CONTROL OF HYDROGEN SULFIDE EMISSION
FROM GEOTHERMAL POWER PLANTS

Final Report

Volume III

Demonstration Plant Equipment Descriptions,
Test Plan, and Operating Instructions

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EIC CORPORATION
55 Chapel Street
Newton, Massachusetts 02158

CONTROL OF HYDROGEN SULFIDE EMISSION FROM
GEOTHERMAL POWER PLANTS

Contract No. EY-76-C-02-2730.*000

Final Task Report on Task C.4

Detailed Project and Process Engineering

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I. INTRODUCTION

This document summarizes the elements of the final, detailed design of the demonstration plant for the copper sulfate process for the removal of hydrogen sulfide from geothermal steam. It contains descriptions of all items of equipment in sufficient detail that they can serve as purchase specifications, the process and mechanical design criteria which were used to develop the specifications, and the process descriptions and material and energy balance bases to which the design criteria were applied.

This document is intended to serve two purposes: The first is to provide a complete description of all items of equipment which will be purchased and assembled for the demonstration plant. The second is to document the bases which were used in relating the processing requirements for each operation or step to the material and energy balance to arrive at a description or specification for the item(s) of equipment selected. In the broadest sense, the objective of the field trials will be to demonstrate that these assumed bases, or criteria, are in fact correct or to provide new information to support their modification. Then, when sufficient data are available to support the criteria with reasonable confidence, they can be used with the new material and energy balance appropriate for a commercial scale installation to develop the specifications for the larger equipment which will be required. Therefore, the equipment specifications summarized here, which are specific to the 100,000 lb/hr demonstration plant, will not be changed unless field experience show an item to be unsuited to its intended use and it is replaced, or last-minute changes are made in the process configuration prior to purchasing. However, it is to be expected that the criteria documents will be changed as a result of experience gained in the field test work. At the least, the levels of confidence will be updated, and new information will be incorporated as soon as data are available to support a modification of the assumed criteria.

In the body of this report, criteria and specification documents are arranged by class or category of equipment. For some items, such as locally indicating temperature indicators - i.e., dial thermometers, the design

criteria for the selection of a particular item has little process significance. Thus, a separate criteria sheet was not written to indicate that the range required is up to 400°F or that a thermowell is required for corrosion protection: this information is contained in the specification sheets themselves. Some other equipment, such as the controllers, recorders, valve actuators, etc., are standard items, the criteria for which have process significance but are mechanical in nature, e.g., the ability to accept a 3-15 psi air signal and provide a required amount of torque or to convert the output signal for recording on a standard chart. Criteria for this type of standard hardware are also contained in the information on the specification sheets.

Separate criteria sheets have been provided, however, for special or custom designed items such as the scrubbing column, the process copper analyzer-controller, and certain of the pumps, filters, agitators, tank, etc. For items which are modified or special versions of standard items, such as pumps, complete mechanical specifications have been provided. For components which are one-of-a-kind or will be custom fabricated, however, only such general mechanical specifications as are required for bid preparation have been provided along with the design criteria information. More detailed information will be provided when vendor drawings become available.

II. DESIGN CRITERIA AND SPECIFICATION SHEETS

(see following pages).

PRESSURE VESSELS

Pressure Vessels
Specification Sheet Summary

<u>Item No.</u>	<u>Item Description</u>
C101	Scrubbing Tower. Six ft diameter by 32 ft high with skirt support. C20Cb3 construction, 150 psig design. Single segmental sieve tray with downcomers, 8 in. Teflon demister. Platform and caged ladder.
V201	Pressure Leach Reactor. Eight ft diameter by 8 ft straight sides with cooling jacket. Four leg support, 150 psig design 316 stainless steel construction, four 8" wide adjustable baffles. To be equipped with 15 HP turbine agitator.
C102	Decanter. Ten inch diameter by 3 ft straight side with conical bottom, T316 stainless steel construction, 150 psi design, leg support, and pad type sight glass.

Date: 6/1/77 - Rev. 0

Process Equipment
Design Criteria Summary

Item Number: C101

Item Description: Scrubbing Tower. Six ft diameter by 32 ft high with skirt support. C20Cb3 construction, 150 psig design. Single segmental sieve tray with downcomers, 8 in. Teflon demister. Platform and caged ladder.

Design Requirements: Remove 99% of H_2S from 100M pph steam at 120 psig. Nominal pressure drop including inlet/outlet losses 2 psig. Nominal L/G = 1, 200 GPM scrub solution circulation. Nominal froth height and sump level 6 ft each. Demister to provide 99.5% particulate removal with washing as required. Construction to minimize crevices.

Design Bases: Diameter required for steam $F = 1.8$, froth height required for 1.5 sec contact time, size tray open area for hole $F = 7.5$, downcomer capacity of 300 GPM/ft² at 1/2 psi pressure drop. Allow 6 ft disengagement space above normal froth height.

Level of Confidence: For column diameter, sump depth, number of trays - good. For froth height, detailed tray layout, material of construction - fair. For demister resistance to fouling - poor.

Comments: Demister wash nozzles and piping and scrub solution distribution nozzle not included. Except for long term demister performance, design bases demonstrated in field test.

Date: 6/1/77 - Rev. 0

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6' Inside Diameter Steam Scrubbing Column Specifications

	<u>Pressure</u>	<u>Temperature</u>
1. Design Conditions:	150 psig	375°F
2. Operation Conditions:	120 psig	350°F
3. Material:	All wetted parts Carpenter 20 Cb 3	
4. Corrosion Allowance:	1/16" on pressure parts	
5. Gaskets:	Teflon envelope type Anchor 1106 or equal	
6. Code Stamp:	ASME code for unfired pressure vessels Section VIII, Division 1.	
7. Plant Location:	The Geysers, Sonoma County, California.	
8. Insulation Allowance:	4"	
9. Nozzle Projection:	8"	
10. Support:	Skirt	
11. Internals:	Single sectional sieve tray w/two 8" dia. downcomers (see attached notes)	
12. Demister:	8" thick York No. 221 Teflon demister pad w/Carpenter 20 Cb 3 grids.	
13. Insulation Supports:	As required three 3 x 3 x 1/4 angle iron support rings welded to shell and wiring clips welded to each head.	
14. Design Wind Load:	Forty PSF.	
15. Seismic Load:	Seismic zone 3 for Sonoma County, California.	
16. Platform:	One 42" wide platform provided at the 19' level with caged ladder, bolted construction for installation after erection.	
17. Lifting Lugs:	As required for erection.	
18. Finish:	Inside welds to be ground smooth	

Date: 9/1/77 - Rev. 1

6' Inside Diameter Steam Scrubbing Column Design Notes

1. Supply 6" IPS scrubbing liquid distributor pipe with (205) 3/8" diameter drilled holes arranged in three rows along bottom. Distributor to have 8" mounting flange and 6" - 150# external connection flange. Provide internal support on column wall for distributor pipe.
2. Tray loading - tray to be designed for maximum momentary uniform load of 100 pounds per square foot without permanent deflection. Normal operation - max. 1/8" deflection with tray weight and 15 PSF.
3. Tray open area - tray to be designed with approximately 20% open area based on column diameter. Hole size 3/8" diameter.
4. Connection Q liquid level gage - supply (1) Jerguson (or equivalent) size 29 -W- 30 two section Carpenter 20 Cb 3 welding pad gage. Shell to be slotted over full visible length of each section and inside of gage seal welded to shell. Shell to be reinforced as required.

Pad to be provided with 1/8" NPT weep hole near bottom.

Gaskets to be Teflon Lo-Flo type.
5. Connections $S_1 + S_2$ sight glasses - supply (2) Black Diamond (or equivalent) safety sight glasses Model No. BDLL with Teflon process gaskets and Pyrex shielding discs. Sight glasses to be mounted on 4" - 150# studed flange, nozzle projection to be 2".

Date: 9/1/77 - Rev. 1

SCHEDULE OF CONNECTIONS

CONN.#	SIZE	RATING	SERVICE
A	18"	150 ⁰ RF	STEAM INLET
B	4"		INSPECTION PORT-BLANKED
C	8"		LIQUID OUTLET
D, D ₂	1"		LIQUID LEVEL CONNECTION
E, E ₂	1"		dp CONNECTION-TRAY
E ₃ E ₄	1"		dp CONNECTION-DEMISTER
F	8"		SCRUBBING LIQUID INLET WITH 6" DISTRIBUTOR PIPE AND SUPPORT. (SEE ATTACHED NOTES)
G	18"		STEAM OUTLET
H ₁ +H ₃	2"		DEMISTER WASH CONN'S UPPER
H ₄ +H ₆	2"		DEMISTER WASH CONN'S LOWER
L	2"		SPARE - BLANKED
M ₁ M ₂	20"	150 ⁰ RF	MANWAY W/ DAVIT
N	18"	-	REINFORCED INSPECTION OPNG
P ₁ P ₂	1"	150 ⁰ RF	THERMOMETERS
Q	-	SEE NOTES	LIQUID LEVEL GAUGE WELDING PAD TYPE (38" LG.)
R	8"	150 ⁰ RF	RECIRCULATION INLET
S ₁ S ₂	4"	150 ⁰ RF	SIGHT GLASSES (PAD TYPE) SEE NOTES

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NEWTON, MA. 02168

SCALE: AS SHOWN

APPROVED BY

DATE: 1/13/77

DRAWN BY

6' I.D. STEAM SCRUBBING COLUMN

REV: A

DATE: 2/6/77

DRAWING NUMBER

SB-0011

Process Equipment

Design Criteria Summary

Item Number: V201

Item Description: Pressure Leach Reactor. Eight ft diameter by 8 ft straight sides with cooling jacket. Four leg support, 150 psig design T316 stainless steel construction, four 8" wide adjustable baffles. To be equipped with 15 HP turbine agitator. Working volume 3500 gal.

Design Requirements: Regenerate up to 2050 lb/day $\text{Cu}_{1.9}\text{S}$ in 6700-8200 gal solution in 2-3 batches/day. Obtain minimum 90% regeneration in 2-1/2 hr leaching time with 50 psi oxygen pressure at 230°F (55 psig total pressure). Provide for sparging either air or oxygen gas to leach reactor and venting inerts. Provide for pressure and temperature control; heat by direct steam sparge, cool with jacket on reactor sides. Maximum cooling rate 3 mm BTU/hr.

Design Bases: Reactor volume fixed by requirement to process slurry in 2-3 batches, dimensions and baffle arrangement specified by agitator manufacture. Reaction time and pressure/temperature requirements based on lab leaching tests. Cooling requirement is 50% above maximum expected for two batches/day at nominal conditions. Slurry feed and leached CuSO_4 drain times total less than 4-5 hr.

Level of Confidence: For reactor volume, configuration - good. For reaction rate, heat removal rate - fair. For operating gased density, extent of froth formation - poor.

Comments: Volume of slurry specified to provide leach requirements for H_2SO_4 without makeup. Volume (number of batches) can be reduced by making up acid from concentrated H_2SO_4 storage. Reactor and auxiliaries designed to permit reaction time to be halved, if required, by operation at higher temperature/pressure.

Date: 6/1/77 - Rev. 0

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3000 Gallon Oxygen Pressure Leach Reactor

	<u>Pressure</u>	<u>Temperature</u>
1. Design Conditions:	150 psig	366°F
2. Operating Conditions:	100 psig	250°F
3. Material:	All wetted parts 316 stainless steel	
4. Corrosion Allowances:	1/16" on pressure parts	
5. Gaskets:	Teflon envelope type Anchor 1106 or equal	
6. Code Stamp:	ASME code for unfired pressure vessels, Section VIII	
7. Plant Location:	The Geysers, Sonoma County, California	
8. Insulation Allowance:	2"	
9. Nozzle Projection:	6"	
10. Support:	4 legs	
11. Internals:	(4) 8" wide x 60" long baffles - bolted construction	
12. Agitator:	Philadelphia mixers Model PTEM, 15 HP motor, turbine speed 84 rpm, approximate weight - 2000#, agitator by others.	
13. Insulation Supports:	As required.	
14. Design Wind Load:	40 PSF	
15. Seismic Load:	As required for Sonoma County, California	
16. Lifting Lugs:	As required.	
17. Finish:	Inside welds to be ground smooth.	

Date: 1/10/77 ~ Rev. 0

EIC Corporation

3000 Gallon Oxygen Pressure Leach Reactor

Schedule of Connections

<u>Conn. No.</u>	<u>Size (in.)</u>	<u>Rating (lb)</u>	<u>Service</u>
A	8	150 RF	Agitator
D	3	150 RF	Drain
F	3	150 RF	Feed
H	2	150 RF	Process Steam
L ₁ L ₂	1	150 RF	Level
M	24	150 RF	Manway w/davit
O	3	150 RF	Oxygen Inlet
P	1	150 RF	Relief
S	1	150 RF	Sample
T	1	150 RF	Temperature
V	3	150 RF	Vent

Date: 1/10/77 - Rev. 0

SCHEDULE OF CONNECTIONS

CONN#	SIZE	RATING	SERVICE
A	8"	150#	AGITATOR
D	3"		DRAIN
F	3"		FEED
H	2"		PROCESS STEAM
J ₁ , J ₂	4"		COOLING WATER-IN&OUT
L ₁ , L ₂	1"		LEVEL
M	24"		MANWAY W/DAVIT
O	3"		OXYGEN INLET
R	3"		RELIEF
S	1"		SAMPLE
T	1"		TEMPERATURE
V	3"		VENT

E.I.C CORPORATION

NEWTON, MA 02158

SCALE NONE	APPROVED BY	DRAWN BY
DATE 2/6/78		
3000 GALLON OXYGEN PRESSURE LEACH REACTOR		
REV -	DRAWING NUMBER SB-0024	

Process Equipment
Design Criteria Summary

Item Number: C102

Item Description: Decanter. Ten inch diameter by 3 ft straight side with conical bottom. T316 stainless steel construction, 150 psi design, leg, support. Full flange at top, removable feed nozzle and pad type sight glass.

Design Requirements: Separate 1.3-1.5 GPM clear solution to purge neutralization from 6-7 GPM feed slurry. Decantate and underflow withdrawal rates by flow control. Overflow solids content < 100 PPM.

Design Bases: Settling rates, compression times, detention times from lab liter cylinder tests. Upflow centerline velocity less than 1 ft/min, 2 min solids detention time.

Level of Confidence: On settling rate and detention times - good. On fines carryover (flocculating behavior of purge stream) - fair.

Comments: Overflow provided with filter to retain any fines. Decanter provided with bypass piping to permit servicing if required. Then slurry surge tank will serve as a batch decanter.

Date: 6/1/77 - Rev. 0

STORAGE TANKS

Storage Tanks

Specification Sheet Summary

<u>Item No.</u>	<u>Item Description</u>
T101	Slurry Storage Tank - 9600 gallon, 11' diameter by 13'-6" high filament wound FRP storage tank, flat bottom with bolt-on flat cover with manway. Tank to be baffled and have 4" center hole in cover for agitator shaft. Resin to be Derakane 470-36 with white pigmented exterior protective coating, nozzles as required.
T102	Copper Sulfate Tank - Tank to be of same size and construction as T101, except without baffles or provision for an agitator. Nozzles as required.
T201	Regenerated Copper Sulfate Holding Tank - 3660 gallon, 8' diameter by 9'-9" high filament wound FRP storage tank, flat bottom with bolt-on cover with manway. Resin to be Derakane 470-36 with white, pigmented exterior protective coating. Nozzles as required.
T301	General Purpose Surge Tank - 100 gallon 30" diameter by 36" high type 316 stainless steel with removable inner basket.
T302	Neutralization Tank - 2500 gallon, 7' diameter by 9'-9" high filament wound FRP storage tank. Flat bottom with bolt-on cover with manway. Tank to be unbaffled but cover to have cut out on side for an agitator. Side wall to have agitator support bracket. Resin to be Derakane 470-36 with white pigmented exterior protective coating. Nozzles as required.
T303	Sulfuric Acid Storage Tank - 1000 gallon carbon steel closed storage tank, 5' diameter x 6' straight side with ASME flanged and dished heads. Tank to be supported on four legs. Nozzles as required.

Date: 6/1/77 - Rev. 0

Storage Tank - Spec Sheet (continued)

<u>Item No.</u>	<u>Item Description</u>
T304	Process Water Storage Tank - 400 gallon 4' diameter by 4'-4" high, hand layup FRP tank, flat bottom open top. Resin to be Derakane 470-36 with white pigmented exterior protective coating. Nozzles as required.
T305	Liquid Oxygen Storage Tank and Vaporizer - 6000 gallon double wall vacuum insulated cryogenic tank with ambient, finned tube vaporizer. Tank to be provided with necessary valves, regulators, safety devices and piping for proper operation.
T306A	Ammonia Storage Tanks - (2) 500 gallon steel pressure storage tanks interconnected together, with 10 KW electric vaporizer. Tank to be provided with necessary valves, regulators, safety devices and piping for proper operation.

Date: 6/1/77 - Rev. 0

Process Equipment
Design Criteria Summary

Item Number: T101

Item Description: Slurry Storage Tank. Filament wound fiberglass reinforced vinyl ester plastic tank, vertical with flat bottom and open top with bolt-on cover and 22" diameter hinged manway. Tank to be 11' diameter by 13'-6" high, 9612 gal capacity. Fittings to be flanged construction and include (1) 3" gusseted drain nozzle, (3) 2" nozzles, and (2) 1" nozzles. Four baffles 11" wide set 2" off wall on 3 gussets each to run full length of tank, and 4 galvanized tiedown brackets are to be furnished. 4" center hole to be cut in cover for agitator shaft with raised rim. Resin to be Derakane 470-36 with white pigmented exterior protective coating.

Design Requirements: Tank to be suitable for outdoor installation in seismic zone 3 with 100 MPH design wind load. Tank to be baffled for agitation to suspend solids, agitator weight to be carried by separate supports. Agitator and supports by others. Tank materials to be resistant to purge slurry solution containing 2.5% H_2SO_4 , 0.5% $CuSO_4$, and 10% $(NH_4)_2SO_4$ at design temperature of 210°F. Operating temperature 180°F.

Design Bases: Mechanical design of tank to be by manufacturer to meet design requirements of wind and seismic loads. Material selection from resin manufacturer's chemical resistance guide and laboratory evaluations. Volume based on holding one day's purge from column, baffles 1/12 diameter.

Level of Confidence: Good on mechanical design, fair on material selection, good on size and baffle configuration.

Comments: Long term properties of resin system at elevated temperatures may be questionable. Operation at lower temperatures would eliminate problem. Abrasive resistance of the fiberglass resin to slurry suspension is unknown.

Date: 6/1/77 - Rev. 0

Process Equipment
Design Criteria Summary

Item Number: T102

Item Description: Copper Sulfate Storage Tank. Filament wound fiberglass reinforced vinly ester plastic tank, vertical with flat bottom and open top, with flat bolt-on cover and 22" hinged manway. Tank to be 11' diameter by 13'-6" high - 9612 gal capacity. Fittings to be flanged construction and include (1) 3" gusseted drain nozzle, (3) 2" nozzles, and (2) 1" nozzles. Four galvanized steel tiedown brackets to be furnished. Resin to be Derakane 470-36 with white pigmented exterior protective coating.

Design Requirements: Tank to be suitable for outdoor installation in seismic zone 3 with 100 MPH design wind load. Tank materials to be resistant to regenerated copper sulfate solutions containing 0.5% H_2SO_4 and 10% $(NH_4)_2SO_4$ at design temperature of 210°F. Operating temperature 180°F.

Design Bases: Mechanical design of tank to be by manufacturer for wind and seismic loads. Material selection from resin manufacturer's chemical resistance guide and laboratory evaluations. Volume based on holding one days regenerated copper sulfate solution for makeup to column.

Level of Confidence: Good on mechanical design, fair on material selection, good on size.

Comments: Long term properties of resin system at elevated temperatures may be questionable. Operation at lower temperatures would eliminate problem.

Date: 6/1/77 - Rev. 0

Process Equipment
Design Criteria Summary

Item Number: T201

Item Description: Regenerated Copper Sulfate Holding Tank - Filament wound fiberglass reinforced vinyl ester plastic tank, vertical with flat bottom and open top with bolt-on cover and 22" diameter hinged manway. Tank to be 8' diameter by 9'-9" high - 3666 gal capacity. Fittings to be flanged construction and include (1) 3" gusseted drain nozzle, (3) 2" nozzles and (2) 1" nozzles. Four galvanized steel tiedown brackets to be furnished. Resin to be Derakane 470-36 with white pigmented exterior protective coating.

Design Requirements: Tank to be suitable for outdoor installation in seismic zone 3 with 100 MPH design wind load. Tank materials to be resistant to regenerated copper sulfate solutions containing 0.5% H_2SO_4 , 10% $CuSO_4$ and 10% $(NH_4)_2SO_4$ at design temperature of 210°F. Operating temperature 180°F.

Design Bases: Mechanical design of tank to be by manufacturer for wind and seismic loads. Material selection from resin manufacturer's chemical resistance guide and laboratory evaluations. Volume based on holding one batch of regenerated copper sulfate from the leach reactor.

Level of Confidence: Good on mechanical design, fair on material selection, good on size.

Comments: Long term properties of resin system at elevated temperatures may be questionable. Operation at lower temperatures would eliminate problem.

Date: 6/1/77 ~ Rev. 0

Process Equipment

Design Criteria Summary

Item Number: T301

Item Description: 100 gallon type 316 stainless steel general purpose surge tank 30" ID by 36" high. Tank to be mounted on legs and fitted with a small agitator and a removable inner basket.

Design Requirements: Tank to be used to carry out experiments in decopperization of the clear liquid purge stream from the neutralization tank. Basket to hold de-tinned steel scrap for batch or continuous cementation reaction. Agitator to be used to thoroughly mix H_2S into clear liquid purge to precipitate CuS on a batch basis.

Design Bases: Tank size selected to allow reasonable size batches to be processed at field conditions.

Level of Confidence: Good for mechanical operation, fair for H_2S precipitation and for cementation reactions.

Comments: Process specifications other than for holding volume are not firm. Decopperization experiments will be done only occasionally.

Date: 11/1/77 - Rev. 0

Process Equipment

Design Criteria Summary

Item Number: T302

Item Description: Neutralization Tank - Filament wound fiberglass reinforced vinyl ester plastic tank, vertical with flat bottom and open top with bolt-on cover and 22" diameter hinged manway. Tank to be 7' diameter by 9'-9" high - 2511 gal capacity. Fittings to be flanged construction and include (1) 3" gusseted drain nozzle, (2) 2" nozzles. Four galvanized steel tiedown brackets to be furnished. Top cover to have cut out on side and tank wall to be fitted with an agitator support bracket.

Design Requirements: Tank to be suitable for outdoor installation in seismic zone 3 with 100 MPH design wind load. Agitator support on tank wall to be design for 2 HP agitator weighing up to 200 pounds. Tank materials to be resistant to clear liquid purge solution containing 2.5% H_2SO_4 , 0.5% $CuSO_4$, and 10% $(NH_4)_2SO_4$ at design temperature of 210°F. Operating temperature 180°F.

Design Bases: Mechanical design of tank to be by manufacturer for wind and seismic loads. Material selection from resin manufacturer's chemical resistance guide and laboratory evaluations. Volume based on holding one days clear liquid purge from column.

Level of Confidence: Good on mechanical design, fair on material selection, good on size.

Comments: Long term properties of resin system at elevated temperatures may be questionable. Operation at lower temperatures would eliminate problem.

Date: 6/1/77 - Rev. 0

Process Equipment

Design Criteria Summary

Item Number: T303

Item Description: Sulfuric Acid Storage Tank. 1000 gallon carbon steel closed storage tank. Five foot diameter by 6' straight side with ASME flanged and dished heads, 3/8" wall thickness, (3) 1-1/2" nozzles and (1) 1" nozzle. Tank to be supported on four legs.

Design Requirements: Maintain dry storage of 93% sulfuric acid to meet process needs during test campaign.

Design Bases: Provide storage for initial acid copper sulfate makeup requirements, and makeup acid requirements in leach reactor as necessary.

Level of Confidence: Good

Comments: Standard design for this service.

Date: 6/1/77 - Rev. 0

Process Equipment

Design Criteria Summary

Item Number: T304

Item Description: Process Water Storage Tank. Hand layup fiberglass reinforced vinyl ester plastic tank, vertical with flat bottom and open top. Tank to be 4' diameter by 4'-4" high - 407 gallon capacity. Fittings to be flanged construction and include (1) 2" siphon drain nozzle, (2) 1-1/2" diameter nozzle and (2) 1" diameter nozzles. Four galvanized steel tiedown brackets to be furnished. Resin to be Derakane 470-36 with white pigmented exterior protective coating.

Design Requirements: Tank to hold filtered cooling tower water for use as seal pressurizing fluid and for demister wash. Tank to be suitable for outdoor installation.

Design Bases: Holding capacity for 1 to 2 hours usage rate of seal fluid and demister wash water.

Level of Confidence: Good

Comments: Standard design for this service.

Date: 6/1/77 - Rev. 0

Process Equipment

Design Criteria Summary

Item Number: T305

Item Description: Liquid oxygen storage tank and vaporizer, 6000 gallon double wall vacuum insulated cryogenic tank with ambient, finned tube vaporizer. Tank to be designed for 250 psig operation and to be fabricated and tested in accordance with the ASME code, Section VIII. Tank to be provided with necessary valves, regulators, safety devices and piping for proper operation.

Design Requirements: Tank to provide storage of liquid oxygen required for leach regeneration of copper sulfate solution. Vaporizers to deliver gaseous oxygen to reactor system at up to 500 lb/hr. Tank to be suitable for outdoor installation in seismic zone 3 with 100 MPH design wind load.

Design Bases: Tank sized to store approximately 45 days supply of oxygen required by regeneration reaction. Vaporizers sized to meet maximum rate of usage expected in reaction. Mechanical design of tank for wind and seismic loads to be by manufacturer.

Level of Confidence: Good for tank size, vaporizer size and usage rates.

Comments: Oxygen vendor's standard design for this service.

Date: 11/21/77 - Rev. 0

Process Equipment

Design Criteria Summary

Item Number: T306, T306A

Item Description: (2) 500 gallon liquid ammonia storage tank designed for 250 psig operation and fabricated and tested in accordance with ASME code, Section VIII. Tanks to be mounted horizontally one above the other and interconnected. Tanks to be fitted with liquid fill valve assembly, pressure equalizing assembly, dual safety relief valve, liquid level float gage, pressure gage, outlet valves and one 10 kW electric vaporizer. Electric heater to be provided with suitable controls and interlocks to provide safe operation. Material of construction - steel.

Design Requirements: Provide pressurized storage of anhydrous liquid ammonia required to neutralize the clear liquid purge prior to disposal. Vaporizer to deliver up to 100 lb/hr of gaseous ammonia to the neutralization system. Tanks to be designed for outdoor installation in seismic zone 3 and 100 MPH wind load.

Design Bases: Tanks sized to store approximately 30 days supply of ammonia required to neutralize clear liquid purge. Vaporize adequate to meet maximum usage rate in neutralization. Mechanical design of tank to be by manufacturer.

Level of Confidence: Good

Comments: Ammonia vendors' standard design for this service.

Date: 11/21/77 - Rev. 0

CONTROLLER LOOPS

Controller Loops

Specification Sheets Summary

<u>Sheet No.</u>	<u>Item No.</u>	<u>Description</u>
3	FY-101	Foxboro Model 557-30. Pneumatic square root extractor. Input and output signals 3-15 psi, Tag FY-101.
9	FE-103/ FT-103	Magnetic flow transmitter. Teflon lined T304 stainless steel 4" metering tube with T316 stainless steel electrodes, 150 lb flange, 120 V 60 Hertz supply, parallel coil connection, electrical classification: FM, 30' signal cable. Flow range 67-800 GPM; 2.5% H_2SO_4 , 10% $(NH_4)_2SO_4$, 0.2% $CuSO_4$, 3% CuS . Temperature: Nom 353°F, max 366°F Pressure: Nom 120 psig, max 150 psig Foxboro Model No. 2804 SABA-TSA-G. Transmitter Model No. M/E96-P-I-FNF-B. I/P Model No. 69TA-2RI-INS-FB.
13	AIT-105/ E/P-105	Purge analyzer indicator transmitter. Teledyne analytical instruments Model 611LX photometric analyzer with remote control unit. Application 0-5 g/l copper (approximately 0-12.5 g/l copper sulfate) in water containing 0-100 g/l ammonia sulfate, and 0-30 g/l sulfuric acid. Sample temperature - up to 350°F. Sample pressure - up to 150 psig. Measurement wavelength to be 825 microns. Reference wavelength to be determined. Cell length to be 0.25 inches. Output meter on control unit to read 0-5 g/l copper (linear). Output signal to controller 0-100 mV. Optical span filter to be supplied. Millivolt to pneumatic transducer. Transmation Model No. 430T with Robertshaw Type 443 transducer for control room service with integral electronics. Overall accuracy $\pm 1/2\%$. Input 0-100 mV (adjustable 5-250 mV. Output 3-15 psig.

Sheet No.	Item No.	Description
16	FIT-105	<p>Wallace and Tiernan straight through metal tube type Varea meter with pneumatic transmitter.</p> <p>Tube No.: WT-1-40-M-5</p> <p>Float No.: 1-M-6 VI-197</p> <p>Tube & Float Material: 316 stainless steel.</p> <p>Flange Material: 316 stainless steel.</p> <p>Fluid: 12 gal/min max of copper sulfate makeup solution</p> <p>Specific Gravity: 1.14 @ 120°F</p> <p>Viscosity: 1 cps</p> <p>Operating Temperature: 120°F</p> <p>Operating Pressure: 150 psig</p> <p>End Flanges: 1" 150# ANSI</p> <p>Calibration: Standard</p> <p>Dial Units: gal/min of fluid @ specific gravity = 1.14</p> <p>Exact flow rate at 15 psig transmitter output to be:</p> <p>12 gpm of 1.14 specific gravity fluid.</p> <p>Transmitter Output: 3-15 psig</p> <p>Filter Regulator: Not required.</p> <p>Tag FIT-105</p>
18	PHE-106	<p>Great Lakes Instruments Inc. Model No. P60D-3-1 pH probe.</p> <p>Material of construction - Derakane, process connection 1-1/2" NPT for mounting in a CPVC tee for a flowthrough installation. Probe to be rated for operation at up to 95°C at 100 psig. Probe to have a 10 foot cable terminated with lugs for use with a terminal strip.</p>
19	PHI-106	<p>Great Lakes Instruments Inc. Model No. A60-1-1-3-1A pH analyzer. Scale 0-10 pH units, output voltage/ current 0-100 mV/4-20 mA.</p>
22	FY-107	<p>Foxboro Model 557-30, pneumatic square root extractor.</p> <p>Input and output signals 3-15 psi. Tag FY-107.</p>

Sheet No.	Item No.	Description
25	FIT-108	<p>Wallace & Tiernan straight through metal tube type Varea meter with pneumatic transmitter. Tube No.: WT-1/2-25-M-5 Float No.: 1/2-M-6 VI-117 Tube & Float Materials: 316 stainless steel Flange Material: 316 stainless steel Fluid: 3 GPM max of decanted copper sulfate purge solution Specific Gravity: 1.05 Viscosity: 1.0 cps Operating Temperature: 120°F Operating Pressure: 5 psig End Flanges: 1"-150# ANSI Calibration: Standard Dial Units: GPM of fluid @ specific gravity = 1.05 Exact flow rate at 15 psig transmitter output to be: 3.0 GPM of 1.05 specific gravity fluid Transmitter Output: 3-15 psig Filter Regulator: Not required Tag: FIT-108</p>
41	FIT-108	<p>Wallace & Tiernan straight through metal tube type Varea meter with pneumatic transmitter. Tube No.: WT-3/4-40-M-5 Float No.: 3/4-M-2 VI-95 Tube & Float Materials: 316 stainless steel Flange Material: 316 stainless steel Fluid: Oxygen Specific Gravity: 1.103 Viscosity: 0.02 cps Operating Temperature: 70°F Operating Pressure: 126 psig End Flanges: 150# ANSI</p>

Sheet No.	Item No.	Description
41 (continued)	FIT-108	<p>Calibration: Standard</p> <p>Dial Units: lb/hr oxygen @ 125 psig</p> <p>Exact flow rate at 15 psig transmitter output to be: 400 lb/hr. Oxygen at 125 psig and 70°F.</p> <p>Transmitter Output: 3-15 psig</p> <p>Filter Regulator: Not required</p> <p>Tag: FIT-207</p>
43	FIT-208	<p>Wallace & Tiernan straight through metal tube type Varea meter with pneumatic transmitter.</p> <p>Tube No.: WT-1-1/2-39-M-5</p> <p>Float No.: 1-1/2-M-6 VI-436</p> <p>Tube & Float Materials: 316 stainless steel</p> <p>Flange Material: Carbon steel</p> <p>Fluid: 300 SCFM compressed air @ 125 psig</p> <p>Specific Gravity: 1.0</p> <p>Viscosity: 0.02 cps</p> <p>Operating Temperature: 170°F</p> <p>Operating Pressure: 125 psig</p> <p>End Flanges: 1"-150# ANSI</p> <p>Calibration: Standard</p> <p>Dial Units: SCFM air @ 125 psig</p> <p>Exact flow rate at 15 psig transmitter output to be: 300 SCFM air at 125 psig and 170°F</p> <p>Transmitter Output: 3-15 psig.</p> <p>Filter Regulator: Not required</p> <p>Tag: FIT-208</p>
44	KC-301	<p>Demister wash cycle timer. Six-circuit, solid state, programmable timer. Voltage 120 V, 60 Hertz</p> <p>Design Requirements: Timer to cycle (3) solenoid valves FCV-301A, B, and C, individually to alternately wash 1/3 of the demister at a time. Each cycle to be</p>

Sheet No.	Item No.	Description
44 (continued)	KC-301	<p>separated by an adjustable span to allow column operation to stabilize. Timer to turn on pump P304 before each valve is opened and turn pump off after valve closes. Total cycle time to be variable and to repeat automatically.</p> <p>Design Bases: Column demister washing by thirds to minimize upset in operation. Solid state timer to minimize electrical contact corrosion from ambient H_2S. Cycle times - total 10 min - 1 hr, valves on 5 sec - 60 sec, pump on 15-30 sec before valves off 5 sec after valves, adjustable span (to stabilize) 2-10 min.</p> <p>Level of Confidence: Good - cycle times permit wide variation in washing operation. Ambient corrosion - fair, will require careful selection of a protective enclosure.</p>

ORIFICE PLATES & FLANGES

SPECIFICATION SHEET

SHEET NO. _____
 TAG NO. FE-101
 DATE 3-14-77
 REVISED _____
 BY RNW

MAIN STEAM LINE TO SCRUBBING TOWER

GENERAL SPECIFICATION

ORIFICE PLATES

ORIFICE FLANGES

1	MAKE TO ASA STANDARD ☒ OTHER _____	6	RATING & FACING <u>300# RATED FACE</u>
2	PLATE MATERIAL: 316SS. ☐ OTHER <u>304SS</u>	7	TYPE: WELD NECK ☒ OTHER _____
3	RTJ RING MAT'L & TYPE _____	8	MAT'L: STEEL ☒ OTHER _____
4	BORE MAXIMUM RATE ☒ NEAREST 1/8" ☐ _____	9	TAP SIZE 1/2" NPT ☒ OTHER _____
5	STAMP TO ISA STANDARD ☒ OTHER _____	10	FLANGES BY <u>WITH PLATE</u>

11	TAG NO.	FE-101			
12	LINE NO.	16" 3/4 WNU			
SERVICE CONDITIONS					
13	FLUID	STEAM			
14	FLOW UNITS	# / HR			
15	MAXIMUM FLOW	120,000			
16	NORMAL FLOW	100,000			
17	FLOW PRESSURE-PSIG	120			
18	FLOW TEMPERATURE °F	353			
19	S.G. @ 60°F & PSIA	-			
20	S.G. @ F.T. & PSIA	-			
21	SUPERCOMP. FACTOR @ O.P.	-			
22	VAPOR GAS MOL WT	18			
23	VISCOSITY, CP @ F.T.	-			
24	STEAM QUALITY, %	100			
25	STEAM SUPERHEAT °F	0°F			
26					
27					
28					
29					
MEASURING STATION DATA					
30	ACTUAL ORIFICE I.D., INS.	AS REQ'D.			
31	LINE FLANGE I.D., INS.	15.25"			
32	SEAL S.G. @ 60°F	-			
33	MANOMETER TYPE	DP CELL			
34	DIFF. RANGE INS H ₂ O DRY	60" H ₂ O			
35	STATIC RANGE, PSIA	135			
36	CHART OR SCALE RANGE	0-120 UNITS			
37	CHART MULTIPLIER	1000			
38					
39					
40					
41					

NOTES:

- GASKETS TO BE SPIRAL WOUND, STAINLESS STEEL 304 + ASBESTOS FILLER, COMPRESSION GAGE TYPE, COMPLETE WITH 1/8" THICK SOLID STAINLESS STEEL INNER & OUTER GAGE RINGS.

2. SEAL POT - BY _____

DIFFERENTIAL PRESSURE INSTRUMENTS

SPECIFICATION SHEET

SHEET NO. 2
 TAG NO. FT-101
 DATE 3-14-77
 REVISED
 BY R.B.W.

MAIN STEAM FLOW TO CONDENSER TANK

GENERAL		DIFFERENTIAL UNIT	
1 DESCRIPTION	RECORDER ☐ INDICATOR ☐ BLIND ☒	28 FLOW ☒ LEVEL ☐ PRESSURE ☐	
2 CASE	CONTROLLER ☐ TRANSMITTER ☒	29 MERCURY ☐ BELLONS ☐ DIAPHRAGM ☒	
	RECTANGULAR ☐ CIRCULAR ☐	30 OTHERS	
	OTHERS <u>MAN. SPN</u>		
3 CASE COLOR	BLACK ☐ OTHER ☒ <u>MAN SPN</u>	31 MAT'L	BODY DIAPHRAGM OR BELLONS
4 MOUNTING	FLUSH ☐ SURFACE ☐ YOKE ☒		<u>316 SS</u> <u>316 SS</u>
5 NO. PTS. RECORDING	INDICATING	32 BODY RATING PSIG	<u>1500</u> @ <u>60°F</u>
6 CHART TYPE	12" CIRC. ☐ OTHER	33 DIFFERENTIAL RANGE	<u>1.0</u> to <u>4.0</u>
7 CHART RANGE	NUMBER	34 DIFFERENTIAL CONN. 1/4" ☐ 1/2" ☒ OTHER	
8 SCALE RANGE	TYPE		
9 CHART DRIVE	SPRING ☐ ELECTRIC ☐ PNEUM. ☐		
10 CHART SPEED	WIND		
11 V <u>C</u> E.P. ☐ AIR PRESS.			
12 OTHER			
TRANSMITTER		ACCESSORIES	
13 TYPE	PNEUMATIC ☒ ELECTRIC ☐	35 FILTER & REGULATOR	<u>YES</u>
14 OUTPUT	3-15 PSI ☒ OTHER ☐	36 AIR SUPPLY GAGE	<u>YES</u>
15 RECEIVERS ON SHEET NO. <u>4 & 5</u>		37 LOCAL INDICATOR	<u>N/A</u>
		38 CHARTS & INKSET	<u>-</u>
		39 MOUNTING YOKE	<u>YES</u>
		40 PULSATION DAMPENER	<u>N/A</u>
		41 MERCURY	<u>-</u>
		42 LUBRICATOR & ISO. VALVE	<u>-</u>
		43 INTEGRATOR	<u>-</u>
		44 PRIMARY MEASURING ELEMENT	<u>YES</u>
		TYPE <u>ORIFICE</u> <u>PIA</u> <u>FLANGES</u> <u>*</u>	
		45 ALARM SWITCH	<u>NO</u>
		HERMETICALLY SEALED ☐ E.P. ☐ G.P. ☐	
		46 SCALE POTS - SEE SPEC SHEET #1	
		47 <u>V</u> EXTRACTED SEE FT-101 (P-3)	
		48 <u>2-5</u> HIGH TEMPERATURE CAPSULES	
		49 <u>1-1</u> P.T.C. PROCESS & ASKET	
CONTROL		SERVICE CONDITIONS *	
15 TYPE	PNEUMATIC ☐ ELECTRIC ☐	FLUID	FLOW UNITS
17 PROP. %	AUTO-RESET ☐ RATE-ACTION ☐ ON-OFF ☐	FLOW NORMAL	FULL SCALE
18 OUTPUT	3-15 PSI ☐ OTHER	@ 60°F & PSIA	
19 ON MEASUREMENT INCREASE	OUTPUT: INCREASES ☒ DECREASES ☐	OPERATING PRESS. PSIG	TEMP. °F
		SPEC. GRAV. @ 60°F	PSIA
		SPEC. GRAV. @ F.T.	PSIA
		VAPOR GAS MOL. WT.	
		VISCOSITY @ °F	
		SUPER-COMPRESSIBILITY FACTOR @ O.P.	
		SEAL FLUID OR PURGE	
		SPEC. GRAV. @ 60°F	
		PIPE I.D.	TYPE TAPS
		FLANGE PATING & FACING	
		ORIFICE BORE NEAR 1/8" ☐ EVEN MULTIPLE ☐	
		PLATE MAT'L	ACTUAL BORE
		CHART MULTIPLIER	
		FLOW EQUALS X DIFF. X	
AUTO-MANUAL SWITCH		* SEE SPEC SHEET #1 FT-101	
20 NO. POSITIONS	EXTERNAL ☐ INTERNAL ☐		
	INTERNAL ☐		
SETPOINT ADJUSTMENTS			
21 MANUAL	INTERNAL ☐ EXTERNAL ☐		
22 AUTO-SET	PNEUMATIC ☐ ELECTRIC ☐		
23 BAND	FIXED ☐ ADJUSTABLE ☐		
24 OTHER			
STATIC PRESSURE OR RECEIVER ELEMENT			
25 TYPE	MATERIAL		
26 RANGE			
27 FOR OTHER ELEMENTS SEE TAG NO.			
	ON SHEET NO.		

