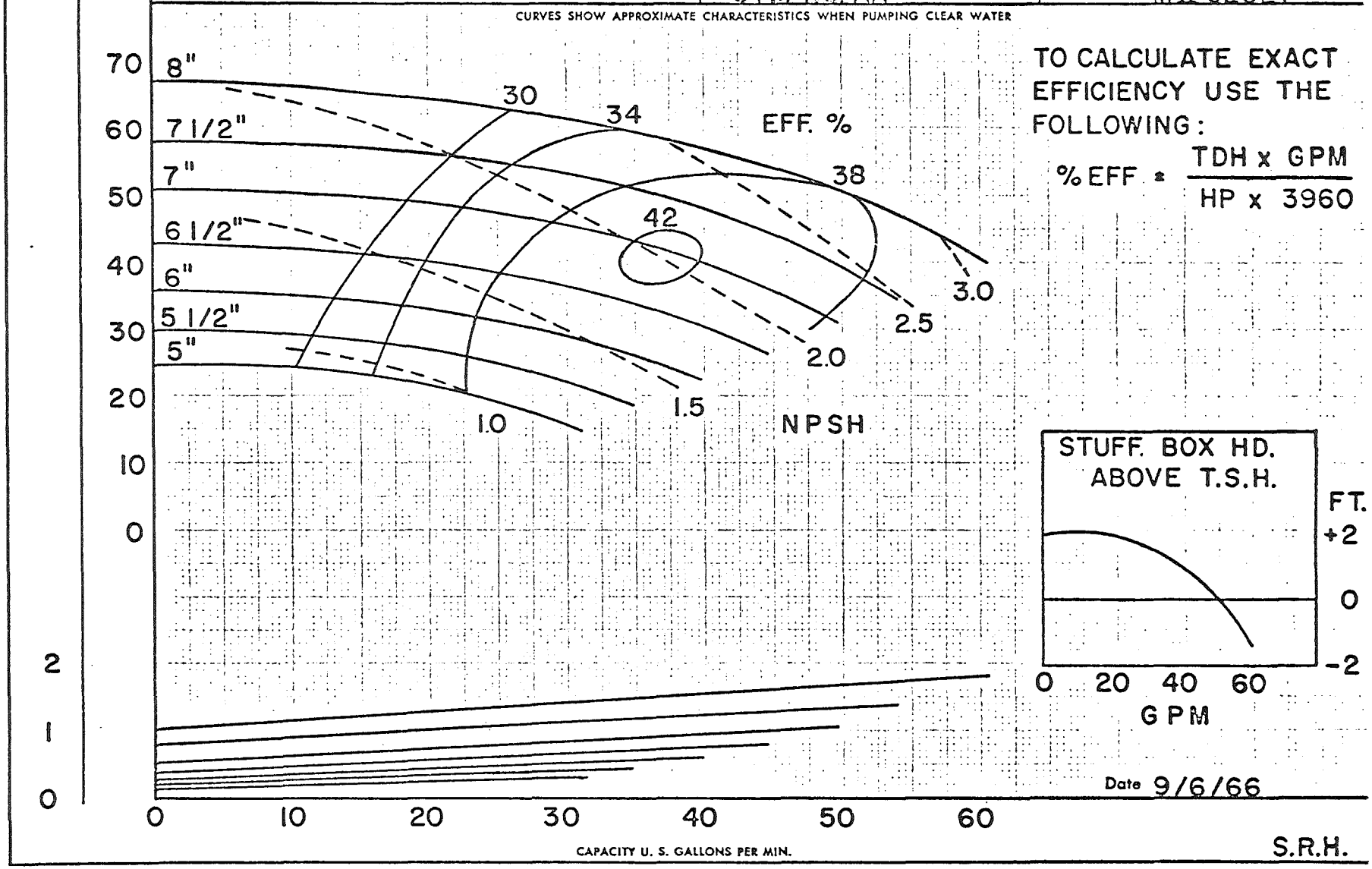
DAYTON, OHIO

DURCOPUMP PERFORMANCE CHARACTERISTICS

EYE AREA 2.18 SQ. IN.
MAX. SPHERE 5/16 IN.
IMP. PATT. CT29502A
STD. NO. AA

DURCO MARK II
1 1/2 x 1-8
SPEED 1750 RPM
CURVE NO. MII 8202V

CURVES SHOW APPROXIMATE CHARACTERISTICS WHEN PUMPING CLEAR WATER



TO CALCULATE EXACT EFFICIENCY USE THE FOLLOWING:

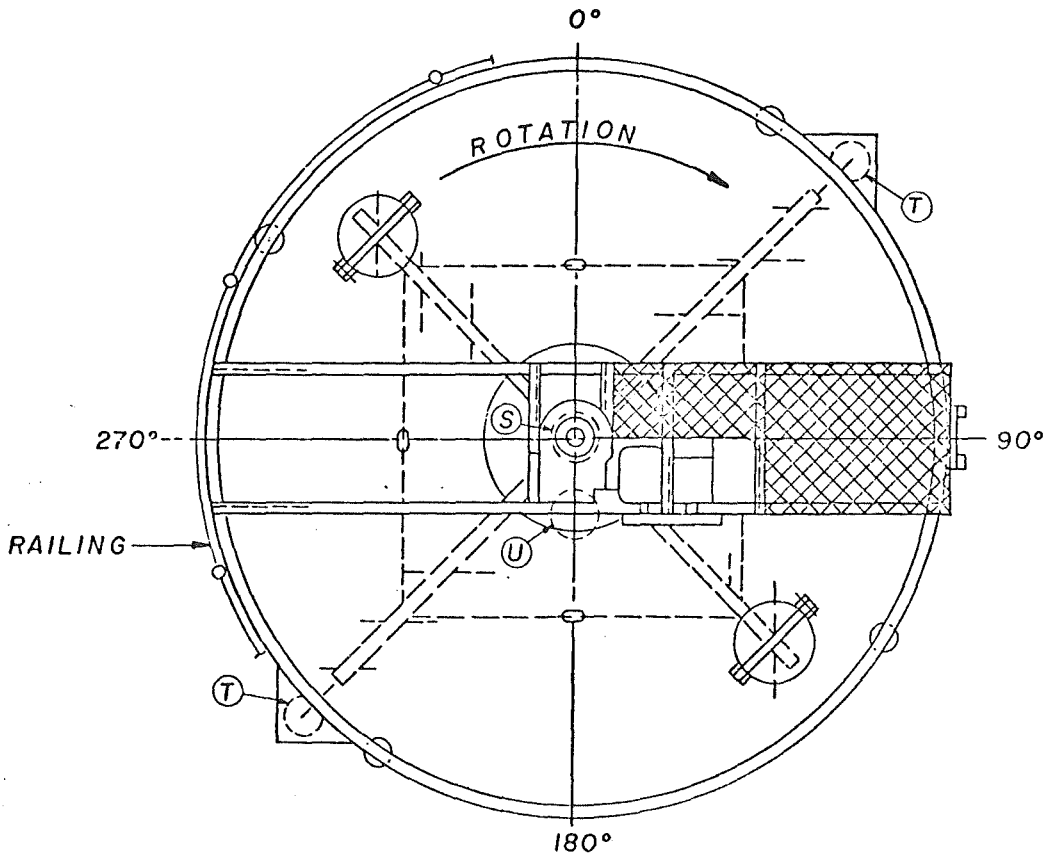
$$\%\,EFF = \frac{TDH \times GPM}{HP \times 3960}$$

Date 9/6/66

S.R.H.

Series

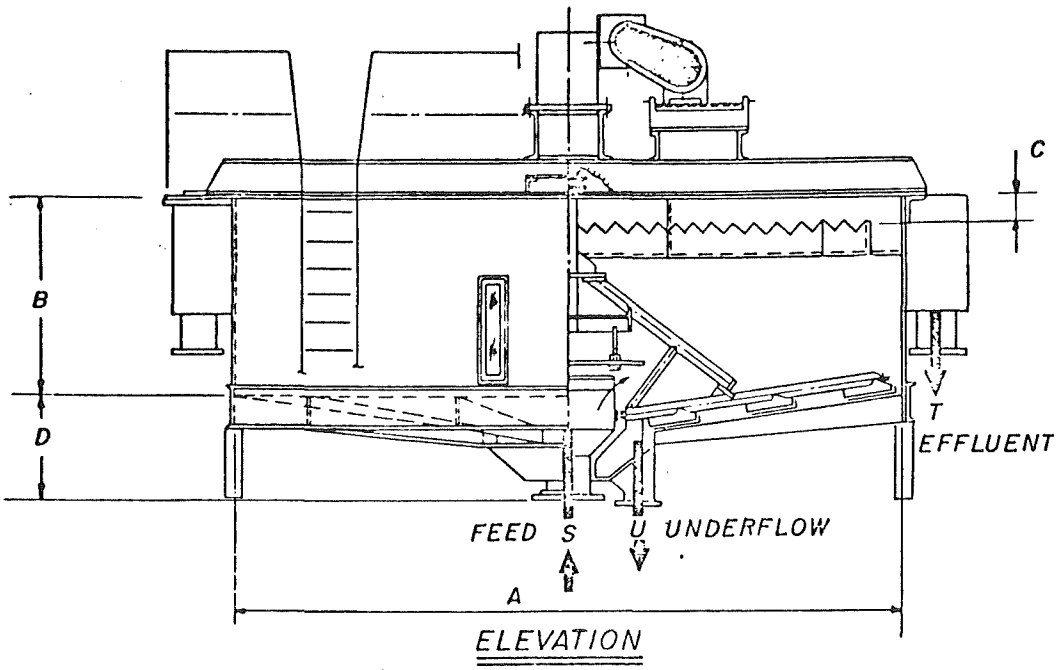
FEED | BOTTOM
[illegible] | COVERED
[illegible] | STRUCTURAL
[illegible] | NONE



PLAN

Enviro-Clear
A DIVISION OF Amstar CORPORATION

U.S. PATENT NO. 3523889



ELEVATION

ENVIRO-CLEAR MODEL NUMBER	PRINCIPAL DIMENSIONS				SUBJECT TO CHANGE DEPENDING ON FLOW AND SOLIDS FEED				FILLED WITH WATER TO OPER. LEVEL		AREA
					PIPE CONNECTIONS NOMINAL PIPE SIZE			MOTOR DRIVE	NO. OF SUPPT.	LOAD PER SUPPT.	
	A	B	C	D	S	T	U	H.P.	NO.	KIPS	SQ.FT.
B-2000	12'-6"	3'-10"	7 1/2"	2'-1"	10"	6"	4"	1 1/2	4	11	123
B-3000	15'-0"	4'-4"	7 1/2"	2'-3"	12"	8"	6"	2	4	17	177
B-4000	17'-0"	4'-10"	7 1/2"	2'-6"	14"	10"	8"	2	4	26	227

Dimensions and other data subject to change without notice. Do not use for construction.