RECEIVER INSTRUMENTS

SPECIFICATION SHEET

SHEET NO. 4
TAG NO. FIC-181
DATE 9-7-79
REVISED _____
BY 12.6 v

MANUAL SEVEN FLOW CONTROLLER

GENERAL		RECEIVER ELEMENT	
1	DESCRIPTION RECORDER ☐ INDICATOR ☒ CONTROLLER ☒	25	SPIRAL ☐ BELLOWS ☒ SOUDDGI ☐
2	CASE RECTANGULAR ☒		DIAPHRAGM ☐ ELEC. ☐
3	COLOR CASE BLACK ☐ OTHER <u>MAN. STD</u>		
DIAL			
4	MOUNTING FLUSH ☒ SURFACE ☐ YOKE ☐		
5	NO. PYS. RECORDING _____ INDICATING <u>1</u>		
6	CHART TYPE _____ STRIP ☐ 12" CIRCULAR ☐ OTHER _____		
7	CHART RANGE _____ NUMBER _____		
8	SCALE RANGE <u>0 - 130</u> TYPE <u>UNIFORM</u>		
9	CHART DRIVE SPRING ☐ ELECTRIC ☐ PNEUM. ☐		
10	CHART SPEED _____ WIND _____		
11	V. _____ C. _____ EX. PRF. ☐ AIR PRESS. _____		
12	OTHER _____		
MATERIAL			
26	BRONZE ☒ OTHER _____		
27	RANGE _____ 3-15 PSI ☒ OTHER _____		
	CONNECTION-NPT _____ 1/4" ☒ OTHER _____		
	BACK ☒ BOTTOM ☐		
	OTHER _____		
ACCESSORIES			
28	FILTER & REGULATOR <u>N/O</u>		
29	AIR SUPPLY GAGE _____		
30	CHARTS & INKSET _____		
31	MOUNTING YOKE _____		
32	RESTRICTION DAMPENER _____		
33	MANIFOLDS _____		
34	ALARM SWITCH _____		
	HERMETICALLY SEALED ☐ EP ☐ GP ☐		
GENERAL			
13	TRANSMITTERS ON SHEET NO. <u>2</u>		
CONTROL			
14	TYPE PNEUMATIC ☒ ELECTRIC ☐		
15	PROP. <u>50%</u> AUTO-RESET ☒ RATE ACTION ☐ ON-OFF ☐		
16	OTHER _____		
17	OUTPUT 3-15 PSI ☒ OTHER _____		
18	ON MEASUREMENT INCREASE		
	OUTPUT: INCREASES ☐ DECREASES ☒		
19	CONTROL LOCATION REMOTE ☐ INSTR. ☒		
	OTHER _____		
AUTO MANUAL SWITCH			
20	NO. POSITIONS <u>2</u> EXTERNAL ☒ INTERNAL ☐		
	INTEGRAL ☐		
SET POINT ADJUSTMENTS			
21	MANUAL INTERNAL ☐ EXTERNAL ☒		
22	MANUAL PNEUMATIC ☐ ELECTRIC ☐		
23	AUTO-SET PNEUMATIC ☐ ELECTRIC ☐		
24	BAND FIXED ☐ ADJUSTABLE ☐		
25	OTHER _____		
NOTE			

RECEIVER INSTRUMENTS

SPECIFICATION SHEET

SHEET NO. 5
 TAG NO. FR-101
 DATE 3-15-77
 REVISED _____
 BY RBW

STEAM FLOW TO SCRUBBER TOWER
PNEUMATIC RECORDER

GENERAL		RECEIVER ELEMENT	
1	DESCRIPTION RECORDER ☒ INDICATOR ☐ CONTROLLER ☐	25	SPIRAL ☐ BELLOWS ☒ BOURDON ☐
2	CASE RECTANGULAR ☒		DIAPHRAGM ☐ ELEC. ☐
3	COLOR CASE BLACK ☐ OTHER <u>MAN. STD.</u>		
4	DIAL _____		
5	MOUNTING FLUSH ☒ SURFACE ☐ YOKE ☐		
6	NO. PTS. RECORDING _____ INDICATING _____		
7	CHART TYPE <u>4"</u> STRIP ☒ 12" CIRCULAR ☐ OTHER _____		
8	CHART RANGE <u>0-120</u> NUMBER <u>53009-10k</u>		
9	SCALE RANGE <u>0-120</u> TYPE <u>UNIFORM</u>		
10	CHART DRIVE SPRING ☐ ELECTRIC ☒ PNEUM. ☐		
11	CHART SPEED <u>3 1/4" / MIN.</u> WIND _____		
12	<u>V120</u> C60 EX. PRF. ☐ AIR PRESS. _____		
13	OTHER _____		
13 TRANSMITTERS ON SHEET NO. <u>2</u>			
CONTROL		26 BRONZE ☒ OTHER _____	
14	TYPE PNEUMATIC ☐ ELECTRIC ☐	RANGE 3-15 PSI ☒ OTHER _____	
15	PROP. % AUTO-RESET ☐ RATE ACTION ☐ ON-OFF ☐	27 CONNECTION-NPT 1/4" ☒ OTHER _____	
16	OTHER _____	BACK ☒ BOTTOM ☐	
17	OUTPUT 3-15 PSI ☐ OTHER _____	OTHER _____	
18	ON MEASUREMENT INCREASE		
19	OUTPUT INCREASES ☐ DECREASES ☐		
20	CONTROL LOCATION REMOTE ☐ INSTR. ☐		
21	OTHER _____		
AUTO MANUAL SWITCH		ACCESSORIES	
22	NO. POSITIONS _____ EXTERNAL ☐ INTERNAL ☐	28 FILTER & REGULATOR <u>NO</u>	
23	INTEGRAL ☐	29 AIR SUPPLY GAGE _____	
SET POINT ADJUSTMENTS		30 CHARTS & INKSET <u>YES</u>	
24	MANUAL INTERNAL ☐ EXTERNAL ☐	31 MOUNTING YOKE <u>NO</u>	
25	MANUAL PNEUMATIC ☐ ELECTRIC ☐	32 RESTRICTION DAMPENER _____	
26	AUTO-SET PNEUMATIC ☐ ELECTRIC ☐	33 MANIFOLDS _____	
27	BAND FIXED ☐ ADJUSTABLE ☐	34 ALARM SWITCH _____	
28	OTHER _____	HERMETICALLY SEALED ☐ EP ☐ GP ☐	
NOTE			
<u>FORNOLD PNEUM. " 121-1E</u>			

DIFFERENTIAL PRESSURE INSTRUMENTS

SPECIFICATION SHEET

SHEET NO. 6
 TAG NO. 1PT-103
 DATE 3-15-77
 REVISED BY RBL

POWER TRAY Δ P

GENERAL		DIFFERENTIAL UNIT	
1 DESCRIPTION	RECORDER ☐ INDICATOR ☐ BLIND ☒	28 FLOW ☐ LEVEL ☐ PRESSURE ☒	
2 CASE	CONTROLLER ☐ TRANSMITTER ☒	29 MERCURY ☐ BELLOWS ☐ DIAPHRAGM ☒	
	RECTANGULAR ☐ CIRCULAR ☐	30 OTHERS	
	OTHERS <u>MAN STD</u>		
3 CASE COLOR	BLACK ☐ OTHER ☒ <u>MAN STD</u>	31 MAT'L	BODY DIAPHRAGM OR BELLOWS
4 MOUNTING	FLUSH ☐ SURFACE ☐ YOKE ☒		<u>316 SS 316 SS</u>
5 NO. PTS.-RECORDING	<u>0</u> INDICATING <u>1</u>	32 BODY RATING PSIG	<u>1500 @ 60°F</u>
6 CHART TYPE	12" CIRC. ☐ OTHER ☐	33 DIFFERENTIAL RANGE	<u>2-44" H₂O</u>
7 CHART RANGE	NUMBER	34 DIFFERENTIAL CONN. 1/4" ☐ 1/2" ☒ OTHER	
8 SCALE RANGE	TYPE		
9 CHART DRIVE	SPRING ☐ ELECTRIC ☐ PNEUM. ☐		
10 CHART SPEED	WIND		
11 V <u>C</u> E.P. ☐ AIR PRESS.			
12 OTHER			
TRANSMITTER		ACCESSORIES	
13 TYPE	PNEUMATIC ☒ ELECTRIC ☐	35 FILTER & REGULATOR	<u>YES</u>
14 OUTPUT	3-15 PSI ☒ OTHER ☐	36 AIR SUPPLY GAGE	<u>YES</u>
15 RECEIVERS ON SHEET NO. <u>7 + 8</u>		37 LOCAL INDICATOR	<u>NO</u>
		38 CHARTS & INKSET	<u>NO</u>
		39 MOUNTING YOKE	<u>YES</u>
		40 PULSATION DAMPENER	<u>NO</u>
		41 MERCURY	<u>NO</u>
		42 LUBRICATOR & ISO. VALVE	<u>NO</u>
		43 INTEGRATOR	
		44 PRIMARY MEASURING ELEMENT	
		45 ALARM SWITCH	
			HERMETICALLY SEALED ☐ E.P. ☐ G.P. ☐
			<u>3 VALVE FLANNETT DM-M4HVS</u>
			<u>DB-5 HIGH TEMP. RATING GASKETS</u>
			<u>UG-7 PTFE PRESS. GASKETS</u>
			<u>SUPPLIES 1/4" 1/2" INCHES O.D. PIPE</u>
CONTROL		SERVICE CONDITIONS	
16 TYPE	PNEUMATIC ☐ ELECTRIC ☐	FLUID	FLOW UNITS
17 PROP. <u>%</u> AUTO-RESET ☐ RATE-ACTION ☐ ON-OFF ☐	OTHER	FLOW NORMAL	FULL SCALE
18 OUTPUT	3-15 PSI ☐ OTHER	@ 60°F &	PSIA
19 ON MEASUREMENT INCREASE		OPERATING PRESS. PSIG	TEMP. °F
OUTPUT: INCREASES ☐ DECREASES ☐		SPEC. GRAV. @ 60°F	PSIA
		SPEC. GRAV. @ F.T.	PSIA
		VAPOR GAS MOL. WT.	
		VISCOSITY @ °F	
		SUPER-COMPRESSIBILITY FACTOR @ O.P.	
		SEAL FLUID OR PURGE	
		SPEC. GRAV. @ 60°F	
		PIPE I.D.	TYPE TAPS
		FLANGE RATING & FACING	
		ORIFICE BORE NEAR 1/8" ☐ EVEN MULTIPLE ☐	
		PLATE MAT'L	ACTUAL BORE
		CHART MULTIPLIER	
		FLOW EQUALS	X DIFF. X
AUTO-MANUAL SWITCH			
20 NO. POSITIONS	EXTERNAL ☐ INTERNAL ☐		
	INTEGRAL ☐		
SETPPOINT ADJUSTMENTS			
21 MANUAL	INTERNAL ☐ EXTERNAL ☐		
22 AUTO-SET	PNEUMATIC ☐ ELECTRIC ☐		
23 BAND	FIXED ☐ ADJUSTABLE ☐		
24 OTHER			
STATIC PRESSURE OR RECEIVER ELEMENT			
25 TYPE	MATERIAL		
26 RANGE			
27 FOR OTHER ELEMENTS SEE TAG NO.			
	ON SHEET NO.		
<u>PIPING M/131-1122-L, 06-1</u> <u>DM-M4HVS, IN 5-11</u>			

RECEIVER INSTRUMENTS

SPECIFICATION SHEET

SHEET NO. 7
 TAG NO. APIC-103
 DATE 9.12.77
 REVISED
 BY RAW

GENERAL		RECEIVER ELEMENT	
1	DESCRIPTION RECORDER ☐ INDICATOR ☒ CONTROLLER ☒	25	SPIRAL ☐ BELLONS ☒ BOURDON ☐ DIAPHRAGM ☐ ELEC. ☐
2	CASE RECTANGULAR ☒	MATERIAL	
3	COLOR CASE BLACK ☐ OTHER <u>MAN. STD</u>	26	BRONZE ☒ OTHER <u> </u>
4	DIAL	27	RANGE 3-15 PSI ☒ OTHER <u> </u>
5	NO. PTS. - RECORDING <u> </u> INDICATING <u>1</u>	CONNECTION - NPT 1/4" ☒ OTHER <u> </u>	
6	CHART TYPE <u> </u> STRIP ☐ 12" CIRCULAR ☐ OTHER <u> </u>	BACK ☒ BOTTOM ☐	
7	CHART RANGE <u> </u> NUMBER <u> </u>	OTHER <u> </u>	
8	SCALE RANGE <u>0-40</u> TYPE <u>UNIFORM</u>		
9	CHART DRIVE SPRING ☐ ELECTRIC ☐ PNEUM. ☐		
10	CHART SPEED <u> </u> WIND <u> </u>		
11	V <u> </u> C <u> </u> EX. PRF. ☐ AIR PRESS. <u> </u>		
12	OTHER <u> </u>		
13 TRANSMITTERS ON SHEET NO. <u>60</u>		ACCESSORIES	
CONTROL		28 FILTER & REGULATOR <u>N0</u>	
14	TYPE PNEUMATIC ☒ ELECTRIC ☐	29 AIR SUPPLY GAGE <u> </u>	
15	PROP. <u> </u> AUTO-RESET ☒ RATE ACTION ☒ ON-OFF ☐	30 CHARTS & INK SET <u> </u>	
16	OUTPUT 3-15 PSI ☒ OTHER <u> </u>	31 MOUNTING YOKE <u> </u>	
17	ON MEASUREMENT INCREASE	32 RESTRICTION DAMPENER <u> </u>	
18	OUTPUT: INCREASES ☒ DECREASES ☐	33 MANIFOLDS <u> </u>	
19	CONTROL LOCATION REMOTE ☐ INSTR. ☒	34 ALARM SWITCH <u> </u>	
AUTO MANUAL SWITCH		HERMETICALLY SEALED ☐ EP ☐ GP ☐	
20	NO. POSITIONS <u>2</u> EXTERNAL ☐ INTERNAL ☐		
SET POINT ADJUSTMENTS			
21	MANUAL INTERNAL ☐ EXTERNAL ☒		
22	MANUAL PNEUMATIC ☐ ELECTRIC ☐		
23	AUTO-SET PNEUMATIC ☐ ELECTRIC ☐		
24	BAND FIXED ☐ ADJUSTABLE ☒		
NOTE			
<u>RECEIVER INSTRUMENT 130 M - 115</u>			

RECEIVER INSTRUMENTS

SPECIFICATION SHEET

SHEET NO. 8
 TAG NO. RP 20.1 Dwg 10a
 DATE 3-25-77
 REVISED
 BY R.B.W.

GENERAL		RECEIVER ELEMENT	
1	DESCRIPTION RECORDER ☒ INDICATOR ☐ CONTROLLER ☐	25	SPIRAL ☐ BELLOWS ☒ BOURDON ☐
2	CASE RECTANGULAR ☒		DIAPHRAGM ☐ ELEC. ☐
3	COLOR CASE BLACK ☐ OTHER <u>RAW. SPD</u>	MATERIAL	
4	DIAL	26	BRONZE ☒ OTHER
5	MOUNTING FLUSH ☒ SURFACE ☐ YOKE ☐	27	RANGE 3-15 PSI ☒ OTHER
6	NO. PTS. -RECORDING <u>2</u> INDICATING		CONNECTION-NPT 1/4" ☒ OTHER
7	CHART TYPE <u>4"</u> STRIP ☒ 12" CIRCULAR ☐ OTHER		BACK ☒ BOTTOM ☐
8	CHART RANGE <u>0-4 / 0-900</u> NUMBER <u>53953-6X</u>		OTHER
9	SCALE RANGE <u>0-40, 0-500</u> TYPE <u>UNIFORM</u>	ACCESSORIES	
10	CHART DRIVE SPRING ☐ ELECTRIC ☒ PNEUM. ☐	28	FILTER & REGULATOR <u>NO</u>
11	CHART SPEED <u>3 1/2" / MIN</u> WIND	29	AIR SUPPLY GAGE
12	V. <u>120</u> C.G.D. EX. PRF. ☐ AIR PRESS.	30	CHARTS & INKSET <u>1/2" x 5"</u>
	OTHER	31	MOUNTING YOKE
13	TRANSMITTERS ON SHEET NO. <u>6</u>	32	RESTRICTION DAMPER
	CONTROL	33	MANIFOLDS
14	TYPE PNEUMATIC ☐ ELECTRIC ☐	34	ALARM SWITCH
15	PROP. % AUTO-RESET ☐ RATE ACTION ☐ ON-OFF ☐		HERMETICALLY SEALED ☐ EP ☐ GP ☐
16	OUTPUT 3-15 PSI ☐ OTHER		
17	ON MEASUREMENT INCREASE		
18	OUTPUT: INCREASES ☐ DECREASES ☐		
	CONTROL LOCATION REMOTE ☐ INSTR. ☐		
	OTHER		
19	AUTO MANUAL SWITCH		
	NO. POSITIONS EXTERNAL ☐ INTERNAL ☐		
	INTEGRAL ☐		
20	SET POINT ADJUSTMENTS		
21	MANUAL INTERNAL ☐ EXTERNAL ☐		
22	MANUAL PNEUMATIC ☐ ELECTRIC ☐		
23	AUTO-SET PNEUMATIC ☐ ELECTRIC ☐		
24	BAND FIXED ☐ ADJUSTABLE ☐		
	OTHER		
NOTE <u>1000000 INCHES 122 - FE</u>			

RECEIVER INSTRUMENTS

SPECIFICATION SHEET

SHEET NO. 10
 TAG NO. FIC-103
 DATE 3-15-77
 REVISED
 BY RBW

SCRUBBING SOLUTION FLOW CONTROL

GENERAL		RECEIVER ELEMENT	
1	DESCRIPTION RECORDER ☐ INDICATOR ☒ CONTROLLER ☒	25	SPIRAL ☐ BELLOWS ☒ SOUPDOON ☐ DIAPHRAGM ☐ ELEC. ☐
2	CASE RECTANGULAR ☒		
3	COLOR CASE BLACK ☐ OTHER <u>MAN. STD</u> DIAL <u>WHITE</u>		
4	MOUNTING FLUSH ☒ SURFACE ☐ YOKE ☐		
5	NO. PTS. RECORDING <u>0</u> INDICATING <u>1</u>		
6	CHART TYPE <u>1</u> STRIP ☐ 12" CIRCULAR ☐ OTHER <u> </u>		
7	CHART RANGE <u> </u> NUMBER <u> </u>		
8	SCALE RANGE <u>0-500</u> TYPE <u>UNIFASCI</u>		
9	CHART DRIVE SPRING ☐ ELECTRIC ☐ PNEUM. ☐		
10	CHART SPEED <u> </u> WIND <u> </u>		
11	V <u> </u> C <u> </u> EX. PRF. ☐ AIR PRESS. <u> </u>		
12	OTHER <u> </u>		
		MATERIAL 26 BRONZE ☒ OTHER <u> </u> RANGE 3-15 PSI ☒ OTHER <u> </u> 27 CONNECTION-NPT 1/4" ☒ OTHER <u> </u> BACK ☒ BOTTOM ☐ OTHER <u> </u>	
		ACCESSORIES 28 FILTER & REGULATOR <u> </u> 29 AIR SUPPLY GAGE <u> </u> 30 CHARTS & INKSET <u> </u> 31 MOUNTING YOKE <u> </u> 32 RESTRICTION DAMPENER <u> </u> 33 MANIFOLDS <u> </u> 34 ALARM SWITCH <u> </u> HERMETICALLY SEALED ☐ EP ☐ GP ☐	
13	TRANSMITTERS ON SHEET NO. <u>9</u>		
CONTROL 14 TYPE PNEUMATIC ☒ ELECTRIC ☐ OTHER <u> </u> 15 PROP. 50% AUTO-RESET ☒ RATE ACTION ☐ ON-OFF ☐ OTHER <u> </u> 16 OUTPUT 3-15 PSI ☒ OTHER <u> </u> 17 ON MEASUREMENT INCREASE OUTPUT: INCREASES ☐ DECREASES ☒ 18 CONTROL LOCATION REMOTE ☐ INSTR. ☒ AND OTHER <u>1/16" - 1/2"</u>			
AUTO MANUAL SWITCH 19 NO. POSITIONS <u>2</u> EXTERNAL ☒ INTERNAL ☐ INTEGRAL ☐			
SET POINT ADJUSTMENTS 20 MANUAL INTERNAL ☐ EXTERNAL ☒ 21 MANUAL PNEUMATIC ☐ ELECTRIC ☐ 22 AUTO-SET PNEUMATIC ☒ ELECTRIC ☐ 23 BAND FIXED ☒ ADJUSTABLE ☐ 24 OTHER <u>RELATIVE - LOCAL SWITCH FOR FLOW</u>			
NOTE <u>100% 1300 1300 1300</u>			

DIFFERENTIAL PRESSURE INSTRUMENTS

SPECIFICATION SHEET

SHEET NO. 11
 TAG NO. LP-104
 DATE 9.14.77
 REVISED BY R.B.W.

TOWER SUMP LEVEL TRANSMITTER

GENERAL		DIFFERENTIAL UNIT	
1 DESCRIPTION	RECORDER ☐ INDICATOR ☐ BLIND ☒	28 FLOW ☐ LEVEL ☒ PRESSURE ☐	
2 CASE	CONTROLLER ☐ TRANSMITTER ☒	29 MERCURY ☐ BELLOWS ☐ DIAPHRAGM ☒	
3 CASE COLOR	RECTANGULAR ☐ CIRCULAR ☐	30 OTHERS	
4 MOUNTING	OTHERS <u>MAN. STD</u>	31 MAT'L	
5 NO. PTS. - RECORDING	FLUSH ☐ SURFACE ☐ YOKE ☒		
6 CHART TYPE	OTHER ☒ <u>MAN. STD</u>	32 BODY RATING PSIG	<u>1500</u> @ 60°F
7 CHART RANGE	INDICATING ☐	33 DIFFERENTIAL RANGE	<u>0-68" H₂O</u>
8 SCALE RANGE	NUMBER	34 DIFFERENTIAL CORR.	<u>1/4" ☐ 1/2" ☒ OTHER <u>NPT</u></u>
9 CHART DRIVE	TYPE		
10 CHART SPEED	SPRING ☐ ELECTRIC ☐ PNEUM. ☐		
11 V <u>C</u>	WIND		
12 OTHER	AIR PRESS. ☐		
TRANSMITTER		ACCESSORIES	
13 TYPE	PNEUMATIC ☒ ELECTRIC ☐	35 FILTER & REGULATOR	<u>YES</u>
14 OUTPUT	3-15 PSI ☒ OTHER ☐	36 AIR SUPPLY GAGE	<u>YES</u>
15 RECEIVERS ON SHEET NO. <u>12</u>		37 LOCAL INDICATOR	<u>NO</u>
CONTROL		38 CHARTS & INKSET	<u>-</u>
16 TYPE	PNEUMATIC ☐ ELECTRIC ☐	39 MOUNTING YOKE	<u>YES</u>
17 PROP. <u> </u> %	OTHER ☐	40 PULSATION DAMPENER	<u>NO</u>
18 OUTPUT	AUTO-RESET ☐ RATE-ACTION ☐ ON-OFF ☐	41 MERCURY	<u>NO</u>
19 ON MEASUREMENT INCREASE	OTHER ☐	42 LUBRICATOR & ISO. VALVE	<u>-</u>
OUTPUT: INCREASES ☐ DECREASES ☐		43 INTEGRATOR	<u>-</u>
AUTO-MANUAL SWITCH		44 PRIMARY MEASURING ELEMENT	<u>-</u>
20 NO. POSITIONS	EXTERNAL ☐ INTERNAL ☐	TYPE	<u>-</u>
SETPOINT ADJUSTMENTS		45 ALARM SWITCH	<u>-</u>
21 MANUAL	INTERNAL ☐ EXTERNAL ☐	HERMETICALLY SEALED ☐ E.P. ☐ G.P. ☐	
22 AUTO-SET	PNEUMATIC ☐ ELECTRIC ☐	3 VALVE MANIFOLD 8M - 1/4" NPT	
23 BAND	FIXED ☐ ADJUSTABLE ☐	DC - 5 HIGH TEMPERATURE GASKETS	
24 OTHER		DC - 7 NTC PROCESS GASKETS	
STATIC PRESSURE OR RECEIVER ELEMENT		46 SUPPRESSION <u> </u> INCHES OF H ₂ O	
25 TYPE	MATERIAL	SERVICE CONDITIONS	
26 RANGE		FLUID <u> </u> FLOW UNITS <u> </u>	
27 FOR OTHER ELEMENTS SEE TAG NO. <u> </u>	ON SHEET NO. <u> </u>	FLOW NORMAL <u> </u> FULL SCALE <u> </u>	
		@ 60°F & <u> </u> PSIA	
		OPERATING PRESS. PSIG <u> </u> TEMP. <u> </u> °F	
		SPEC. GRAV. @ 60°F <u> </u> & <u> </u> PSIA	
		SPEC. GRAV. @ F.T. <u> </u> & <u> </u> PSIA	
		VAPOR GAS MOL. WT. <u> </u>	
		VISCOSITY @ <u> </u> °F <u> </u> cP	
		SUPER-COMPRESSIBILITY FACTOR @ G.P. <u> </u>	
		SEAL FLUID OR PURGE <u> </u>	
		SPEC. GRAV. @ 60°F <u> </u>	
		PIPE I.D. <u> </u> TYPE TAPS <u> </u>	
		FLANGE PATING & FACING <u> </u>	
		ORIFICE SIZE NEAR 1/8" ☐ EVEN MULTIPLE ☐	
		PLATE MAT'L <u> </u> ACTUAL SOPS <u> </u>	
		CHART MULTIPLIER <u> </u>	
		FLOW EQUALS <u> </u> X DIFF. X <u> </u>	

For 20.1 11/13A-MS-2, DG-5, UG-1

31.11.77, 11.5.77

RECEIVER INSTRUMENTS

SPECIFICATION SHEET

SHEET No. 12
 TAG NO. LF 104
 DATE _____
 REVISED _____
 BY _____

POWER SUPPLY LEVEL INDICATOR

GENERAL		RECEIVER ELEMENT	
1	DESCRIPTION RECORDER ☐ INDICATOR ☒ CONTROLLER ☐	25	SPIRAL ☐ BELLONS ☒ BOURDON ☐ DIAPHRAGM ☐ ELEC. ☐
2	CASE RECTANGULAR ☒		
3	COLOR CASE BLACK ☐ OTHER <u>MAN. STD</u>		
4	DIAL _____		
5	MOUNTING FLUSH ☒ SURFACE ☐ YOKE ☐		
6	NO. PTS. RECORDING _____ INDICATING <u>1</u>		
7	CHART TYPE <u>STRIP</u> ☐ 12" CIRCULAR ☐ OTHER _____		
8	CHART RANGE _____ NUMBER _____		
9	SCALE RANGE <u>0-100</u> TYPE <u>UNIFORM</u>		
10	CHART DRIVE SPRING ☐ ELECTRIC ☐ PNEUM. ☐		
11	CHART SPEED _____ WIND _____		
12	V. <u>C</u> EX. PRF. ☐ AIR PRESS. _____		
13	OTHER _____		
		MATERIAL	
		26 BRONZE ☒ OTHER _____	
		RANGE 3-15 PSI ☒ OTHER _____	
		27 CONNECTION-NPT 1/4" ☒ OTHER _____	
		BACK ☒ BOTTOM ☐	
		OTHER _____	
		ACCESSORIES	
		28 FILTER & REGULATOR _____	
		29 AIR SUPPLY GAGE _____	
		30 CHARTS & INKSET _____	
		31 MOUNTING YOKE _____	
		32 RESTRICTION DAMPENER _____	
		33 MANIFOLDS _____	
		34 ALARM SWITCH <u>YES</u>	
		HERMETICALLY SEALED ☐ EP ☐ GP ☐	
13 TRANSMITTERS ON SHEET NO. <u>11</u>			
CONTROL			
14	TYPE PNEUMATIC ☐ ELECTRIC ☐		
15	OTHER _____		
16	PROP. % AUTO-RESET ☐ RATE ACTION ☐ ON-OFF ☐		
17	OTHER _____		
18	OUTPUT 3-15 PSI ☐ OTHER _____		
19	ON MEASUREMENT INCREASE		
20	OUTPUT: INCREASES ☐ DECREASES ☐		
21	CONTROL LOCATION REMOTE ☐ INSTR. ☐		
22	OTHER _____		
AUTO MANUAL SWITCH			
23	NO. POSITIONS _____ EXTERNAL ☐ INTERNAL ☐		
24	INTEGRAL ☐		
SET POINT ADJUSTMENTS			
25	MANUAL INTERNAL ☐ EXTERNAL ☐		
26	MANUAL PNEUMATIC ☐ ELECTRIC ☐		
27	AUTO-SET PNEUMATIC ☐ ELECTRIC ☐		
28	BAND FIXED ☐ ADJUSTABLE ☐		
29	OTHER _____		
NOTE			
for Bellows Type L 11-A			

RECEIVER INSTRUMENTS

SPECIFICATION SHEET

SHEET NO. 14

Trans. No. IC-105

Date _____

REVISED _____

By _____

COPPER ANALYZED INDICATES 5.4% Cu. (1.0)

GENERAL		RECEIVER ELEMENT	
1	DESCRIPTION RECORDER ☐ INDICATOR ☒ CONTROLLER ☒	25	SPIRAL ☐ BELLOWS ☒ EXHAUST ☐
2	CASE RECTANGULAR ☒		DIAPHRAGM ☐ ELEC. ☐
3	COLOR CASE BLACK ☐ OTHER <u>MAN. STD</u>		
4	DIAL _____		
5	MOUNTING FLUSH ☒ SURFACE ☐ YOKE ☐		
6	NO. PTS. - RECORDING <u>0</u> INDICATING <u>1</u>		
7	CHART TYPE <u>8</u> STRIP ☐ 12" CIRCULAR ☐ OTHER _____		
8	CHART RANGE _____ NUMBER _____		
9	SCALE RANGE <u>0-5</u> TYPE <u>UNIFORM</u>		
10	CHART DRIVE SPRING ☐ ELECTRIC ☐ PNEUM. ☐		
11	CHART SPEED _____ WIND _____		
12	V _____ C _____ EX. PRF. ☐ AIR PRESS. _____		
13	OTHER _____		
MATERIAL			
26	BRONZE ☒ OTHER _____		
27	RANGE 3-15 PSI ☒ OTHER _____		
	CONNECTION-NPT 1/4" ☒ OTHER _____		
	BACK ☒ BOTTOM ☐		
	OTHER _____		
ACCESSORIES			
13	TRANSMITTERS ON SHEET NO. <u>13</u>	28	FILTER & REGULATOR _____
14	TYPE PNEUMATIC ☒ ELECTRIC ☐	29	AIR SUPPLY GAGE _____
15	PROP. <u>50%</u> AUTO-RESET ☒ RATE ACTION ☒ ON-OFF ☐	30	CHARTS & INKSET _____
16	OUTPUT 3-15 PSI ☒ OTHER _____	31	MOUNTING YOKE _____
17	ON MEASUREMENT INCREASE	32	RESTRICTION DAMPENER _____
18	OUTPUT: INCREASES ☐ DECREASES ☒	33	MANIFOLDS _____
	CONTROL LOCATION REMOTE ☐ INSTR. ☐	34	ALARM SWITCH _____
	OTHER _____		HERMETICALLY SEALED ☐ EP ☐ GP ☐
AUTO MANUAL SWITCH			
19	NO. POSITIONS <u>2</u> EXTERNAL ☐ INTERNAL ☐		
	INTEGRAL ☐		
SET POINT ADJUSTMENTS			
20	MANUAL INTERNAL ☐ EXTERNAL ☒		
21	MANUAL PNEUMATIC ☐ ELECTRIC ☐		
22	AUTO-SET PNEUMATIC ☐ ELECTRIC ☐		
23	BAND FIXED ☐ ADJUSTABLE ☐		
24	OTHER _____		
NOTE			
FOXBORO Model # 130M-N5			

RECEIVER INSTRUMENTS

SPECIFICATION SHEET

SHEET NO. 15
 TAG NO. AR-105/ER-105
 DATE 3-12-75
 REVISED _____
 BY RHW

PLEASE COPY CONTENT AND PRINT

GENERAL		RECEIVER ELEMENT	
1	DESCRIPTION RECORDER ☒ INDICATOR ☐ CONTROLLER ☐	25	SPIRAL ☐ BELLOWS ☒ SPOON ☐
2	CASE RECTANGULAR ☒		DIAPHRAM ☐ ELEC. ☐
3	COLOR CASE BLACK ☐ OTHER <u>MAN STD</u>		
	DIAL _____		
4	MOUNTING FLUSH ☒ SURFACE ☐ YOKE ☐		
5	NO. PTS. - RECORDING <u>2</u> INDICATING <u>-</u>		
6	CHART TYPE <u>4"</u> STRIP ☒ CIRCULAR ☐ OTHER _____		
7	CHART RANGE <u>0-5/0-12</u> NUMBER <u>55068</u>	26	BRONZE ☒ OTHER _____
8	SCALE RANGE <u>0-5/0-12</u> TYPE <u>UNIFORM</u>		RANGE 3-15 PSI ☒ OTHER _____
9	CHART DRIVE SPRING ☐ ELECTRIC ☒ PNEUM. ☐	27	CONNECTION-NPT 1/4" ☒ OTHER _____
10	CHART SPEED <u>1/4" / HR</u> WIND _____		BACK ☒ BOTTOM ☐
11	V120 C60 EX. PRF. ☐ AIR PRESS. _____		OTHER _____
12	OTHER _____		
13 TRANSMITTERS ON SHEET NO. <u>13 AND 16</u>			
CONTROL		ACCESSORIES	
14	TYPE PNEUMATIC ☐ ELECTRIC ☐	28	FILTER & REGULATOR _____
	OTHER _____	29	AIR SUPPLY GAGE _____
15	PROP. % AUTO-RESET ☐ RATE ACTION ☐ ON-OFF ☐	30	CHARTS & INSET <u>YES</u>
	OTHER _____	31	MOUNTING YOKE _____
16	OUTPUT 3-15 PSI ☐ OTHER _____	32	RESTRICTION DAMPER _____
17	ON MEASUREMENT INCREASE	33	MANIFOLDS _____
	OUTPUT: INCREASES ☐ DECREASES ☐	34	ALARM SWITCH _____
18	CONTROL LOCATION REMOTE ☐ INSTR. ☐		HERMETICALLY SEALED ☐ EP ☐ GP ☐
	OTHER _____		
AUTO MANUAL SWITCH			
19	NO. POSITIONS _____ EXTERNAL ☐ INTERNAL ☐		
	INTEGRAL ☐		
SET POINT ADJUSTMENTS			
20	MANUAL INTERNAL ☐ EXTERNAL ☐		
21	MANUAL PNEUMATIC ☐ ELECTRIC ☐		
22	AUTO-SET PNEUMATIC ☐ ELECTRIC ☐		
23	BAND FIXED ☐ ADJUSTABLE ☐		
24	OTHER _____		
NOTE			

ORIFICE PLATES & FLANGES

SPECIFICATION SHEET

SHEET NO. 20
 TAG NO. PR-107
 DATE 9-14-77
 REVISED
 BY PCW

GENERAL SPECIFICATION

ORIFICE PLATES			ORIFICE FLANGES		
1	MAKE TO <u>AGA</u> STANDARD	☒ OTHER	5	RATING & FACING	<u>300# R.P. 50# FALB</u>
2	PLATE MATERIAL: <u>316S.S.</u>	☒ OTHER	7	TYPE: WELD NECK	☒ OTHER
3	RTJ RING MAT'L & TYPE		8	MAT'L: STEEL	☐ OTHER <u>316S.S.</u>
4	BORE MAXIMUM RATE	☒ NEAREST 1/8" ☐	9	TAP SIZE 1/2" NPT	☒ OTHER
5	STAMP TO ISA STANDARD	☒ OTHER	10	FLANGES BY	<u>WITH PLATE</u>
11	TAG NO.	<u>PR-107</u>			
12	LINE NO.	<u>1"</u>			
13	SERVICE CONDITIONS	<u>DOWNSTREAM</u>			
14	FLUID	<u>UNDERFLOW</u>			
15	FLOW UNITS	<u>GPM</u>			
16	MAXIMUM FLOW	<u>9.0</u>			
17	NORMAL FLOW	<u>5.7</u>			
18	FLOW PRESSURE, PSIG	<u>13.0</u>			
19	FLOW TEMPERATURE °F	<u>170</u>			
20	S.G. @ 60°F & PSIA	<u>1.15</u>			
21	S.G. @ F.T. & 15.1 PSIA	<u>1.15</u>			
22	SUPERCOMP. FACTOR @ O.P.	<u>1.0</u>			
23	VAPOR GAS MOL WT	<u>1.0</u>			
24	VISCOSITY, CP @ F.T.	<u>WATER LINE</u>			
25	STEAM QUALITY, %	<u>1.0</u>			
26	STEAM SUPERHEAT °F	<u>1.0</u>			
27					
28					
29					
30	MEASURING STATION DATA				
31	ACTUAL ORIFICE I.D., INS.	<u>AS R.O.N</u>			
32	LINE FLANGE I.D., INS.	<u>1.049</u>			
33	SEAL S.G. @ 60°F	<u>1.0</u>			
34	MANOMETER TYPE	<u>2" C-11</u>			
35	DIFF. RANGE INS H ₂ O DRY	<u>20</u>			
36	STATIC RANGE, PSIA	<u>13.5</u>			
37	CHART OR SCALE RANGE	<u>0-200</u>			
38	CHART MULTIPLIER	<u>1.0</u>			
39					
40					
41					
NOTES:					
FLUID COMPOSITION 2 g/l CUSC 100 g/l NH ₄ OH 15 g/l H ₂ O 2-3 g/l H ₂ O					

RECEIVER INSTRUMENTS

SPECIFICATION SHEET

SHEET NO. 23
 TAG NO. FIG-107
 DATE 9-1-77
 REVISED
 BY R.B.W.

DECENTER UNDERFLOW CONTROLLER

GENERAL		RECEIVER ELEMENT	
1	DESCRIPTION RECORDER ☐ INDICATOR ☐ CONTROLLER ☒	25	SPIRAL ☐ BELLOWS ☒ BOURDON ☐ DIAPHRAGM ☐ ELEC. ☐
2	CASE RECTANGULAR ☒		
3	COLOR CASE BLACK ☐ OTHER <u>PHALSTO</u>		
4	DIAL _____		
5	MOUNTING FLUSH ☒ SURFACE ☐ YOKE ☐		
6	NO. PTS.-RECORDING _____ INDICATING <u>1</u>		
7	CHART TYPE _____ STRIP ☐ 12" CIRCULAR ☐ OTHER _____		
8	CHART RANGE _____ NUMBER _____		
9	SCALE RANGE <u>0-8</u> TYPE <u>UNIFORM</u>		
10	CHART DRIVE SPRING ☐ ELECTRIC ☐ PNEUM. ☐		
11	CHART SPEED _____ WIND _____		
12	V _____ C _____ EX. PRF. ☐ AIR PRESS. _____		
13	OTHER _____		
		MATERIAL	
		26 BRONZE ☒ OTHER _____	
		RANGE 3-15 PSI ☒ OTHER _____	
		27 CONNECTION-NPT 1/4" ☐ OTHER _____	
		BACK ☒ BOTTOM ☐	
		OTHER _____	
		ACCESSORIES	
		28 FILTER & REGULATOR <u>N/A</u>	
		29 AIR SUPPLY GAGE _____	
		30 CHARTS & INKSET _____	
		31 MOUNTING YOKE _____	
		32 RESTRICTION DAMPENER _____	
		33 MANIFOLDS _____	
		34 ALARM SWITCH _____	
		HERMETICALLY SEALED ☐ EP ☐ GP ☐	
CONTROL			
14	TYPE PNEUMATIC ☒ ELECTRIC ☐		
15	OTHER _____		
16	PROP. % AUTO-RESET ☒ RATE ACTION ☐ ON-OFF ☐		
17	OTHER _____		
18	OUTPUT 3-15 PSI ☒ OTHER _____		
19	ON MEASUREMENT INCREASE		
20	OUTPUT: INCREASES ☐ DECREASES ☒		
21	CONTROL LOCATION REMOTE ☐ INSTR. ☒		
22	OTHER _____		
AUTO MANUAL SWITCH			
23	NO. POSITIONS <u>2</u> EXTERNAL ☒ INTERNAL ☐		
24	INTEGRAL ☐		
SET POINT ADJUSTMENTS			
25	MANUAL INTERNAL ☐ EXTERNAL ☒		
26	MANUAL PNEUMATIC ☐ ELECTRIC ☐		
27	AUTO-SET PNEUMATIC ☐ ELECTRIC ☐		
28	BAND FIXED ☐ ADJUSTABLE ☐		
29	OTHER _____		
NOTE			
FOR 60000 MODEL # 13017-NY			

RECEIVER INSTRUMENTS

SPECIFICATION SHEET

SHEET NO. 24
 TAG NO. FR-107/FR-108
 DATE 7-21-72
 REVISED
 BY R.B.W.

DETAIL: INDIATOR AND OVERFLOW RECORDER

GENERAL		RECEIVER ELEMENT	
1	DESCRIPTION RECORDER ☒ INDICATOR ☐ CONTROLLER ☐	25	SPIRAL ☐ BELLOWS ☒ DIAPHRAGM ☐ ELEC. ☐
2	CASE RECTANGULAR ☒		
3	COLOR CASE BLACK ☐ OTHER <u>MAN STD</u>		
4	DIAL _____		
5	MOUNTING FLUSH ☒ SURFACE ☐ YOKE ☐		
6	NO. PTS. RECORDING <u>2</u> INDICATING _____		
7	CHART TYPE <u>4"</u> STRIP ☒ 12" CIRCULAR ☐ OTHER _____		
8	CHART RANGE <u>0-100</u> NUMBER _____		
9	SCALE RANGE <u>0-100</u> TYPE <u>UNIFORM</u>		
10	CHART DRIVE SPRING ☐ ELECTRIC ☒ PNEUM. ☐		
11	CHART SPEED <u>3 1/4" / MIN</u> WIND _____		
12	<u>V120 C60</u> EX. PRF. ☐ AIR PRESS. _____		
13	TRANSMITTERS ON SHEET NO. <u>21 + 25</u>		
CONTROL		ACCESSORIES	
14	TYPE PNEUMATIC ☐ ELECTRIC ☐	28	FILTER & REGULATOR _____
15	PROP. % AUTO-RESET ☐ RATE ACTION ☐ ON-OFF ☐	29	AIR SUPPLY GAGE _____
16	OUTPUT 3-15 PSI ☐ OTHER _____	30	CHARTS & INKSET <u>YES</u>
17	ON MEASUREMENT INCREASE	31	MOUNTING YOKE _____
18	OUTPUT: INCREASES ☐ DECREASES ☐	32	RESTRICTION DAMPENER _____
19	CONTROL LOCATION REMOTE ☐ INSTR. ☐	33	MANIFOLDS _____
AUTO-MANUAL SWITCH		34	ALARM SWITCH _____
20	NO. POSITIONS _____	HERMETICALLY SEALED ☐ EP ☐ CP ☐	
SET POINT ADJUSTMENTS		GREEN PEN	
21	MANUAL INTERNAL ☐ EXTERNAL ☐	RED PEN	
22	MANUAL PNEUMATIC ☐ ELECTRIC ☐		
23	AUTO-SET PNEUMATIC ☐ ELECTRIC ☐		
24	BAND FIXED ☐ ADJUSTABLE ☐		
NOTE			
REVISION 102-276			

RECEIVER INSTRUMENTS

SPECIFICATION SHEET

SHEET NO. 26
 TAG NO. RIC-108
 DATE 9.14.77
 REVISED
 BY RBW

DESIGNER OVERVIEW CONTROLLER

GENERAL		RECEIVER ELEMENT	
1	DESCRIPTION RECORDER ☐ INDICATOR ☒ CONTROLLER ☒	25	SPIRAL ☐ BELLOWS ☒ BOURDON ☐ DIAPHRAGM ☐ ELEC. ☐
2	CASE RECTANGULAR ☒		
3	COLOR CASE BLACK ☐ OTHER <u>MAN STD</u>		
4	MOUNTING FLUSH ☒ SURFACE ☐ YOKE ☐		
5	NO. PTS. RECORDING <u>0</u> INDICATING <u>1</u>		
6	CHART TYPE <u>STRIP</u> ☐ 12" CIRCULAR ☐ OTHER <u>STRIP</u>		
7	CHART RANGE <u>0 -</u> NUMBER <u>1</u>		
8	SCALE RANGE <u>0 -</u> TYPE <u>LINEAR</u>		
9	CHART DRIVE SPRING ☐ ELECTRIC ☐ PNEUM. ☐		
10	CHART SPEED <u>WIND</u>		
11	V. <u>C</u> EX. PRF. ☐ AIR PRESS. <u>WIND</u>		
12	OTHER <u>WIND</u>		
		MATERIAL	
		26 BRONZE ☒ OTHER <u>BRONZE</u>	
		27 RANGE <u>3-15 PSI</u> ☒ OTHER <u>3-15 PSI</u>	
		CONNECTION-NPT <u>1/4"</u> ☒ OTHER <u>1/4"</u>	
		BACK ☒ BOTTOM ☐	
		OTHER <u>WIND</u>	
		ACCESSORIES	
		28 FILTER & REGULATOR <u>N/A</u>	
		29 AIR SUPPLY GAGE <u>N/A</u>	
		30 CHARTS & INKSET <u>N/A</u>	
		31 MOUNTING YOKE <u>N/A</u>	
		32 RESTRICTION DAMPENER <u>N/A</u>	
		33 MANIFOLDS <u>N/A</u>	
		34 ALARM SWITCH <u>N/A</u>	
		HERMETICALLY SEALED ☐ SP ☐ GP ☐	
13 TRANSMITTERS ON SHEET NO. <u>25</u>			
CONTROL			
14	TYPE PNEUMATIC ☒ ELECTRIC ☐		
15	PROP. <u>50%</u> AUTO-RESET ☒ RATE ACTION ☐ ON-OFF ☐		
16	OUTPUT <u>3-15 PSI</u> ☒ OTHER <u>3-15 PSI</u>		
17	ON MEASUREMENT INCREASE		
18	OUTPUT: INCREASES ☐ DECREASES ☒		
19	CONTROL LOCATION REMOTE ☐ INSTR. ☒		
20	OTHER <u>WIND</u>		
AUTO MANUAL SWITCH			
21	NO. POSITIONS <u>3</u> EXTERNAL ☒ INTERNAL ☐		
22	INTERNAL ☐		
SET POINT ADJUSTMENTS			
23	MANUAL INTERNAL ☐ EXTERNAL ☒		
24	MANUAL PNEUMATIC ☐ ELECTRIC ☐		
25	AUTO-SET PNEUMATIC ☐ ELECTRIC ☐		
26	BAND FIXED ☐ ADJUSTABLE ☐		
27	OTHER <u>WIND</u>		
NOTE			
<u>FORBOLD M/130M-N4</u>			

DIFFERENTIAL PRESSURE INSTRUMENTS

SPECIFICATION SHEET

SHEET NO. 37
 TAG NO. APT-107
 DATE 9.17.77
 REVISED
 BY RAW

DEMECO PNEUMATIC TRANSMITTER

GENERAL		DIFFERENTIAL UNIT	
1 DESCRIPTION	RECORDER ☐ INDICATOR ☒ BLIND ☒	28 FLOW ☐ LEVEL ☐ PRESSURE ☐	
2 CASE	CONTROLLER ☐ TRANSMITTER ☒	29 MERCURY ☐ BELLOWS ☐ DIAPHRAGM ☐	
	RECTANGULAR ☒ CIRCULAR ☐	30 OTHERS <u>DIFFERENTIAL TRANSMITTER</u>	
3 CASE COLOR	BLACK ☐ OTHER ☒ <u>MAN STD</u>	31 MAT'L	BODY <u>316 SS</u> DIAPHRAGM OR BELLOWS <u>316 SS</u>
4 MOUNTING	FLUSH ☐ SURFACE ☐ YOKE ☒	32 BODY RATING PSIG	<u>500 PSIG @ 60°F</u>
5 NO. PTS. - RECORDING	<u>0</u> INDICATING <u>0</u>	33 DIFFERENTIAL RANGE	<u>0-5" H₂O</u>
6 CHART TYPE	12" CIRC. ☐ OTHER ☐	34 DIFFERENTIAL CONN. 1/4" ☐ 1/2" ☒ OTHER ☐	
7 CHART RANGE	NUMBER		
8 SCALE RANGE	TYPE		
9 CHART DRIVE	SPRING ☐ ELECTRIC ☐ PNEUM. ☐		
10 CHART SPEED	WIND		
11 V <u>C</u> E.P. ☐ AIR PRESS.			
12 OTHER			
TRANSMITTER		ACCESSORIES	
13 TYPE	PNEUMATIC ☒ ELECTRIC ☐	35 FILTER & REGULATOR	<u>YES</u>
14 OUTPUT	3-15 PSI ☒ OTHER ☐	36 AIR SUPPLY CAGE	<u>YES</u>
15 RECEIVERS ON SHEET NO.	<u>22</u>	37 LOCAL INDICATOR	<u>NO</u>
		38 CHARTS & INKSET	
		39 MOUNTING YOKE	<u>YES</u>
		40 PULSATION DAMPENER	<u>YES</u>
		41 MERCURY	
		42 LUBRICATOR & ISO. VALVE	
		43 INTEGRATOR	
		44 PRIMARY MEASURING ELEMENT	
		45 ALARM SWITCH	
		HERMETICALLY SEALED ☐ E.P. ☐ G.P. ☐	
		46 3 VALVE MANIFOLD 8M-M4HVS	
		47 DG-5, HIGH TEMPERATURE GASKETS	
		48 DG-7 ptfc PROCESS GASKETS	
		49 SUPPRESSION 24" INCHES OF WATER	
CONTROL		SERVICE CONDITIONS	
16 TYPE	PNEUMATIC ☐ ELECTRIC ☐	FLUID	FLOW UNITS
17 PROP. %	AUTO-RESET ☐ RATE-ACTION ☐ ON-OFF ☐	FLOW NORMAL	FULL SCALE
18 OUTPUT	3-15 PSI ☐ OTHER ☐	@ 60°F &	PSIA
19 ON MEASUREMENT INCREASE	OUTPUT: INCREASES ☐ DECREASES ☐	OPERATING PRESS. PSIG	TEMP. °F
		SPEC. GRAV. @ 60°F	PSIA
		SPEC. GRAV. @ F.T.	PSIA
		VAPOR GAS MOL. WT	
		VISCOSITY @ °F	
		SUPER-COMPRESSIBILITY FACTOR @ O.P.	
		SEAL FLUID OR PURGE	
		SPEC. GRAV. @ 60°F	
		PIPE I.D.	TYPE TAPS
		FLANGE RATING & FACING	
		ORIFICE BORE NEAR 1/8" ☐ EVEN MULTPL'R ☐	
		PLATE MAT'L	ACTUAL BORE
		CHART MULTIPLIER	
		FLOW EQUALS	X DIFF. X
AUTO-MANUAL SWITCH			
20 NO. POSITIONS	EXTERNAL ☐ INTERNAL ☐		
	INTEGRAL ☐		
SETPOINT ADJUSTMENTS			
21 MANUAL	INTERNAL ☐ EXTERNAL ☐		
22 AUTO-SET	PNEUMATIC ☐ ELECTRIC ☐		
23 BAND	FIXED ☐ ADJUSTABLE ☐		
24 OTHER			
STATIC PRESSURE OR RECEIVER ELEMENT			
25 TYPE	MATERIAL		
26 RANGE			
27 FOR OTHER ELEMENTS SEE TAG NO.			
	ON SHEET NO.		
<p>1. DEMCO P115A-P152-4, DG-5, 1/4"-1, 8M-M4HVS, 2AS-12</p>			

RECEIVER INSTRUMENTS

SPECIFICATION SHEET

SHEET NO. 28
TAG NO. dl²T - 1.9
DATE 2.14.77
REVISED _____
BY ICB W

Demetrius Prescote Dyer, Jr.

GENERAL		RECEIVER ELEMENT	
1	DESCRIPTION RECORDER ☐ INDICATOR ☒ CONTROLLER ☐	25	SPIRAL ☐ BELLONS ☒ BOURDON ☐
2	CASE RECTANGULAR ☒		DIAPHRAGM ☐ ELEC. ☐
3	COLOR CASE BLACK ☐ OTHER <u>MAN STD</u>		
DIAL			
4	MOUNTING FLUSH ☒ SURFACE ☐ YOKE ☐		
5	NO. PTS. - RECORDING _____ INDICATING <u>1</u>		
6	CHART TYPE _____ STRIP ☐ 12" CIRCULAR ☐ OTHER _____		
7	CHART RANGE _____ NUMBER _____		
8	SCALE RANGE <u>0 - 5</u> TYPE <u>UNIFORM</u>		
9	CHART DRIVE SPRING ☐ ELECTRIC ☐ PNEUM. ☐		
10	CHART SPEED _____ WIND _____		
11	V. _____ C. _____ EX. PRF. ☐ AIR PRESS. _____		
12	OTHER _____		
MATERIAL			
	BRONZE ☒ OTHER _____		
	RANGE 3-15 PSI ☐ OTHER _____		
	CONNECTION-NPT 1/4" ☒ OTHER _____		
	BACK ☒ BOTTOM ☐		
	OTHER _____		
ACCESSORIES			
	FILTER & REGULATOR <u>1/0</u>		
	AIR SUPPLY GAGE _____		
	CHARTS & INKSET _____		
	MOUNTING YOKE _____		
	RESTRICTION DAMPENER _____		
	MANIFOLDS _____		
	ALARM SWITCH _____		
	HERMETICALLY SEALED ☐ EP ☐ GP ☐		
TRANSMITTERS ON SHEET NO. <u>2.7</u>			
CONTROL			
14	TYPE PNEUMATIC ☐ ELECTRIC ☐		
	OTHER _____		
15	PROP. % AUTO-RESET ☐ RATE ACTION ☐ ON-OFF ☐		
	OTHER _____		
16	OUTPUT 3-15 PSI ☐ OTHER _____		
17	ON MEASUREMENT INCREASE		
	OUTPUT: INCREASES ☐ DECREASES ☐		
18	CONTROL LOCATION REMOTE ☐ INSTR. ☐		
	OTHER _____		
AUTO MANUAL SWITCH			
19	NO. POSITIONS _____ EXTERNAL ☐ INTERNAL ☐		
	INTEGRAL ☐		
SET POINT ADJUSTMENTS			
20	MANUAL INTERNAL ☐ EXTERNAL ☐		
21	MANUAL PNEUMATIC ☐ ELECTRIC ☐		
22	AUTO-SET PNEUMATIC ☐ ELECTRIC ☐		
23	BAND FIXED ☐ ADJUSTABLE ☐		
24	OTHER _____		
NOTE			

PRESSURE INSTRUMENTS

SPECIFICATION SHEET

SHEET NO. 29
 TAG NO. PT-110
 DATE 9-14-51
 REVISED
 BY KBW

TOWER PRESSURE TRANSMITTER

GENERAL		PRESSURE ELEMENT	
1 DESCRIPTION	RECORDER ☐ INDICATOR ☐ BLIND ☒	25 SPIRAL ☐ BELLOWS ☐ BOURDON ☐	
2 CASE	CONTROLLER ☐ TRANSMITTER ☒	DIAPHRAGM ☐ HELICAL ☐	
3 CASE COLOR	RECTANGULAR ☒ CIRCULAR ☐	OTHER _____	
4 MOUNTING	OTHER _____		
5 NO. PTS. -- RECORDING	BLACK ☐ OTHER <u>MAN STD</u>		
6 CHART TYPE	FLUSH ☐ SURFACE ☐ YOKE ☒		
7 CHART RANGE	NO. _____		
8 SCALE RANGE	TYPE _____		
9 CHART DRIVE	SPRING ☐ ELECTRIC ☐ PNEUM. ☐		
10 CHART SPEED	WIND _____		
11 V _____ C _____	EX. PRF. ☐ AIR PRESS. _____		
12 OTHER _____			
TRANSMITTER		ACCESSORIES	
13 TYPE	PNEUMATIC ☒ ELECTRIC ☐	31 FILTER & REGULATOR	<u>YES</u>
14 OUTPUT	3-15 PSI ☒ OTHERS _____	32 AIR SUPPLY GAGE	<u>YES</u>
15 RECEIVERS ON SHEET NO. <u>30</u>		33 LOCAL INDICATOR	<u>NO</u>
		34 CHARTS & INKSET	<u>NO</u>
		35 MOUNTING YOKE	<u>YES</u>
		36 PULSATION DAMPENER	<u>NO</u>
		37 SYPHON	<u>NO</u>
		38 ALARM SWITCH	<u>NO</u>
		HERMETICALLY SEALED ☐ E.P. ☐ G.P. ☐	
		39 DG-7 CORROSIVE PROTECTION	<u>PTFE GASKET</u>
		40 ELEVATION KIT (4 PSI LIMIT)	<u>NO</u>
CONTROL		OPERATING CONDITIONS	
16 TYPE	PNEUMATIC ☐ ELECTRIC ☐	PRESSURE, NORMAL	<u>120 PSI MAX. 140 PSI</u>
17 PROP. %	AUTO-RESET ☐ RATE ACTION ☐ ON-OFF ☐	TEMPERATURE NORMAL	<u>350 MAX. 360</u>
18 OUTPUT	OTHER _____	FLUID	<u>SEAL OIL</u>
19 ON MEASUREMENT INCREASE:		SEAL FLUID	<u>WATER</u> S.G. @ 60°F <u>1</u>
OUTPUT: INCREASES ☐ DECREASES ☐			
AUTO MANUAL SWITCH			
20 NO. POSITIONS	EXTERNAL ☐ INTERNAL ☐		
	INTERNAL ☐		
SETPOINT ADJUSTMENTS			
21 MANUAL	INTERNAL ☐ EXTERNAL ☐		
22 AUTO-SET	PNEUMATIC ☐ ELECTRIC ☐		
23 BAND	FIXED ☐ ADJUSTABLE ☐		
24 OTHERS _____			
NOTE: <u>2 AS - 11</u>			

RECEIVER INSTRUMENTS

SPECIFICATION SHEET

SHEET NO. 30
 TAG NO. PR-114
 DATE 2-14-77
 REVISED REV
 BY REV

TOWER PRESSURE RECORDER

GENERAL		RECEIVER ELEMENT	
1	DESCRIPTION RECORDER ☒ INDICATOR ☐ CONTROLLER ☐	25	SPIRAL ☐ BELLOWS ☒ GOURDON ☐
2	CASE RECTANGULAR ☒		DIAPHRAGM ☐ ELEC. ☐
3	COLOR CASE BLACK ☐ OTHER <u>MAN STD</u>	MATERIAL	
4	DIAL	26	BRONZE ☒ OTHER
5	MOUNTING FLUSH ☒ SURFACE ☐ YOKE ☐		RANGE 3-15 PSI ☒ OTHER
6	NO. PTS. RECORDING _____ INDICATING _____	27	CONNECTION-NPT 1/4" ☒ OTHER
7	CHART TYPE <u>4"</u> STRIP ☒ 12" CIRCULAR ☐ OTHER		BACK ☒ BOTTOM ☐
8	CHART RANGE <u>0-150</u> NUMBER <u>53003</u>		OTHER
9	SCALE RANGE <u>0-150</u> TYPE <u>UNIFORM</u>	ACCESSORIES	
10	CHART DRIVE SPRING ☐ ELECTRIC ☒ PNEUM. ☐	28	FILTER & REGULATOR <u>NO</u>
11	CHART SPEED <u>3 1/4" / HOUR</u> WIND	29	AIR SUPPLY GAGE <u>NO</u>
12	V. 12% C.O. EX. PRF. ☐ AIR PRESS. _____	30	CHARTS & INKSET <u>YES</u>
13	OTHER	31	MOUNTING YOKE _____
14	TRANSMITTERS ON SHEET NO. <u>29</u>	32	RESTRICTION DAMPENER _____
15	CONTROL	33	MANIFOLDS _____
16	TYPE PNEUMATIC ☐ ELECTRIC ☐	34	ALARM SWITCH _____
17	PROP. % AUTO-RESET ☐ RATE ACTION ☐ ON-OFF ☐		HERMETICALLY SEALED ☐ EP ☐ GP ☐
18	OTHER _____		
19	OUTPUT 3-15 PSI ☐ OTHER _____		
20	ON MEASUREMENT INCREASE		
21	OUTPUT: INCREASES ☐ DECREASES ☐		
22	CONTROL LOCATION REMOTE ☐ INSTR. ☐		
23	OTHER _____		
24	AUTO MANUAL SWITCH		
25	NO. POSITIONS _____ EXTERNAL ☐ INTERNAL ☐		
26	INTERNAL ☐ EXTERNAL ☐		
27	MANUAL PNEUMATIC ☐ ELECTRIC ☐		
28	AUTO-SET PNEUMATIC ☐ ELECTRIC ☐		
29	BAND FIXED ☐ ADJUSTABLE ☐		
30	OTHER _____		
31	NOTE		

DIFFERENTIAL PRESSURE INSTRUMENTS SPECIFICATION SHEET

SHEET NO. 31
TAG NO. LT-201
DATE 9-17-77
REVISED BY R.W.

SLURRY STORAGE LEVEL TRANSMITTER

GENERAL		DIFFERENTIAL UNIT	
1 DESCRIPTION	RECORDER ☐ INDICATOR ☐ BLIND ☒	28 FLOW ☐ LEVEL ☒ PRESSURE ☐	
2 CASE	CONTROLLER ☐ TRANSMITTER ☒	29 MERCURY ☐ BELLONS ☐ DIAPHRAGM ☐	
3 CASE COLOR	RECTANGULAR ☐ CIRCULAR ☐	30 OTHER	
4 MOUNTING	OTHERS _____	31 MAT'L	BODY DIAPHRAGM OR BELLONS
5 NO. PTS. RECORDING	BLACK ☐ OTHER ☒ <u>MAN STD</u>		<u>316 SS</u> <u>316 SS</u>
6 CHART TYPE	FLUSH ☐ SURFACE ☐ YOKE ☒	32 BODY RATING PSIG	<u>1500</u> @ <u>60°F</u>
7 CHART RANGE	INDICATING ☐ NUMBER _____	33 DIFFERENTIAL RANGE	<u>200" H₂O</u>
8 SCALE RANGE	TYPE _____	34 DIFFERENTIAL CONN. 1/4" ☐ 1/2" ☒ OTHER _____	
9 CHART DRIVE	SPRING ☐ ELECTRIC ☐ PNEUM. ☐		
10 CHART SPEED	WIND _____		
11 V _____ C _____	E.P. ☐ AIR PRESS. _____		
12 OTHER			
TRANSMITTER		ACCESSORIES	
13 TYPE	PNEUMATIC ☒ ELECTRIC ☐	35 FILTER & REGULATOR	<u>YES</u>
14 OUTPUT	3-15 PSI ☒ OTHER ☐	36 AIR SUPPLY GAGE	<u>YES</u>
15 RECEIVERS ON SHEET NO. <u>37</u>		37 LOCAL INDICATOR	<u>NO</u>
		38 CHARTS & INKSET	<u>-</u>
		39 MOUNTING YOKE	<u>YES</u>
		40 PULSATION DAMPENER	<u>NO</u>
		41 MERCURY	<u>NO</u>
		42 LUBRICATOR & ISO. VALVE	<u>NO</u>
		43 INTEGRATOR	<u>NO</u>
		44 PRIMARY MEASURING ELEMENT	
		TYPE _____	
		45 ALARM SWITCH	
		HERMETICALLY SEALED ☐ E.P. ☐ G.P. ☐	
CONTROL		SERVICE CONDITIONS	
16 TYPE	PNEUMATIC ☐ ELECTRIC ☐	FLUID _____ FLOW UNITS _____	
17 PROP. _____ %	OTHER _____	FLOW NORMAL _____ FULL SCALE _____	
18 OUTPUT	AUTO-RESET ☐ RATE-ACTION ☐ ON-OFF ☐	@ 60°F & _____ PSIA	
19 ON MEASUREMENT INCREASE	OTHER _____	OPERATING PRESS. PSIG _____ TEMP. _____ °F	
OUTPUT: INCREASES ☐ DECREASES ☐		SPEC. GRAV. @ 60°F _____ & _____ PSIA	
		SPEC. GRAV. @ F.T. _____ & _____ PSIA	
		VAPOR GAS VOL. WT. _____	
		VISCOSITY @ _____ °F	
		SUPER-COMPRESSIBILITY FACTOR @ O.P. _____	
		SEAL FLUID OR PURGE _____	
		SPEC. GRAV. @ 60°F _____	
		PIPE I.D. _____ TYPE TAPS _____	
		FLANGE RATING & FACING _____	
		ORIFICE BORE NEAR 1/8" ☐ EVEN MULTIPLE ☐	
		PLATE MAT'L _____ ACTUAL BORE _____	
		CHART MULTIPLIER _____	
		FLOW EQUALS _____ X DIFF. X _____	
AUTO-MANUAL SWITCH			
20 NO. POSITIONS	EXTERNAL ☐ INTERNAL ☐		
	INTEGRAL ☐		
SETPOINT ADJUSTMENTS			
21 MANUAL	INTERNAL ☐ EXTERNAL ☐		
22 AUTO-SET	PNEUMATIC ☐ ELECTRIC ☐		
23 BANG	FIXED ☐ ADJUSTABLE ☐		
24 OTHER			
STATIC PRESSURE OR RECEIVER ELEMENT			
25 TYPE _____ MATERIAL _____			
26 RANGE _____			
27 FOR OTHER ELEMENTS SEE TAG NO. _____			
ON SHEET NO. _____			

TEMPERATURE INSTRUMENTS
(FILLED SYSTEM)

SPECIFICATION SHEET

SHEET NO. 33
 TAG NO. FP-202
 DATE 3-16-77
 REVISED BY R B W

REGISTRATION PUNCTION TEMPERATURE

GENERAL		THERMAL ELEMENT	
1 DESCRIPTION	RECORDER ☐ INDICATOR ☒ BLIND ☐	27 CLASS	1A ☒ 11A ☐ 111A ☐ YB ☐
2 CASE	RECTANGULAR ☒ CIRCULAR ☐	1B ☐ 11B ☐ 111B ☐ YB ☐	
3 CASE COLOR	BLACK ☐ OTHER <u>MAN STE</u>	11C ☐ 11D ☐	
4 MOUNTING	FLUSH ☐ SURFACE ☐ YOKE ☒	28 RANGE	<u>50 300°F</u> OVERRANGE PROTECTION <u>YES</u>
5 NO. PTS. RECORDING	INDICATING ☐		
6 CHART SIZE	12" CIRC. ☐ OTHER ☐	29 BULB	
7 CHART RANGE	NUMBER ☐	PLAIN ☐ UNION CONN. ☒ SANITARY ☐	
8 SCALE RANGE	<u>100-300 °F</u> TYPE <u>UNIFORM</u>	30 EXTENSION	RIGID ☐ ANGLE ☐
9 CHART DRIVE	SPRING ☐ ELECTRIC ☐ PNEUM. ☐	31 INSERTION LENGTH, INCHES	<u>18" BENDABLE</u> OTHER ☐
10 CHART SPEED	WIND ☐	32 MATERIAL	316SS ☒ OTHER ☐
11 V ☐ C ☐ EX. PRF. ☐ AIR PRESS. ☐		33 BULB IS	<u>—</u> FEET ABOVE INSTRUMENT CASE <u>—</u> FEET BELOW INSTRUMENT CASE
12 OTHER		34 BULB CONNECTIONS	
		FLANGE ☐ THREADED ☒ CLAMP ☐	
		OTHER <u>1" ADJUSTABLE UNION</u>	
13 TYPE	PNEUMATIC ☒ ELECTRIC ☐	35 BUSHING	3/4" ☐ 1" ☒
14 OUTPUT	3-15 PSI ☒ OTHER ☐	36 WELL	3/4" ☐ 1" ☒ <u>50 #12 EXT.</u>
15 RECEIVERS ON SHEET NO. <u>34</u>		37 MATERIAL	316SS ☒ OTHER ☐
		38 SANITARY	3A ☐ OTHER ☐
		39 CAPILLARY TUBING	
		LENGTH <u>10'</u>	
		40 TYPE	ARMORED ☐ PLAIN ☒
16 TYPE	PNEUMATIC ☐ ELECTRIC ☐	MATERIAL	CAPILLARY ☐ ARMOR ☐
17 PROP.	AUTO-RESET ☐ RATE-ACTION ☐ ON-OFF ☐	STN. ST. ☒ STN. STEEL ☒	
18 OUTPUT	3-15 PSI ☐ OTHER ☐	COPPER ☐ BRONZE ☐	
19 ON MEASUREMENT INCREASE	OUTPUT: INCREASES ☐ DECREASES ☐	OTHER ☐ PLASTIC OVER BRO. ☐	
20 ELECTRIC SWITCH TYPE - ON MEASUREMENT INCREASE	CONTACTS OPEN ☐ CLOSE ☐	LEAD ☐	
21 CONTACT RATING AMPS. ☐ VOLTS ☐		41 CONNECTION AT CASE	BACK ☐ BOTTOM ☒
		42 ACCESSORIES	
22 NO. POSITIONS	AUTO-MANUAL SWITCH	FILTER & REGULATOR	<u>YES</u>
	EXTERNAL ☐ INTERNAL ☐	AIR SUPPLY GAGE	<u>YES</u>
	INTEGRAL ☐	LOCAL INDICATOR	<u>—</u>
23 MANUAL	SETPOINT ADJUSTMENTS	CHARTS & INSET	<u>—</u>
24 AUTO-SET	INTERNAL ☐ EXTERNAL ☐	MOUNTING YOKE	<u>YES</u>
25 BAND	PNEUMATIC ☐ ELECTRIC ☐	PORTABLE CASE FEATURES	<u>—</u>
26 OTHER	FIXED ☐ ADJUSTABLE ☐	MOUNTING ACCESSORIES FOR WET & DRY BULBS	<u>—</u>
		ALARM SWITCH	<u>—</u>
		HERMETICALLY SEALED ☐ E.P. ☐ G.P. ☐	
NOTE:			

RECEIVER INSTRUMENTS

SPECIFICATION SHEET

SHEET NO. 34
TAG NO. FLC-203
DATE _____
REVISED _____
BY RBW

REGENERATION REACTOR TEMPERATURE

GENERAL		RECEIVER ELEMENT	
1	DESCRIPTION RECORDER ☐ INDICATOR ☒ CONTROLLER ☒	25	SPIRAL ☐ BELLOWS ☒ BOURDON ☐
2	CASE RECTANGULAR ☒		DIAPHRAGM ☐ ELEC. ☐
3	COLOR CASE BLACK ☐ OTHER <u>MAN STD</u>		
4	MOUNTING FLUSH ☐ SURFACE ☐ YOKE ☐	MATERIAL	
5	NO. PYS.-RECORDING _____ INDICATING <u>1</u>	26	BRONZE ☒ OTHER _____
6	CHART TYPE _____ STRIP ☐ 12" CIRCULAR ☐ OTHER _____	27	RANGE 3-15 PSI ☒ OTHER _____
7	CHART RANGE _____ NUMBER _____		CONNECTION-NPT 1/4" ☒ OTHER _____
8	SCALE RANGE <u>50-300</u> TYPE <u>UNIFORM</u>		BACK ☒ BOTTOM ☐
9	CHART DRIVE SPRING ☐ ELECTRIC ☐ PNEU. ☐		OTHER _____
10	CHART SPEED _____ WIND _____		
11	V _____ C _____ EX. PRF. ☐ AIR PRESS. _____	ACCESSORIES	
12	OTHER _____	28	FILTER & REGULATOR <u>N/A</u>
13	TRANSMITTERS ON SHEET NO. <u>33</u>	29	AIR SUPPLY GAGE <u>N/A</u>
14	TYPE PNEUMATIC ☒ <u>CONTROL</u> ELECTRIC ☐	30	CHARTS & INKSET <u>N/A</u>
15	PROP. <u>1/2</u> % AUTO-RESET ☒ RATE ACTION ☐ ON-OFF ☐	31	MOUNTING YOKE <u>N/A</u>
16	OUTPUT 3-15 PSI ☐ OTHER _____	32	RESTRICTION DAMPENER <u>N/A</u>
17	ON MEASUREMENT INCREASE	33	MANIFOLDS <u>N/A</u>
18	OUTPUT: INCREASES ☐ DECREASES ☒	34	ALARM SWITCH <u>N/A</u>
19	CONTROL LOCATION REMOTE ☐ INSTR. ☒		HERMETICALLY SEALED ☐ GP ☐ GP ☐
AUTO MANUAL SWITCH			
20	NO. POSITIONS <u>1</u> EXTERNAL ☒ INTERNAL ☐		
21	INTERNAL ☐ EXTERNAL ☒		
22	MANUAL PNEUMATIC ☐ ELECTRIC ☐		
23	AUTO-SET PNEUMATIC ☐ ELECTRIC ☐		
24	BAND FIXED ☐ ADJUSTABLE ☐		
SET POINT ADJUSTMENTS			
25	MANUAL INTERNAL ☐ EXTERNAL ☒		
26	MANUAL PNEUMATIC ☐ ELECTRIC ☐		
27	AUTO-SET PNEUMATIC ☐ ELECTRIC ☐		
28	BAND FIXED ☐ ADJUSTABLE ☐		
29	OTHER _____		
NOTE			
<u>130MB-N4</u>			

RECEIVER INSTRUMENTS

SPECIFICATION SHEET

SHEET NO. 35
 TAG NO. 7R-202
 DATE 9.15.77
 REVISED BY RBW

REGENERATION ROASTING TEMPERATURE

GENERAL		RECEIVER ELEMENT	
1	DESCRIPTION RECORDER ☒ INDICATOR ☐ CONTROLLER ☐	25	SPIRAL ☐ BELLOWS ☒ BOURDON ☐ DIAPHRAGM ☐ ELEC. ☐
2	CASE RECTANGULAR ☐		
3	COLOR CASE BLACK ☐ OTHER <u>MAN STD</u>		
4	DIAL MOUNTING FLUSH ☒ SURFACE ☐ YOKE ☐		
5	NO. PTS. RECORDING _____ INDICATING _____		
6	CHART TYPE <u>4"</u> STRIP ☒ <u>12"</u> CIRCULAR ☐ OTHER _____		
7	CHART RANGE <u>50-300</u> NUMBER <u>53761-6X</u>		
8	SCALE RANGE <u>50-300</u> TYPE <u>UNIFORM</u>		
9	CHART DRIVE SPRING ☐ ELECTRIC ☒ PNEUM. ☐		
10	CHART SPEED <u>3 1/4" / MIN</u> WIND _____		
11	V.120 C.12 EX. PRF. ☐ AIR PRESS. _____		
12	OTHER _____		
		<h3>MATERIAL</h3>	
		26 BRONZE ☒ OTHER _____	
		RANGE 3-15 PSI ☒ OTHER _____	
		27 CONNECTION-NPT 1/4" ☒ OTHER _____	
		BACK ☒ BOTTOM ☐	
		OTHER _____	
		<h3>ACCESSORIES</h3>	
		28 FILTER & REGULATOR <u>N/A</u>	
		29 AIR SUPPLY GAGE <u>N/A</u>	
		30 CHARTS & INKSET <u>N/A</u>	
		31 MOUNTING YOKE <u>N/A</u>	
		32 RESTRICTION DAMPER <u>N/A</u>	
		33 MANIFOLDS <u>N/A</u>	
		34 ALARM SWITCH <u>N/A</u>	
		HERMETICALLY SEALED ☐ EP ☐ GP ☐	
<h3>CONTROL</h3>			
14	TYPE PNEUMATIC ☐ ELECTRIC ☐		
15	PROP. & AUTO-RESET ☐ RATE ACTION ☐ ON-OFF ☐		
16	OUTPUT 3-15 PSI ☐ OTHER _____		
17	ON MEASUREMENT INCREASE OUTPUT: INCREASES ☐ DECREASES ☐		
18	CONTROL LOCATION REMOTE ☐ INSTR. ☐		
19	OTHER _____		
<h3>AUTO MANUAL SWITCH</h3>			
19	NO. POSITIONS _____ EXTERNAL ☐ INTERNAL ☐		
<h3>SET POINT ADJUSTMENTS</h3>			
20	MANUAL INTERNAL ☐ EXTERNAL ☐		
21	MANUAL PNEUMATIC ☐ ELECTRIC ☐		
22	AUTO-SET PNEUMATIC ☐ ELECTRIC ☐		
23	BAND FIXED ☐ ADJUSTABLE ☐		
24	OTHER _____		
NOTE			

DIFFERENTIAL PRESSURE INSTRUMENTS

SPECIFICATION SHEET

SHEET NO. 36
 TAG NO. CT-203
 DATE 8-21-77
 REVISED BY REW

LEACH REACTOR LEVEL TRANSMITTER

GENERAL		DIFFERENTIAL UNIT	
1 DESCRIPTION	RECORDER ☐ INDICATOR ☐ BLIND ☒	28 FLOW ☐ LEVEL ☒ PRESSURE ☐	
2 CASE	CONTROLLER ☐ TRANSMITTER ☒	29 MERCURY ☐ BELLONS ☐ DIAPHRAGM ☒	
	RECTANGULAR ☐ CIRCULAR ☐	30 OTHERS	
	OTHERS <u>MAN. STD</u>	31 MAT'L	
3 CASE COLOR	BLACK ☐ OTHER ☒ <u>MAN STD</u>		
4 MOUNTING	FLUSH ☐ SURFACE ☐ YOKE ☒	32 BODY RATING PSIG	<u>150</u> @ <u>60°F</u>
5 NO. PTS. RECORDING	INDICATING <u>0</u>	33 DIFFERENTIAL RANGE	<u>150</u> <u>INCHES</u> <u>4.0</u>
6 CHART TYPE	12" CIRC. ☐ OTHER ☐	34 DIFFERENTIAL CONN. 1/4" ☐ 1/2" ☒ OTHER ☐	
7 CHART RANGE	NUMBER		
8 SCALE RANGE	TYPE		
9 CHART DRIVE	SPRING ☐ ELECTRIC ☐ PNEUM. ☐		
10 CHART SPEED	WIND		
11 V <u>C</u> E.P. ☐ AIR PRESS.			
12 OTHER			
TRANSMITTER		ACCESSORIES	
13 TYPE	PNEUMATIC ☒ ELECTRIC ☐	35 FILTER & REGULATOR	<u>YES</u>
14 OUTPUT	3-15 PSI ☒ OTHER ☐	36 AIR SUPPLY GAGE	<u>YES</u>
15 RECEIVERS ON SHEET NO.		37 LOCAL INDICATOR	<u>NO</u>
		38 CHARTS & INKSET	<u>-</u>
		39 MOUNTING YOKE	<u>YES</u>
		40 PULSATION DAMPENER	<u>-</u>
		41 MERCURY	<u>-</u>
		42 LUBRICATOR & ISO. VALVE	<u>-</u>
		43 INTEGRATOR	<u>-</u>
		44 PRIMARY MEASURING ELEMENT	<u>-</u>
		TYPE	<u>-</u>
		45 ALARM SWITCH	<u>-</u>
		HERMETICALLY SEALED ☐ E.P. ☐ G.P. ☐	
		46 3 VALVE MANIFOLD	<u>-</u>
		47 D.G. 5 HIGH TEMPERATURE GASKET	<u>-</u>
		48 D.G. 7 DCFE PROCESS GASKET	<u>-</u>
		SUGGESTION <u>105</u> INCHES OF WATER	
CONTROL		SERVICE CONDITIONS	
16 TYPE	PNEUMATIC ☐ ELECTRIC ☐	FLUID	FLOW UNITS
17 PROP. <u>3</u> AUTO-RESET ☐ RATE-ACTION ☐ ON-OFF ☐	OTHER ☐	FLOW NORMAL	FULL SCALE
18 OUTPUT	3-15 PSI ☐ OTHER ☐	@ 60°F &	PSIA
19 ON MEASUREMENT INCREASE		OPERATING PRESS. PSIG	TEMP. °F
OUTPUT: INCREASES ☐ DECREASES ☐		SPEC. GRAV. @ 60°F	PSIA
		SPEC. GRAV. @ F.T.	PSIA
		VAPOR GAS MOL. WT.	
		VISCOSITY @ °F	
		SUPER-COMPRESSIBILITY FACTOR @ O.P.	
		SEAL FLUID OR PURGE	
		SPEC. GRAV. @ 60°F	
		PIPE I.D.	TYPE TAPS
		FLANGE RATING & FACING	
		ORIFICE BORE NEAR 1/8" ☐ EVEN MULT. R ☐	
		PLATE MAT'L	ACTUAL BORE
		CHART MULTIPLIER	
		FLOW EQUALS	X DIFF. X
AUTO-MANUAL SWITCH			
20 NO. POSITIONS	EXTERNAL ☐ INTERNAL ☒		
	INTEGRAL ☐		
SETPOINT ADJUSTMENTS			
21 MANUAL	INTERNAL ☐ EXTERNAL ☐		
22 AUTO-SET	PNEUMATIC ☐ ELECTRIC ☒		
23 BAND	FIXED ☐ ADJUSTABLE ☒		
24 OTHER			
STATIC PRESSURE OR RECEIVER ELEMENT			
25 TYPE	MATERIAL		
26 RANGE			
27 FOR OTHER ELEMENTS SEE TAG NO.			
ON SHEET NO.			