Approximate dimensions–Sperry Filter Presses

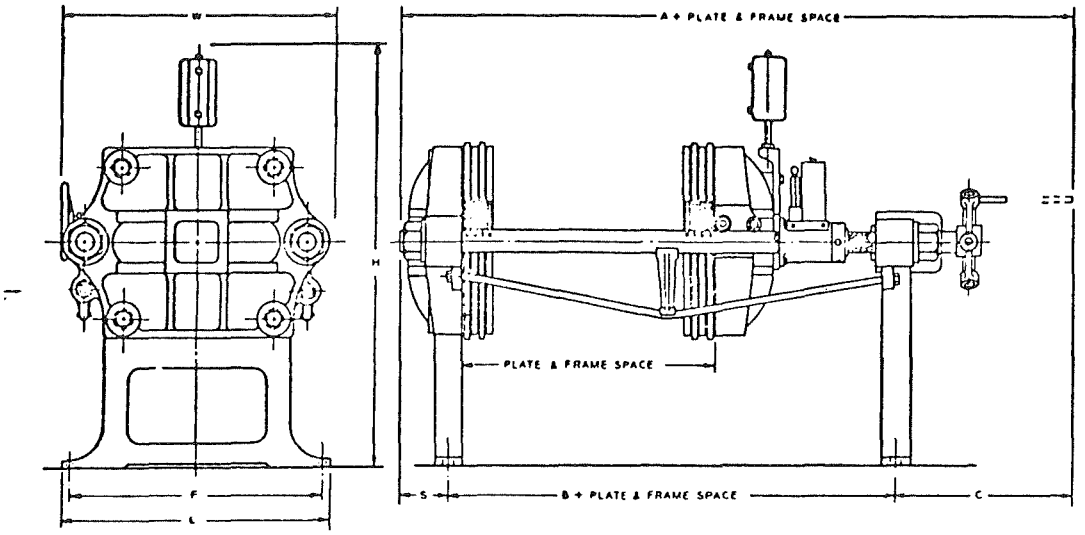


Plate Thickness — **All Dimensions in Inches**

SIZE OF PLATE	Iron & Alum.	Rubber Cov'd	Polypro-pylene	Stainless Steel	Plyplate	A	B	C	F	H	L	S	W
10"	5/8	1/8	1/2	1/2		31¾	13½	16¼	10½	17½	12	2	15
12"	¾	1	1	5/8	1½	34⅝	15⅝	16⅝	11	18	13	2⅜	17
18"	1	1¼	1	5/8	1½	63	28½	28¾	25	55	27½	5¾	30½
24"	1	1¼	1	¾	1½	66¼	34	25⅝	33½	63	35⅜	6⅝	39
30"	1	1¼	1	¾	1½	71¼	37¼	26⅛	40½	70	43	7⅛	49
32"	1	1¼		¾	1½	72¾	37¾	27½	40½	72	43	7½	53
36"	1⅛	1⅜	1 1/16	1	1½	84¾	42½	32½	45	76½	49	9¾	52
42"	1⅜	1⅜	1 3/16	1⅛	1½	92	48¾	32¾	24	85	42	10½	60
48"	1½	1¾	1¼	1 3/16	1½	92	48¾	32¾	24	89	48	10½	66

10" & 12" filter press dimensions are given for capstan closing devices. Dimensions are for Sperry "Handraulic" closing devices. Dimension for Sperry Electric Hydraulic and other closing devices will be furnished on request.

The plate and frame space is the combined thickness of all plates and frames in the filter press. Filter presses 30" and smaller, with cast iron plates and frames, have one less plate than the number of chambers or frames.

Filter presses with plates and frames of other metals or materials and cast iron presses 32" and larger, have one more plate than the number of chambers or frames.

Recessed plate filter presses generally have no frames.

Examples:

A 24", 30 chamber, cast iron plate and frame filter press with frames 1" thick would have a chamber space of
29 plates, 1" thick = 29"
30 frames, 1" thick = 30"
Total plate and frame space 59"

A 30", 30 chamber, aluminum plate and frame filter press with frames 1¼" thick would have a chamber space of
31 plates, 1" thick = 31"
30 frames, 1¼" thick = 37½"
Total plate and frame space 68½"

A 36", 30 chamber, plywood filter press with frames 1½" thick, would have a chamber space of
31 plates, 1½" thick=46½"
30 frames, 1¾" thick=52½"
Total plate and frame space 99"