PRESSURE INSTRUMENTS

SPECIFICATION SHEET

SHEET NO. 38
 TAG NO. PT-205
 DATE 3-21-77
 REVISED BY R.B.W.

LEACH REGENERATION REACTOR PRESSURE

GENERAL		PRESSURE ELEMENT	
1 DESCRIPTION	RECORDER ☐ INDICATOR ☐ BLIND ☒	25 SPIRAL ☐ BELLOWS ☐ BOURDON ☐	
2 CASE	CONTROLLER ☐ TRANSMITTER ☒	DIAPHRAGM ☐ HELICAL ☐	
3 CASE COLOR	RECTANGULAR ☒ CIRCULAR ☐	OTHER <u>CAPSULE</u>	
4 MOUNTING	OTHER _____		
5 NO. PTS. ... RECORDING	BLACK ☐ OTHER <u>MAN STD</u>		
6 CHART TYPE	FLUSH ☐ SURFACE ☐ YOKE ☒		
7 CHART RANGE	INDICATING _____		
8 SCALE RANGE	12" CIRC. ☐ OTHER _____		
9 CHART DRIVE	NUMBER _____		
10 CHART SPEED	TYPE _____		
11 V _____ C _____ EX. PRF. ☐	SPRING ☐ ELECTRIC ☐ PNEUM. ☐		
12 OTHER _____	WIND _____		
	AIR PRESS. _____		
	OTHER _____		
TRANSMITTER		ACCESSORIES	
13 TYPE	PNEUMATIC ☒ ELECTRIC ☐	31 FILTER & REGULATOR	<u>YES</u>
14 OUTPUT	3-15 PSI ☒ OTHERS _____	32 AIR SUPPLY GAGE	<u>YES</u>
15 RECEIVERS ON SHEET NO. <u>39 AND 40</u>		33 LOCAL INDICATOR	<u>NO</u>
		34 CHARTS & INKSET	<u>NO</u>
		35 MOUNTING YOKE	<u>YES</u>
		36 PULSATION DAMPENER	<u>NO</u>
		37 SYPHON	<u>NO</u>
		38 ALARM SWITCH	<u>NO</u>
		HERMETICALLY SEALED ☐ E.P. ☐ G.P. ☐	
		39 <u>OPTION DG-7 CORROSIVE PROTECTION PTFE GASKET</u>	
CONTROL		OPERATING CONDITIONS	
16 TYPE	PNEUMATIC ☐ ELECTRIC ☐	PRESSURE, NORMAL	<u>125</u> MAX. <u>150</u>
17 PROP. %	OTHER _____	TEMPERATURE NORMAL	<u>270</u> MAX. <u>300</u>
18 OUTPUT	AUTO-RESET ☐ RATE ACTION ☐ ON-OFF ☐	FLUID	<u>WATER</u>
19 ON MEASUREMENT INCREASE:	OTHER _____	SEAL FLUID	<u>S.G. @ 60°F</u>
OUTPUT: INCREASES ☐ DECREASES ☐			
AUTO MANUAL SWITCH			
20 NO. POSITIONS	INTERNAL ☐ EXTERNAL ☐		
	INTERNAL ☐		
SETPOINT ADJUSTMENTS			
21 MANUAL	INTERNAL ☐ EXTERNAL ☐		
22 AUTO-SET	PNEUMATIC ☐ ELECTRIC ☐		
23 BAND	FIXED ☐ ADJUSTABLE ☐		
24 OTHERS _____			
NOTE: <u>LEACH REGENERATION REACTOR - P. 2-205-77</u> <u>TAS-NE</u>			

RECEIVER INSTRUMENTS

SPECIFICATION SHEET

LEACH REACTOR
OXYGEN / AIR FLOW RECORDER

SHEET NO. 42
TAG NO. FB-202/KA
DATE 9.15.77
REVISED BY RLW

GENERAL		RECEIVER ELEMENT	
1	DESCRIPTION RECORDER ☒ INDICATOR ☐ CONTROLLER ☐	25	SPIRAL ☐ BELLOWS ☒ BOURDON ☐ DIAPHRAGM ☐ ELEC. ☐
2	CASE RECTANGULAR ☒		
3	COLOR CASE BLACK ☐ OTHER <u>MAN STD</u>		
4	DIAL		
5	MOUNTING FLUSH ☒ SURFACE ☐ YOKE ☐		
6	NO. PTS. RECORDING <u>3</u> INDICATING		
7	CHART TYPE <u>4"</u> STRIP ☐ 12" CIRCULAR ☐ OTHER		
8	CHART RANGE <u>0-100</u> NUMBER		
9	SCALE RANGE TYPE <u>UNIFORM</u>		
10	CHART DRIVE SPRING ☐ ELECTRIC ☒ PNEUM. ☐		
11	CHART SPEED <u>3/4 IN / MIN</u> WIND		
12	V. <u>120</u> C. <u>60</u> EX. PRF. ☐ AIR PRESS. ☐		
13	OTHER		
13 TRANSMITTERS ON SHEET NO. <u>41 AND 43</u>			
14 TYPE PNEUMATIC ☐ ELECTRIC ☐ OTHER			
15 PROP. % AUTO-RESET ☐ RATE ACTION ☐ ON-OFF ☐ OTHER			
16 OUTPUT 3-15 PSI ☐ OTHER			
17 ON MEASUREMENT INCREASE OUTPUT: INCREASES ☐ DECREASES ☐			
18 CONTROL LOCATION REMOTE ☐ INSTR. ☐ OTHER			
19 NO. POSITIONS <u>AUTO MANUAL SWITCH</u> EXTERNAL ☐ INTERNAL ☐ INTEGRAL ☐			
20 MANUAL INTERNAL ☐ EXTERNAL ☐			
21 MANUAL PNEUMATIC ☐ ELECTRIC ☐			
22 AUTO-SET PNEUMATIC ☐ ELECTRIC ☐			
23 BAND FIXED ☐ ADJUSTABLE ☐			
24 OTHER			
NOTE			
		26 BRONZE ☒ OTHER RANGE 3-15 PSI ☒ OTHER 27 CONNECTION-NPT 1/4" ☒ OTHER BACK ☒ BOTTOM ☐ OTHER	
		28 FILTER & REGULATOR <u>N/A</u>	
		29 AIR SUPPLY GAGE <u>N/A</u>	
		30 CHARTS & INKSET <u>YES</u>	
		31 MOUNTING YOKE	
		32 RESTRICTION DAMPER	
		33 MANIFOLDS	
		34 ALARM SWITCH HERMETICALLY SEALED ☐ EP ☐ GP ☐	

AGITATORS

Agitators

Specification Sheet Summary

<u>Item No.</u>	<u>Item Description</u>
A101	Slurry Storage Tank Agitator. Three HP turbine type center mounted agitator, with TEFC 1750 rpm 460 volts, 3-phase 60 Hertz motor. 31.4:1 gear reducer, 56 rpm output speed. Dual turbines with 20" diameter lower flat bladed turbine and 40" diameter upper pitched blade turbine. Shaft diameter 2-1/4", length to center of lower turbine 156". Estimated weight 700#. All wetted parts 316 stainless steel.
A201	Pressure Leach Reactor Gas Dispersion Agitator. Fifteen HP turbine type flange mounted agitator with two speed (1800/1200 rpm) TEFC 460 volt, 3-phase 60 Hertz motor, 20.8:1 gear reducer, 84/56 rpm output speed. Dual turbines with 40" diameter lower flat bladed turbine and adjustable 40" diameter upper, pitch bladed turbine. Shaft diameter 3" and length to center of lower turbine 108". Eight inch, 150# ANSI mounting flange, balanced double mechanical seal and Viton "O" rings. All wetted parts 316 stainless steel, including seal housing.
A301	Portable General Purpose Agitator with 1750 rpm, 1/4 HP, 3-phase 60 cycle 230/460 volt, TEFC motor. Single 4" propeller mounted on a 5/8" diameter shaft 36" long, all wetted parts 316 stainless steel. Agitator to have mounting clamp.
A302	Neutralization Tank Agitator. Two HP dual propeller clamp on portable agitator with TEFC 3-phase 60 Hertz 230/460 volt motor. Propeller diameter 14", shaft diameter 7/8", speed 420 rpm, shaft length 72".

Process Equipment

Design Criteria Summary

Item Number: A101

Item Description: Slurry Storage Tank Agitator. Three HP turbine type center mounted agitator, with TEFC 1750 rpm, 460 volt, 3-phase 60 Hertz motor, 31.4:1 gear reducer, 56 rpm output speed. Dual turbines with lower flat bladed turbine 20" diameter and upper pitched blade turbine 40" diameter. Shaft diameter 2-1/4" and length to center of lower turbine 156". Estimated weight 700 pounds.

Design Requirements: Maintain uniform suspension of solids in slurry storage tank so that a representative batch can be withdrawn at any time. Tank (T101) to be 11' diameter by 13'-6" high - level to vary from maximum of 12' down to 2' minimum. Wetted parts to be 316 stainless steel. Shaft length 156". Baseplate included. Shaft mounted vapor seal required.

Design Bases: Manufacturer's recommendation based on tank dimensions. Copper sulfide solids content of 4-6% by weight. Solids specific gravity 4.6, particle size 1-20 microns, liquid specific gravity 1.05. Solids settling rate approximately 1 foot/min.

Level of Confidence: Good - solids settle rapidly but are easily resuspended.

Comments: Agitator will require (2) support beams located across top of T101 - independently supported. Beam size approximately 8" deep, beams about 3" above tank top. Agitator may also be required to assist in suspension-aeration when carrying out ambient leach experiments.

Date: 10/1/77 - Rev. 1

Process Equipment

Design Criteria Summary

Item Number: A201

Item Description: Pressure Leach Reactor Gas Dispersion Agitator. Fifteen HP turbine type flange mounted agitator with two speed (1800/1200 rpm), TEFC 460 volt, 3-phase 60 Hertz motor, 20.8:1 gear reducer, 84/56 rpm output speed. Dual turbines with lower 40" diameter flat bladed turbine and adjustable upper 40" diameter pitched blade turbine. Shaft diameter 3" and length to center of lower turbine 108". Eight-inch, 150# ANSI mounting flange, balanced double mechanical seal with Teflon shaft seal and Viton "O" rings.

Design Requirements: Provide agitation sufficient to suspended solids and provide adequate mass transfer rates for dissolving oxygen in the leach liquor. Agitator to also be used with compressed air as the O₂ source at pressures of 130 psig and flow rates of 230 CFM.

Design Bases: Manufacturer's recommendations based on reactor dimensions of 8' diameter and 8' straight side with dished head, working volume of 2500 gallon, temperature 230°F. Total pressure 75 psig and O₂ partial pressure of 50 psia.

Level of Confidence: Good for oxygen dispersion and mass transfer, similar to equipment supplied by hydrogenations; fair for air dispersion - large volumes and low partial pressures make contacting more difficult.

Comments: Agitators will require a pressurized seal water source at 150 psig to cool the double mechanical seal. Gassed density under operating conditions for air leaching unknown.

Date: 6/1/77 - Rev. 0

Process Equipment
Design Criteria Summary

Item Number: A301

Item Description: Portable general purpose agitator with 1750 rpm, 1/4 HP 3-phase 60 Hertz 230/460 volt, TEFC motor. Single 4" propeller mounted on a 5/8" diameter shaft 36" long, all wetted parts 316 stainless steel. Agitator to have mounting clamp. Weight approximately 35 pounds.

Design Requirements: Provide agitation for 100 gallon stainless steel tank to be used in decopperization studies that will be carried out on the clear liquid purge from the decanter.

Design Bases: Manufacturer's recommendations based on tank dimensions and volume and requirements for light duty mixing.

Level of Confidence: Good for mechanical design

Comments: Decopperization experiments will be carried out infrequently and under a variety of conditions. No general process specifications are available.

Date: 6/1/77 - Rev. 0

Process Equipment

Design Criteria Summary

Item Number: A302

Item Description: Neutralization Tank Agitator. Two HP, dual propeller, clamp on portable agitator, with TEFC 3-phase 60 Hertz 230/460 volt motor. Propeller diameter 14", shaft diameter 7/8", speed 420 rpm, shaft length 72". Weight 160 pounds.

Design Requirements: Provide sufficient turn over to thoroughly mix clear liquid purge in the neutralization tank with circulated purge which has been mixed with ammonia to neutralize free acid.

Design Bases: Manufacturer's recommendations based on tank dimensions - 7' diameter by 8'-9" high. Volume of purge per day - approximately 2000 gallons. Depth of liquid in tank approximately 7'. Holding time during batch neutralization about 2 hours. Tank turnover time about 2 minutes.

Level of Confidence: Good for mechanical design.

Comments: Ammonia introduced into external stream circulating through static mixer at 20 GPM.

Date: 6/1/77 - Rev. 0

HEAT EXCHANGERS

Heat Exchangers
Specification Sheet Summary

<u>Item No.</u>	<u>Item Description</u>
HX101	Energy Recovery Exchanger. 31 square foot plate type heat exchanger. Wetted parts titanium with asbestos gaskets. Three pass arrangement on each side. Connections 2" - 150# flanges. Exchanger to be foot mounted.
HX102	Purge Slurry After Cooler. 33 square foot shell and tube heat exchanger. Single pass shell side, 4 pass tube side, (21) 3/8" OD x 22 BWG x 48" long tubes per pass, 2 1/4" baffle spacing. Wetted parts type 316 stainless steel. Tube side connection 1" NPT, shell side 1-1/2" NPT. Brackets for horizontal mounting.
HX103	Makeup Copper Sulfate. Same as HX102.
HX201	Decanted Slurry Heater. 33 square foot heat exchanger. Same as HX102, except single pass tube side and 6" baffle spacing. Tube side connections 2-1/2" NPT. Brackets for vertical mounting.
HX202	Leached Copper Sulfate Cooler. 131 square foot shell and tube heat exchanger. Single pass tube side and shell side, (224) 3/8" OD x 22 BWG x 72" long tubes, 6" baffle spacing. All wetted parts type 316 stainless steel. Tube side connections 4" NPT, shell side 3" NPT. Brackets for vertical mounting.
HX104	Sample cooler for filtered purge stream to ALT - 105, copper analyzer. One 6' long x 1/4 OD type 316 stainless steel tube with a 1/2" IPS carbon steel water jacket.

Date: 11/1/77 - Rev. 1

Process Equipment

Design Criteria Summary

Item Number: HX101

Item Description: Energy Recovery Exchanger. American Heat Reclaiming Type 22 - H plate heat exchanger with 31.2 square feet of heat transfer surface. All heat exchanger surface and nozzles to be titanium. Gasket material to be asbestos. Each side to be arranged for 3 passes. All connections to be 2" - 150# flanges. Heat exchanger to be foot mounted.

Design Requirements: Exchanger to cool purge stream from 350°F to 210°F while heating copper sulfate makeup stream from 148°F to 320°F. Purge rate to be approximately 7 GPM and makeup rate to be 5.7 GPM. Heat duty to be approximately 500,000 BTU/hr.

Design Bases: Rates fixed by material balance, temperatures by steam operating pressure. Overall U 400 BTU/hr/sq ft/°F, based on manufacturer's clean U of 660 and combined fouling factor of 0.001. Pressure drop approximately 11 psig on the purge stream side and 9 psig on the makeup copper sulfate stream side.

Level of Confidence: Fair. Rate of fouling of heat transfer surfaces not well defined, possibility of plugging on slurry side, severe fouling at hot end of copper sulfate side.

Comments: Plate heat exchanger design selected because of relative ease of cleaning. Exchanger will be piped into bypass to permit continued system operation during servicing.

Date: 10/06/77 - Rev. 1

Process Equipment
Design Criteria Summary

Item Number: HX102

Item Description: Purge Slurry Aftercooler, Whitelock Model No. 5-Y-48. Type AHT-4-B - SS shell and tube heat exchanger with all wetted parts of type 316 stainless steel. Single pass shell side with 4 pass tube side, containing (84) 3/8" OD x 22 BWG by 4 foot long tubes. Surface area to be 33 square feet. Connections to the tube side to be 1" NPT and to the shell side to be 1-1/2" NPT. Shell side baffle spacing to be 2-1/4". Two support brackets for horizontal mounting.

Design Requirements: Exchanger to cool purge stream from column C101 from 210°F to 140°F. Purge rate approximately 7 GPM through tube side, cooling tower water at about 25 GPM through shell. Cooling duty = 250,000 BTU/hr, minimum tube side velocity 1'/sec.

Design Bases: Purge slurry rate fixed by material balance, temperatures by desired storage conditions. Overall U estimated at 150 BTU/hr/sq ft/°F, allows for 50% greater cooling duty.

Level of Confidence: For heat duty-good, for resistance to fouling by suspended solids - fair.

Comments: Fouling not expected to be a major problem in high acidity purge stream. Exchanger will serve as primary cooler for purge if HX101 is out of service.

Date: 11/02/77 - Rev. 1

Process Equipment
Design Criteria Summary

Item Number: HX103

Item Description: Makeup copper sulfate cooler (same as HX102).

Design Requirements: Exchanger to cool makeup copper sulfate stream from tank T102 before entering HX101. Inlet temperatures up to 180°F, outlet temperature to 120°F, flow rate approximately 5.7 GPM through tube side with cooling tower water at 20 GPM through shell. Cooling duty approximately 200,000 BTU/hr.

Design Bases: Makeup copper sulfate rate fixed by material balance, temperature in by makeup copper sulfate heat exchanger. Overall U estimated at 150 BTU/hr/sq ft/°F, sizing allows for 50% greater cooling duty.

Level of Confidence: For cooling duty and flow rates - good for fouling allowances - fair.

Comments: Primary purpose of exchanger is to permit HX101 to achieve lower purge slurry temperature if desired.

Date: 6/1/77 - Rev. 1

Process Equipment

Design Criteria Summary

Item Number: HX201

Item Description: Decanted Slurry Heater. Whitelock Model No. 5-Y-48 Type AHT-1-S-SS shell and tube heat exchanger with all wetted parts of type 316 stainless steel. Single pass tube side with 84 -3/8" OD x 22 BWG tubes four feet long, surface area 33 square feet. Connections tube side 2-1/2" NPT, shell side 1-1/2" NPT, shell side baffle spacing 6". Two support brackets for vertical mounting.

Design Requirements: Provide heat to externally circulated stream from slurry storage tank to makeup for heat losses and to heat up slurry stream during transfer to leach reactor. Heat input to be at a rate of up to 3/4 MM BTU/hr during side stream heat up or transfer. Tube side velocity 1 ft/sec during circulation.

Design Bases: Recirculating liquid around loop @ 100 GPM. Temperature rise to be 15°F, transferring slurry temperature rise to be 30°F. Steam in shell at 50 psig, 800 lb/hr. Overall U estimated at 200 BTU/hr/sq ft/°F.

Level of Confidence: General configuration - good, fouling film resistance-fair.

Comment: If higher temperature rise of slurry transferred to regeneration is required, transfer rate will be decreased below nominal 50 GPM.

Date: 10/05/77 - Rev. 0

Process Equipment
Design Criteria Summary

Item Number: HX202

Item Description: Leached Copper Sulfate Cooler. Whitelock Model No. 8-Y-72 Type AHT-1-S-SS shell and tube heat exchanger with all wetted parts of type 316 stainless steel. Single pass tube side with 224 - 3/8" OD x 22 BWG tubes, 6 feet long. Surface area 130.8 square feet. Connection tube side 4" NPT, shell side 3" NPT. Shell side baffle spacing 6". Two support brackets for vertical mounting.

Design Requirement: Provide cooling capacity to reduce the temperature of the regenerated copper sulfate from leach temperatures of 230°F down to storage temperatures of 140°F. The total cooling duty 3 MM BTU will be split between the reactor jacket and HX202. Cooling and discharge time approximately 1 hour, tube side velocity 1 ft/sec.

Design Bases: Flow rates determined by leach reactor draining time. Outlet temperature by desired storage and filtration conditions. Overall U estimated at 250 BTU/hr/ft²/°F.

Level of Confidence: Good. Service is clean.

Comments: Reactor drain time can be decreased if required to reduce outlet temperature.

Date: 10/05/77 - Rev. 0

Process Equipment
Design Criteria Summary

Item Number: HX104

Item Description: Sample cooler for filtered purge stream to copper analyzer AIT-105. One 6' long $\times$ 1/4" OD type 316 stainless steel tube with a 1/2" IPS carbon steel water jacket.

Design Requirement: Provide a sample at uniform temperature to the copper analyzer. Sample rate 100-200 ml/min.

Design Bases: Cooler to reduce filtered sample to a temperature approaching cooling tower water temperature. Cooler to be small to minimize transportation lag in sampling loop. Overall U estimated at 100 BTU/U/ft²/°F.

Level of Confidence: Good. Clean service, cooler is oversized from heat transfer point of view.

Comments: If cooler operation is erratic, temperature compensation on copper analyzer can be used.

Date: 11/1/77 - Rev. 0

FILTERS

Filters

Specification Sheet Summary

<u>Item No.</u>	<u>Item Description</u>
F101 F101A	Sampling Stream Filters. Two bypass type sampling filters, 6" diameter type 316 stainless steel body with 10 micron pore size. Teflon filters on polypropylene support pads. Filters to be equipped with back flush arrangement.
F102 F102A	Decanted Purge Filters. Single shell cartridge type filters, 4" diameter by 13" long with one 10" long Dynel cartridge. 3/4" NPT connections, 316 stainless steel wetted parts.
F201 F201A	Leached Copper Sulfate Polish Filters. Single shell cartridge type filters 7-9/16" diameter by 40" overall height with (3) 30" long Dynel cartridges. 1-1/2" NPT connections, 316 stainless steel wetted parts.
F301	Process Water Filter. Single shell cartridge type filter 7-9/16" diameter by 20" overall height with (3) 10" long cellulose acetate cartridges. 1-1/2" NPT connections, head and shell - iron and steel.
F302	Decopperized Purge Filter. Single shell cartridge type filter 4" in diameter by 13" long with one 10" long Dynel filter cartridge. 3/4" NPT connections, 316 stainless steel wetted parts.

Date: 10/1/77 - Rev. 0

Process Equipment
Design Criteria Summary

Item Number: F101 and F101A

Item Description: Bypass Type Analyzer Sampling Filters. Six-inch diameter type 316 stainless steel Swirlklean Model II with 3/8" NPT tangential slurry inlet and outlet ports, 1/4" OD tube filtrate outlet connection. Filter elements to be Teflon with 10 micron pore size supported on polypropylene support pad and screen filters. To be equipped with a back flush arrangement to allow off-line cleaning without disassembly.

Design Requirements: Provide continuous flow of filtered purge stream to on-line copper analyzer at a rate of approximately 100-200 cc/min. Maintain long term operation withdrawing sample from 3 to 5 percent solids slurry containing micron sized particles. Operating pressures up to 150 psig, flow rates of approximately 7 GPM.

Design Bases: Laboratory tests on 3" diameter Swirlklean filter and simulated purge stream containing field or lab produced solids demonstrated operability, filtration rates, cleaning cycles time and back flow cleaning.

Level of Confidence: On filtration rates - good, on cleaning cycle time and back flow cleaning - fair.

Comments: Dual filters provides 100% back up.

Date: 9/28/77 - Rev. 0

Process Equipment

Design Criteria Summary

Item Number: F102, F102A

Item Description: Single Sheel Cartridge Type Filter. Four inches in diameter by 13 inches long, with one 10" long Dynel filter cartridge, code D-15R-10-S. 3/4" NPT connections, bottom drain plug, top air vent, and asbestos gasket. Wetted metal parts type 316 stainless steel.

Design Requirements: Filter to remove copper sulfide particles carried over with the decanter overflow during periods of upset and to polish filter overflow stream during normal operation. Flow rate to be 1-2 GPM at pressures up to 150 psig and temperatures of 100-160°F. Filter to have a particle size removal rating of 10 microns at a flow rate of 3 GPM of aqueous liquid. Initial pressure drops 2-3 psi.

Design Bases: Liquid rates, initial pressure drops and particle size removal rating from manufacturer's literature. Normal decantate solids content < 50 ppm; > 100 ppm during upset conditions.

Level of Confidence: Good on general performance as outlined above. Fair on amount of solids carried over from decanter during upset conditions.

Comments: Filters can be bypassed if cycle proves to be too short for convenience, although material balance could then not be closed.

Date: 9/28/77 ~ Rev. 0

Process Equipment

Design Criteria Summary

Item Number: F201, F201A

Item Description: Single Shell Cartridge Type Filter. 7-9/16" diameter by 40" overall height with (3) 30" long Dynel filter cartridges, code D-15R-10-S. In-line 1-1/2" NPT pipe connections with bottom drain cock and top air vent, asbestos gasket. Wetted parts 316 stainless steel.

Design Requirements: Filter to remove unleached solids from regenerated copper sulfate leaving the oxygen pressure leach reactor. Flow rate to be up to 80 GPM at pressures of 30 psig and temperatures of 100-160°F. Filter to have particle size removal rating of 10 microns at a flow rate of 45 GPM of aqueous liquid. Initial pressure drops 3-5 psi.

Design Bases: Liquid rates, initial pressure drops and particle size removal rating from manufacturer's literature.

Level of Confidence: Good on general performance, fair on amount of unleached solids leaving reactor. Second filter in parallel to allow filter changing during operation.

Comments: Solids removal required to close reactor material balance and insure proper operation of CuSO_4 makeup turbine pump. Filtration cycle time will be increased if necessary.

Date: 10/1/77 - Rev. 0

Process Equipment

Design Criteria Summary

Item Number: F301

Item Description: Single Shell Cartridge Type Filter. 7-9/16" diameter by 20" overall height with (3) 10" long cellulose acetate filter cartridges. Code W-12R-10-A. In-line 1-1/2" NPT pipe connections with brass drain and vent cocks. Head and shell iron and steel.

Design Requirements: Provide up to 15 GPM of filtered cooling tower water for use as demister spray wash and for seal pressurizing system. Particle size removal rating 40 microns, initial pressure drop 3 psig, maximum pressure drop approximately 30 psig.

Design Bases: Seal pressurizing system to require approximately 5 GPM, continuous duty. Demister spray wash equivalent to 1-2 GPM continuous duty. Operating safety factor of two.

Level of Confidence: Good, generally. Cooling tower water may blind filter with slime rather than loading cartridge.

Comments: Standard design for this service.

Date: 9/24/77 - Rev. 0

Process Equipment

Design Criteria Summary

Item Number: F302

Item Description: Single Shell Cartridge Type Filter. Four inches in dia by 13 inches long with one 10" long Dynel filter cartridge. Code D-15R-10-S 3/4" NPT connections, bottom drain plug, top vent and asbestos gasket. Wetted metal parts type 316 stainless steel.

Design Requirements: Provide filtration capability for general purpose tank and copper removal experiments. Stream from tank T301 to be filtered prior to discharge to cooling tower sump. Capacity to be 5 GPM initial flow rate at 3 psi pressure drop. Particle size removal rating - 10 microns.

Design Bases: Liquid rates, initial pressure drops and particle size removal rating from manufacturer's literature.

Level of Confidence: Fair. Properties of solids produced during neutralizing/decupperization not known.

Comments: Filter will be used only occasionally to check material balance and filtration cycle can be extended if necessary.

Date: 10/1/77 - Rev. 0

PUMPS AND COMPRESSORS

Pumps and Compressors
Specification Sheet Summary

<u>Item No.</u>	<u>Item Description</u>
P101 & P101A	Scrubbing Slurry Circulating Pumps. 6" x 4" - 13" centrifugal pumps to deliver 800 GPM at 52' total dynamic head with 20 HP motors. Pumps to be fitted with double mechanical seals. Wetted parts Durimet 20.
P102 & P102A	Makeup Copper Sulfate Feed Pumps. 3 x 1-1/2" turbine pumps to deliver 10 GPM at 350' total dynamic head with 7-1/2 HP motors. Pumps to be fitted with double mechanical seals. Wetted parts 316 stainless steel.
P103 & P103A	Decanted Slurry Transfer Pumps. 3" x 2" - 7" centrifugal pumps to deliver 100 GPM at 47' total dynamic head with 3 HP motors. Pumps to be fitted with double mechanical seals. Wetted parts type 316 stainless steel.
P201	Leached Copper Sulfate Transfer Pumps. 3" x 1-1/2" - 6" centrifugal pump to deliver 80 GPM at 63' total dynamic head with 5 HP motor. Pump to be fitted with single mechanical seal. Wetted parts 316 stainless steel.
P301	General Purpose Circulating Pump. 1-1/2" x 1" - 6" centrifugal pump to deliver 20 GPM at 35' total dynamic head with 1 HP motor. Pump to be fitted with single mechanical seal. Wetted parts 316 stainless steel.
P302	Neutralized Purge Transfer Pump. Same as P301.
P303	Sulfuric Acid Transfer Pump. 1" x 3/4" sealless magnetic drive centrifugal pump to deliver 3 GPM at 25' total dynamic head with 1/2 HP motor. Wetted parts to be Ryton, Teflon and ceramic.

Pump and Compressors - Spec. Sheet Summary (continued)

<u>Item No.</u>	<u>Item Description</u>
P304	Demister Wash Water Pump. 1-1/4" x 1-1/4" turbine pump to deliver 11 GPM at 405' total dynamic head with 7-1/2 HP motor. Pump to be fitted with single mechanical seal. Wetted parts iron.
P305	Seal Water Supply Pump. 1-1/4" x 1-1/4" turbine pump to deliver 5 GPM at 360' total dynamic head with 3 HP motor. Pump to be fitted with single mechanical seal. Wetted parts iron.
P307	Portable General Purpose Pump. 1" x 3/4" sealless magnetic drive centrifugal pump to deliver 10 GPM at 44' total dynamic head with 1/2 HP motor. Wetted parts to be Ryton, Teflon and ceramic.
P401	Pressure Leach Air Compressor. Packaged rotary screw compressor 7' long by 4' wide by 4' high to deliver 230 SCFM at 150 psig maximum output pressure with 75 HP motor. Compressor to be complete with auxiliary equipment and controls.

Date: 11/1/77 - Rev. 1

Process Equipment

Design Criteria Summary

Item Number: P101, P101A

Item Description: 6" x 4" - 13" centrifugal pump with pressurized double mechanical seal and Durimet 20 wetted pressure parts. Driver to be 20 HP 1180 rpm TEFC motor, 3-phase, 60 Hertz, 460 volts. Twelve inch impeller to deliver 800 GPM at 52' TDH. Seal to be water cooled. Second pump (same specifications) to be piped as spare and to circulate sump liquid.

Design Requirements: Circulate up to 800 GPM from scrubber sump to distribution nozzle at a temperature of 360°F and a pressure of 120-150 psig. Resist corrosive/erosive action of scrubbing solution (slurry). Maintain leak free shaft seal to minimize copper loss. Provide spare pump piped in parallel to eliminate down time for pump maintenance.

Design Bases: Design rate of 800 GPM based on maximum expected circulation rate and field tests of 8" scrubber. Materials selection based on lab corrosion tests and experience with 8" field test unit.

Level of Confidence: Good for maximum rate, good for material selection.

Comments: Provide high pressure water seal coolant system for both pumps. Spare pump may be used to recirculate slurry in scrubber sump.

Date: 4/28/77 - Rev. 0

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS CENTRIFUGAL PUMP INQUIRY

GENERAL		Job No. <u>424</u>	
*For <u>FIELD</u>		Item No. <u>P101, P101A</u>	
*Plant <u>PG & E</u>		*Spec. No. <u>P-1</u>	
*Location <u>THE GEYSERS</u>		*Rev. No. <u>Q</u> *Date <u>3-9-77</u>	
*Service <u>SEWAGE LIQUID RECL</u>		Quote No. _____	
*Motor Drive <u>YCS</u>		Reference _____	
*Turbine Drive _____		*Disch. Pressure: <u>141</u> p.s.i.g.	
*Liquid Pumped: <u>40/11.50, 160/60, 1144/50 @ 350</u> *F.P.T.		*Suct. Pressure: <u>120</u> p.s.i.g.	
*Capacity, g.p.m. @ <u>350</u> *F.: Normal <u>440</u> : Design <u>500</u>		*Diff. Pressure: <u>21.0</u> p.s.i.	
@ P.T.: *Sp. Gr. <u>1.3</u> *Visc. <u>1.0</u> cps; *Vap. Pr. <u>135</u> p.s.i.a.		*Diff. Head: <u>52</u> ft.	
@ 60° F.: *Sp. Gr. <u>1.02</u> *Visc. _____ cps; *Vap. Pr. _____ p.s.i.a.		*Corr. Material? <u>150y/60</u> *Erosive Material? <u>CLS</u>	
N *Available _____ ft. (liquid)		*2.5/1.2 % or _____ p.p.m. * _____ % or _____ p.p.m.	
P Required <u>4.3</u> ft. (liquid)		*User's Experience with Material Specified:	
S Required _____ ft. (water)		Good _____ Fair _____ None _____	
H _____			
OPERATING CONDITIONS			
PUMP SPECS.			
Manufacturer <u>DURCO</u>		No. of Stages <u>1</u>	
Size & Type <u>6 x 4 - 13 A</u>		Performance Curve <u>FEQUILRHD</u>	
*R.P.M. <u>1180</u> Efficiency <u>73%</u>		Impeller Diam.: Bld <u>12</u> Min. <u>9</u> Max. <u>13</u>	
Bhp: @ Design <u>13</u> Max. Bhp. Req'd <u>14</u>		Recommended Driver Hp. <u>10</u>	
Circular No. _____		Dimension Print _____ Section Dwg. _____	
MATERIALS OF CONSTRUCTION		CONSTRUCTION FEATURES	
*Casing & Nozzle: <u>PAULMET 20</u>		*Case Split Horiz. _____ Vert. ☒	
*Impeller: _____		Support C/L ☒ Foot _____ Bracket _____	
*Casing Ring: _____		*Impeller Open _____ Closed _____ Semi-Enc. ☒	
*Impeller Rings: _____		*Suff. Box Water Jacket: Yes _____ No _____	
*Shaft: <u>208 Corbust 375</u>		*Mech. Seal <u>YCS</u> Internal _____ External _____	
*Shaft Sleeve: <u>708</u>		Single _____ Double ☒ Balanced _____ Unbal. ☒	
*Packing Gland: _____		*Bearings: Water Jacketed: Yes ☒ No ☒	
*Packing: _____		Lubrication: Oil _____ Grease _____	
*Seal Cage: <u>YCS</u>		*Flexible Coupling: Make <u>Wesco</u> Type <u>57100</u>	
*Base Plate: <u>STC-1</u>		*Coupling Guard: Yes ☒ No _____	
DRIVER DATA		TURBINE	
MOTOR			
*Make: <u>US</u> *Hp: <u>25</u>		*Make: _____ *Hp: _____	
*Type: <u>TEFC</u> *R.P.M. <u>1150</u>		*Type: _____ *R.P.M.: _____	
*Phase <u>3</u> *Cycle <u>1-0</u> *Volts <u>480</u>		Water Rate @ Design Load: _____ lb./hr./Bhp.	
Frame <u>206T</u>		*Steam Inlet: _____ p.s.i.g. @ _____	
		*Steam Exhaust: _____ p.s.i.g. @ _____	
WT.		SHIPPING WEIGHT	
NET WEIGHT { Pump, Base, Cplg. <u>500</u> lb.		Pump, Base, Cplg. _____ lb.	
Motor <u>271</u> lb.			