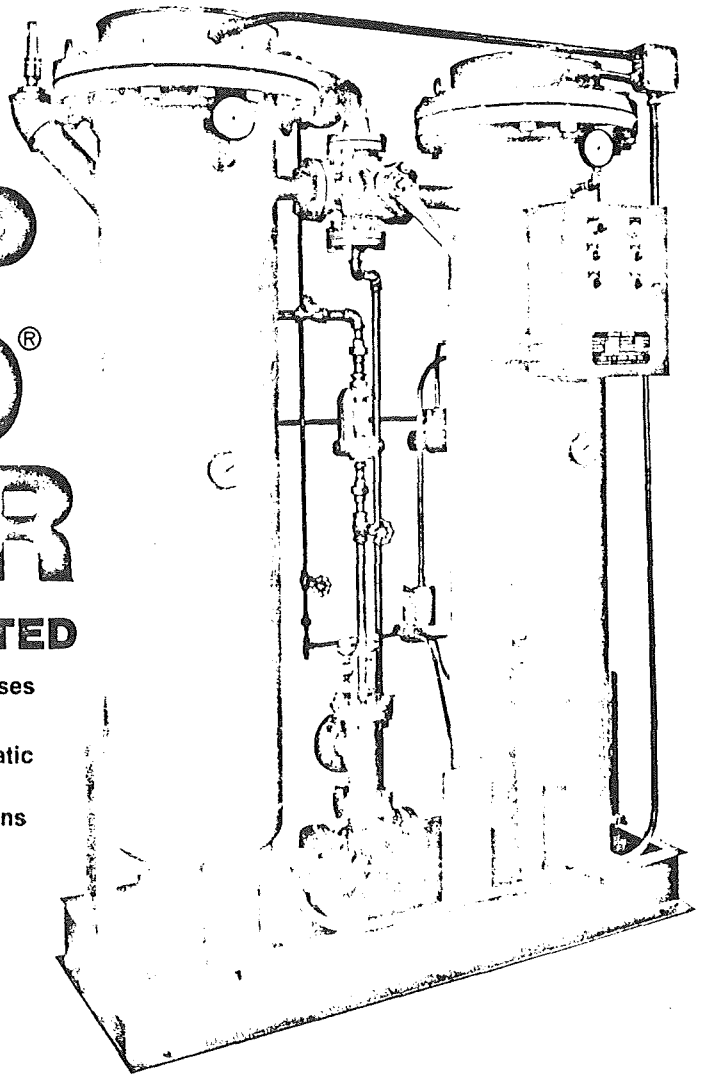
		48"	42"	36"	32"	30"	24"	18"	12"	10"	6"
Square feet per Chamber	Metal	28.2	21.7	15.6	12.1	10.5	6.7	3.7	1.5	1.0	0.3
	Plyplate	19.5	15.0	10.7	9.0	7.6	4.2	2.0	0.9	—	—
	Polypropylene	24.2	18.1	13.0	—	9.0	5.8	2.4	1.0	—	—
Cubic feet per Chamber, 1" thick	Metal	1.17	0.90	0.65	0.50	0.44	0.28	0.15	0.06	0.04	0.03
	Plyplate	0.81	0.66	0.45	0.37	0.32	0.17	0.08	0.04	—	—
	Polypropylene	0.96	0.73	0.54	—	0.37	0.22	0.08	—	—	—

The above information is approximate.

KEMP ORIAD® DRYER

ELECTRIC REACTIVATED

- Remove moisture from process air and gases
- Eliminate condensation and freeze-up
- Protect air-operated instruments, pneumatic valves and tools
- Improve product quality—process functions
- Prevent corrosion—reduce maintenance
- Dry industrial gases

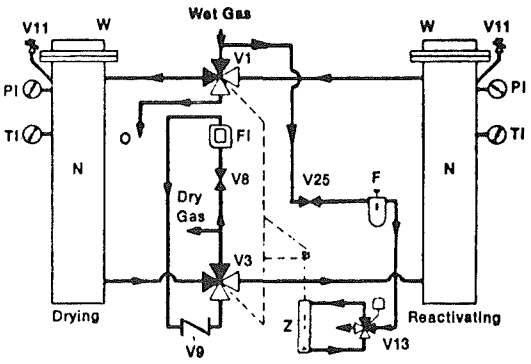


OPERATION AND CONTROL

The ORIAD Dryer is furnished fully assembled and complete in all details, including desiccant—ready for installation and operation. Dual adsorbing towers, each charged with sufficient quantity of desiccant, continuously dry the volume of gas entering under service conditions specified.

Reversal of process gas flow from one tower to the other is accomplished by shifting a single lever which is mechanically interlinked with both the inlet and outlet four-way valves. While process gas is being dried during its passage through the desiccant bed, a small quantity of this same dried gas is used to remove the heat liberated moisture from the tower being reactivated.

Kemp ORIAD Dryers are backed by Kemp engineering knowledge and application experience gained over the past 35 years. Each unit assures you the following: ☐ Dependable service ☐ Economical operation ☐ Highest efficiency ☐ Positive trouble-free operation ☐ Furnished fully assembled ☐ Minimum space requirements ☐ Low initial cost ☐ Standardized series.



LEGEND

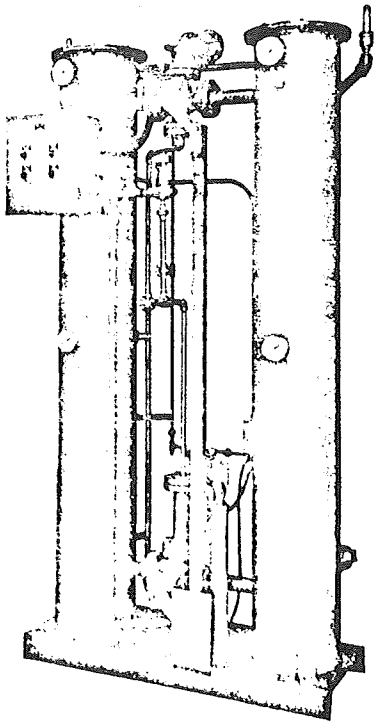
F—Filter
PI—Indicator, Pressure
TI—Indicator, Temperature
N—Tower
O—Orifice
W—Heater, Electric
FI—Indicator, Flow
Z—Cylinder, Operating
V1—Wet Gas Inlet & Reactivating Gas Outlet Valve
V3—Dry Gas Outlet & Reactivating Gas Inlet Valve
V8—Reactivating Gas Bleed Control Valve
V9—Check Valve
V11—High Pressure Relief Valve
V13—Solenoid Valve, Operating Cylinder
V25—Operating Cylinder Shut-Off Valve

NOTE: V1 and V3 Are Interlinked

Dimensional Data and Utilities Required

Model No.	Model No.*	React. Heater KW	React. Purge SCFM	Approx. Overall Dimen.			Inlet & Discharge Connection**	Approx. Shipping Wt.-Lbs.
				Length	Width	Height		
15E	15U	0.65	0.4	30″	17″	62″	½″	550
25E	25U	1.0	0.8	33″	18″	70″	¾″	700
50E	50U	1.95	2.0	40″	23″	7′0″	1″	1300
75E	75U	2.4	3.5	46″	30″	7′0″	1½″	1700
100E	100U	3.5	4.5	54″	31″	6′3″	1½″	2000
150E	150U	5.0	7.0	56″	31″	8′0″	2″	2400
200E	200U	6.5	9.0	64″	31″	7′4″	2″	3100
300E	300U	10.5	14.0	67″	31″	9′6″	2½″	3700
400E	400U	13.5	18.0	6′4″	43″	9′1″	3″	4500
500E	500U	17.5	23.0	7′1″	53″	9′6″	4″	6300
600E	600U	20.5	27.0	7′1″	53″	10′6″	4″	7000

*ORIAD Ultra Dryers designated by suffix "U".
**Connections 1½" and larger are flanged.



1. Manual

Manual shifting of the valve interlinkage at the end of each adsorption cycle reverses the flow of gas from one tower to the other. The heating period is manually controlled by operation of the heater switch.

2. Semi-Automatic

Manual shifting of the valve interlinkage at the end of each adsorption cycle reverses the flow of gas from one tower to the other. Dryer cycle timer automatically terminates the heating period.

3. Full Automatic

All operations are accomplished automatically and are controlled by a program timer. The interlinked valves are shifted automatically at the end of each adsorption cycle by means of a pneumatic cylinder operated by a four-way solenoid valve. After towers have been reversed, program timer automatically starts and terminates the heating period.

RECOMMENDED PRODUCT STANDARD FOR CUSTOM CONTACT-MOLDED REINFORCED POLYESTER CHEMICAL-RESISTANT PROCESS EQUIPMENT

(Based on an original proposal submitted to the National Bureau of Standards, U. S. Department of Commerce by the Society of the Plastics Industry, Inc., for development under the Product Standards Procedures and adjusted in accordance with comment from the trade.)

1. PURPOSE

1.1 The purpose of this Product Standard is to establish on a national basis the standard sizes and dimensions and significant quality requirements for commercially available glass-fiber-reinforced chemical-resistant process equipment for chemical service. The information contained in this Product Standard will be helpful to producers, distributors, and users, and will promote understanding between buyers and sellers.

2. SCOPE

2.1 This Standard covers materials, construction and workmanship, physical properties and methods of testing reinforced-polyester materials for process equipment and auxiliaries intended for use in aggressive chemical environments, including but not limited to pipe, ducts and tanks. An identifying hallmark and recommended statement of compliance are included.

2.2 This Standard is based on the technology of fabrication by hand lay-up or contact pressure molding.

2.3 Work is in progress by the industry to prepare standards covering other resins, reinforcing materials, laminate constructions, fabrication methods, and design considerations that are not covered by this Standard.

3. REQUIREMENTS

3.1 General

3.1.1 Terminology - Unless otherwise indicated, the plastics terminology used in this Standard shall be in accordance with the definitions given in ASTM Designation D883-64bT, Tentative Nomenclature Relating to Plastics.[1]

3.1.2 General description - This Standard describes glass-fiber-reinforced process equipment for chemical service. Other materials may be used for reinforcement of the surface exposed to the chemical environment. This Standard is not intended to cover selection of the exact resin or reinforcement combination for use in specific chemical and structural conditions. For recommended chemical resistance test procedures, see Appendix A.

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[1] Later issues of the ASTM publication may be used providing the requirements are applicable and consistent with the issue designated. Copies of ASTM Copies of ASTM publications are obtainable from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103

3.2 Materials

3.2.1 Resin - The resin used shall be of a commercial grade and shall be evaluated as a laminate by test (see Appendix A for a recommended test) or previous service to be acceptable for the environment.

3.2.2 Fillers and pigments - The resins used shall not contain fillers except as required for viscosity control or fire retardance. Up to 5 percent by weight of thixotropic agent which will not interfere with visual inspection may be added to the resin for viscosity control. Resins may contain pigments and dyes by agreement between fabricator and purchaser, recognizing that such additions may interfere with visual inspection of laminate quality. Antimony compounds or other fire retardant agents may be added as required for improved fire resistance.

3.2.3 Reinforcing material - The reinforcing material shall be a commercial grade of glass fiber having a coupling agent which will provide a suitable bond between the glass reinforcement and the resin.

3.2.4 Surfacing materials - Unless otherwise agreed upon between fabricator and purchaser, material used as reinforcing on the surface exposed to chemical attack shall be a commercial grade chemical-resistant glass having a coupling agent.

Note. The use of other fibrous materials such as acrylic and polyester fibers and asbestos may affect the values obtained for the Barcol hardness of the surface.

3.3 Laminate - The laminate shall consist of an inner surface, an interior layer, and an exterior layer or laminate body. The compositions specified for the inner surface and interior layer are intended to achieve optimum chemical resistance.

3.3.1 Inner surface - The inner surface shall be free of cracks and crazing with a smooth finish and with an average of not over 2 pits per square foot, providing the pits are less than 1/8 inch diameter and not over 1/20 inch deep and are covered with sufficient resin to avoid exposure of inner surface fabric. Some waviness is permissible as long as the surface is smooth and free of pits. Between 0.010 and 0.020 inches of reinforced resin rich surface shall be provided.[2] This surface may be reinforced with glass surfacing mat, synthetic fibers, asbestos or other material as usage requires.