Special Instructions or Features: _____

*User to complete
*Characteristic curve to show head, capacity, efficiency, NPSH required

**AMERICAN INSTITUTE OF CHEMICAL ENGINEERS
CENTRIFUGAL PUMP INQUIRY**

GENERAL		*For <u>ETC (COP)</u>		*Job No. <u>6431</u>		
		*Plant <u>PG+E</u>	*No. Required <u>2</u>	*Item No. <u>P 102, P 102A</u>		
		*Location <u>THE S. YSERS</u>	*Motor Drive <u>YES</u>	*Spec. No. <u>P-2</u>	*Rev. No. <u>0</u> *Date <u>3-2-72</u>	
		*Service <u>CUSON MANG UP</u>	*Turbine Drive	Quote No.	Reference	
OPERATING CONDITIONS		*Liquid Pumped: <u>50% BELOW</u> @ <u>MAX 180</u> *F.P.T.		*Disch. Pressure: <u>123</u> p.s.i.g.		
		*Capacity, g.p.m. @ <u>140</u> *F.: Normal <u>5.7</u> Design <u>10.0</u>		*Suct. Pressure: <u>2</u> p.s.i.g.		
		@ P.T.: *Sp. Gr. <u>1.13</u> *Visc. <u>~1</u> cps; *Vap. Pr. <u>3.0</u> p.s.i.a.		*Diff. Pressure: <u>121</u> p.s.i.		
		@ 60° F: *Sp. Gr. <u>1.16</u> *Visc. <u>~1</u> cps; *Vap. Pr. <u>2.5</u> p.s.i.a.		*Diff. Head: <u>350</u> ft.		
		N *Available <u>8</u> ft. (liquid)	*Corr. Material? <u>H2SO4</u>	*Erosive Material? <u>NO</u>		
		P Required <u>6</u> ft. (liquid)	* <u>5</u> % or _____ p.p.m.	* <u>5</u> % or _____ p.p.m.		
		S Required _____ ft. (water)	*User's Experience with Materials Specified:			
		H _____	Good ☒	Fair _____	None _____	
PUMP SPECS.		Manufacturer <u>AURORA</u>		No. of Stages <u>1</u>		
		Size & Type <u>3 x 1 1/2 TURBINE</u>		Performance Curve <u>SECT 150 P 408</u>		
		*R.P.M. <u>1750</u> ; Efficiency <u>~26%</u>		Impeller Diam.: Bid _____ Min. _____ Max. _____		
		Bhp. @ Design _____; Max. Bhp. Req'd. <u>1.0</u>		Recommended Driver Hp. <u>5</u>		
		Circular No. _____		Dimension Print <u>150-252</u> Section Dwg. _____		
MATERIALS OF CONSTRUCTION		*Casing & Nozzle: <u>316 SS</u>	CONSTRUCTION FEATURES	*Case Split: Horiz. _____ Vert. ☒		
		*Impeller: <u>316 SS</u>		Support: C/L ☒ Foot _____ Bracket _____		
		*Casing Ring: <u>316 SS</u>		*Impeller: Open <u>JUGLINE</u> Closed _____ Semi-Enc. _____		
		*Impeller Rings: <u>316 SS</u>		*Stuff. Box: Water Jacket: Yes _____ No _____		
		*Shaft: <u>316 SS</u>		*Mech. Seal? <u>YES</u> ; Internal ☒ External _____		
		*Shaft Sleeve: <u>316 SS</u>		Single ☒ Double _____; Balanced _____; Unbal. ☒		
		*Packing Gland: _____		*Bearings: Water Jacketed: Yes _____ No ☒		
		*Packing: _____		Lubrication: Oil _____ Grease _____		
		*Seal Cage: <u>316 SS</u>		*Flexible Coupling: Make <u>WOODS</u> Type <u>SP-212</u>		
		*Base Plate: <u>STEEL</u>		*Coupling Guard: Yes ☒ No _____		
DRIVER DATA		MOTOR		TURBINE		
WT.		NET WEIGHT		SHIPPING WEIGHT		

Special Instructions or Features:

LIQUID PUMPED - 10% H2SO4, 80% (NH4)2SO4 5% H2SO4
BALANCE H2O

*User to complete

†Characteristic curve to show head, capacity, efficiency, NPSH required.

Process Equipment

Design Criteria Summary

Item Number: P103, P103A

Item Description: 3 x 2-7 centrifugal pump with a double mechanical seal and 316 stainless steel wetted parts. Driver to be 3 HP 1800 rpm TEFC motor, 3-phase, 60 Hertz, 460 volts. Seven inch impeller to deliver 100 GPM at 47' TDH. Seal to be water cooled. Second pump (same specifications) to be piped as a spare to provide back up for transfer operation.

Design Requirements: Circulate up to 100 GPM of purged slurry from storage tank T101 through the heat exchanger HX201 and ambient leach contacting device or out to the leach reactor. Temperatures to be 120-180°F at a pressure of 20 psig.

Design Bases: Design rate of 100 GPM based on a leach reactor charging time of 30 minutes.

Level of Confidence: Good on mechanical design.

Comments: Specification of pump requires that ambient leach air-liquid contactor be a low pressure drop type of device.

Date: 10/24/77 - Rev. 1

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS CENTRIFUGAL PUMP INQUIRY

GENERAL		*Job No. <u>QY31</u> *Item No. <u>P-1034</u> *Spec. No. <u>P-3</u> *Rev. No. <u>0</u> *Date <u>3-9-77</u> *Location <u>THE GEYERS</u> *Motor Drive <u>YES</u> *Turbine Drive _____ *Reference _____	
*For <u>EEC CORP</u> *Plant <u>7600</u> *Location <u>THE GEYERS</u> *Service <u>SEW-Y 22-205-1-10</u>		*No. Required <u>2</u> *Motor Drive <u>YES</u> *Turbine Drive _____	
OPERATING CONDITIONS		*Liquid Pumped: <u>SEW ABTTS</u> *Capacity, g.p.m. @ <u>180</u> *F.: Normal <u>100</u> *Design <u>100</u> @ P.T.: *Sp. Gr. <u>1.055</u> *Visc. <u>4</u> cps: *Vap. Pr. <u>15.3</u> p.s.i.a. @ 60° F.: *Sp. Gr. _____ *Visc. _____ cps: *Vap. Pr. _____ p.s.i.a. *Available _____ *Corr. Material? _____ P Required <u>1.5</u> ft. (liquid) _____ % or _____ p.p.m. *Erosive Material? <u>YES</u> C.S. S Required _____ ft. (water) _____ *User's Experience with Materials Specified: _____ H _____ Good _____ Fair _____ None _____	
PUMP SPECS.		Manufacturer <u>DUNLOP</u> Size & Type <u>3X2-7</u> *R.P.M. <u>1750</u> Efficiency _____ Bhp. @ Design <u>2.2</u> Max. Bhp. Req'd <u>6.8</u> Circular No. _____ Dimension Print _____ Section Dwg. _____	
MATERIALS OF CONSTRUCTION		CONSTRUCTION FEATURES	
*Casing & Nozzle: <u>316 SS</u> *Impeller: _____ *Casing Ring: _____ *Impeller Rings: _____ *Shaft: <u>D 48 CARBON STEEL</u> *Shaft Sleeve: <u>0CS</u> *Packing Gland: _____ *Packing: _____ *Seal Cage: <u>STEEL</u> *Base Plate: <u>STEEL</u>		*Case Split: Horiz. _____ Vert. _____ *Support: C/L _____ Foot _____ Bracket _____ *Impeller: Open _____ Closed _____ Semi-Enc. _____ *Stuff. Box: Water Jacket: Yes _____ No _____ *Mech. Seal? _____ Internal _____ External _____ *Single _____ Double _____ *Bearings: Water Jacketed: Yes _____ No _____ *Flexible Coupling: Make <u>HYDROC</u> Type <u>STEEL</u> *Coupling Guard: Yes _____ No _____	
DRIVER DATA		TURBINE	
*Motor *Make: <u>1.5</u> *Hp.: <u>3</u> *Type: <u>TFC</u> *R.P.M. <u>1800</u> *Phase <u>3</u> *Cycle <u>60</u> *Volts <u>480</u> *Frame <u>182 Y</u>		*Make: _____ *Hp.: _____ *Type: _____ *R.P.M.: _____ *Water Rate @ Design Load: _____ lb./hr./Bhp. *Steam Inlet: _____ p.s.i.g. @ _____ *F. *Steam Exhaust: _____ p.s.i.g. @ _____ *F.	
*NET WEIGHT { Pump, Base, Cplg. _____ lb. Motor _____ lb.		*SHIPPING WEIGHT { Pump, Base, Cplg. _____ lb.	

Special Instructions or Features:
1. 100% DELIVERED - 2. 100% DELIVERED - 3. 100% DELIVERED
4. 100% DELIVERED - 5. 100% DELIVERED
6. 100% DELIVERED - 7. 100% DELIVERED
8. 100% DELIVERED - 9. 100% DELIVERED
10. 100% DELIVERED - 11. 100% DELIVERED
12. 100% DELIVERED - 13. 100% DELIVERED
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16. 100% DELIVERED - 17. 100% DELIVERED
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30. 100% DELIVERED - 31. 100% DELIVERED
32. 100% DELIVERED - 33. 100% DELIVERED
34. 100% DELIVERED - 35. 100% DELIVERED
36. 100% DELIVERED - 37. 100% DELIVERED
38. 100% DELIVERED - 39. 100% DELIVERED
40. 100% DELIVERED - 41. 100% DELIVERED
42. 100% DELIVERED - 43. 100% DELIVERED
44. 100% DELIVERED - 45. 100% DELIVERED
46. 100% DELIVERED - 47. 100% DELIVERED
48. 100% DELIVERED - 49. 100% DELIVERED
50. 100% DELIVERED - 51. 100% DELIVERED
52. 100% DELIVERED - 53. 100% DELIVERED
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68. 100% DELIVERED - 69. 100% DELIVERED
70. 100% DELIVERED - 71. 100% DELIVERED
72. 100% DELIVERED - 73. 100% DELIVERED
74. 100% DELIVERED - 75. 100% DELIVERED
76. 100% DELIVERED - 77. 100% DELIVERED
78. 100% DELIVERED - 79. 100% DELIVERED
80. 100% DELIVERED - 81. 100% DELIVERED
82. 100% DELIVERED - 83. 100% DELIVERED
84. 100% DELIVERED - 85. 100% DELIVERED
86. 100% DELIVERED - 87. 100% DELIVERED
88. 100% DELIVERED - 89. 100% DELIVERED
90. 100% DELIVERED - 91. 100% DELIVERED
92. 100% DELIVERED - 93. 100% DELIVERED
94. 100% DELIVERED - 95. 100% DELIVERED
96. 100% DELIVERED - 97. 100% DELIVERED
98. 100% DELIVERED - 99. 100% DELIVERED
100. 100% DELIVERED - 101. 100% DELIVERED
102. 100% DELIVERED - 103. 100% DELIVERED
104. 100% DELIVERED - 105. 100% DELIVERED
106. 100% DELIVERED - 107. 100% DELIVERED
108. 100% DELIVERED - 109. 100% DELIVERED
110. 100% DELIVERED - 111. 100% DELIVERED
112. 100% DELIVERED - 113. 100% DELIVERED
114. 100% DELIVERED - 115. 100% DELIVERED
116. 100% DELIVERED - 117. 100% DELIVERED
118. 100% DELIVERED - 119. 100% DELIVERED
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**AMERICAN INSTITUTE OF CHEMICAL ENGINEERS
CENTRIFUGAL PUMP INQUIRY**

GENERAL		*For <u>ETC Corp.</u> *Plant <u>FG-1</u> *Location <u>THE GAYSONS</u> *Service <u>REGENERATED COPPER SULFATE</u>		*Job No. <u>C 434</u> *Item No. <u>P 201</u> *Spec. No. <u>P-4</u> *Rev. No. _____ *Date <u>3-9-77</u> Quote No. _____ Reference _____	
		*No. Required <u>1</u> *Motor Drive ☒ *Turbine Drive _____			
OPERATING CONDITIONS		*Liquid Pumped: <u>REGEN. CuSO₄ SEE FIG. 1</u> *F.P.T. _____ *Capacity, g.p.m. @ <u>140</u> *F.: Normal <u>80</u> Design <u>75</u> @ P.T.: *Sp. Gr. <u>1.13</u> *Visc. <u>1</u> cps; *Vap. Pr. <u>7.6</u> p.s.i.a. @ 60° F.: *Sp. Gr. <u>1.16</u> *Visc. <u>1</u> cps; *Vap. Pr. <u>25</u> p.s.i.a.		*Disch. Pressure: <u>33.8</u> p.s.i.g. *Suct. Pressure: <u>5</u> p.s.i.g. *Diff. Pressure: <u>28.8</u> p.s.i. *Diff. Head: <u>63</u> ft.	
		N *Available _____ ft. (liquid) P Required <u>2.5</u> ft. (liquid) S Required _____ ft. (water) H _____		*Corr. Material? <u>H₂SO₄</u> *Erosive Material? <u>100</u> * <u>0.5</u> % or _____ p.p.m. * _____ % or _____ p.p.m. *User's Experience with Materials Specified: Good ☒ Fair _____ None _____	
PUMP SPECS.		Manufacturer <u>Durco</u> No. of Stages <u>1</u> Size & Type <u>3 x 1 1/2 - 6</u> Performance Curve <u>MD 71404V</u> *R.P.M. <u>3500</u> Efficiency _____ Impeller Diam.: Bid <u>4 1/2</u> Min. <u>4</u> Max. <u>12</u> Bhp. @ Design <u>2.2</u> Max. Bhp. Req'd. <u>3.2</u> Recommended Driver Hp. <u>5.0</u> Circular No. _____ Dimension Print _____ Section Dwg. _____			
MATERIALS OF CONSTRUCTION		*Casing & Nozzle: <u>316 SS</u> *Impeller: _____ *Casing Ring: _____ *Impeller Rings: _____ *Shaft: <u>171-5</u> *Shaft Sleeve: <u>1.5x1.5</u> *Packing Gland: _____ *Packing: _____ *Seal Cage: <u>316</u> *Base Plate: <u>STAINLESS</u>		CONSTRUCTION FEATURES	
				*Case: Split: Horiz. _____ Vert. ☒ Support: C/L ☒ Foot _____ Bracket _____ *Impeller: Open _____ Closed _____ Semi-Enc. ☒ *Stuff. Box: Water Jacket: Yes _____ No ☒ *Mech. Seal? <u>YES</u> ; Internal ☒ External _____ Single ☒ ; Double _____; Balanced _____; Unbal. ☒ *Bearings: Water Jacketed: Yes _____ No ☒ Lubrication: Oil ☒ Grease _____ *Flexible Coupling: Make <u>WILCOX</u> Type <u>SHACAL</u> *Coupling Guard: Yes ☒ No _____	
DRIVER DATA		MOTOR		TURBINE	
		*Make: <u>TEFC</u> *Hp.: _____ *Type: <u>TEFC</u> *R.P.M.: <u>3500</u> *Phase <u>3</u> *Cycle <u>60</u> *Volts <u>480</u> Frame <u>100T</u>		*Make: _____ *Hp.: _____ *Type: _____ *R.P.M.: _____ Water Rate @ Design Load: _____ lb./hr./Bhp. *Steam Inlet: _____ p.s.i.g. @ _____ °F. *Steam Exhaust: _____ p.s.i.g. @ _____ °F.	
WT.		NET WEIGHT		SHIPPING WEIGHT	
		{ Pump, Base, Cplg. <u>100</u> lb. Motor <u>25</u> lb.		{ Pump, Base, Cplg. _____ lb.	

Special Instructions or Features:

1. Pump to be used for REGEN. CuSO₄ solution. See FIG. 1 for details.
2. Material of construction to be 316 SS.
3. Motor to be TEFC, 3 phase, 480V, 3500 RPM.
4. Impeller to be open type.
5. Mechanical seal to be internal.
6. Bearings to be water jacketed.
7. Lubrication to be oil.
8. Flexible coupling to be Wilcox SHACAL type.
9. Coupling guard to be present.
10. Shipping weight to include pump, base, coupling, and motor.
11. Net weight to include pump, base, coupling, and motor.
12. Motor to be 3 phase, 480V, 3500 RPM.
13. Impeller to be open type.
14. Mechanical seal to be internal.
15. Bearings to be water jacketed.
16. Lubrication to be oil.
17. Flexible coupling to be Wilcox SHACAL type.
18. Coupling guard to be present.
19. Shipping weight to include pump, base, coupling, and motor.
20. Net weight to include pump, base, coupling, and motor.

*User to complete
 I Characteristic curve to show head, capacity, efficiency, NPSH required

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS CENTRIFUGAL PUMP INQUIRY

GENERAL		*Job No. <u>C 434</u>	
*For <u>East Coast</u>		*Item No. <u>P 301</u>	
*Plant <u>P.E.T.S. STYRENE</u>		*Spec. No. <u>P.S.</u>	
*Location <u>745 S.E. 65</u>		*Rev. No. <u>Date 3-22-77</u>	
*Service <u>GEN. PUMP ALI. WATER</u>		*Quote No. _____	
*Turbine Drive _____		*Reference _____	
OPERATING CONDITIONS		*Disch. Pressure: <u>18</u> p.s.i.g.	
*Liquid Pumped: <u>ALUM. SUCC. SER. @ 140 °F. P.T.</u>		*Suct. Pressure: <u>2</u> p.s.i.g.	
*Capacity, g.p.m. @ <u>140</u> °F.: Normal <u>70</u> ; Design <u>70</u>		*Diff. Pressure: <u>16</u> p.s.i.	
*P.T.: *Sp. Gr. <u>1.06</u> ; *Visc. <u>1.0</u> cps; *Vap. Pr. <u>3.0</u> p.s.i.a.		*Diff. Head: <u>35</u> ft.	
@ 60 °F.: *Sp. Gr. <u>1.00</u> ; *Visc. <u>1.0</u> cps; *Vap. Pr. <u>25</u> p.s.i.a.			
N *Available <u>2.1</u> ft. (liquid)		*Corr. Material? <u>✓</u>	
P Required <u>0.8</u> ft. (liquid)		% or _____ p.p.m. % or _____ p.p.m.	
S Required _____ ft. (water)		*User's Experience with Materials Specified:	
H _____		Good _____ Fair _____ None _____	
PUMP SPECS.		CONSTRUCTION FEATURES	
Manufacturer <u>WILCO</u>		*Case Split: Horiz. <u>✓</u> Vert. _____	
Size & Type <u>1 1/2 x 1-6</u>		Support: C/L <u>✓</u> Foot _____ Bracket _____	
*R.P.M. <u>1725</u> Efficiency _____		*Impeller: Open _____ Closed _____ Semi-Enc. <u>✓</u>	
Bhp. @ Design <u>57</u> Max. Bhp. Req'd. <u>72</u>		*Stuff. Box: Water Jacketed: Yes _____ No _____	
Circular No. _____ Dimension Print _____		*Mech. Seal? <u>YHS</u> Internal _____ External _____	
		Single <u>✓</u> Double _____; Balanced _____; Unbal. <u>✓</u>	
		*Bearing: Water Jacketed: Yes _____ No _____	
		Lubrication: Oil _____ Grease _____	
		*Flexible Coupling: Make <u>Wilco</u> Type <u>SPACER</u>	
		*Coupling Guard: Yes _____ No _____	
MATERIALS OF CONSTRUCTION		DRIVER DATA	
*Casing & Nozzle: <u>316 SS</u>		MOTOR	
*Impeller: _____		*Make: <u>115</u> Hp.: <u>1.0</u>	
*Casing Ring: _____		*Type: <u>TESE</u> ; R.P.M. <u>1725</u>	
*Impeller Rings: _____		*Phase <u>3</u> *Cycle <u>60</u> *Volts <u>460</u>	
*Shaft: <u>DCB</u>		Frame <u>1Y3</u>	
*Shaft Sleeve: <u>ALUM.</u>			
*Packing Gland: _____			
*Packing: _____			
*Seal Cage: <u>316</u>			
*Base Plate: <u>STEE</u>			
		TURBINE	
		*Make: _____ Hp.: _____	
		*Type: _____; R.P.M.: _____	
		Water Rate @ Design Load: _____ lb./hr./Bhp.	
		*Steam Inlet: _____ p.s.i.g. @ _____ °F.	
		*Steam Exhaust: _____ p.s.i.g. @ _____ °F.	
NET WEIGHT { Pump, Base, Cplg. _____ lb.		SHIPPING WEIGHT { Pump, Base, Cplg. _____ lb.	
Motor _____ lb.		_____ lb.	

Special Instructions or Features: _____

*User to complete.
*Characteristic curve to show head, capacity, efficiency, NPSH required.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS CENTRIFUGAL PUMP INQUIRY

GENERAL		*For <u>ETC. CO.</u> *Plant <u>PE #1</u> *No. Required <u>1</u> *Location <u>THE GULF STATES</u> *Motor Drive <u>YES</u> *Service <u>WATER PUMP FOR 7" DIA.</u> *Turbine Drive _____		*Job No. <u>0434</u> *Item No. <u>P 202</u> *Spec. No. <u>0-0</u> *Rev. No. <u>0</u> *Date <u>3-22-77</u> Quote No. _____ Reference _____					
OPERATING CONDITIONS		*Liquid Pumped: <u>WATER @ 170 F.P.T.</u> *Capacity, g.p.m. @ <u>170</u> *F. Normal <u>1/2</u> Design <u>170</u> @ P.T.: *Sp. Gr. <u>1.00</u> *Visc. <u>1.0</u> cps; *Vap. Pr. <u>3.0</u> p.s.i.a. @ 60° F.: *Sp. Gr. <u>1.00</u> *Visc. <u>1</u> cps; *Vap. Pr. <u>3.5</u> p.s.i.a.		*Disch. Pressure: <u>16.5</u> p.s.i.g. *Suct. Pressure: <u>2</u> p.s.i.g. *Diff. Pressure: <u>14.5</u> p.s.i. *Diff. Head: <u>32</u> ft.					
		N *Available <u>FLOODED</u> ft. (liquid) P Required <u>2</u> ft. (liquid) S Required _____ ft. (water) H _____		*Corr. Material? <u>1.500</u> *Erosive Material? <u>No</u> * <u>2</u> % or _____ p.p.m. * _____ % or _____ p.p.m. *User's Experience with Materials Specified: Good ☒ Fair _____ None _____					
PUMP SPECS.		Manufacturer <u>DUPLO</u> No. of Stages <u>1</u> Size & Type <u>1 1/2" x 1" V6</u> Performance Curve <u>M 7002 AV</u> *R.P.M. <u>1750</u> Efficiency _____ Impeller Diam.: Bid <u>6</u> Min. <u>4</u> Max. <u>6</u> Bhp. @ Design <u>1.69</u> Max. Bhp. Req'd. <u>7.5</u> Recommended Driver Hp. <u>1.0</u> Circular No. _____ Dimension Print _____ Section Dwg. _____							
MATERIALS OF CONSTRUCTION		*Casing & Nozzle: <u>316 SS</u> *Impeller: _____ *Casing Ring: _____ *Impeller Rings: _____ *Shaft: <u>1/2" 316</u> *Shaft Sleeve: _____ *Packing Gland: _____ *Packing: _____ *Seal Cage: <u>316 SS</u> *Base Plate: <u>316 SS</u>		CONSTRUCTION FEATURES		*Case Split: Horiz. ☒ Vert. _____ Support: C/L ☒ Foot _____ Bracket _____ *Impeller: Open _____ Closed _____ Semi-Enc. ☒ *Stuff. Box: Water Jacket: Yes _____ No ☒ *Mech. Seal? <u>YES</u> Internal ☒ External _____ Single ☒ Double _____ Balanced _____ Unbal. ☒ *Bearings: Water Jacketed: Yes _____ No ☒ Lubrication: Oil _____ Grease _____ *Flexible Coupling: Make <u>WEDS</u> Type <u>SPHER</u> *Coupling Guard: Yes _____ No _____			
DRIVER DATA		MOTOR		TURBINE		*Make: _____ Hp.: _____ *Type: <u>T-200</u> R.P.M. <u>1750</u> *Phase <u>3</u> *Cycle <u>60</u> *Volts <u>480</u> Frame <u>143</u>		*Make: _____ Hp.: _____ *Type: _____ R.P.M.: _____ Water Rate @ Design Load: _____ lb./hr./Bhp. *Steam Inlet: _____ p.s.i.g. @ _____ °F. *Steam Exhaust: _____ p.s.i.g. @ _____ °F.	
WT.		NET WEIGHT		Pump, Base, Cplg. _____ lb. Motor _____ lb. <u>140</u>		SHIPPING WEIGHT		Pump, Base, Cplg. _____ lb.	

Special Instructions or Features: _____

*User to complete
 †Characteristic curve to show head, capacity, efficiency, NPSH required

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS CENTRIFUGAL PUMP INQUIRY

GENERAL		*Job No. <u>P 434</u>	
		*Item No. <u>P 303</u>	
		*Spec. No. <u>7-7</u>	
		*Rev. No. <u>3-21-17</u>	
		Quote No. _____	
		Reference _____	
OPERATING CONDITIONS		*For <u>FIELD DATA</u>	
		*Plant <u>PLANT 6-451A5</u>	
		*Location <u>PLANT 6-451A5</u>	
		*Service <u>PLANT 6-451A5</u>	
		*No. Required <u>1</u>	
		*Motor Drive <u>1/2</u>	
		*Turbine Drive _____	
OPERATING CONDITIONS		*Liquid Pumped: <u>93% H. SC4</u> @ <u>70</u> *F.P.T.	
		*Capacity, g.p.m. @ <u>70</u> *F.: Normal _____; Design <u>3</u>	
		@ P.T.: *Sp. Gr. <u>1.05</u> ; *Visc. <u>30</u> cps; *Vap. Pr. _____ p.s.i.a.	
		@ 60° F.: *Sp. Gr. _____; *Visc. _____ cps; *Vap. Pr. _____ p.s.i.a.	
		*Disch. Pressure: <u>20</u> p.s.i.g.	
		*Suct. Pressure: <u>1</u> p.s.i.g.	
		*Diff. Pressure: <u>17</u> p.s.i.	
		*Diff. Head: <u>25</u> ft.	
OPERATING CONDITIONS		N *Available _____ ft. (liquid)	
		P Required _____ ft. (liquid)	
		S Required _____ ft. (water)	
		H _____	
		*Corr. Material? _____ *Erosive Material? _____	
		* _____ % or _____ p.p.m. * _____ % or _____ p.p.m.	
		*User's Experience with Materials Specified:	
		Good _____ Fair _____ None _____	
PUMP SPECS.		Manufacturer <u>MARCH</u>	
		Size & Type <u>1" NPT 2" NPT MAR DRUM CENTRIFUGAL</u>	
		*R.P.M. <u>3450</u> Efficiency _____ Impeller Diam.: Bid _____ Min. _____ Max. _____	
		Bhp. @ Design _____ Max. Bhp. Req'd. _____ Recommended Driver Hp. <u>1/2</u>	
		Circular No. <u>EQ473</u> Dimension Print _____ Section Dwg. _____	
MATERIALS OF CONSTRUCTION		*Casing & Nozzle: <u>RYTON</u>	
		*Impeller: _____	
		*Casing Ring: _____	
		*Impeller Rings: _____	
		*Shaft: _____	
		*Shaft Sleeve: _____	
		*Packing Gland: _____	
		*Packing: <u>RYTON</u>	
		*Seal Cage: _____	
		*Base Plate: <u>RYTON</u>	
		*Impeller: <u>RYTON</u>	
		*Seal: <u>RYTON</u>	
		*Turbine: <u>RYTON</u>	
CONSTRUCTION FEATURES		*Case: Split: Horiz. _____ Vert. _____	
		Support: C/L _____ Foot _____ Bracket _____	
		*Impeller: Open ☒ Closed _____ Semi-Enc. _____	
		*Stuff. Box: Water Jacket: Yes _____ No ☒	
		*Mech. Seal? <u>RYTON</u> Internal _____ External _____	
		Single _____; Double _____; Balanced _____; Unbal. _____	
		*Bearings: Water Jacketed: Yes _____ No ☒	
		Lubrication: Oil _____ Grease _____	
		*Flexible Coupling: Make _____ Type _____	
		*Coupling Guard: Yes _____ No _____	
		*Coupling Guard: <u>RYTON</u>	
		*Coupling Guard: <u>RYTON</u>	
DRIVER DATA		*Make: <u>RYTON</u> Hp.: <u>1/2</u>	
		*Type: <u>RYTON</u> R.P.M.: <u>3450</u>	
		*Phase: <u>1</u> *Cycle: <u>1</u> *Volts: <u>115</u>	
		Frame _____	
TURBINE		*Make: _____ Hp.: _____	
		*Type: _____ R.P.M.: _____	
		Water Rate @ Design Load: _____ lb./hr./Bhp.	
		*Steam Inlet: _____ p.s.i.g. @ _____ °F.	
		*Steam Exhaust: _____ p.s.i.g. @ _____ °F.	
WT.		NET WEIGHT { Pump, Base, Cplg. _____ lb.	
		Motor _____ lb.	
SHIPPING WEIGHT		Pump, Base, Cplg. _____ lb.	
		Motor _____ lb.	

Special Instructions or Features:

IMPELLER DIA. 1.5" TO 2.0" - 1/2" NPT (MARCH DRUM)
ALSO PUMPING 1" NPT (MARCH DRUM)
1.5" DIA.
MARCH 1" NPT 1/2" - 2" - 1/2" (MARCH DRUM)
SEALING & TIGHT

*User to complete

†Characteristic curve to show head, capacity, efficiency, NPSH required

**AMERICAN INSTITUTE OF CHEMICAL ENGINEERS
CENTRIFUGAL PUMP INQUIRY**

GENERAL		*For <u>ETC CORP</u>		*Job No. <u>C 434</u>	
		*Plant <u>PE-1 F</u>	*No. Required <u>1</u>	*Item No. <u>P 204</u>	
		*Location <u>THE GUYTON</u>	*Motor Drive <u>YES</u>	*Spec. No. <u>P-2</u>	
		*Service <u>DEHISTER WASH WATER</u>	*Turbine Drive	*Rev. No. <u>0-2</u> *Date <u>3-22-71</u>	
		Reference		Quote No.	
OPERATING CONDITIONS		*Liquid Pumped: <u>PROCESS WATER</u> @ <u>70</u> *F.P.T.		*Disch. Pressure: <u>176</u> p.s.i.g.	
		*Capacity, g.p.m. @ <u>70</u> *F: Normal <u>11.0</u> ; Design <u>11.0</u>		*Suct. Pressure: <u>1</u> p.s.i.g.	
		@ P.T.: *Sp. Gr. <u>1.0</u> ; *Visc. <u>1.0</u> cps; *Vap. Pr. <u>225</u> p.s.i.a.		*Diff. Pressure: <u>175</u> p.s.i.	
		@ 60° F: *Sp. Gr. <u>1.0</u> ; *Visc. <u>1.0</u> cps; *Vap. Pr. <u>25</u> p.s.i.a.		*Diff. Head: <u>405</u> ft.	
		N *Available <u>> 20</u> ft. (liquid)	*Corr. Material? <u>No</u>	*Erosive Material? <u>No</u>	
		P Required <u>7</u> ft. (liquid)	*User's Experience with Materials Specified:		
		S Required <u>7</u> ft. (water)	Good <u> </u> Fair <u> </u> None <u> </u>		
		H <u> </u>			
PUMP SPECS.		Manufacturer <u>AURORA</u>		No. of Stages <u>1</u>	
		Size & Type <u>1.5 S 14x14 NPT</u>		Performance Curve <u>Suct S 1116 P 7</u>	
		*R.P.M. <u>1750</u> Efficiency <u> </u>		Impeller Diam.: Bid <u> </u> Min. <u> </u> Max. <u> </u>	
		Bhp. @ Design <u> </u> Max. Bhp. Req'd. <u> </u>		Recommended Driver Hp. <u>7 1/2</u>	
		Circular No. <u> </u> Dimension Print <u> </u>		Section Dwg. <u> </u>	
MATERIALS OF CONSTRUCTION		*Casing & Nozzle: <u>ALL IRON CAST.</u>		*Case Split: Horiz. <u> </u> Vert. <u> </u>	
		*Impeller: <u> </u>		Support: C/L <u> </u> Foot <u> </u> Bracket <u> </u>	
		*Casing Ring: <u> </u>		*Impeller: Open <u>TURBINE</u> Closed <u> </u> Semi-Enc. <u> </u>	
		*Impeller Rings: <u> </u>		*Stuff. Box: Water Jacket: Yes <u> </u> No <u> </u>	
		*Shaft: <u>416</u>		*Mech. Seal? <u>YES</u> ; Internal <u> </u> External <u> </u>	
		*Shaft Sleeve: <u> </u>		Single <u> </u> ; Double <u> </u> ; Balanced <u> </u> ; Unbal. <u> </u>	
		*Packing Gland: <u> </u>		*Bearings: Water Jacketed: Yes <u> </u> No <u> </u>	
		*Packing: <u> </u>		Lubrication: Oil <u> </u> Grease <u> </u>	
		*Seal Cage: <u> </u>		*Flexible Coupling: Make <u>WATSON</u> Type <u> </u>	
		*Base Plate: <u> </u>		*Coupling Guard: Yes <u> </u> No <u> </u>	
DRIVER DATA		MOTOR		TURBINE	
		*Make: <u>TEFC</u> Hp.: <u>7 1/2</u>		*Make: <u> </u> Hp.: <u> </u>	
		*Type: <u> </u> R.P.M. <u>1750</u>		*Type: <u> </u> R.P.M. <u> </u>	
		*Phase <u>3</u> *Cycle <u>60</u> *Volts <u>460</u>		Water Rate @ Design Load: <u> </u> lb./hr./Bhp.	
		Frame <u>333T</u>		*Steam Inlet: <u> </u> p.s.i.g. @ <u> </u> °F.	
				*Steam Exhaust: <u> </u> p.s.i.g. @ <u> </u> °F.	
WT.		NET WEIGHT		SHIPPING WEIGHT	
		Pump, Base, Cplg. <u>19</u> lb.		Pump, Base, Cplg. <u> </u> lb.	
		Motor <u>14</u> lb.			
		<u>340</u>			

Special Instructions or Features:

*User to complete
Characteristic curve to show head, capacity, efficiency, NPSH required

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS CENTRIFUGAL PUMP INQUIRY

GENERAL		*Job No. <u>C 434</u> *Item No. <u>P 305</u> *Spec. No. <u>0-9</u> *Rev. No. <u>1</u> *Date <u>5.3.17</u> Quote No. _____ Reference _____	
*For <u>FTC Cond</u> *Plant <u>Process</u> *Location <u>THE CHLORIDE</u> *Service <u>STEAM WATER</u> *Turbine Drive _____		*No. Required <u>1</u> *Motor Drive <u>YES</u> *Turbine Drive _____	
OPERATING CONDITIONS		*Liquid Pumped: <u>Phos. Crs</u> *Waters _____ @ <u>70</u> *F.P.T. *Capacity, g.p.m. @ <u>70</u> *F.: Normal <u>35</u> *Design <u>35</u> @ P.T.: *Sp. Gr. <u>1.0</u> ; *Visc. <u>1.0</u> cps; *Vap. Pr. <u>25</u> p.s.i.a. @ 60° F.: *Sp. Gr. <u>1.0</u> ; *Visc. <u>1.0</u> cps; *Vap. Pr. <u>25</u> p.s.i.a. *Diff. Head: <u>366</u> ft.	
N *Available <u>1100 DED</u> ft. (liquid) P Required <u>2.0</u> ft. (liquid) S Required _____ ft. (water) H _____		*Corr. Material? <u>NO</u> *Erosive Material? <u>NO</u> % or _____ p.p.m. % or _____ p.p.m. *User's Experience with Materials Specified: Good _____ Fair _____ None _____	
PUMP SPECS.		Manufacturer <u>AURORA</u> Size & Type <u>1000 GHT 1 1/4 x 1 1/4 NPT</u> No. of Stages <u>1</u> R.P.M. <u>1750</u> Efficiency _____ Performance Curve <u>S 111.6 P 5</u> Bhp. @ Design <u>2.4</u> Max. Bhp. Req'd. <u>3 @ 366 ft.</u> Impeller Diam. Bid. _____ Min. _____ Max. _____ Circular No. _____ Dimension Print _____ Section Dwg. _____	
MATERIALS OF CONSTRUCTION		CONSTRUCTION FEATURES	
*Casing & Nozzle: <u>ALL IRON COVER</u> *Impeller: _____ *Casing Ring: _____ *Impeller Rings: _____ *Shaft: _____ *Shaft Sleeve: <u>1/16</u> *Packing Gland: _____ *Packing: _____ *Seal Cage: <u>316 SS</u> *Base Plate: <u>STEEL</u>		*Case Split: Horiz. <u>✓</u> Vert. _____ Support: C/L <u>✓</u> Foot _____ Bracket _____ *Impeller: Open <u>Teeth</u> Closed _____ Semi-Enc. _____ *Stuff. Box: Water Jacketed: Yes _____ No <u>✓</u> *Mech. Seal? <u>1/2"</u> Internal _____ External _____ Single <u>✓</u> ; Double _____; Balanced _____; Unbal. <u>✓</u> *Bearings: Water Jacketed: Yes _____ No <u>✓</u> Lubrication: Oil _____ Grease _____ *Flexible Coupling: Make <u>Wilson</u> Type _____ *Coupling Guard: Yes _____ No _____	
DRIVER DATA		TURBINE	
*Make: _____ *Hp: <u>3</u> *Type: <u>IEFC</u> *R.P.M. <u>1750</u> *Phase <u>3</u> *Cycle <u>60</u> *Volts <u>440</u> Frame _____		*Make: _____ *Hp: _____ *Type: _____ *R.P.M.: _____ Water Rate @ Design Load: _____ lb./hr./Bhp. Steam Inlet: _____ p.s.i.g. @ _____ F. Steam Exhaust: _____ p.s.i.g. @ _____ F.	
WT.		SHIPPING	
NET WEIGHT { Pump, Base, Cplg. _____ lb. Motor _____ lb.		{ Pump, Base, Cplg. _____ lb.	

Special Instructions or Features: _____

*User to complete
 *Characteristic curve to show head, capacity, efficiency, NPSH required

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS CENTRIFUGAL PUMP INQUIRY

*Job No. <u>C 431</u> *Item No. <u>P 367</u> *Spec. No. <u>P</u> *Rev. No. <u>1</u> *Date <u>3-27-77</u> *Quote No. _____ *Reference _____	
*For <u>General</u> *Plant <u>General</u> *Location <u>General</u> *Service <u>General</u> *Turbine Drive _____	
*No. Required <u>1</u> *Motor Drive <u>1/5</u>	
*Liquid Pumped: <u>Water</u> @ <u>110</u> *F. Normal <u>5-10</u> *Design <u>10</u> *F.P.T. @ <u>66-170</u> *F.P.T. *Capacity, g.p.m. @ <u>10</u> *F. Normal <u>5-10</u> *Design <u>10</u> @ P.T.: *Sp. Gr. <u>1.0</u> *Visc. <u>1.0</u> cps; *Vap. Pr. _____ p.s.i.a. @ 60° F. *Sp. Gr. _____ *Visc. _____ cps; *Vap. Pr. _____ p.s.i.a.	
*Disch. Pressure: <u>20</u> p.s.i.g. *Suct. Pressure: <u>1</u> p.s.i.g. *Diff. Pressure: <u>19</u> p.s.i. *Diff. Head: <u>44</u> ft.	
*Corr. Material? <u>H₂CO₃</u> *Erosive Material? <u>Yes</u> *User's Experience with Materials Specified: Good <u>✓</u> Fair _____ None _____	
*N Available <u>10 Min</u> ft. (liquid) *P Required _____ ft. (liquid) *S Required _____ ft. (water) *H _____	
*Manufacturer <u>MANCIT</u> *No. of Stages <u>1</u> *Size & Type <u>1" NPT x 1/2" NPT Man Drive Cent</u> *Performance Curve <u>Catalog</u> *R.P.M. <u>3450</u> *Efficiency _____ *Impeller Diam.: Bid _____ Min. _____ Max. _____ *Bhp. @ Design _____ *Max. Bhp. Req'd. _____ *Recommended Driver Hp. <u>1/2 HP</u> *Circular No. <u>F-6933</u> *Dimension Print _____ *Section Dwg. _____	
*Casing & Nozzle: <u>RYTON</u> *Impeller: _____ *Casing Ring: _____ *Impeller Rings: _____ *Shaft: _____ *Shaft Sleeve: _____ *Packing Gland: _____ *Packing: <u>C Ring</u> <u>RYTON</u> *Seal Cage: <u>Feet</u> <u>Steel</u> *Base Plate: <u>Feet</u> <u>Steel</u> *Impeller Mounting: <u>CHEMICAL</u> *Mounting: <u>General</u>	
*Construction Features *Caster Split: Horiz. _____ Vert. _____ *Support C/L _____ Foot _____ Bracket _____ *Impeller Open <u>✓</u> Closed _____ Semi-Enc. _____ *Stuff. Box: Water Jacketed: Yes _____ No _____ *Mech. Seal? <u>Sealless</u> Internal _____ External _____ *Single _____ Double _____ Balanced _____ Unbal. _____ *Bearings: Water Jacketed: Yes _____ No _____ *Flexible Coupling: Make _____ Type _____ *Coupling Guard: Yes _____ No _____ *Type <u>Flange</u> <u>Flange</u> <u>Flange</u> *Magnetic Drive <u>Sealless</u>	
*Driver Data *Motor *Make <u>MAN SDO</u> *Hp.: <u>1/2</u> *Type <u>TEFC</u> *R.P.M. <u>3450</u> *Phase <u>1</u> *Cycle <u>60</u> *Volts <u>115</u> *Frame _____	
*Turbine *Make _____ *Hp.: _____ *Type _____ *R.P.M.: _____ *Water Rate @ Design Load: _____ lb./hr./Bhp. *Steam Inlet: _____ p.s.i.g. @ _____ *Steam Exhaust: _____ p.s.i.g. @ _____	
*Shipping Weight { Pump, Base, Cplg. _____ 2 c _____ lb. Motor _____ lb.	