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[2] This resin-rich surface layer will usually contain less than 20 percent of reinforcing material. A specific limit is not included because of the impracticability of determining this value in the finished product.

3.3.2 Interior layer - A minimum of 0.100 inch of the laminate next to the inner surface shall be reinforced with not less than 20 percent nor more than 30 percent by weight of non-continuous glass strands, (See 4.3.1) e.g., having fiber lengths from 0.5 to 2.0 inches.

3.3.3 Exterior layer - The exterior layer or body of the laminate shall be of chemically resistant construction suitable for the service and providing the additional strength necessary to meet the tensile and flexural requirements. Where separate layers such as mat, cloth or woven roving are used, all layers shall be lapped a minimum of one inch. Laps shall be staggered as much as possible. If woven roving or cloth is used, a layer of chopped strand glass shall be placed as alternate layers. The exterior surface shall be relatively smooth with no exposed fibers or sharp projections. Hand work finish is acceptable, but enough resin shall be present to prevent fiber show.

3.3.3.1 When the outer surface is subject to a corrosive environment, the exterior surface shall consist of a chopped strand glass over which shall be applied a resin-rich coating as described in 3.3.1. Other methods of surface protection may be used as agreed upon between buyer and seller.

3.3.4 Cut edges - All cut edges shall be coated with resin so that no glass fibers are exposed and all voids filled. Structural elements having edges exposed to the chemical environment shall be made with chopped strand glass reinforcement only.

3.3.5 Joints - Finished joints shall be built up in successive layers and be as strong as the pieces being joined and as crevice free as is commercially practicable. The width of the first layer shall be 2 inches minimum. Successive layers shall increase uniformly to provide the specified minimum total width of overlay which shall be centered on the joint. (See 3.3.1, 3.4.6.1, 3.5.6, and 3.6.5.) Crevices between jointed pieces shall be filled with resin or thixotropic resin paste, leaving a smooth inner surface. (See 3.3.1.) The interior of joints may also be sealed by covering with not less than 0.100 inch of reinforced resin rich surface as described in 3.3.1 and 3.3.2.

3.3.6 Wall thickness - The minimum wall thickness shall be as specified in the tables under the appropriate sections, but in no case shall be less than 1/8 inch in the case of duct and 3/16 inch in pipes and tanks regardless of operating conditions. Isolated small spots may be as thin as 80 percent of the minimum wall thickness, but in no case more than 1/8 inch below the specified wall thickness.

3.3.7 Mechanical properties - In order to establish proper wall thickness and other design characteristics, the minimum physical properties for any laminate shall be as shown in Table 1 and 3.3.7.1. Laminates which do not meet the minimum values of Table 1 are considered acceptable provided they are made to afford the same overall strength that would be obtained with a laminate meeting the specified thickness. For example, if the specified thickness for a laminate is 1/4 inch, reading from Table 1 a minimum tensile strength of 12,000 psi is required. By multiplying thickness times minimum tensile strength a value of 3,000 lbs. breaking load for a 1 inch wide specimen is obtained. A laminate having a tensile strength of 10,000 psi will therefore be acceptable for the 1/4 inch requirement if it has an actual thickness of at least 0.3 inch.

Table 1 - Requirements for properties of reinforced-polyester laminates.

Property at 23°C (73.4°)	Thickness (inches)			
	1/8 to 3/16	1/4	5/16	3/8 and up
	psi	psi	psi	psi
Ultimate tensile strength-minimum[1]	9,000	12,000	13,500	15,000
Flexural strength-minimum[2]	16,000	19,000	20,000	22,000
Flexural modulus of elasticity (tangent) minimum[3]	700,000	800,000	900,000	1,000,000

[1] See 4.3.2

[2] See 4.3.3

[3] See 4.3.4

3.3.7.1 Surface hardness - The laminate shall have a Barcol hardness of at least 90 percent of the resin manufacturer's minimum specified hardness for the cured resin when tested in accordance with 4.3.5. This applies to both interior and exterior surfaces.

3.3.8 Appearance - The finished laminate shall be as free as commercially practicable from visual defects such as foreign inclusions, dry spots, air bubbles, pinholes, pimples, and delamination.

3.3.9 By agreement between buyer and seller, a representative laminate sample may be used for determination of acceptable surface finish and visual defects (see 3.3.1, 3.3.3 and 3.3.8.)

3.5.10.4 Bolts, nuts and washers - Bolts, nuts, and washers shall be furnished by the customer. Metal washers shall be used under all nut and bolt heads. All nuts, bolts and washers shall be of materials suitable for use in the exterior environment.

3.5.10.5 Gaskets - Gaskets shall be furnished by the customer. Recommended gasketing materials shall be a minimum of 1/8 inch in thickness with a suitable chemical resistance to the service environment. Gaskets should have a Shore A or Shore A2 Hardness of 40 to 70.

3.6 Reinforced-polyester tanks (stationary nonpressure vessels)

3.6.1 Cylindrical flat bottom vertical tanks

3.6.1.1 Sizes - Standard tank sizes are 2, 2½, 3, 3½, 4, 4½, 5, 5½, 6, 7, 8, 9, 10, 11, and 12 feet in inside diameter.

3.6.1.2 Dimensions and tolerances - The tank diameter shall be measured internally. Tolerance on the inside diameter, including out-of-roundness, shall be ± 1 percent. Measurement shall be taken with tank in vertical position. Taper, if any, shall be increasing and shall be added to the nominal diameter. Taper shall not exceed 1/2° per side. Tolerance on overall height shall be ± 1/2 percent, but shall not exceed ± 1/2 inch. The radius at bottom to wall shall be a minimum of 1½ inch.