Special Instructions or Features: _____

*User to complete
 Characteristic curve to show head, capacity, efficiency, NPSH required

Process Equipment

Design Criteria Summary

Item Number: P401

Item Description: Process Air Compressor for Pressure Leach Reactor. Packaged rotary screw compressor approximately 7' long by 4' wide by 4' high, 150 psig maximum output pressure, 75 HP TEFC motor, 460 volts, 3-phase, 60 Hertz, 1750 rpm. With magnetic across-the-line starter, high discharge air pressure switch and high coolant temperature switch.

Design Requirements: Provide compressed air to leach reactor to regenerate up to 2050 lb/day $\text{Cu}_{1.9}\text{S}$ in 6700-8200 gal of solution in 2 or 3 batches/day, processing time 12 hours maximum. Compressor to have variable output volume control regulated on output pressure.

Design Bases: Minimum air requirement fixed by stoichiometry, solids composition, solids quantity, and leach time. Design air requirement determined by oxygen partial pressure, fixed at $3 \times$ minimum to give 18 psi O_2 pressure at 135 psig operating pressure and 120°C. Maximum air flow 230 SCFM at 135 psig.

Level of Confidence: Good on mechanical and process specifications.

Comments: Use of oil free compressor to be considered to minimize oil carry-over to reactor.

Date: 6/1/77 - Rev. 0

CONTROL VALVES AND ACTUATORS

CONTROL VALVES

SPECIFICATION SHEET

SHEET NO. _____
 TAG NO. SEE 1000
 DATE 10-27-77
 REVISED D
 BY RHW

		GENERAL SPECIFICATION									
		BODIES					OPERATORS				
1	DOUBLE SEATED BODIES SHALL BE <u>CAGE</u> GUIDED. SINGLE SEATED BODIES SHALL BE <u>STEM</u> GUIDED						PNEUM.: SPRING & DIAPHRAGM _____, SHALL FULL STROKE _____ PSI				
2	END CONNECTIONS AS SPECIFIED BY LINE 12. BODY JOINTS SHALL BE NFR, STD, OR _____						OTHER _____ OPERATING SUPPLY IS _____ PSI				
3	OTHER BODY FORM _____						OTHER _____ OPERATING SUPPLY IS _____ PSI				
4	FLUID UNITS: LIQUIDS IN <u>GPM</u> GASES IN <u>SCFM</u> STEAM IN <u>POUNDS PER HOUR</u>										
7	TAG NO.	FCV-101A		FCV-101B		FCV-103		FCV-105		FCV-101	
8	LINE NO.										
9	BODY SIZE	16"		8"		6"		1"		1" 3/8"	
10	PORT SIZE	16"		8"		6"		1"		1" 3/8"	
11	FORM	BUTTERFLY		GLOBE		V-PORT		GLOBE		ANGLE	
12	MATERIAL	STAINLESS		STAINLESS		316 SS		316 SS		316 SS	
13	END CONNECTIONS	150# FLANGES		150# FLG		150# FLG		150# FLANGES		150# FLG	
14	BONNET	STANDARD		STANDARD		STANDARD		STANDARD		STANDARD	
15	LUBRICATOR	NO		NO		NO		NO		NO	
16	ISOLATING VALVE	NO		NO		NO		NO		NO	
17	PACKING OR SEAL	TFC		TFC		TFC		TFC		TFC	
18	SPECIAL GUIDES	ALLOY C		TFC		TFC		TFC		TFC	
19	TRAIN	316 SS		316 SS		316 SS		316 SS		316 SS	
20	NO. OF PORTS	1		1		1		1		1	
21	PLUG FORM	EIGHTH		EIGHTH		EIGHTH		EIGHTH		EIGHTH	
22	PLUG & SEAT MATERIAL	316 SS / C STL		316 SS		316 SS		316 SS		316 SS	
23	ACTION	3 15		3 15		3 15		3 15		3 15	
24	CLOSE @	3		3		3		3		3	
25	OPEN @	15		15		15		15		15	
26	FAILURE POSITION	LAST POSITION		CLOSED		CLOSED		CLOSED		CLOSED	
27	POSITIONER	YES		YES		YES		YES		YES	
28	REQUIRED	YES		YES		YES		YES		YES	
29	BYPASS	YES		YES		YES		YES		YES	
30	GAUGES	YES		YES		YES		YES		YES	
31	FOR INPUT SIGNAL OF	3 15		3 15		3 15		3 15		3 15	
32	OUTPUT SHALL BE	3 15		3 15		3 15		3 15		3 15	
33	ACCESSORIES	YES		YES		YES		YES		YES	
34	FILTER & REGULATOR	YES		YES		YES		YES		YES	
35	HANDWHEEL	NO		NO		NO		NO		NO	
36	SERVICE CONDITIONS	STEAM		STEAM		STEAM		STEAM		STEAM	
37	FLUID	STEAM		STEAM		STEAM		STEAM		STEAM	
38	QTY. MIN.	1200		1200		1200		1200		1200	
39	QTY. MAX.	1200		1200		1200		1200		1200	
40	QTY. NORM. @ F.T.	1200		1200		1200		1200		1200	
41	PRESS. MAX. IN / NORM. OUT	150 / 150		150 / 150		150 / 150		150 / 150		150 / 150	
42	TEMP. MAX. / CP STRINGS	150 / 150		150 / 150		150 / 150		150 / 150		150 / 150	
43	TEMP. MAX. / NORM. F.T.	150 / 150		150 / 150		150 / 150		150 / 150		150 / 150	
44	SP. GR. @ 60°F	1.00		1.00		1.00		1.00		1.00	
45	VISCOSITY @ F.T.	1.00		1.00		1.00		1.00		1.00	
46	NOTES:	478 2 513 R 84									

CONTROL VALVES

SPECIFICATION SHEET

SHEET NO. _____
 TAG NO. SEE BELOW
 DATE 12-22-77
 REVISED 0
 BY RJW

GENERAL SPECIFICATION									
BODIES					OPERATORS				
1 DOUBLE SEATED BODIES SHALL BE <u>CAGE</u> GUIDED, SINGLE					5 PNEUM.: SPRING & DIAPHRAGM _____, SHALL FULL				
2 SEATED BODIES SHALL BE <u>STEM</u> GUIDED					STROKE _____ PSI				
3 END CONNECTIONS AS SPECIFIED BY LINE 12. BODY JOINTS					OTHER _____				
SHALL BE MFG. STD. OR _____					OPERATING SUPPLY IS _____ PSI				
4 OTHER BODY FORM _____					OTHER _____				
					OPERATING SUPPLY IS _____				
4 FLUID UNITS: LIQUIDS IN <u>GPM</u> GASES IN <u>SCFM</u> STEAM IN <u>POUNDS PER SQ. IN.</u>									
7 TAG NO.		<u>FCV-107</u>		<u>REV-107</u>		<u>PCV-105A</u>		<u>PCV-105B</u>	
8 LINE NO.									
9 BODY SIZE		<u>1/2"</u>		<u>3/4"</u>		<u>1"</u>		<u>1 1/2"</u>	
10 PORT SIZE		<u>1/2"</u>		<u>3/4"</u>		<u>1"</u>		<u>1 1/2"</u>	
11 FORM		<u>ANGLE</u>		<u>ANGLE</u>		<u>ANGLE</u>		<u>ANGLE</u>	
12 MATERIAL		<u>316 SS</u>		<u>316 SS</u>		<u>316 SS</u>		<u>316 SS</u>	
13 END CONNECTIONS		<u>SCREWED</u>		<u>1/2" FLG</u>		<u>1/2" FLG</u>		<u>1/2" FLG</u>	
14 BOWNET		<u>STD</u>		<u>STD</u>		<u>STD</u>		<u>STD</u>	
15 LUBRICATOR		<u>NO</u>		<u>NO</u>		<u>NO</u>		<u>NO</u>	
16 ISOLATING VALVE		<u>NO</u>		<u>NO</u>		<u>NO</u>		<u>NO</u>	
17 PACKING OR SEAL		<u>TFE</u>		<u>TFE</u>		<u>TFE</u>		<u>TFE</u>	
18 SPECIAL GUIDES		<u>NONE</u>		<u>NONE</u>		<u>NONE</u>		<u>NONE</u>	
TRIM									
19 MATERIAL		<u>316</u>		<u>316</u>		<u>316</u>		<u>316</u>	
20 NO. OF PORTS		<u>1</u>		<u>1</u>		<u>1</u>		<u>1</u>	
21 PLUG FORM		<u>90° M. GEAR</u>		<u>90° M. GEAR</u>		<u>90° M. GEAR</u>		<u>90° M. GEAR</u>	
22 PLUG & SEAT MATERIAL		<u>316</u>		<u>316</u>		<u>316</u>		<u>316</u>	
ACTION									
23 CLOSE @		<u>3</u>		<u>15</u>		<u>3</u>		<u>15</u>	
24 OPEN @		<u>15</u>		<u>3</u>		<u>15</u>		<u>3</u>	
25 FAILURE POSITION		<u>CLOSED</u>		<u>CLOSED</u>		<u>CLOSED</u>		<u>CLOSED</u>	
POSITIONER									
26 REQUIRED		<u>YES</u>		<u>NO</u>		<u>NO</u>		<u>NO</u>	
27 BYPASS		<u>YES</u>		<u>NO</u>		<u>NO</u>		<u>NO</u>	
28 GAUGES		<u>3</u>		<u>15</u>		<u>3</u>		<u>15</u>	
29 FOR INPUT SIGNAL OF		<u>3</u>		<u>15</u>		<u>3</u>		<u>15</u>	
30 OUTPUT SHALL BE		<u>3</u>		<u>15</u>		<u>3</u>		<u>15</u>	
ACCESSORIES									
31 FILTER & REGULATOR		<u>YES</u>		<u>NO</u>		<u>NO</u>		<u>NO</u>	
32 HANDHEEL		<u>NO</u>		<u>NO</u>		<u>NO</u>		<u>NO</u>	
SERVICE CONDITIONS									
33 FLUID		<u>CLEAN</u>		<u>WATER</u>		<u>CLEAN</u>		<u>AIR</u>	
34 QTY. MIN.		<u>1.5</u>		<u>100</u>		<u>500</u>		<u>150</u>	
35 QTY. MAX.		<u>2</u>		<u>200</u>		<u>500</u>		<u>220</u>	
36 QTY. NORM. @ F.T.		<u>1.5 @ 120°</u>		<u>100</u>		<u>500</u>		<u>150</u>	
37 PRESS. MAX. IN		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
38 PRESS. MAX. OUT		<u>50</u>		<u>30</u>		<u>75</u>		<u>15</u>	
39 - MAX. @ 50°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
40 - MAX. @ 100°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
41 - MAX. @ 200°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
42 - MAX. @ 300°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
43 - MAX. @ 400°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
44 - MAX. @ 500°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
45 - MAX. @ 600°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
46 - MAX. @ 700°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
47 - MAX. @ 800°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
48 - MAX. @ 900°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
49 - MAX. @ 1000°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
50 - MAX. @ 1100°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
51 - MAX. @ 1200°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
52 - MAX. @ 1300°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
53 - MAX. @ 1400°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
54 - MAX. @ 1500°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
55 - MAX. @ 1600°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
56 - MAX. @ 1700°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
57 - MAX. @ 1800°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
58 - MAX. @ 1900°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
59 - MAX. @ 2000°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
60 - MAX. @ 2100°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
61 - MAX. @ 2200°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
62 - MAX. @ 2300°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
63 - MAX. @ 2400°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
64 - MAX. @ 2500°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
65 - MAX. @ 2600°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
66 - MAX. @ 2700°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
67 - MAX. @ 2800°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
68 - MAX. @ 2900°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
69 - MAX. @ 3000°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
70 - MAX. @ 3100°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
71 - MAX. @ 3200°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
72 - MAX. @ 3300°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
73 - MAX. @ 3400°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
74 - MAX. @ 3500°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
75 - MAX. @ 3600°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
76 - MAX. @ 3700°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
77 - MAX. @ 3800°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
78 - MAX. @ 3900°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
79 - MAX. @ 4000°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
80 - MAX. @ 4100°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
81 - MAX. @ 4200°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
82 - MAX. @ 4300°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
83 - MAX. @ 4400°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
84 - MAX. @ 4500°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
85 - MAX. @ 4600°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
86 - MAX. @ 4700°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
87 - MAX. @ 4800°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
88 - MAX. @ 4900°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
89 - MAX. @ 5000°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
90 - MAX. @ 5100°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
91 - MAX. @ 5200°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
92 - MAX. @ 5300°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
93 - MAX. @ 5400°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
94 - MAX. @ 5500°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
95 - MAX. @ 5600°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
96 - MAX. @ 5700°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
97 - MAX. @ 5800°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
98 - MAX. @ 5900°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
99 - MAX. @ 6000°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
100 - MAX. @ 6100°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
101 - MAX. @ 6200°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
102 - MAX. @ 6300°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
103 - MAX. @ 6400°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
104 - MAX. @ 6500°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
105 - MAX. @ 6600°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
106 - MAX. @ 6700°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
107 - MAX. @ 6800°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
108 - MAX. @ 6900°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
109 - MAX. @ 7000°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
110 - MAX. @ 7100°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
111 - MAX. @ 7200°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
112 - MAX. @ 7300°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
113 - MAX. @ 7400°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
114 - MAX. @ 7500°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
115 - MAX. @ 7600°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
116 - MAX. @ 7700°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
117 - MAX. @ 7800°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
118 - MAX. @ 7900°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
119 - MAX. @ 8000°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
120 - MAX. @ 8100°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
121 - MAX. @ 8200°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
122 - MAX. @ 8300°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
123 - MAX. @ 8400°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
124 - MAX. @ 8500°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
125 - MAX. @ 8600°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
126 - MAX. @ 8700°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
127 - MAX. @ 8800°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
128 - MAX. @ 8900°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
129 - MAX. @ 9000°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
130 - MAX. @ 9100°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
131 - MAX. @ 9200°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
132 - MAX. @ 9300°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
133 - MAX. @ 9400°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
134 - MAX. @ 9500°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
135 - MAX. @ 9600°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
136 - MAX. @ 9700°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
137 - MAX. @ 9800°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	
138 - MAX. @ 9900°F		<u>150</u>		<u>60</u>		<u>100</u>		<u>75</u>	

HAND VALVES AND LOCAL INSTRUMENTATION

PRESSURE SAFETY (RELIEF) VALVES

SPECIFICATION SHEET

SHEET NO. _____
 TAG NO. 568 A-LOW
 DATE 11-1-77
 REVISED 0
 BY RBW

GENERAL		DIAPHRAGM BACK PRESSURE		FULL NUTTING		FULL NUTTING		DIAPHRAGM BACK PRESSURE		DIAPHRAGM BACK PRESSURE	
DESIGN TYPE		LIQUID RELIEF		SAFETY RELIEF		SAFETY RELIEF		LIQUID RELIEF		LIQUID RELIEF	
1	SEAT TYPE	CLOSED		CLOSED		CLOSED		CLOSED		CLOSED	
2	BONNET	CLOSED		CLOSED		CLOSED		CLOSED		CLOSED	
3	TAG NO.	PRV-121		PRV-125		PSV-224		PRV-323		PRV-324	
4	LINE OR EQUIPMENT NO.	P102 + P101A		P101		V-201		P304		P305	
BODY		316SS		CARBON STEEL		CARBON STEEL		CAST IRON		CAST IRON	
5	MATERIAL	316SS		CARBON STEEL		CARBON STEEL		CAST IRON		CAST IRON	
6	SIZE INLET OUTLET	1" 1"		2" 10"		1" 2"		1" 1"		1/2" 1/2"	
7	FLANGE RATING-ASA	NPT		300		150		NPT		NPT	
8	TYPE FACING	-		RF		RF		-		-	
9	ORIFICE DESIGNATION	-		R		-		-		-	
TRIM MATERIAL		316SS		C-STEEL		C-STEEL		COMPOSITION DIAPHRAGM		COMPOSITION DIAPHRAGM	
10	SEAT & DISC	316SS		C-STEEL		C-STEEL		COMPOSITION DIAPHRAGM		COMPOSITION DIAPHRAGM	
11	GUIDE & RING(S)	316		C-STEEL		C-STEEL		-		-	
12	SPRING	C-STEEL		C-STEEL		C-STEEL		C-STEEL		C-STEEL	
13	SPRING PART NUMBER	-		-		-		1L3801-2732		1L3801-2732	
ACCESSORIES		-		-		-		BLVD		BLVD	
14	CAP & NO LEVER	✓		-		-		✓		✓	
15	LEVER PLAIN PACKED	-		-		-		-		-	
16	GAG	-		-		-		-		-	
17	OTHER	EXTERNAL		EXTERNAL		EXTERNAL		EXTERNAL		EXTERNAL	
BASIS OF SELECTION		ASME VIII		ASME VIII		ASME VIII		ASME VIII		ASME VIII	
18	CODE	ASME VIII		ASME VIII		ASME VIII		ASME VIII		ASME VIII	
19	FIRE	-		-		-		-		-	
20	OTHER	PUMP CURVES		PUMP CURVES		PUMP CURVES		PUMP CURVES		PUMP CURVES	
SERVICE CONDITIONS		MAKE UP		STEAM		AIR		WATER		WATER	
21	FLUID	COLD OIL		STEAM		AIR		WATER		WATER	
22	REQUIRED CAPACITY & UNITS	10 GPM		10 GPM		10 GPM		10 GPM		10 GPM	
23	MOL. WT. OR SP. GR. @ F.T.	1.13		1.13		1.13		1.13		1.13	
24	VISCOSITY @ F.T.	1.0		1.0		1.0		1.0		1.0	
25	PRESS. PSIG-NORM. RELIEVING	170		170		170		170		170	
26	TEMP. °F NORM. RELIEVING	170		170		170		170		170	
27	CONSTANT BACK PRESSURE	5 PSI		ATM		ATM		ATM		ATM	
28	DEVELOPED BACK PRESSURE	-		NONE		NONE		NONE		NONE	
29	SPRING SET PRESSURE	165		150		150		150		150	
30	OVERPRESSURE - %	0%		10%		10%		10%		10%	
ORIFICE AREA		-		-		-		-		-	
31	CALCULATED SQ. INS.	-		.14		.093		-		-	
32	SELECTED SQ. INS.	-		.14		.136		-		-	
33	MANUFACTURER'S MODEL NO.	AWCASH		FARRIS		FARRIS		FISHER		FISHER	
NOTES:		MODEL 123		MODEL NO		MODEL NO		MODEL NO		MODEL NO	
		FURLINE		26 RH 1"		26 RH 1"		26 RH 1"		26 RH 1"	
		VALVE TO		NOTE BURST		NOTE BURST		NOTE BURST		NOTE BURST	
		P102 + P101A		NOTE BURST		NOTE BURST		NOTE BURST		NOTE BURST	
		AT 170 PSIG		NOTE BURST		NOTE BURST		NOTE BURST		NOTE BURST	

Process Equipment
Design Criteria Summary

Item Number: HCV-122

Item Description: Recycled Scrub Slurry Flow Control Valve. 4" - 150# ANSI flanged Model No. 2475-A-RF Powell Globe Valve. Outside screw rising stem valve with bolted flanged yoke bonnet. Wetted metal parts Carpenter 20 (CN-7M), Teflon packing and compressed asbestos gasket.

Design Requirements: Provide bypass from circulating pumps P101 and P101A back to tower sump to prevent pumps from being dead headed and cavitating and to provide some agitation in the sump.

Design Bases: Valve to pass up to 600 GPM of liquid of specific gravity 0.93 at a pressure drop of 20 psi; C_v required is 130.

Level of Confidence: Good on mechanical design, fair on ability to throttle without plugging, corrosion/erosion.

Comments: Valve may be susceptible to crevice corrosion.

Date: 11/1/77 - Rev. 0

Hand Valves and Local Instrumentation

Specification Sheet Summary

<u>Item No.</u>	<u>Item Description</u>
HCV-123	Sample Filtrate Flow Control Valve. 1/4" Swagelock Model No. SS-1RS-4. Whitey needle valve with 0.172" orifice. Wetted part 316 stainless steel.
PSE-124	Scrubbing Tower Rupture Disc. Six-inch, 150# flange safety head assembly No. RB-7R with reverse buckling Teflon coated 316 stainless steel disc. Inlet flange 316 stainless steel, outlet carbon steel. Assembly to bolt between flanges. Burst pressure 150 psig.

Process Equipment

Design Criteria Summary

Item Number: CKV-126

Item Description: Tower Steam Inlet Check Valve. Mission duo check Model No. K15CPF (16" Style K) check valve. Valve to be bolted between (2) 16"-150# ANSI flanges, to have 316 stainless steel plate and body material, metal to metal seal, and raised face end connections.

Design Requirements: Valve to provide corrosion resistant protection against back flow from the scrubbing tower into the steam supply line. Valve to pass the required amount of steam in forward flow (100,000-120,000 lb/hr) without excessive pressure drop.

Design Bases: Forward flow 100,000 lb/hr steam at 120 psig. Valve C_v computed from manufacturers water data at approximately 7300. Resultant pressure drop with steam is 0.16 psi.

Level of Confidence: Good on mechanical design, fair on pressure drop - bottom end of operating range.

Comments: Steam line drain and trap to be provided upstream of valve.

Date: 11/1/77 - Rev. 0

Hand Valves and Local Instrumentation

Specification Sheet Summary

<u>Item No.</u>	<u>Item Description</u>
PRV-220	Decanted Slurry Heater Steam Pressure Reducing Valve. 1-1/4" NPT cast iron steam pressure regulator with stainless steel seat and disc. Adjustable range 30-150 psig. Spring and Model No. 142, Series 152A. Capacity 800 pounds per hour at 50 psig.
PRV-221	Pressure Leach Reactor Steam Pressure Reducing Valve. Two inch NPT cast iron steam pressure regulator with stainless steel seat and disc. Adjustable range 30-100 psig. Spring and Model No. 299, Series 152A. Capacity 1500 pounds per hour at 50 psig.
HCV-222	Pressure Leach Reactor Drain Valve. Two inch, 150# flange, type 316 stainless steel ram type drain valve with air operator and adapter for two inch schedule 80 nozzle and four inch piston extension.
PSE-223	Pressure Leach Reactor Rupture Disc. One inch, 150# flange safety head assembly No. RB-7R with reverse buckling Teflon coated 316 stainless steel disc. Inlet flange 316 stainless steel, outlet carbon steel. Assembly to bolt between flanges. Burst pressure 150 psig.
PRV-225	Oxygen Pressure Reducing Valve. One inch NPT stainless steel Cashco Type 1000 HP-5 pressure reducing valve with stainless steel valve seat, diaphragm and trim. Reduced pressure ranges 50-200 psig, maximum inlet pressure 400 psig. Suitable for oxygen service.
HCV-226	Oxygen Flow Control Valve. One inch NPT type 316 stainless steel. Powell catalog No. 2474A globe valve.

Hand Valves & Local Instrumentation -
Spec. Sheet Summary (continued)

<u>Item No.</u>	<u>Item Description</u>
PRV-320	Ammonia Pressure Reducing Valve - 1/2" NPT aluminum body pressure regulator, Fisher Model No. 64B, with Nitrile diaphragm and stainless steel valve stem. Maximum inlet pressure 250 psig, outlet pressure range 3-15 psig.
HCV-321	Ammonia Flow Control Valve. 3/4" NPT Vogt Series No. 12443 carbon steel globe valve with V-port disc.
HCV-322	Sulfuric Acid Flow Control Valve. 1/2" Vogt Series No. 12443 carbon steel globe valve with V-port disc.

PRESSURE GAGES SPECIFICATION SHEET

SHEET NO. 24712
TAG NO. SEP 1961
DATE 9-15-61
REVIEWED 0
BY RR

SCRUBBING SECTION

GENERAL SPECIFICATION							
1	TYPE	INDICATING ☒ RECEIVER ☐					
2	MOUNTING	SURFACE ☐ LOCAL ☒ FLUSH ☐					
3	DIAL DIAMETER	<u>1 1/2"</u>					
4	DIAL COLOR	BLACK ☐ WHITE ☒					
5	CASE MAT'L	CAST IRON ☐ ALUMINUM ☐ PHENOL ☒					
6	RING TYPE	SCREENED ☐ HINGED ☐ SLIP ☐					
7	MANUFACTURER'S MODEL NO.	<u>1279 E</u>					
8	PRESS ELEMENT	BOURDON ☒ BELLONS ☐					
9	ELEMENT MAT'L	BRONZE ☐ STEEL ☐					
10	TYPE	STL. STL ☒ OTHER ☐					
11	CONNECTION-NPT	1/4" ☒ 1/2" ☐					
12	MOVEMENT	BOTTOM ☒ BACK ☐					
		BRONZE ☐ STL. STL ☒					
		NYLON ☐ OTHER ☐					

REV	QUAN	TAG NO.	RANGE	OPER. PRESS	SERVICE	ACCESSORIES	NOTES
			TUBE	DIAL			
	1	PI-120		0-160	120	STEAM / TOWER BELOW TRAY	
	1	PI-121		0-160	120	STEAM / TOWER ABOVE TRAY	
	1	PI-122		0-160	120	STEAM / TOWER INLET LINE	
	1	PI-123		0-160	120	STEAM / TOWER OUTLET LINE	
	1	PI-124		0-200	140	RECIR LID / P101 DISCHARGE	
	1	PI-125		0-200	140	RECIR LID / P101A "	
	1	PI-126		0-200	195	PURGE / HX 101 EXIT	
	1	PI-127		0-200	135	PURGE / HX 102 EXIT	
	1	PI-128		0-200	125	PURGE / F101A EXIT	
	1	PI-129		0-200	60	CLEAN LIL PURGE / F101 INLET	
	1	PI-130		0-30	10	" " / F102 OUTLET	
	1	PI-131		0-200	150	CUSBY PHRENE / P102 DISC.	
	1	PI-132		0-200	150	" " / P102A "	
	1	PI-133		0-200	150	" " / HX 103 EXIT	
	1	PI-134		0-200	150	FILTERED PURGE TO AT-135	

NOTES:

SPECIFICATION SHEET

SHEET NO. LATER
TAG NO. SEE BELOW
DATE 9.15.77
REVISED 0
BY RBW

REGENERATION SECTION

GENERAL SPECIFICATION									
1	TYPE	INDICATING ☒ OTHER _____	RECEIVER ☐	6	PRESS ELEMENT	BOURDON ☒ OTHER _____	BELLOWS ☐		
2	MOUNTING	SURFACE ☐ LOCAL ☒ FLUSH ☐		9	ELEMENT MAT'L	BRONZE ☐ STEEL ☒ OTHER _____			
3	DIAL DIAMETER	4 1/2			TYPE 3 1/2	STN. STL ☒			
4	DIAL COLOR	BLACK ☐ WHITE ☒		10	SOCKET MAT'L	BRONZE ☐ STEEL ☒ OTHER _____			
5	CASE MAT'L	CAST IRON ☐ ALUMINUM ☐ PHENOL ☒			TYPE 3 1/2	STN. STL ☒			
6	RING TYPE	OTHER _____		11	CONNECTION-NPT	1/4" ☒ 1/2" ☐			
		SCREWED ☐ HINGED ☐ SLIP ☐				BOTTOM ☒ BACK ☐			
		OTHER <u>SWAP RING</u>		12	MOVEMENT	BRONZE ☐ STN. STL ☒			
7	MANUFACTURER'S MODEL NO.	1279 S OR 1279 B				NYLON ☐ OTHER _____			

REV	QUAN	TAG NO.	RANGE		OPER. PRESS	SERVICE	ACCESSORIES	NO.
			TUBE	DIAL				
	1	PI 220		0-60	25	SLURRY / P103A DISCHARGE		1
	1	PI 221		0-60	25	" / P103 "		
	1	PI 222		0-200	130	AIR O ₂ / REACTOR VAPOR		17
	1	PI 223		0-200	130	AIR / COMPRESSOR DISC		2
	1	PI 224		0-200	100	O ₂ / FROM VAPORIZER		17
	1	PI 225		0-160	60	O ₂ / PRV-225 EXIT		17
	1	PI 226		0-60	35	6N SO ₄ MAKEUP / P201 DISC		1
	1	PI 227		0-160	15	STEAM SL V201 / PRV-221 "		2
	1	PI 228		0-160	60	STEAM SL H2 201 / PRV-220 "		2
	1	PI 229		0-60	25	" 201 H2 EXIT		1
	1	PI 230		0-100	25	CT WA. 201 / 1001 SP4 "		2

NOTES: 1. 1279 S 316SS TUBE + COCKNEY
2. 1719 B STEEL " " "
3. CLEANED FOR OXYGEN SERVICE

SPECIFICATION SHEET

SHEET NO. LATE 12
TAG NO. 500-3860W
DATE 9-14-77
REVISED 0
BY SPW

NEUTRALIZATION SECTION
PROCESS WATER SECTION

[illegible]

SPECIFICATION SHEET

SHEET NO. LATE 26
TAB NO. SEE BELOW
DATE 7-14-77
REVISED 0
BY R. J. W.

GENERAL							WELL	
1	BULB TYPE	THREADED ☐	PLAIN ☐	UNION ☐	5	MATERIAL	304SS ☐	316SS ☐
2	CASE MATERIAL	MFR STD ☐	OTHER _____		6	OTHER _____		
3	DIAL SIZE	COLOR _____			7	CONSTRUCTION	BUILT-UP ☐	DRILLED BAR STOCK
4	FORM	STRAIGHT ☐	ANGLE ☐		8	OTHER _____		
5	BULB OR UNION THREAD SIZE	1/2" ☐	3/4" ☐		9	THREAD SIZE MPT	MALE 1" ☐	OTHER _____
6	MFR MODEL NO.				10	LAG EXTENSION	1/2" ☐	OTHER _____
					11	NONE	SHOWN BELOW ☐	
						3"		
						MFR. MODEL NO.		

REV	QUAN	TAG NO.	RANGE	OPER TEMP	"U" DIMEN.	"T" DIMEN.	SERVICE	NOTES
	1	TI 240	0/250	160	6"	5"	SURVY REGISTRATION LINE / HX 201 EXIT	1
	1	TI 241	0/250	160	4"	3"	SURVY TRANSFER LINE / P103A DISC	3
	1	TI 242	0/300	210	12"	5"	LEACH REACTOR	1+
	1	TI 243	0/250	180	6"	3"	HIK / COMB. ESSO: P401 DISC	2
	1	TI 244	0/200	70	6"	3"	C ₂ / FROG / APC/111K HX 301	2
	1	TI 245	0/250	140	6"	3"	CUSO ₄ MAKEUP / HX 202 EXIT	2
	1	TI 246	0/200	80	4"	3"	LTW RETURN / HX 202	2
	1	TI 247	0/100	100	4"	3"	LTW OUT OF V201 JACKET	3
	1	TI 340	0/200	100	4"	3"	CELL: P-11 NERT / P302 DISC	2
	1	TI 341	0/200	90	4"	3"	AMP / 1111111111111111 T302	2
	1	TI 343	0/200	120	4"	3"	CLP / P3-1 DISCHARGE	2

NOTES:

1. SURVY REGISTRATION LINE - 6560 E.H.
2. COMB. REGISTRATION - 431-6560 E.H.
3. BACK REGISTRATION - 431-6560 E.H.

INSTRUMENT CONTROL PANEL AND MISCELLANEOUS

Process Equipment
Design Criteria Summary

Item Number: Control Panel

Item Description: Instrument Control Panel. 8' wide x 7' high by 3' deep, with flat front face, gasketed double doors in back, with protective canopy and side wind shields. Panel to be of weatherproof construction and purged with instrument quality air. Two Foxboro ten unit shelves and two six unit shelves are to be flushed mounted. An annunciator, cycle timer, pH analyzer and a number of valves and switches are all to be flush mounted. Cabinet and panel fact are to be 1/8" thick carbon steel with an angle iron frame.

Design Requirements: Panel to be central location for all recording and controlling instruments for column and leach reactor operation. Panel to provide emergency shutdown location to deactivate all skids (electrical) and to control block valves to isolate scrubbing unit from the steam supply.

Design Bases: Panel to be purged to minimize the corrosion of copper instrument parts and wiring by ambient H_2S . Panel to be free standing in an outdoor location subject to cooling tower drift.

Level of Confidence: Good on general design, fair on weatherproof construction and on maintenance of H_2S -free atmosphere.

Comments: Manufacturers standard design for severe service application.

Date: 11/4/74 - Rev. 0

Process Equipment
Design Criteria Summary

Item Number: V202

Item Description: Leach Reactor Vent Demister. Ten inch diameter by 2'-6" high chamber with drained, dished bottom head and open top. Unit to be supplied with a 4" thick Teflon demister pad. Inlet nozzle 3"-150# flange, drain 1" NPT coupling. Wetted parts to be 316 stainless steel. Vessel to be mounted on four legs.

Design Requirements: Vessel to disengage any liquid carryover from the leach reactor and remove any mist from the vent gas during the air leaching step.

Design Bases: Air rate of 260 SCFM determined by maximum compressor output. Diameter sized on bases of $F = 2.5$ for demister operation, inlet nozzle sized for $F = 40$.

Level of Confidence: Good - carryover from the reactor should be minimal.

Comments: Demister can be easily removed for periodic cleaning if required.

Flow Indicator
Specification Sheet Summary

<u>Item No.</u>	<u>Item Description</u>
FI-363	(1) Wallace and Tiernan Glass Tube Varea Meter. Capacity 18 GPM water End Fittings: Carbon steel "O" Rings: Buna N Float: 316 stainless steel Tube Retainers: KYNAR Scale: 0-18 GPM water - detached Tube Length: 10 inches Tube No.: WT-1-40-G-10 Float No.: 1-G-14VI-154 Pressure Drop: 44 inches of water Connections: One inch NPT - vertical Service: 0-18 GPM water @ 150 psig and 70°F.
FI-160 FI-160A	(2) Wallace and Tiernan Glass Tube Low Flow Meter, Model 34A086 SI XX Capacity: 0-8.4 GPH water Control: Valve with knob End Fittings: 316 stainless steel "O" Rings: Viton Valve and Trim: 316 stainless steel Float: 316 stainless steel Tube Retainer: TFE Differential Regulator: None Bezel: None Service: Filtered purge to AIT-105

Date: 9/27/77 - Rev. 0

Flow Indicator - Spec. Sheet Summary (continued)

<u>Item No.</u>	<u>Item Description</u>
FI-360	<p>(1) Wallace and Tiernan Glass Tube Varea Meter.</p> <p>Capacity: 21.0 SCFM air equivalent</p> <p>End Fittings: Carbon steel</p> <p>"O" Rings: 316 stainless steel</p> <p>Tube Retainer: KYNAR</p> <p>Scale: 0-100% detached</p> <p>Tube Length: Ten inches</p> <p>Tube No.: WT-3/4-40-G-10</p> <p>Float No.: 3/4-G-8VI-35</p> <p>Pressure Drop: Fourteen inches of water</p> <p>Connections: 3/4" NPT - horizontal</p> <p>Service: 0-100 lb/hr ammonia gas @ 15 psig and 70°F</p>
FI-364	Wallace and Tiernan Glass Tube Purge Meters, Model No.:
FI-365	24-A153-1-S
FI-366	Fluid: Water @ 150 psig and 70°F
FI-367	Capacity: 0-40 gal/hr
	Controls: Valve with knob
	End Fittings: 316 stainless steel
	"O" Rings: EPR
	Valve and Trim: 316 stainless steel
	Float: Tantalum
	Tube Retainer: KYNAR
	Differential Regulator: None
	Bezel: None
	Tag: Service
	FI-364: P101A Seal Purge
	FI-365: P101 Seal Purge
	FI-366: A201 Seal Purge
	FI-367 AIT-105 Cell Flush

Date: 9/27/77 - Rev. 0

Flow Indicator - Spec. Sheet Summary (continued)

<u>Item No.</u>	<u>Item Description</u>
SFG-161	Jacoby-Tarbox Sight Flow Indicator Size: 1/2" NPT Style: 300 S Material: Type 316 stainless steel with Teflon rotor Gaskets: Teflon
SFG-260	(1) Jacoby-Tarbox Sight Flow Indicator Size: One inch, 150 lb ANSI flange Style: 960 F Material: Type 316 stainless steel with Teflon rotor. Gasket: Teflon

III.

PROCESS FLOW DIAGRAMS

H₂S Removal from Geothermal Steam

Scrubbing Section - SD-0012

Regeneration Section - SD-0013

Neutralization Section - SD-0014

ISSUE	REVISION	BY	DATE
1	PRELIMINARY	WJ	12/1/82
2	AS PER COMMENTS	WJ	8-25-83
3	AS PER COMMENTS	WJ	10-27-83

124

H ₂ S REMOVAL FROM GEOTHERMAL STEAM	EIC
SCRUBBING SECTION	DATE 10-0012

REVISION	DESCRIPTION	BY	DATE
1	DESIGN	W. J. HARRIS	10/1/61
2	REVISION	W. J. HARRIS	10/1/61
3	REVISION	W. J. HARRIS	10/1/61
4	REVISION	W. J. HARRIS	10/1/61

H ₂ S REMOVAL FROM GEOTHERMAL STEAM	EIC
REGENERATION SECTION	SD-0019

EDUF	REVISION	BY	DATE
P-1	RECOMMENDED	WJS	2/15/77
-	ASIA G. 3.006	WJS	8/1/77
A	1000 7/14 - 8/1/77	WJS	8/1/77

H₂S REMOVAL FROM
GEOTHERMAL STEAM
NEUTRALIZATION SECTION

EIC
DWG NO 5D-0014

IV. SKID ASSEMBLY DRAWINGS

H₂S Removal from Geothermal Steam

Slurry Circulating Pumps, Skid No. 1 - SD-0018

Energy Recovery/Purge Decant, Skid No. 2 - SD-0019, Sheet 1 of 2

Energy Recovery/Purge Decant, Skid No. 2 - SD-0019, Sheet 2 of 2

Regeneration Reactor, Skid No. 3 - SD-0020

Service, Skid No. 4, SD-0021

Process Water, Skid No. 5 - SD-0022

[illegible][illegible]

SECTION D-D

DETAIL OF WATER PUMP TO MOTOR AND MOTOR
7/20/64, 1/20/65, 1/20/66

SECTION E-E

VIEW C-C (SOUTH)

SHEET 1 OF 2

EIC		Corporation	
1415 CHANDLER AVENUE, CHANDLER, ARIZONA 85226			
ELECTRIC MOTOR REPAIR/REMANUFACTURING			
SHEET 1 OF 2			
DATE	BY	CHKD	APPD
7/20/64	J. W. W.	J. W. W.	J. W. W.

[illegible]

EIC Corporation
55 Chapel Street
Newton, Massachusetts 02158

CONTROL OF HYDROGEN SULFIDE EMISSION FROM
GEOTHERMAL POWER PLANTS

Contract No. EY-76-C-02-2730.*000

Final Report on Task C.5

Test Plan and Operating Instructions

TP-i

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TEST PLAN

SECTION 1

BACKGROUND AND OUTLINE OF TEST PLAN

SECTION 1

BACKGROUND AND OUTLINE

Development of a test program for demonstrating the process design criteria must be carried out in view of confliction requirements. On the one hand, the tests must be carried out at a stable operating condition for a sufficiently long period to demonstrate unequivocally the appropriateness of the preliminary design criteria. On the other hand, for reasons of economy, the test program must be limited and a wide range of processing conditions must be investigated to demonstrate system operability over potential ranges anticipated in commercial service. In response to these needs, the proposed demonstration plant test campaign will be carried out in four phases:

- Water test phase.
- Open circuit scrub, liquid/solid separation, and regeneration tests.
- Closed circuit, short term testing over a wide range of operating conditions.
- Closed circuit, long term testing at "optimal" operating conditions.

The measurements to be made during the test program, the information derived from them, and their impact upon scaleup are summarized in Table 1. It should be emphasized that there are limitations inherent in the proposed facility. While scrubbing and liquid/solid separation would be demonstrated with equipment of scalable design in a continuous manner, regeneration would be carried out batchwise. Since it is anticipated that the liquid/solid separation and regeneration equipment chosen for the demonstration plant will not necessarily be appropriate for all possible commercial uses, additional off-line test work is included to obtain design parameters appropriate for alternative approaches for these steps. This can be done with a high degree of confidence since representative copper sulfides will be available; however, these steps may not be demonstrated for a long period of time on equipment types required for commercial service.

Water Tests. In the first phase of testing, geothermal steam would be passed through the scrubbing tower, but "scrubbing" will be done with water containing neither acids nor copper sulfate. The objectives of this test are to demonstrate system mechanical integrity with a minimum of safety hazards or operational problems and to obtain data on the system in a clean condition. System behavior when clean will be used as a reference condition, since it is anticipated that fouling may occur when precipitated sulfides are circulated through the system. Barring mechanical difficulties, it is anticipated that the duration of this phase would be relatively short, less than a month; it would be extended only if required for training operators or modifying equipment.

Table 1

Summary of Demonstration Plant Measurements and Operational Information

TPI-3

<u>Measurements Made</u>	<u>Information Derived</u>	<u>Impact on Scaleup</u>
Steam and scrub solution flow rates, column pressure, ΔP (water flow tests).	Pressure drops as a function of operating conditions for clean service.	Establish a reference case for column hydraulics, against which performance in service will be rated.
Steam, scrub, makeup, and purge flow rates. Steam quality (water flow tests).	Column material balance.	Establishes column material and energy balance.
Exit steam quality, steam flow rates, L/G ratio, scrub rate (water flow tests).	Entrainment level as a function of operating conditions, demister design.	Determines extent of copper loss by this mechanism, as well as potential impact on generating equipment stream factor.
Purge, makeup flow rates and temperatures (water flow tests).	Energy balance on recovery exchangers and cooler.	Establishes clean service heat-transfer coefficients for comparison with calculated values and as a reference for determining the rate of fouling.
Steam flow rate and compositions, makeup and purge flow rates and compositions.	System material balances for S^0 , NH_3 , SO_4^{2-} , Cu, B solids in steam, etc., as a function of operating conditions.	Determines rates and extents of removal of NH_3 , H_2S , and other impurities as a function of operating conditions (and internals designs, if tested). Confirms rate data established on lab columns; influence of pH, and $CuSO_4$ content on scrubbing effectiveness. Influence of velocities, L/G ratio, temperature, etc., at a scale of internals design which permits reliable extrapolation to commercial scale.
Tray and demister ΔP as a function of time. Visual inspection of tray and demister condition.	Relation between extent of fouling and column hydraulics. Rate of fouling.	Determines operability of various internals designs. Establishes service requirements and provides information on the effects of operating conditions on the rates of fouling. Determines effectiveness of use of ΔP as a control variable for commercial operation.

Table 1
(continued)

Measurements Made	Information Derived	Impact on Scaleup
Composition and size distribution of precipitated sulfides. Trace constituent and "modifier" composition.	Process chemistry. Influence of operating conditions, system composition on nature of products formed.	Determines extent to which column operation may be manipulated to influence process conditions in the subsequent regeneration steps. Provides information on impurities effects as influencing design for other installations. Permits correlation between form and composition of precipitated and scrubbed solids and rate of fouling of tower internals.
Test coupon weight loss, corrosimeter reading. Build-up of precipitated solids in the tower.	Rate of corrosion for test materials as a function of operating environment. Propensity of various materials to foul.	Confirms laboratory tests establishing suitability of materials of construction. Provides information on the influence of trace constituents on corrosion rate. Information on the rates of fouling of various materials will be generated, as influencing operability.
Rates-of-change of flow rates, pressure drops, temperature/pressure, etc. (water tests).	Column dynamic response to upsets in controlled variables. Limits of stable operation.	Confirms suitability of proposed system-hydraulics control philosophy, in view of expected magnitude of fluctuations of steam rate and pressure and required delivery condition.
Rates-of-change of steam, makeup, and purge compositions and rates.	Scrubbing system dynamic response to upsets in controlled variables. Influence of operating conditions on stability.	Determines capacity of proposed system to meet removal requirements in view of expected magnitude of fluctuations of steam rate and composition, and operating requirements necessary to insure compliance with performance specifications.
Flow rates and temperatures of makeup and purge streams.	Energy balance on recovery exchangers and cooler under process conditions.	Determines rate of fouling of heat transfer surfaces. Provides information on the influence of temperature, velocity, composition, materials of construction, and solids characteristics on fouling.

Table 1
(continued)

	<u>Measurements Made</u>	<u>Information Derived</u>	<u>Impact on Scaleup</u>
	Extent of buildup of solids. Loss of metal in pumps, valves, meters, lines, tanks, etc.	Extent and rates of fouling and corrosion of system comp- onents under operating condi- tions.	Confirms laboratory tests determining suitability of materials of construction. Provides infor- mation on the influence of velocity and composi- tions on corrosion-erosion-buildup. Indicates suitability of control hardware.
	Test coupon weight loss and buildup of precipitated solids in holding tanks.	Rates of corrosion and fouling for test materials in these operating environments.	Confirms laboratory tests determining suitability of materials of construction for auxiliary equip- ment. Provide information on the effects of trace constituents.
TPI-5	Change in solids size distri- bution and character in storage.	Effect of storage temperature and time on solids properties.	Determines influence of holding conditions on subsequent process steps. Provides information on the influence of trace constituent and "modifier" composition.
	Solids contents of over and underflow streams from decanter.	Settling rate and overflow clarity for scrub solution produced under varying con- ditions and at various flow rates.	Defines scale up parameters for a continuous decanter. Indicates stability of system to up- sets caused by varying over and under flow rates and inlet solids densities and purge solution compositions, temperature, etc.
	Off-line tests on liquid/solid separation and wash rates on various test devices.	Solid and liquid filtration rates in 0.1 sq. ft leaf tests, wash efficiencies. Solid settling rates and compression points in liter cylinders, influence of flocculants. Rates of solids settling at high g's.	Determines filtra tion behavior on real slurries. Results can be scaled up to determine commer- cial-scale requirements for other types of liquid/ solid separation devices, e.g., rotary drum filters, clarifiers, centrifuges, etc.

Table 1
(continued)

Measurements Made	Information Derived	Impact on Scaleup
Filtrate composition.	Influences of operating conditions - characteristics of solids, type of L/S separation device, use of aid/floc, etc. - on clarity.	Determines non-soluble copper loss at the liquid/solid separation step (done for both on- and off-line tests). Solution composition also largely fixes soluble copper losses, wash efficiency, fixes effectiveness of NH_3 purge. Indicates necessity of subsequent treatment steps, e.g., neutralization, prior to disposal, as well as possible methods.
Separated solids physical properties: density, pumping limit, cohesion/stickiness, etc.	Influence of operating conditions on external properties for fresh/aged/wet/dried solids.	Will determine how separated solids will be transferred from separation to regeneration steps at commercial scale. Data derived from both on- and off-line tests.
Regeneration reactor slurry composition, temperature, pressure, O_2 /air flow rates, vent gas composition, agitation conditions.	System material balance for S^{--} , S^0 , SO_4^{--} , Cu, and others as a function of operating conditions. Rate and extent of regeneration of precipitated sulfides.	Confirms laboratory data on the rates and stoichiometry of aqueous sulfide oxidation and influence of solution composition. Establishes influence of agitation on mass transfer in equipment of scalable size. Provides information on the effects of trace constituent and "modifier" composition.
Test Coupon weight loss and buildup of solids in reactor/agitator.	Rate of corrosion and fouling for test materials in these operating environments.	Confirms laboratory tests determining suitability of materials of construction. Determines operability of various internals and agitator designs. Provides information on the effects of operating conditions on rates of fouling.
Off-line tests on sulfide oxidation by other techniques.	Rate and extent of oxidation and formation of insoluble copper compounds during roasting in air. Rate and stoichiometry of aqueous oxidation at high temperatures and pressures.	Determines suitability and obtains preliminary design information for scaleup of regeneration step to commercial scale on representative materials for alternate techniques. Provides information on the effects of operating conditions and compositions.

Table 1
(continued)

Measurements Made	Information Derived	Impact on Scaleup
Leached slurry flow rate and temperatures (water flow tests).	Energy balance on cooler.	Establishes clean service heat transfer coefficients for comparison with calculated values and as a reference for determining the rate of fouling.
Leached slurry flow rate and temperatures.	Energy balance on cooler under process conditions.	Determines rate of fouling of heat transfer surfaces. Provides information on the influence of operating conditions on the rate and extent of fouling.
Leached solids size distribution and character.	Effect of regeneration operating conditions, system properties, cooling rate, etc., on solids properties.	Determines influence of regeneration conditions on subsequent process steps. Provides information on the influence of trace constituents and "modifier" composition.
Liquid/solid separation behavior; polish filters; flow rate, pressure drop.	Same as for liquid/solid separation of precipitated sulfides.	Same as for liquid/solid separation of precipitated sulfides. Data required on rates, wash efficiencies, solids and filtrate properties and compositions, etc. Both on- and off-line testing will be carried out.
Waste solids composition and properties.	Physical and chemical stability of process solid wastes. Influence of process conditions on fresh/aged/wet/dried solids.	Determines how waste solids will be transferred from separation to disposal steps at commercial scale as well as possible methods of disposal. Information required on properties of solids generated in off-line tests as well. Provides data on the effects of operating conditions on waste properties.
Makeup copper and acid addition rates.	Material balance on Cu and SO_4^{--} requirements.	Confirms overall system material balances based on other stream composition measurements.

Table 1
(continued)

<u>Measurements Made</u>	<u>Information Derived</u>	<u>Impact on Scaleup</u>
Rates of water addition to process streams at all points of the system.	System water balance.	Fixes liquid waste purge requirements at commercial scale and the relationship to operating conditions, e.g., heat loss, demister wash requirements.
Power input to all motors.	System operating power requirements.	Determines process power requirements, especially for leach reactor in gassed and ungassed conditions.
Rate of removal of Cu from purge stream with H_2S , Fe.	Materials consumption, degree of recovery of Cu.	Defines loss of Cu in purge streams for these recovery techniques, indicates need for further treatment.

Open Circuit Tests. The second phase of testing would involve open circuit demonstration of scrubbing, liquid/solid separation, and regeneration. Open circuit testing on the scrubber module, for instance, would entail use of makeup scrub solution derived directly from purchased copper sulfate and continuous purging of depleted scrub solution without regard to the requirements of separation and makeup. The objective of this test would be to demonstrate stable operation of the scrubber under carefully controlled conditions. In addition, a limited but systematic investigation of the effects of process conditions (temperature, pressure, liquid to gas ratios, copper content, pH, etc.) on mass transfer efficiency would be carried out. Finally, a determination of tower dynamics would be made in a mode of operation uncoupled to liquid/solid separation and regeneration to ease control problems. These tests would be interrupted, as required, by intervals of water testing to permit makeup of fresh scrub solution and disposal of purge solution.

Open circuit liquid/solid separation tests would be carried out in conjunction with open circuit scrubbing tests, subject only to the constraints of timing and availability of copper sulfides. The object of these tests would be to determine the behavior of the solids produced by the scrubbing tower in the separator selected for the demonstration plant. The liquid/solid separation behavior would be related to tower and decanter operating conditions, such as temperature, slurry density, underflow density, etc. In addition, off-line testing would be carried out to determine basic data on filtration and settling rates appropriate to other types of filtration equipment, for example, continuous rotary vacuum filters, and settling equipment, such as thickeners and clarifiers. These data would be related to operating conditions in the scrubbing tower as well as aging times and temperature of precipitated solids, influence of habit modifiers and conditioning agents, effects of trace elements, etc.

Solids produced during the open circuit separation testing would be used to determine the basic parameters for operation of the regeneration reactor. The effects of temperature, pressure, excess air, pH, residence time, and agitation on reaction rates and stoichiometry would be determined for solids produced under varying conditions in the tower and subject to various aging cycles. This information would be used to confirm the overall process stoichiometry and thereby define the overall material balance. Effects of reactor operating conditions on the nature of the residues produced and their liquid/solid separation characteristics would be determined.

Off-line testing of alternate regeneration schemes, such as roasting, oxidation under continuous conditions with limited oxygen supply, and oxidation under conditions favoring complete conversion of sulfide to sulfate, would be carried out with solids produced in the open circuit separation tests. It is anticipated that some of this testing would be carried out in laboratory scale equipment at EIC Corporation or in vendor shops.

Following the open circuit tests, the plant would be run for a short duration in the water test mode to determine the rate of fouling, and would then be cleaned and flushed prior to initiation of continuous, closed circuit testing.

Closed Circuit, Short Term Tests. Closed circuit, short term testing would be carried out to demonstrate plant operability and dynamics under integrated conditions. Operational procedures would be confirmed during this period to insure that longer periods of testing, scheduled to follow, could be carried out in an orderly manner. The plant would be operated at the extremes of anticipated operating conditions in order to demonstrate operability and obtain scoping data for subsequent test work. The plant would be operated in a closed circuit mode for a sufficient time (approximately one month) to systematically explore the effects of operating parameters on overall performance. An object of this phase of the program would be to obtain data which may be used to extrapolate operation to conditions not considered "optimum" for the site chosen as well as to obtain copper sulfides in significant quantities for evaluation in off-line liquid/solid separation and regeneration testing. Water testing would follow integrated closed circuit short term testing, and the plant would then be inspected, cleaned, and modified as required.

Closed Circuit, Long Term Testing. The final four months of the test program would be devoted to a long term, continuous test under conditions controlled about the point determined as "optimal" for operation at the test site. The objectives of this test would be to demonstrate plant operability, confirm design criteria, and measure rates of fouling under steady conditions; i.e., without ambiguities introduced by operation under a variety of test conditions.

The data to be gathered, summarized in Table 1, would provide overall material and energy balances for the process as well as a compilation of information on the operating characteristics of elements of the system; viz, the scrubbing tower C101, decanter C102, and regeneration reactor V201. Flow rates, temperatures, and pressures would be measured by instrumentation provided as a part of the test facility equipment package. Samples would be withdrawn from the process streams as appropriate and analyzed in equipment installed at the site to provide information for process control and interpretation of results. Analytical instrumentation, including portable corrosimeter, spectrophotometer, gas chromatograph, and required wet chemistry hardware, would have been calibrated in the laboratory. Suitable experimental procedures would also be determined prior to use in the field. Specialized analytical procedures, such as petrographic examination of precipitated sulfides, would be carried out off-site.

A detailed description of the tasks required to achieve these objectives, including procedures, outputs, timing, and levels of effort required are summarized in the detailed statement of work.

TEST PLAN

SECTION 2

STATEMENT OF WORK, FIELD TEST OPERATIONS

SECTION 2

INTRODUCTION

The total program for demonstrating the copper sulfate process in an integrated configuration and at a size which is sufficient to obtain valid scale up data will require the execution of 14 tasks.

Tasks 1 through 7 comprise the activities necessary to procure equipment, carry out detailed engineering and prepare the site, install the equipment and auxiliaries and carry out mechanical integrity testing.

Tasks 12 through 14 include the activities required for data reduction and analysis, post test equipment inspection, and preparation of a final report.

Tasks 8 through 11 constitute the activities which will take place during field test work necessary to carry out a complete process demonstration. Detailed description of the objectives and procedures for each task are included in this section.

TASK 8

OPERATOR TRAINING AND WATER TESTING

BACKGROUND

During the purchasing and procurement and design and installation phases (Tasks 1-6), only full time and senior personnel in the process engineering effort will be heavily committed to project work. When the procurement task has been completed (Task 3) and documentation of manufacturers' information has been included in the operating instructions, it will be possible to begin formal training of part time personnel who will serve as operators during the field test campaign (Tasks 8-11). Simultaneously, training may begin for analytical technicians. Final training for all personnel will take place in the field with the system operating on steam and water prior to initiation of scrubbing for hydrogen sulfide removal.

OBJECTIVES

The objectives of Task 8 are to provide the personnel who will be assigned to the project on a part time basis for the field test campaign sufficient background information and training to permit them to be of immediate service once process testing begins. The objectives of the final training exercise in the field using steam and water are two fold: to give the operators hands-on training in a mode in which there is the least danger of accidents to personnel and damage to equipment and to obtain data on the performance of the system in a clean condition for calibration purposes.

PROCEDURES

Operator training will begin as soon as manufacturer's information is complete and incorporated into the operating manual. Copies of the test plan and operating manual will be distributed to the personnel who have been designated as operators for the field test program as well as to the appropriate personnel designated by the site operator's project manager.

Classroom training sessions will be conducted by senior personnel in which the background and objectives of the program will be presented, the function of each item of equipment and operation explained, and the rationale for the test plan developed. The sequence of operations in the operating manual will be covered, item by item, to insure that all personnel understand the function of all items and their interrelations. Operation of the system in normal and upset conditions will be covered, and safety policy, and emergency procedures will be thoroughly explained.

Simultaneously, analytical technicians will be given laboratory training in techniques which will be used in the field to provide analytical support. Cross training will be provided so that all personnel will be able to function in the categories of lead and shift operators and analytical technicians at a basic level of competency in emergency situations.

At the completion of mechanical integrity testing, the balance of the project personnel who will be involved in test operations at any time will be brought to the field to participate in hands-on training while running the system on steam and water. Detailed instructions for carrying out steam water testing will be included in the operating instructions for the field test facility. Broadly, the system will be run with steam and water in a mode which fully simulates the conditions anticipated when scrubbing tests are to be run in subsequent tasks (Tasks 9-11). The data obtained will serve as a reference or bench mark for clean system

performance against which later performance during hydrogen sulfide removal tests can be compared.

Training imparted during class room instructions will be reinforced during actual operation of the system, and the personnel will be acquainted with working conditions and procedures at the site. Any desirable modifications to operating procedures developed during the course of this testing will be documented and incorporated in the formal operating procedures document.

Site operator's personnel will be included in this training exercise at a level of effort determined appropriate by the program manager.

OUTPUT

The data obtained in the cleaned system calibration of the equipment during steam-water testing will be reduced and analyzed for incorporation in the final report (Tasks 12, 14). Modifications of the operating procedures, if any, will be incorporated in the operating procedure document. A letter report will be issued at the completion of the task summarizing the results.

TIMING

Operator training will begin as soon as manufacturers' information is available to complete the operating procedures document, within nine months of initiation of work on the project. Water testing will begin as soon as mechanical integrity testing is completed, within eleven months, and will be completed within an additional two weeks.

LEVEL OF EFFORT

Operator training and water testing will require the expenditure of 41 man weeks of effort, with three trips to the site required to bring the balance of the operating personnel to the field.

TASK 9

OPEN CIRCUIT SCRUBBING/REGENERATION TESTING

BACKGROUND

After completion of mechanical integrity and steam-water testing (Tasks 7, 8), operators will have been trained and system integrity, performance, and operability in the clean state demonstrated. At this stage, scrubbing tests with copper sulfate can begin so that system performance can be demonstrated in the commercial operation mode, and the proposed design criteria and specifications can be verified.

The test program in the scrubbing mode will be conducted in three phases:

- Open circuit scrubbing/regeneration testing,
- closed circuit short term testing,
- and closed circuit long term testing.

OBJECTIVES

It is the objective of Task 9 to carry out short term tests on the removal of hydrogen sulfide from geothermal steam by scrubbing with copper sulfate (the scrubbing mode) in the field test facility without requiring the system to run in a fully integrated state. This will permit the performance of each step to be evaluated independently thereby easing operating problems, as well as determining the limits of operability for each step unconstrained by the operating limits of adjacent operations. A collateral objective of this task is to provide additional training for operating personnel with the system operating in the simplest manner.

PROCEDURES

Detailed instructions for carrying out open circuit scrubbing/regeneration testing will be included in the operating instructions for the field test facility. Broadly, open circuit testing will be executed in a series of steps in which only one operation at a time (e.g., scrubbing, liquid/solid separation, regeneration) will be carried out.

Scrubbing will be investigated over a range of steam rates, L/V ratios, and solution compositions with make up scrub solution derived from dissolving fresh copper sulfate in a simulated recycle solution containing fresh ammonium sulfate and sulfuric acid as well. The purged scrub solution would bypass the liquid solid separation step and be held in slurry surge for subsequent decantation and regeneration.

If scrubbing testing reveals that modifications to the scrubber design are required, such as revised tray open area or downcomer height or size, demister wash nozzle configuration or timing cycle, return scrub solution nozzle position etc., the changes will be made prior to the resumption of further testing on the scrubber.

Meanwhile, purged slurry will be recycled through the decanter to determine its performance and the limits of operability for a given underflow density and/or overflow clarity. As is the case with the scrubber, any modifications deemed necessary will be made.

Subsequently, the purged slurry will be regenerated in the leach reactor. Regeneration will be carried out with both air and oxygen over a range of total pressures, temperatures, and agitation rates, and any modifications required will be carried out.

Other steps in the process, such as on-line sample filtration and analysis, purge neutralization and purge copper recovery, etc. which can only be tested following scrubbing (and therefore were not evaluated during Task 8) will also be tested, mechanical and process revisions and modifications will be made as required.

Execution of tests on individual steps in the process, without the pressure to be cognizant of the impact of changes in up or downstream operations, will provide an opportunity for additional training to be carried out. Experience will be gained on the operating characteristics of all steps in the scrubbing mode, and the dynamic response of the system to operator inputs can be evaluated. This will also provide a basis for modifying the operating instructions for tests to be carried out in subsequent tasks.

Once all steps have been demonstrated and it is felt that integrated operation should begin, the system will be thoroughly flushed, inspected, and rerun in the steam-water mode to reverify the base line conditions.

OUTPUT

The data obtained in the open circuit scrubbing/regeneration testing will be reduced and analyzed for incorporation in the final report (Tasks 12, 14). Modifications to equipment and operating procedures, if any, will be incorporated in the operating procedure document. A letter report will be issued at the completion of the task summarizing results.

TIMING

Open circuit scrubbing/regeneration testing will begin as soon as mechanical integrity testing has been completed, within eleven and one half months after initiation of work on the project, and will be completed within two weeks.

LEVEL OF EFFORT

Open circuit scrubbing/regeneration testing will require the expenditure of 26 man weeks of effort.

TASK 10

CLOSED CIRCUIT SHORT TERM TESTING

BACKGROUND

After the completion of open circuit-scrubbing/regeneration testing (Task 9), all components of the system and operations will have been demonstrated individually. However, all testing will have been of short duration since only one days surge capacity has been provided within the process, and little time will have been spent at any particular operating condition.

OBJECTIVE

The objectives of Task 10 are to operate in the scrubbing mode in an integrated fashion, with all steps demonstrated simultaneously, and copper precipitated in the scrubber regenerated and recycled thereby closing the circuit. Tests are to be carried out over the widest expected range of operating and process conditions to determine the limits of operability for the integrated system. A collateral objective of this task is to provide additional operator training.

PROCEDURES

Detailed instructions for carrying out closed circuit short term testing will be included in the operating instructions for the field test facility. Broadly, closed circuit short term testing will be carried out in a fashion which simulates the final, commercial operating mode. Operation will be continuous, with round-the-clock scrubbing and daily regeneration and recycle of purged copper sulfide solids.

Operating procedures which were developed and refined during Tasks 8 and 9 will be used routinely, if possible, to carry out this test series.

Operating conditions, however, will be controlled so as to force the system to operate for sustained periods of time at the limits of operability. Thus, the effects of make up scrub solution acidities, copper and ammonium sulfate contents, scrubber froth heights and steam flow rates and L/V ratios, regeneration temperatures, oxygen partial pressures, and agitation rates, and other process variables will be examined at the extreme ranges of values envisioned appropriate for each.

Testing at a given condition will be carried out for a sufficient period of time, nominally ten displacements or two days, for transients to have largely died out so that the results can be evaluated unequivocally. The system will be shut down and inspected weekly, however, to determine the condition of components with respect to fouling, corrosion, etc. and to make repairs and revisions as necessary.

Testing in this mode will provide additional operator training, particularly with respect to system dynamics and control procedures since the interactions of system components with one another will be evident in the integrated mode of operation.

Once the extremes of operability have been explored and short term testing completed, the system will be thoroughly flushed, inspected, and rerun in the steam-water mode to reverify the base line condition.

OUTPUT

The data obtained in the closed circuit short term testing will be reduced and analyzed for incorporation in the final report (Tasks 12, 14). Modifications to equipment and operating procedures, if any, will be incorporated in the operating procedure document. A letter report will be issued at the completion of the task summarizing results.

TIMING

Closed circuit short term testing will begin as soon as open circuit scrubbing/regeneration testing has been completed, within twelve months after initiation of work on the project, and will be completed within one month.

LEVEL OF EFFORT

Closed circuit short term testing will require the expenditure of 82 man weeks of effort and four trips to the test site for operator rotation.

TASK 11

CLOSED CIRCUIT LONG TERM TESTING

BACKGROUND

After the completion of closed circuit short term testing (Task 10), the system will have been operated over the extremes of the expected range of operating conditions. Testing in this mode will have provided data on the relation between operating conditions of temperature, pressure, pH, L/V, etc. on scrubbing and regeneration efficiency, system dynamics, and operability for relatively short periods of time.

OBJECTIVES

It is the objective of Task 11 to run the integrated system in a mode which simulates the anticipated normal commercial conditions for a sufficient period of time to demonstrate system reliability and operability. Information will be derived on the effects of phenomena such as slow corrosion or fouling or the build up of trace elements.

PROCEDURES

Detailed instructions for carrying out closed circuit long term testing will be included in the operating instructions for the field test facility. Broadly, the system will be run for long periods of time at a fixed condition with a minimum of changes to determine the effects, if any, of prolonged operation on system performance.

Operating procedures developed during Tasks 8, 9, and 10 will be used routinely, if possible. A minimum of changes in operating conditions is planned, and these will be carried out only after the system is known to have come to steady state or after three weeks operation at a given

condition. In general, the system will be allowed to operate under conditions which prove to be "natural" for the particular steam composition and scrubbing efficiency at the site.

A four month test campaign is planned, with an assumed overall stream factor of 75% and a maximum on-line time of 85%.

Revisions to operating procedures and equipment repairs and revisions will be made as required. Some solids produced during the course of this task will be reserved for off line testing in vendor's pilot plants to obtain design data on alternate methods of regeneration and liquid/solid separation, for example. Limited testing on copper and ammonium sulfate recovery from the solubles purge stream is also planned.

OUTPUT

The data obtained in the closed circuit long term testing will be reduced and analyzed for incorporation in the final report (Tasks 12, 14). Modifications to equipment and operating procedures, if any, will be incorporated in the operating procedure document. A letter report will be issued at the completion of the task summarizing results.

TIMING

Closed circuit long term testing will begin as soon as closed circuit short term testing has been completed, within thirteen months after initiation of work on the project, and will be completed within four months.

LEVEL OF EFFORT

Closed circuit long term testing will require the expenditure of 189 man weeks of effort and 24 trips to the test site for operator rotation.

TEST PLAN

SECTION 3

DETERMINATIONS TO BE MADE DURING TEST OPERATIONS

SECTION 3

DETERMINATION NO. 1

**FUNCTION TO
BE DETERMINED:**

Scrubbing efficiency for removal of hydrogen sulfide.

**OPERATIONS AND
EQUIPMENT ITEMS:**

Steam scrubbing using a column with a single sieve tray.

**STREAMS OF
INTEREST:**

- a) Unscrubbed geothermal steam entering.
- b) Scrubbed geothermal steam exiting.
- c) The makeup scrub solution.
- d) The purge slurry.
- e) The demister wash.
- f) Recirculating copper sulfate.

**INFORMATION
TO BE DERIVED:**

- a) The extent of removal of hydrogen sulfide from the steam.
- b) The dependence of efficiency on process and operating conditions.

**MEASUREMENTS
TO BE MADE:**

- a) Concentration of hydrogen sulfide in entering steam to column.
- b) Concentration of hydrogen sulfide in exiting steam.
- c) Composition of purge stream.

**INDEPENDENT
VARIABLES TO
BE CONSIDERED:**

- a) The scrub-liquid-to-steam flow rate ratio within the column.
- b) The steam flow rate.
- c) The scrubbing solution pH and copper content.
- d) The concentration of copper, boron and ammonia.
- e) The height of froth above the contacting tray.
- f) The differential pressure across the tray.
- g) Solids content in the scrub solution.
- h) Details of tray designs.

DETERMINATION NO. 2

FUNCTION TO BE DETERMINED:	Scrubbing efficiency for removal of ammonia.
OPERATIONS AND EQUIPMENT ITEMS:	Steam scrubbing using a column with a single tray.
STREAMS OF INTEREST:	<ul style="list-style-type: none">a) Unscrubbed geothermal steam entering.b) Scrubbed geothermal steam leaving.c) The makeup scrub solution.d) The purge slurry.e) The demister wash.f) Recirculating copper sulfate.
INFORMATION TO BE DERIVED:	<ul style="list-style-type: none">a) The extent of removal of ammonia from the steam.b) The dependence of efficiency on process and operating conditions.
MEASUREMENTS TO BE MADE:	<ul style="list-style-type: none">a) Concentration of ammonia in entering steam to column.b) Concentration of ammonia in exiting steam from column.c) Concentration of ammonium sulfate in purge and makeup scrub solution streams.
INDEPENDENT VARIABLES TO BE CONSIDERED:	<ul style="list-style-type: none">a) The scrub liquid-to-steam flow rate ratio within the column.b) The steam flow rate.c) The scrubbing solution pH.d) The concentration of copper, boron, and ammonia.e) The height of froth above the contacting tray.f) The differential pressure across the tray.g) Solids content in the scrub solution.h) Details of tray designs.

DETERMINATION NO. 3

FUNCTION TO BE DETERMINED:	Scrubbing efficiency for removal of boron.
OPERATIONS AND EQUIPMENT ITEMS:	Steam scrubbing using column with a single tray.
STREAMS OF INTEREST:	<ul style="list-style-type: none">a) Unscrubbed geothermal steam entering.b) Scrubbed geothermal steam leaving.c) The makeup scrub solution.d) The purge slurry.e) The demister wash.f) Recirculating copper sulfate.
INFORMATION TO BE DERIVED:	<ul style="list-style-type: none">a) The extent of removal of boron from the steam.b) The dependence of efficiency on process and operating conditions.
MEASUREMENTS TO BE MADE:	<ul style="list-style-type: none">a) Concentration of boron in entering steam to column.b) Concentration of boron in exiting steam.c) Concentration of boron in purge and makeup scrub solution streams.
INDEPENDENT VARIABLES TO BE CONSIDERED:	<ul style="list-style-type: none">a) The scrub liquid-to-steam flow rate ratio within the column.b) The steam flow rate.c) The scrubbing solution pH.d) The concentration of copper, boron, and ammonia.e) The height of froth above the contacting tray.f) The differential pressure across the tray.g) The solids content in the scrub solution.h) Details of tray designs.

DETERMINATION NO. 4

**FUNCTION TO
BE DETERMINED:** Differential pressure across the column contacting tray under clean operating conditions, i.e., during start up or with steam and water.

**OPERATIONS AND
EQUIPMENT ITEMS:** Monitoring of differential pressure across the column tray with a differential pressure recorder.

**STREAMS OF
INTEREST:** a) The steam flow entering the column.
b) The recirculating water (scrub solution).

**INFORMATION
TO BE DERIVED:** Pressure drop of a clean contacting tray as a function of hydraulic conditions.

**MEASUREMENTS
TO BE MADE:** a) Tray differential pressure
b) Steam flow rate.
c) Water (scrub) makeup.
d) Recirculating water (scrub).
e) Column pressure.

**INDEPENDENT
VARIABLES TO
BE CONSIDERED:** a) Liquid scrub-to-steam flow rate ratios.
b) Steam flow rate.
c) Froth height (if observable)
d) Time tray has been in service.
e) Details of tray design.

DETERMINATION NO. 5

FUNCTION TO
BE DETERMINED:

Change of differential pressure across the column contacting tray during system operation.

OPERATIONS AND
EQUIPMENT ITEMS:

Monitoring of the change of differential pressure across the column tray with a differential pressure recorder.

STREAMS OF
INTEREST:

- a) The steam flow entering the column.
- b) The makeup scrub solution of copper sulfate.
- c) The recirculated scrub solution to steam flow rate ratio.

INFORMATION
TO BE DERIVED:

- a) Fouling tendencies of the tray; i.e., rate of change of pressure drop at fixed hydraulics.
- b) Indication of operating conditions necessary for the most efficient scrubbing.
- c) Indirect indication of froth height above the tray.

MEASUREMENTS
TO BE MADE:

- a) Tray differential pressure
- b) Steam flow rate.
- c) Copper sulfate makeup.
- d) Copper sulfate recirculation
- e) Column pressure.

INDEPENDENT
VARIABLES TO
BE CONSIDERED:

- a) Liquid scrub solution-to-steam flow rate ratios.
- b) Steam flow rate.
- c) Froth height (if observable).
- d) Time at conditions.
- e) Details of tray design.

DETERMINATION NO. 6

FUNCTION TO
BE DETERMINED:

Demister pressure drop during clean operation.

OPERATIONS AND
EQUIPMENT ITEMS:

Monitoring of differential pressure across the column
demister with a differential pressure indicator.

STREAMS OF
INTEREST:

- a) The steam flow entering and leaving the column.
- b) The demister wash water streams.

INFORMATION
TO BE DERIVED:

Pressure drop of a clean demisting system under varying
steam and wash flow rates.

MEASUREMENTS
TO BE MADE:

- a) Demister differential pressure
- b) Steam flow rate.
- c) Wash water flow rate.
- d) Column pressure.

INDEPENDENT
VARIABLES TO
BE CONSIDERED:

- a) Steam flow rate.
- b) Rate of wash.
- c) Frequency of wash.
- d) Time demister has been in service.
- e) Style of demister element.

DETERMINATION NO. 7

FUNCTION TO
BE DETERMINED:

Change of differential pressure on demister element during system operation.

OPERATIONS AND
EQUIPMENT ITEMS:

Monitoring of differential pressure and its changes across the demister with a differential pressure indicator.

STREAMS OF
INTEREST:

- a) The steam flow entering and leaving the column.
- b) The demister wash water streams.

INFORMATION
TO BE DERIVED:

- a) Fouling tendencies of the demister during normal and upset conditions.
- b) Effectiveness of demister wash system to restore an acceptable differential pressure.
- c) Rate and frequency of wash necessary for best demister performance.

MEASUREMENTS
TO BE MADE:

- a) Demister differential pressure.
- b) Steam flow rate.
- c) Wash water flow rate.
- d) System pressure.

INDEPENDENT
VARIABLES TO
BE CONSIDERED:

- a) Steam flow rate.
- b) Rate of wash.
- c) Frequency of wash.
- d) Time demister has been in service.
- e) Previous column operating history (i.e., time since last upset in froth height, maximum froth height attained, durations of upset, etc.
- f) Style of demister element.

DETERMINATION NO. 8

FUNCTION TO
BE DETERMINED: Efficiency of demister in removing entrained scrub
solutions.

OPERATIONS AND
EQUIPMENT ITEMS: Removal of entrainment from scrubbed steam by demister.

STREAMS OF
INTEREST: a) Scrubbed steam exiting the column.
b) Scrub solution.
c) Demister wash water.

INFORMATION
TO BE DERIVED: a) Demister efficiency under clean conditions for
various hydraulic conditions.
b) Rate of loss of demister efficiency under operating
conditions.
c) Effectiveness of various wash rate and wash cycles
in restoring efficiency.

MEASUREMENTS
TO BE MADE: a) Tracer content of cleaned steam.
b) Tracer content of scrub solution.
c) Tracer content of demister wash.

INDEPENDENT
VARIABLES TO
BE CONSIDERED: a) Steam flow rate.
b) Rate of wash.
c) Frequency of wash.
d) Time demister has been in service.
e) Froth height (if observable, otherwise tray pressure
drop).
f) Previous column operating history (see Determination No. 7).
g) Style of demister element.

DETERMINATION NO. 9

FUNCTION TO BE DETERMINED:	Total material and energy balance around the scrubbing column.
OPERATIONS AND EQUIPMENT ITEMS:	Monitoring and recording flow rates of streams entering and exiting the scrubbing column.
STREAMS OF INTEREST:	a) Scrub solution makeup and purge. b) Demister wash. c) Steam entering and leaving.
INFORMATION TO BE DERIVED:	a) Consistency and reliability of the data. b) State of operation of the scrub column.
MEASUREMENTS TO BE MADE:	a) Scrub solution makeup and purge stream flows and temperatures. b) Demister wash flow and temperature. c) Change of volume of column sump. d) Column heat losses (see Determination No. 39). e) Inlet moisture of steam (see Determination No. 39). f) Heat of reaction during scrubbing (see Determina- tion No. 40).
INDEPENDENT VARIABLES TO BE CONSIDERED:	To be assessed during column operation.

DETERMINATION NO. 10

FUNCTION TO BE DETERMINED:	Component material balances for the scrubbing column.
OPERATIONS AND EQUIPMENT ITEMS:	Steam scrubbing with copper sulfate in the absorption column.
STREAMS OF INTEREST:	<ul style="list-style-type: none">a) Steam entering and exiting.b) Makeup and purge scrub solutions.c) Demister wash solution (if not water).
INFORMATION TO BE DERIVED:	<ul style="list-style-type: none">a) The conditions necessary for optimal column operation.b) The ability of the column to operate at a steady state condition.c) Scrubbing reaction stoichiometry as of function of operating conditions.d) Consistency and reliability of data.
MEASUREMENTS TO BE MADE:	<ul style="list-style-type: none">a) Ammonia concentration in the inlet and cleaned steam and steam flow rate. Makeup and purge scrub solutions flow rate and ammonium sulfate concentration.b) Boron concentration in the inlet and cleaned steam and makeup and purge scrub solutions.c) Copper, sulfate, and free acidity concentrations in the makeup and purge scrub solutions.d) Solids content and solids composition in the purge scrub solution.e) Hydrogen sulfide composition in the inlet and cleaned steam.
INDEPENDENT VARIABLES TO BE CONSIDERED:	<ul style="list-style-type: none">a) Liquid-to-gas flow rate ratios in the column.b) Steam flow rate.c) Tray pressure drop (froth height if observable).d) Concentration of copper, boron, ammonia and pH of the scrub solution.e) Solids residence time in the scrubber (sump level).

DETERMINATION NO. 11

FUNCTION TO
BE DETERMINED:

Overall heat transfer coefficient, clean service,
and dependence of film coefficients on flow rate.

OPERATIONS AND
EQUIPMENT ITEMS:

Counter current heat exchange of makeup and purge
scrub solutions (water) in heat exchanger 101.

STREAMS OF
INTEREST:

- a) Makeup copper sulfate scrub solution (using water).
- b) Purge copper sulfate scrub solution (using water).