3.6.1.3 Wall thickness - The minimum wall thickness shall be in accordance with Table 7. See also 3.3.6.

3.6.2 Horizontal cylindrical tanks -

3.6.2.1 Sizes, dimensions, and tolerances - These shall be the same as for vertical cylindrical tanks (see 3.6.1). Standard end closures shall be standard convexed, domed heads with a maximum radius of curvature equal to the tank diameter. The knuckle radius shall be a minimum of 1-1/2 inches.[5]

3.6.2.2 Support cradle - Two support cradles shall be provided. The cradles shall be at least 6 inches wide supporting at least 120° of the tank circumference. Wear plates (reinforced areas) 12 inches wide covering 180° of support surface shall be provided when required. Laminate construction and minimum thickness shall be as agreed upon between fabricator and purchaser. Tanks longer than 24 feet require special design and support consideration.

3.6.2.3 Wall thickness - The minimum wall thickness shall be in accordance with Table 8. See also 3.3.6.

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[5] Larger knuckle radii are commonly used, such as for ASME torispherical heads.

Table 7. Minimum wall and bottom thickness of vertical tanks relative to diameter and distance from top.[1/]

Distance From Top	Minimum wall and bottom thickness for tanks of diameter														
feet	2 ft	2½ ft	3 ft	3½ ft	4 ft	4½ ft	5 ft	5½ ft	6 ft	7 ft	8 ft	9 ft	10 ft	11 ft	12 ft
2	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16
4	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16
6	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	1/4	1/4	1/4
8	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	1/4	1/4	1/4	1/4	1/4	5/16
10	3/16	3/16	3/16	3/16	3/16	3/16	3/16	1/4	1/4	1/4	1/4	1/4	5/16	5/16	5/16
12	3/16	3/16	3/16	3/16	3/16	3/16	1/4	1/4	1/4	1/4	1/4	5/16	5/16	5/16	3/8
14	3/16	3/16	3/16	3/16	1/4	1/4	1/4	1/4	1/4	5/16	5/16	5/16	5/16	3/8	3/8
16	3/16	3/16	3/16	1/4	1/4	1/4	1/4	1/4	1/4	5/16	5/16	3/8	3/8	3/8	7/16
18	3/16	3/16	3/16	1/4	1/4	1/4	1/4	5/16	5/16	5/16	3/8	3/8	3/8	7/16	1/2
20	3/16	3/16	1/4	1/4	1/4	1/4	5/16	5/16	5/16	3/8	3/8	3/8	7/16	1/2	1/2
22	3/16	1/4	1/4	1/4	1/4	5/16	5/16	5/16	5/16	3/8	3/8	7/16	1/2	1/2	9/16
24	3/16	1/4	1/4	1/4	1/4	5/16	5/16	5/16	3/8	3/8	7/16	1/2	1/2	9/16	5/8

[1/] Based on a safety factor of 10 to 1 using the mechanical property data in Table 1 and a liquid specific gravity of 1.2. For tanks intended for service above 180°F (82.2°C) consideration in design should be given to the physical properties of the material at the operating temperature. Tanks with physical loadings, such as agitation, should be given special design consideration.

Table 8 - Minimum wall and head thicknesses for reinforced-polyester horizontal cylindrical tanks using two support cradles.[1]

Tank Length	Minimum wall and head thickness for tanks of diameter:[2]							
	2 ft	3 ft	4 ft	5 ft[3]	6 ft[4]	8 ft[5]	10 ft[6]	12 ft[7]
feet	in.	in.	in.	in.	in.	in.	in.	in.
8	3/16	3/16	1/4	1/4	5/16	5/16	7/16	9/16
10	3/16	1/4	1/4	5/16	5/16	3/8	7/16	9/16
12	3/16	1/4	1/4	5/16	5/16	7/16	1/2	5/8
14	1/4	1/4	5/16	5/16	3/8	1/2	9/16	3/4
16	1/4	5/16	5/16	3/8	3/8	9/16	11/16	13/16
18	1/4	5/16	3/8	7/16	7/16	5/8	13/16	15/16
20	5/16	5/16	3/8	7/16	1/2	11/16	7/8	1-1/16
22	5/16	3/8	3/8	1/2	9/16	3/4	15/16	1-3/16
24	5/16	3/8	7/16	1/2	5/8	13/16	1	1-1/4

[1] Based on 5 to 1 safety factor using the mechanical property data in Table 1, a liquid specific gravity of 1.2, and support cradles located 1/12 of tank length from each end. For tanks intended for service above 180°F (82.2°C) consideration in design should be given to the physical properties of the material at the operating temperature. Tanks with physical loadings, (such as agitation) other support designs, stiffening rings or for use in situations requiring higher safety factors, should be given special design consideration. In the use of more than two support cradles, maintenance of uniform support of the tank at all points of support is essential.

[2] For intermediate standard tank inside diameters given in 3.6.1.1, the minimum wall and head thickness shall be that given in this table for the next higher diameter.

[3] Wear plates required for 8 foot tank length.

[4] Wear plates required for 8, 10, and 12 foot tank lengths.

[5] Wear plates required for tanks 8 to 18 feet long, inclusive.

[6] Wear plates required for tanks 8 to 20 feet long, inclusive.

[7] Wear plates required for all tank lengths.

4.3 Tests

4.3.1 Glass content - The glass content shall be determined in accordance with ASTM Designation D2584-67T, Tentative Method of Test for Ignition Loss of Cured Reinforced Resins[1] except that the specimens tested shall be approximately 1 square inch in area and low temperature preignition prior to placement in muffle furnace is recommended. The average for five specimens shall be considered to be the glass content.

4.3.2 Tensile strength - Tensile strength shall be determined in accordance with ASTM Designation D638-64T, Test for Tensile Properties of Plastics (Tentative)[1], except that the specimens shall be the actual thickness of the fabricated article and the width of the reduced section shall be one inch. Other dimensions of specimens shall be as designated by the ASTM standard for Type I specimens for materials over 1/2 inch to 1 inch inclusive. Specimens shall not be machined on the surface. Tensile strength shall be the average of five specimens tested at 0.20 - 0.25 in./min. speed.

4.3.3 Flexural strength - Flexural strength shall be determined in accordance with Procedure A and Table 1 of ASTM Designation D790-66, Standard Method of Test for Flexural Properties of Plastics[1] except that the specimens shall be the actual thickness of the fabricated article and the width shall be one inch. Other dimensions of specimens shall be as designated by the ASTM standard. Specimens shall not be machined on the surface. Tests shall be made with the resin rich side in compression using five specimens.

4.3.4 Flexural modulus - The tangent modulus of elasticity in flexure shall be determined by ASTM Method D790-66 (see 4.3.3).

4.3.5 Hardness - The Barcol Impressor (Model GYZJ 934-1) shall be used for determining hardness. Calibration of the Barcol instrument shall be verified by comparing with a blank specimen having a known reading of 85 - 87. Ten (10) readings on the clean resin-rich surface shall be made. After eliminating the two high and two low readings, the average of the remainder shall be the reported hardness reading.[6]

4.3.6 Additional tests - Recommended test methods for the further testing of reinforced-polyester laminates are given in Appendix A.

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[6] Work is in progress to determine the feasibility of using for these measurements Barcol instruments calibrated with a test disk in the range of 42-46.

Appendix A

A.1 Chemical resistance

A1.1 Test - ASTM Designation C581-65T[1], Tentative Method of Test for Chemical Resistance of Thermosetting Resins Used in Glass Fiber Reinforced Structures[5] is recommended for the evaluation of the chemical resistance of materials to be used in reinforced-polyester chemical-resistant process equipment. The reinforcing materials prescribed in the test laminate are only for the purpose of establishing a uniform basis for comparison. They many not necessarily represent the preferred materials for the particular environment. This procedure may be adapted to test or evaluate components, composition or fabrication variations and production samples. For information on the basis for selection of the standard test laminate, see Appendix A1 of ASTM C581-65T.

A1.1.1 The 10-mil surfacing mat referred to in paragraph 5.1.2.1 of C581-65T shall be made of chemical resistant glass (Type C or equal).

A1.1.2 The standard test laminate shall be cured at room temperature for 16 hours. Further cure shall be given at room or higher temperature, if necessary, to produce a Barcol hardness equal to the resin manufacturer's minimum specified hardness for the cured resin.

A1.2 Temperature -Tests may be conducted at any or all of these temperatures: 23°C, 50°C, 70°C, 100°C (± 2°C); reflux temperature; required service temperature.

A1.3 Reagents - The following reagents are suggested for use in obtaining general comparative chemical resistance data. The test solutions shall not be agitated, i.e., the exposures shall be under static conditions.

1. 25% Sulfuric acid
2. 15% Hydrochloric acid
3. 5% Nitric acid
4. 25% Acetic acid
5. 15% Phosphoric acid
6. 5% Sodium hydroxide
7. 10% Sodium carbonate
8. Saturated sodium chloride
9. 95% Ethanol
10. 5-1/4% Sodium hypochlorite*
11. 5% Aluminum potassium sulfate
12. Ethyl acetate
13. Methyl ethyl ketone
14. Monochlorobenzene
15. Perchlorethylene
16. n-Heptane
17. Kerosene
18. Toluene
19. 5% Hydrogen peroxide*
20. Distilled Water*

* Replaced every 48 hours with fresh solution.

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[5] This method is based on a test procedure developed by the Reinforced-Plastics Corrosion-Resistant Structures Subcommittee of the Society of the Plastics Industry, Inc.

A1.4 Time - The properties specified in A1.5 shall be determined for specimens immersed in the test solutions for 30 days, 90 days, 180 days, and one year for one set of control specimens immediately following the curing period; and for another set after aging in air at the test temperature for the total test period.

A1.5 Properties - Thickness, Barcol hardness, flexural strength and modulus, and appearance shall be determined at each time interval. Appearance observations shall include any surface changes, color changes, obvious softening or hardening, crazing, delamination, exposure of fibers, or other effects indicative of complete degradation or potential failure. Calculation of percentage change in a property shall be based on the property value obtained immediately following the curing period.

A1.6 Report - Data shall be reported in tabular form for all parameters tested. The composition, including resin, accelerators, catalysts, and reinforcements, and the fabricating and curing conditions of the laminate tested shall be adequately described.

A2. Fire retardancy[7] - The fire retardancy may be determined in accordance with ASTM Designation E84-61 Standard Method of Test for Surface Burning Characteristics of Building Materials.[1]

A3. Compressive strength (edgewise) - The compressive strength may be determined in accordance with ASTM Designation D695-63T, Tentative Method of Test for Compressive Properties of Rigid Plastics.[1]

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[7] Work is in progress to develop test procedures and specification requirements for applications requiring fire resistance.