INFORMATION
TO BE DERIVED:

- a) The overall clean service heat transfer coefficient as a point of reference for determining rate of fouling.
- b) Dependence of film coefficients on flow rates.

MEASUREMENTS
TO BE MADE:

- a) Makeup scrub solution (water) flow and inlet and outlet heat exchanger temperatures.
- b) Purge scrub solution (water) flow and inlet and outlet heat exchanger temperatures.

INDEPENDENT
VARIABLES TO
BE CONSIDERED:

- a) Flow rates of the (water) makeup and purge streams.
- b) Temperatures of the makeup streams.
- c) Time the heat exchanger has been in service.

DETERMINATION NO. 12

**FUNCTION TO
BE DETERMINED:**

Change of overall heat transfer coefficient due to fouling in the counter current makeup-purge scrub solution heat exchanger.

**OPERATION AND
EQUIPMENT ITEMS:**

Counter-current heat exchange of makeup and purge scrub solutions in heat exchanger 101.

**STREAMS OF
INTEREST:**

- a) Makeup copper sulfate scrub solution.
- b) Purge copper sulfate scrub solution (slurry).

**INFORMATION
TO BE DERIVED:**

- a) Rate of changes of the overall heat transfer coefficient in service.
- b) Determination of combined fouling coefficients and their dependence on operating conditions.

**MEASUREMENTS
TO BE MADE:**

- a) Makeup scrub solution flow and inlet and outlet heat exchanger 103 temperatures.
- b) Purge scrub solution flow and inlet and outlet heat exchanger 102 temperatures.

**INDEPENDENT
VARIABLES TO
BE CONSIDERED:**

- a) Flow rates and temperatures of the makeup and purge solutions.
- b) Compositions of the makeup and purge solutions.
- c) Time the heat exchanger has been in service.

DETERMINATION NO. 13

FUNCTION TO
BE DETERMINED:

Overall heat transfer coefficients in clean service
and dependence of film coefficients on flow rate.

OPERATIONS AND
EQUIPMENT ITEMS:

Counter-current heat exchange of makeup and purge scrub
solutions (water) with cooling tower water in heat
exchangers 102 and 103.

STREAMS OF
INTEREST:

- a) Makeup copper sulfate solution (using water).
- b) Purge copper sulfate solution (using water).
- c) Cooling tower water.

INFORMATION
TO BE DERIVED:

- a) The overall clean service heat transfer coefficient
to serve as a reference for determining rate of
fouling.
- b) Dependence of film coefficients on flow rates.

MEASUREMENTS
TO BE MADE:

- a) Makeup scrub solution flow and temperature in and out.
- b) Heat exchanger 103 cooling water temperature.
- c) Purge scrub solution flow and temperature in and out.
- d) Heat exchanger 102 cooling water temperature in and out.

INDEPENDENT
VARIABLES TO
BE CONSIDERED:

- a) Flow rates of the scrub and purge solutions.
- b) Temperatures of the makeup and purge streams.
- c) Cooling water flow rates.
- d) Time the heat exchanger has been in service.

DETERMINATION NO. 14

**FUNCTION TO
BE DETERMINED:**

Change of overall heat transfer coefficient during service due to fouling.

**OPERATIONS AND
EQUIPMENT ITEMS:**

Counter-current heat exchange of makeup and purge scrub solutions with cooling water in heat exchangers 102 and 103.

**STREAMS OF
INTEREST:**

- a) Makeup copper sulfate solution.
- b) Purge copper sulfate solution.
- c) Cooling tower water.

**INFORMATION
TO BE DERIVED:**

- a) Rate of changes of the overall heat transfer coefficient during service.
- b) Determination of combined fouling coefficients and their dependence on operating conditions.

**MEASUREMENTS
TO BE MADE:**

- a) Makeup scrub solution flow and inlet and outlet heat exchanger 103 temperatures.
- b) Purge scrub solution flow and inlet and outlet heat exchanger 102 temperatures.
- c) Cooling water inlet and outlet temperatures.

**INDEPENDENT
VARIABLES TO
BE CONSIDERED:**

- a) Flow rates and temperatures of the makeup and purge solutions.
- b) Compositions of the makeup and purge solutions.
- c) Time the heat exchanger has been in service.

DETERMINATION NO. 15

FUNCTION TO
BE DETERMINED:

Pressure drops across process heat exchangers during
clean service operation.

OPERATIONS AND
EQUIPMENT ITEMS:

Heat transfer in exchangers 101, 102, 103, 201 and 202.

STREAMS OF
INTEREST:

- a) Makeup and purge streams (using water) in
exchanger 101.
- b) Makeup scrub solution (using water) in exchanger 103.
- c) Purge scrub solution (using water) in exchanger 102.
- d) Recirculated slurry (using water) in exchanger 201.
- e) Regenerated CuSO_4 (using water) in exchanger 202.

INFORMATION
TO BE DERIVED:

Clean service pressure drops in the process heat exchangers
as a function of flow rate.

MEASUREMENTS
TO BE MADE:

- a) Purge stream pressures, flow and temperatures.
- b) Makeup stream pressures, flow and temperatures.
- c) Pressure drop, flow rate and temperature on process
sides of exchangers 102, 103, 201 and 202.

INDEPENDENT
VARIABLES TO
BE CONSIDERED:

- a) Flow rates of all streams.
- b) Stream temperature.
- c) Time the heat exchanger has been in service.

DETERMINATION NO. 16

FUNCTION TO
BE DETERMINED:

Pressure drop across heat exchangers during service.

OPERATIONS AND
EQUIPMENT ITEMS:

Heat transfer in exchangers 101, 102, 103, 201 and 202.

STREAMS OF
INTEREST:

- a) Makeup and purge streams of scrub solution in exchanger 101.
- b) Makeup scrub solution in exchanger 103.
- c) Purge scrub solution in exchanger 102.
- d) Recirculated slurry in exchanger 201.
- e) Regenerated CuSO_4 in exchanger 202.

INFORMATION
TO BE DERIVED:

Fouling tendencies of the heat exchanger while in service.

MEASUREMENTS
TO BE MADE:

- a) Purge stream pressures, flow and temperatures.
- b) Makeup stream pressures, flow and temperatures.
- c) Pressure drop, flow and temperature on process side side of exchangers 102, 103, 201 and 202.

INDEPENDENT
VARIABLES TO
BE CONSIDERED:

- a) Flow rates of all streams.
- b) Stream temperatures.
- c) Composition of all streams.
- d) Time the heat exchanger has been in service.

DETERMINATION NO. 17

**FUNCTION TO
BE DETERMINED:**

Pressure drop and observational assessment of process filter performance for clean service with water as test fluid.

**OPERATIONS AND
EQUIPMENT ITEMS:**

Filtration of process fluids in filters F101, F101A, F102, F201, F301 and F302.

**STREAMS OF
INTEREST:**

- a) Filtered scrub solution purge to analysis.
- b) Purge slurry decanter overflow to neutralization.
- c) Leached copper sulfate to storage.
- d) Process water to storage.
- e) Decopperized purge to tower sumps.

**INFORMATION
TO BE DERIVED:**

Pressure drop across the filters in clean service as a function of flow rate.

**MEASUREMENTS
TO BE MADE:**

- a) Pressure drop and flow rate across F101, 101A.
- b) Pressure drop and flow rate across F102.
- c) Pressure drop and rate of change of level in holding tank and/or makeup copper sulfate tank.
- d) Pressure drop and rate of change of level in storage tank.
- e) Pressure drop and rate of change of level in holding tank.

**INDEPENDENT
VARIABLES TO
BE CONSIDERED:**

- a) Stream flow rates and temperatures.
- b) Stream solids contents (if any).
- c) Time in service and backflushing history.
- d) Style of filter element in use.

DETERMINATION NO. 18

**FUNCTION TO
BE DETERMINED:**

Pressure drop and evaluation of particle removal efficiency of process filters.

**OPERATIONS AND
EQUIPMENT ITEMS:**

Filtration of process fluids in filters F101, F101A, F102, F201, F301 and F302.

**STREAMS OF
INTEREST:**

- a) Filtered scrub solution purge to analysis.
- b) Purge slurry decanter overflow to neutralization.
- c) Leached copper sulfate to storage.
- d) Process water to storage.
- e) Decopperized purge to tower sump.

**INFORMATION
TO BE DERIVED:**

Filtering performance and efficiency as a function of process conditions, filter element style, and cleaning or backwash cycle.

**MEASUREMENTS
TO BE MADE:**

- a) Pressure drop and flow rate across F101, 101A.
- b) Pressure drop and flow rate across F102.
- c) Pressure drop and rate of change of level in holding tank.
- d) Pressure drop and rate of change of level in storage tank.
- e) Pressure drop and rate of change of level in holding tank.

**INDEPENDENT
VARIABLES TO
BE CONSIDERED:**

- a) Stream flow rates.
- b) Stream compositions and temperatures
- c) Stream solids content.
- d) Solids properties (compositions, particle size distribution, and density).
- e) Time in service and backflushing history.
- f) Style of filter element in use.

DETERMINATION NO. 19

FUNCTION TO
BE DETERMINED:

Decanter overflow solids content.

OPERATIONS AND
EQUIPMENT ITEMS:

Separation of copper sulfide slurry and
solubles purge in a continuous decanter.

STREAMS OF
INTEREST:

- a) Purge stream from the scrubbing tower.
- b) Decanted overflow and thickened underflow stream.

INFORMATION
TO BE DERIVED:

- a) Effect of operating conditions on overflow clarity.
- b) Settling velocity as a function of operating conditions.

MEASUREMENTS
TO BE MADE:

- a) Observation of overflow clarity.
- b) Slurry level in decanter.
- c) Decanter under and overflow rates.
- d) Average solids content of overflow.
- e) Solids content and solids compositions of underflow.
- f) Purge solution temperature and compositions.

INDEPENDENT
VARIABLES TO
BE CONSIDERED:

- a) Total flow rate to decanter.
- b) Percent of slurry decanted.
- c) Feed slurry density.
- d) Feed slurry composition and temperature.

DETERMINATION NO. 20

FUNCTION TO BE DETERMINED:	Total material balance around the decanter.
OPERATIONS AND EQUIPMENT ITEMS:	Separation of copper sulfide slurry and solubles purge in a continuous decanter.
STREAMS OF INTEREST:	a) Purge stream from the scrubbing tower. b) Decanter overflow. c) Decanter underflow.
INFORMATION TO BE DERIVED:	Total solids and liquid purge rate from the scrubbing column.
MEASUREMENTS TO BE MADE:	a) Flow rates of decanter underflow and overflow streams. b) Underflow solids content. c) Average overflow solids content.
INDEPENDENT VARIABLES TO BE CONSIDERED:	To be assessed during decanter operations.

DETERMINATION NO. 21

FUNCTION TO BE DETERMINED:	Rate of use of makeup copper sulfate solution and/or accuracy of FR105.
OPERATIONS AND EQUIPMENT ITEMS:	Supply copper sulfate from storage tank T102 to replenish that used in the column.
STREAMS OF INTEREST:	Copper sulfate makeup solution to column.
INFORMATION TO BE DERIVED:	A calibration of process instrumentation.
MEASUREMENTS TO BE MADE:	a) Level change in T102 as a function of time. b) Flow rate on FR105; instantaneous and average.
INDEPENDENT VARIABLES TO BE CONSIDERED:	To be assessed during scrubber operation.

DETERMINATION NO. 22

FUNCTION TO BE DETERMINED:	Rate of use of water in the demister wash system.
OPERATIONS AND EQUIPMENT ITEMS:	Intermittant wash of sections of the demister unit in the scrub column and supply of flush water to seals from process water surge Tank T304.
STREAMS OF INTEREST:	a) Demister wash streams b) Seal and analytical instrument flush.
INFORMATION TO BE DERIVED:	Calibration of process instrumentation.
MEASUREMENTS TO BE MADE:	a) Level changes in Tank T304 as a function of time. b) Flow rate on FI363 and cycle time. c) Flow rates to seals and instruments.
INDEPENDENT VARIABLES TO BE CONSIDERED:	To be assessed during scrubber operation.

DETERMINATION NO. 23

**FUNCTION TO
BE DETERMINED:** Rate of purge copper sulfate-copper sulfide slurry
from the column.

**OPERATIONS AND
EQUIPMENT ITEMS:** Purge of spent scrub solution from the scrub column
through the heat exchanger/decanter to regeneration.

**STREAMS OF
INTEREST:** Purge stream from the column.

**INFORMATION
TO BE DERIVED:** Calibration of process instrumentation.

**MEASUREMENTS
TO BE MADE:**

- a) Level change in T101 as a function of time.
- b) Level change in column sump.
- c) Flow rate of decant solution and level change in tank T302.
- d) Flow rate of purge slurry.
- e) Solution density.

**INDEPENDENT
VARIABLES TO
BE CONSIDERED:** To be assessed during scrubber operation.

DETERMINATION NO. 24

FUNCTION TO
BE DETERMINED:

Regeneration rate of copper sulfide at near ambient conditions.

OPERATIONS AND
EQUIPMENT ITEMS:

Storage and agitation of decant slurry with sparging or aspiration of atmospheric air in tank 101 prior to transfer to the pressure leach reactor.

STREAMS OF
INTEREST:

- a) Slurry pumped around circulating loop.
- b) Contents in the storage-tank T101.
- c) Aspirated air.

INFORMATION
TO BE DERIVED:

- a) The rate and extent of leaching possible with air at near ambient conditions as a function of operating conditions.
- b) Subsequently, savings in oxygen consumption and leach time required in pressure leach reactor.

MEASUREMENTS
TO BE MADE:

- a) Rate of slurry input to tank T101.
- b) Solution composition, slurry density, and solids composition input to tank T101.
- c) Solution composition, slurry density, and solids composition and total volume of contents of tank T101 as a function of time.
- d) Flow rate and temperature in circulating loop.
- e) Flow rate of sparged or aspirated air.

INDEPENDENT
VARIABLES TO
BE CONSIDERED:

- a) Slurry density.
- b) Solution composition.
- c) Temperature.
- d) Ratio of air to slurry and contact time.
- e) Method of achieving gas/liquid contact.

DETERMINATION NO. 25

FUNCTION TO BE DETERMINED:	Overall heat transfer coefficient during clean service and dependence of film coefficient on flow rates.
OPERATIONS AND EQUIPMENT ITEMS:	Steam heating in heat exchanger 201 of purged slurry (water) with process steam.
STREAMS OF INTEREST:	a) Slurry (water) pumped around recirculation loop. b) Process steam to the heat exchanger.
INFORMATION TO BE DERIVED:	Overall heat transfer coefficient during clean operation as a reference for determining rate of fouling. Dependence of film coefficients on flow rate.
MEASUREMENTS TO BE MADE:	a) Steam pressure. b) Quantity of condensate from the steam trap per unit time. c) Flow rate of circulating slurry (water). d) Temperature of entering and exiting slurry.
INDEPENDENT VARIABLES TO BE CONSIDERED:	a) Flow rates of circulating slurry (water). b) Time the heat exchanger has been in service.

DETERMINATION NO. 26

**FUNCTION TO
BE DETERMINED:**

Change of overall heat transfer coefficient due to fouling in heat exchanger 201 with process use.

**OPERATIONS AND
EQUIPMENT ITEMS:**

Steam heating of copper sulfate-sulfide slurry passing through heat exchanger 201.

**STREAMS OF
INTEREST:**

- a) Slurry pumped around recirculation loop.
- b) Process steam to the heat exchanger.

**INFORMATION
TO BE DERIVED:**

- a) Rate of change of overall heat transfer coefficient with exchanger service.
- b) Calculation of combined fouling coefficients, and their dependence on operating conditions.

**MEASUREMENTS
TO BE MADE:**

- a) Steam pressure.
- b) Quantity of condensate from the steam trap per unit time.
- c) Flow rate of circulating slurry.
- d) Composition of circulating slurry.
- e) Temperature of entering and exiting slurry.

**INDEPENDENT
VARIABLES TO
BE CONSIDERED:**

- a) Flow rates and temperatures of the circulating slurry.
- b) Composition of slurry stream.
- c) Time the exchanger has been in service.

DETERMINATION NO. 27

FUNCTION TO
BE DETERMINED:

Rate of leaching of copper sulfide solids from scrubber.

OPERATIONS AND
EQUIPMENT ITEMS:

Pressure oxygen/air leaching of purged scrub solution in reactor vessel 201.

STREAMS OF
INTEREST:

- a) Purge slurry transferred from T101 to reactor V201.
- b) Air or oxygen sparged to reactor.

INFORMATION
TO BE DERIVED:

- a) Leach conditions necessary to completely regenerate the copper sulfate scrub solution.
- b) The effect of process conditions on rate of leaching.
- c) The effect of initial solids compositions on the rate and extent of leaching.
- d) Effect of process conditions on reaction stoichiometry.

MEASUREMENTS
TO BE MADE:

- a) Pressure and temperature in reactor.
- b) Oxygen or air flow rate to reactor vs. time.
- c) Composition of slurry in reactor-solution copper, acid, ammonia concentration, slurry density and solids composition.
- d) Agitation speed.
- e) Slurry level.

INDEPENDENT
VARIABLES TO
BE CONSIDERED:

- a) Leach temperature.
- b) Oxygen partial pressure.
- c) Solution (slurry) composition and slurry density.
- d) Agitation speed.
- e) Agitation/gas dispersion arrangement - baffle extensions, turbine height, dispersion pipe design.
- f) Extent of preleaching (see Determination No. 24).

DETERMINATION NO. 28

FUNCTION TO
BE DETERMINED:

Reactor total material balance.

OPERATIONS AND
EQUIPMENT ITEMS:

Pressure oxygen/air leaching of purge scrub solution
in reactor vessel 201.

STREAMS OF
INTEREST:

- a) Slurry stream from Tank 101.
- b) Regenerated scrub solution to Tank 102.
- c) Sulfuric acid stream from Tank 303.
- d) Air/oxygen stream.
- e) Steam sparged to reactor.

INFORMATION
TO BE DERIVED:

- a) Consistency and reliability of the data.
- b) State of operation of the regeneration reactor.

MEASUREMENTS
TO BE MADE:

- a) Extent of liquid depletion (level change) from T101 on charging reactor.
- b) Extent of sulfuric acid use from T303 on charging reactor.
- c) Extent of replenishing (level change) of Tank T201.
- d) Total volume of air sparged.
- e) Initial and final level of reactor.
- f) Temperature use of reactor contents due to steam.

INDEPENDENT
VARIABLES TO
BE CONSIDERED:

To be assessed during reactor operations.

DETERMINATION NO. 29

FUNCTION TO BE DETERMINED:	Component material balances in the regeneration reactor.
OPERATIONS AND EQUIPMENT ITEMS:	Pressure oxygen/air leaching of purge scrub solution in reactor vessel 201.
STREAMS OF INTEREST:	<ul style="list-style-type: none">a) Oxygen/air stream to reactor.b) Sulfuric acid stream.c) Slurry stream from T101.d) Contents of reactor.e) Regenerated scrub solution to Tank T102.
INFORMATION TO BE DERIVED:	<ul style="list-style-type: none">a) Consistency and reliability of data.b) Regeneration reactor stoichiometry as a function of operating conditions.c) Optimal operating conditions for leach regeneration.
MEASUREMENTS TO BE MADE:	<ul style="list-style-type: none">a) Total material balance on reactor (See Determination No. 29).b) Solution compositions at start and end of regeneration - Cu^{++}, NH_4^+, H^+, SO_4^{--}, H_3BO_3.c) Slurry density and solids composition at start and end of regeneration.
INDEPENDENT VARIABLES TO BE CONSIDERED:	<ul style="list-style-type: none">a) Leach temperature.b) Use of air vs. oxygen - oxygen partial pressure.c) Initial solution composition.d) Slurry density.e) Solids composition.f) Extent of preleaching (See Determination No. 24).g) Rate of leaching - total leach time.h) Extent of leaching.

DETERMINATION NO. 30

**FUNCTION TO
BE DETERMINED:**

Overall heat transfer coefficient in clean service and dependence of the film coefficients on operating conditions.

**OPERATIONS AND
EQUIPMENT ITEMS:**

Cooling of hot agitated contents (water) of reaction V201 with jacket cooling water.

**STREAMS OF
INTEREST:**

- a) Contents of reactor V201 (water).
- b) Cooling water flow through reactor jacket.

**INFORMATION
TO BE DERIVED:**

- a) The overall clean service heat transfer coefficient as a point of reference for determining rate of fouling.
- b) Dependence of film coefficients on agitation rate (gassed and ungassed) and cooling water flow rate.

**MEASUREMENTS
TO BE MADE:**

- a) Initial and final contents of reactor V201 (water).
- b) Temperature of reactor contents as function of time.
- c) Temperature of cooling water in/out.
- d) Flow rate of cooling water.
- e) Agitation speed.
- f) Air flow rate and reactor pressure.

**INDEPENDENT
VARIABLES TO
BE CONSIDERED:**

- a) Active volume of reactor.
- b) Agitator speed.
- c) Agitation/gas dispersion arrangement.
- d) Cooling water flow rate.
- e) Air flow rate - gassed density.

DETERMINATION NO. 31

FUNCTION TO
BE DETERMINED:

Change in overall heat transfer coefficient due to fouling in the regeneration reactor during process use.

OPERATIONS AND
EQUIPMENT ITEMS:

Water jacketed cooling of the regeneration reactor to remove exothermic heat of reaction.

STREAMS OF
INTEREST:

- a) Jacket cooling water.
- b) Contents of reactor V201.

INFORMATION
TO BE DERIVED:

- a) Rate of change of overall heat transfer coefficient for the cooling jacket in service.
- b) Determination of combined fouling coefficients and their dependence on operating conditions.

MEASUREMENTS
TO BE MADE:

- a) Jacket water inlet and outlet temperatures and flow rate.
- b) Reactor temperature.
- c) Rate of leaching (see Determination No. 27, 41).
- d) Gassed slurry density.
- e) Agitation speed.
- f) Air flow rate.
- g) Leach slurry compositions.

INDEPENDENT
VARIABLES TO
BE CONSIDERED:

- a) Active volume of reactor.
- b) Agitator speed.
- c) Agitation/gas dispersion arrangement.
- d) Cooling water flow rate.
- e) Air flow rate - gassed density.
- f) Leach slurry composition.

DETERMINATION NO. 32

FUNCTION TO
BE DETERMINED:

Overall heat transfer coefficient during clean service and dependence of film coefficients on flow rate.

OPERATIONS AND
EQUIPMENT ITEMS:

Cooling of regenerated copper sulfate solution (water) in heat exchanger 202.

STREAMS OF
INTEREST:

- a) Cooling water entering and leaving the exchanger.
- b) Slurry (water) entering and leaving the exchanger.

INFORMATION
TO BE DERIVED:

- a) Overall clean service heat transfer coefficient as a point of reference for determining fouling.
- b) Dependence of film coefficients on flow rates.

MEASUREMENTS
TO BE MADE:

- a) Temperature of entering and leaving cooling water.
- b) Temperature of entering and leaving slurry (water).
- c) Flow rate of regenerated copper sulfate stream (water).

INDEPENDENT
VARIABLES TO
BE CONSIDERED:

- a) Flow rate of regenerated copper sulfate streams (water).
- b) Flow rate of cooling water.
- c) Time exchanger has been in service.

DETERMINATION NO. 33

FUNCTION TO
BE DETERMINED:

Rate of change of overall heat transfer coefficient
due to fouling.

OPERATIONS AND
EQUIPMENT ITEMS:

Cooling of regenerated copper sulfate solution in
heat exchanger 202 prior to transfer to holding
tank T201.

STREAMS OF
INTEREST:

- a) Cooling water, entering and leaving the exchanger.
- b) Regenerated copper sulfate solution entering and
leaving the exchanger.

INFORMATION
TO BE DERIVED:

- a) Rate of change of overall heat transfer coefficient
in service.
- b) Determination of combined fouling coefficient and
their dependence on operating conditions.

MEASUREMENTS
TO BE MADE:

- a) Temperature of entering and leaving cooling water.
- b) Temperature of entering and leaving copper sulfate
solution.
- c) Flow rate of copper sulfate solution.
- d) Compositions of copper sulfate solution.

INDEPENDENT
VARIABLES TO
BE CONSIDERED:

- a) Flow rate and temperature of copper sulfate solution.
- b) Composition of copper sulfate solution.
- c) Time the exchanger has been in service.

DETERMINATION NO. 34

**FUNCTION TO
BE DETERMINED:** Rate of consumption of sulfuric acid and/or calibrations of FI361.

**OPERATIONS AND
EQUIPMENT ITEMS:** Supply of makeup sulfuric acid to leach vessel 201 from tank 303.

**STREAMS OF
INTEREST:** Sulfuric acid stream from tank 303.

**INFORMATION
TO BE DERIVED:** Calibrations of process instrumentation.

**MEASUREMENTS
TO BE MADE:**

- a) Flow rate vs. time for sulfuric acid.
- b) Change of level vs. time in tank 303.
- c) Change of level in reactor V201.

**INDEPENDENT
VARIABLES TO
BE CONSIDERED:** To be assessed during reactor operations.

DETERMINATION NO. 35

FUNCTION TO
BE DETERMINED:

Extent of neutralization of the clear liquid purge
prior to disposal.

OPERATIONS AND
EQUIPMENT ITEMS:

Ammonia sparging and agitation of overflow solution
from the decanter in tank 302 to neutralize acid.

STREAMS OF
INTEREST:

- a) Ammonia from tank 306.
- b) Acid purge from decanter.
- c) Contents of tank T302
- d) Neutralized purge to disposal.

INFORMATION
TO BE DERIVED:

- a) pH of neutralized purge to insure safe disposal.
- b) Effect of pH on subsequent copper removal step.
- c) Confirmation of system sulfate balance/acidity
in solubles purge.

MEASUREMENTS
TO BE MADE:

- a) pH of circulating purge stream.
- b) Change of volume versus time in tank 306.
- c) Flow rate and acidity of solubles purge.
- d) Flow rate of ammonia.
- e) Level charge in tank T302.

INDEPENDENT
VARIABLES TO
BE CONSIDERED:

- a) Addition rate of ammonia.
- b) Circulation and agitation rate of tank contents.
- c) Solution temperature and composition.

DETERMINATION NO. 36

FUNCTION TO
BE DETERMINED:

Rate of use of ammonia and material balance in neutralization.

OPERATIONS AND
EQUIPMENT ITEMS:

Depletion of ammonia in Tank 306 for use in neutralization.

STREAMS OF
INTEREST:

- a) Acid purge from decanter.
- b) Ammonia feed stream from Tank 306 to Tank 302.

INFORMATION
TO BE DERIVED:

- a) Calibration of process instrumentation.
- b) Consistency and reliability of data.

MEASUREMENTS
TO BE MADE:

- a) Flow rate on FI360 vs. time.
- b) Level change in Tank 306 vs. time.

INDEPENDENT
VARIABLES TO
BE CONSIDERED:

To be assessed during neutralizer operation.

DETERMINATION NO. 37

FUNCTION TO BE DETERMINED:	Rate of use of oxygen in regeneration and total use.
OPERATIONS AND EQUIPMENT ITEMS:	Storage and supply of oxygen from tank 305.
STREAMS OF INTEREST:	Oxygen feed line from tank 305.
INFORMATION TO BE DERIVED:	a) Calibration of process instrumentation. b) Rate of loss of O_2 due to heat leak.
MEASUREMENTS TO BE MADE:	a) Changes of level versus time in tank 305. b) Flow rate versus time of the oxygen feed.
INDEPENDENT VARIABLES TO BE CONSIDERED:	Rate of use of O_2 for process purposes vs. idle time.

DETERMINATION NO. 38A

FUNCTION TO
BE DETERMINED: Rate and extent of removal of copper from soluble purge.

OPERATIONS AND
EQUIPMENT ITEMS: Recovery of purge stream soluble copper in tank 301 by
addition of scrap iron.

STREAMS OF
INTEREST: a) Neutralized purge stream from tank 302.
b) Scrap iron to tank 301.
c) Decopperized purge from tank 301.

INFORMATION
TO BE DERIVED: a) Rate and extent of copper recovery possible from the
purge stream using scrap iron.
b) The effect of operating conditions, solution composition and type of scrap on removal.

MEASUREMENTS
TO BE MADE: a) Initial copper content and acidity of purge to be
treated.
b) Total amount of batch being treated.
c) Total amount of iron added and its specific area.
d) Solution copper, iron and acid contents as a function
of contact time.
e) Rate of solution circulation and/or agitation.
f) Residual amount of iron and amount of copper produced.

INDEPENDENT
VARIABLES TO
BE CONSIDERED: a) Purge stream composition and temperature.
b) Percent excess iron used.
c) Physical properties of scrap - specific area.
d) Method of achieving solid/liquid contact.
e) Contact time.

DETERMINATION NO. 38B

FUNCTION TO
BE DETERMINED:

Rate and extent of purge stream copper sulfate recovery.

OPERATIONS AND
EQUIPMENT ITEMS:

Recovery of purge stream soluble copper in tank 301
by addition of H_2S .

STREAMS OF
INTEREST:

- a) Neutralized purge stream from tank 302.
- b) H_2S gas to tank 301 or its circulating loop.
- c) Decopperized purge from tank 301.

INFORMATION
TO BE DERIVED:

- a) Rate and extent of copper recovery possible from the
purge stream using H_2S .
- b) The effect of operating conditions and solution com-
position.
- c) Regenerability of precipitated sulfide.

MEASUREMENTS
TO BE MADE:

- a) Initial copper content and acidity of purge to
be treated.
- b) Total amount of batch being treated.
- c) Rate of addition of H_2S .
- d) Solution copper content as a function of time.
- e) Rate of solution circulation and/or agitation.
- f) Amount of solids precipitated.
- g) Rate and extent of regeneration of precipitated
solids.

INDEPENDENT
VARIABLES TO
BE CONSIDERED:

- a) Purge stream composition and temperature.
- b) Method and rate of introduction of H_2S .

DETERMINATION NO. 39

**FUNCTION TO
BE DETERMINED:**

Rate of heat loss from the scrubbing column and the moisture content of the steam.

**OPERATIONS AND
EQUIPMENT ITEMS:**

Steam passing through scrubbing column.

**STREAMS OF
INTEREST:**

- a) Steam entering scrubbing column.
- b) Column sump level.

**INFORMATION
TO BE DERIVED:**

- a) Rate of heat loss from scrubbing column to support material and energy balance calculations.
- b) Moisture content of inlet steams to support material and energy balances.

**MEASUREMENTS
TO BE MADE:**

- a) Rate of level increase in column sump.
- b) Column pressure and temperature.
- c) Steam flow rate.
- d) Ambient conditions - temperature, wind speed, precipitation.
- e) Insulation surface temperature.

**INDEPENDENT
VARIABLES TO
BE CONSIDERED:**

- a) Steam flow rate.
- b) Column pressure.
- c) Ambient conditions (as appropriate).
- d) Integrity of insulation (as appropriate).

DETERMINATION NO. 40

FUNCTION TO
BE DETERMINED: Scrubbing column energy balance, heat of reaction.

OPERATIONS AND
EQUIPMENT ITEMS: Removal of H_2S and NH_3 in scrubbing column by contacting
with acid copper sulfate.

STREAMS OF
INTEREST:

- a) Entering and departing steam.
- b) Makeup and purge scrub solution.
- c) Demister wash.

INFORMATION
TO BE DERIVED:

- a) Inference of flow rate of cleaned steam from scrubbing column.
- b) Consistency and validity of data.

MEASUREMENTS
TO BE MADE:

- a) Flow rate and temperature of makeup copper sulfate.
- b) Flow rate and temperature of demister wash.
- c) Flow rate of purged scrub solutions.
- d) Steam flow rate.
- e) Column heat loss and steam moisture content (see Determination No. 39).
- f) (Calculated) heat of reaction, H_2S removal (see Determination No. 1).
- g) (Calculated) heat of reaction, NH_3 removal (see Determination No. 2).
- h) Steam inlet and outlet pressure and temperature.

INDEPENDENT
VARIABLES TO
BE CONSIDERED: To be assessed during operations of the scrubber.

DETERMINATION NO. 41

FUNCTION TO
BE DETERMINED: Regeneration reactor energy balance, heat of reaction.

OPERATIONS AND
EQUIPMENT ITEMS: Regeneration of copper sulfate from sulfide by air/
 oxygen in pressure leach reactor.

STREAMS OF
INTEREST: a) Contents of reactor V 201
 b) Leach air/oxygen.
 c) Reactor jacket cooling water.

INFORMATION
TO BE DERIVED: Consistency and validity of data.

MEASUREMENTS
TO BE MADE: a) Flow rate and temperature of cooling water.
 b) Temperature and rate of change of temperature
 of reactor contents.
 c) Total amount of reactor contents.
 d) (Calculated) heat of reaction, Cu_2S oxidation
 (see Determination No. 27).
 e) Flow rate and pressure of leach air.

INDEPENDENT
VARIABLES TO
BE CONSIDERED: To be assessed during operation of the reactor.

DETERMINATION NO. 42

FUNCTION TO
BE DETERMINED: Power consumption of process agitators.

OPERATIONS AND
EQUIPMENT ITEMS: . Slurry suspension by agitation in tanks 101, 301,
and 302 and reactor 201.

STREAMS OF
INTEREST: Contents of tanks 101, 301, 302, and reactor 201.

INFORMATION
TO BE DERIVED: Performance of the agitators in suspending solids
and dispersing gas as functions of speed, power,
and impeller configuration.

MEASUREMENTS
TO BE MADE:

- a) Agitator power.
- b) Agitator configuration - height, baffling, speed.
- c) Slurry volume.
- d) Settling rate of slurry.
- e) Solution compositions and slurry density.
- f) Air/oxygen flow rate (for regeneration reactor).

INDEPENDENT
VARIABLES TO
BE CONSIDERED:

- a) Impeller diameter, speed, baffling arrangement.
- b) Slurry volume and density.
- c) Gassed density (for regeneration reactor).

DETERMINATION NO. 43

**FUNCTION TO
BE DETERMINED:**

Build up of trace elements in the system.

**OPERATIONS AND
EQUIPMENT ITEMS:**

Scrubbing of H₂S and regeneration of precipitated sulfides in an integrated scrubber-liquid/solid separation-regeneration system.

**STREAMS OF
INTEREST:**

- a) Inlet and outlet steam.
- b) Makeup process materials.
- c) Solubles purge stream.
- d) Process solid residues.
- e) Demister wash (and other process makeup) water.

**INFORMATION
TO BE DERIVED:**

- a) Extent and rate of build up of trace elements in an integrated system.
- b) Effect of operating conditions on build up of individual impurities.

**MEASUREMENTS
TO BE MADE:**

- a) Flow rate and trace element content of inlet and outlet steam.
- b) Makeup rate and trace element content of process materials.
- c) Flow rate and trace element content of soluble purge stream.
- d) Rate of build up and composition of process solid residues.
- e) Flow rate and trace element content of demister wash (and other process makeup) water.

**INDEPENDENT
VARIABLES TO
BE CONSIDERED:**

- a) Purge stream-to-steam flow rate ratio.
- b) Scrubber operating conditions (solution composition and tray hydraulics).
- c) Rate of addition of makeup water (all sources).

DETERMINATION NO. 44

FUNCTION TO
BE DETERMINED: Process total and major component material and energy
balances.

OPERATIONS AND
EQUIPMENT ITEMS: Scrubbing of H_2S and regeneration of precipitated sul-
fides in an integrated scrubber-liquid/solid separation-
regeneration system.

STREAMS OF
INTEREST:

- a) Inlet and outlet steam.
- b) Demister wash (and other process makeup) water.
- c) Solubles purge stream.
- d) Preleach air, leach air or oxygen and vents.
- e) Makeup process materials ($CuSO_4$, H_2SO_4 , NH_3).
- f) Process solid residues.

INFORMATION
TO BE DERIVED:

- a) Consistency and reliability of the data.
- b) State of operation of the system.

MEASUREMENTS
TO BE MADE:

- a) Copper balance: flow rate and copper content steam
out, solubles purge, process solid residues, makeup
 $CuSO_4$.
- b) Sulfur balance: flow rate and sulfur (sulfides, sul-
fate) content steam in/out, solubles purge, process
solid residues, makeup $CuSO_4$, H_2SO_4 , makeup water.
- c) Ammonia balance: flow rate and ammonia (ammonium)
content steam in/out, solubles purge, process solid
residues, neutralization NH_3 , makeup water.
- d) Boron balance: flow rate and boron content steam
in/out, solubles purge, process solid residues,
makeup process materials and water.
- e) Acidity balance: in conjunction with (b) and (c).
- f) Water balance: steam in, demister wash (and other
process makeup), solubles purge rates. Scrubbing
column energy balance (see Determination No. 39,40),
leach reactor energy balance (see Determination No. 41).

INDEPENDENT
VARIABLES TO
BE CONSIDERED: To be assessed during system operation.

DETERMINATION NO. 45

**FUNCTION TO
BE DETERMINED:**

Suitability of materials of construction under various process conditions.

**OPERATIONS AND
EQUIPMENT ITEMS:**

Steam scrubbing in column, regeneration in leach reactor, storage of solutions and slurries in process tankage.

**STREAMS OF
INTEREST:**

- a) Scrubbed geothermal steam.
- b) Scrubbing solution at upstream conditions.
- c) Cooled scrub (purge) solution.
- d) Decanted slurry-storage and ambient leach.
- e) Decanted slurry-pressure leaching.
- f) Regenerated copper sulfate.
- g) Neutralized purge.

**INFORMATION
TO BE DERIVED:**

- a) Corrosion rate of various alloys at scrubber conditions
- b) Corrosion rate of alloys and performance of composite materials in other process steps.
- c) Effect of process conditions on materials suitability.

**MEASUREMENTS
TO BE MADE:**

- a) Weight loss (gain) of test coupons.
- b) Resistance change of continuous corrosion measuring elements.
- c) Change in mechanical strength of composite materials.
- d) Dimensional change, incidence of pitting, stress corrosion, weld attack, crevice corrosion, etc. of test coupons.

**INDEPENDENT
VARIABLES TO
BE CONSIDERED:**

- a) Location of test coupon/element in the process.
- b) Process conditions: stream temperature, composition, velocity.
- c) Materials subjected to test.
- d) Condition of material tested, e.g., plain, welded, etc.
- e) Length of test.

TEST PLAN

SECTION 4

ANALYTICAL TECHNIQUES TO BE USED AND SCHEDULES

SECTION 4

ANALYTICAL TECHNIQUES TO BE USED AND SCHEDULES

Anal. No.	Measurement	Analytical Technique	Used in Determination No.	Routine Frequency
1	H ₂ S in steam, in/out	Condense in conc. NH ₄ OH. Titrate with AgNO ₃ .	1, 10, 44	Inlet 1/shift Outlet 1/hour
2	NH ₃ in steam, in/out	Condense in standard H ₂ SO ₄ . Back titrate with NaOH.	2, 10, 44	Inlet 1/shift Outlet 2/day shift, 1/shift others
3	B in steam, in/out	Offsite. Argon plasma emission.	3, 10, 44	Inlet, outlet 1/day
4	Total steam composition	Offsite. Refereed analysis for H ₂ S, NH ₃ , B.		Infrequent, as required
5	Cu ⁺⁺ in: Purge slurry Makeup CuSO ₄ CuSO ₄ storage Slurry storage Leach Neutralization Cu removal Steam out	Direct spectrophotometric @ 825 mμ (near-IR)	10 10 10 10, 24 27, 31 35 38 44	2/shift 2/shift 1/day following leach 1/day prior to leach (except during preleach) As required (6/batch) 1/day As required (4/batch)
6	NH ₄ ⁺ in: Purge slurry Makeup CuSO ₄ CuSO ₄ storage Slurry storage Demister wash Leach Neutralization Cu removal	NH ₃ selective electrode Make solution strongly alkaline with conc. NaOH. Measure NH ₃ (aq.) with NH ₃ -specific electrode.	10 10 10 10, 24 10, 24 27, 31 35, 44 38	2/shift 1/shift 1/day 1/day 1/week 1/batch if NH ₃ added for pH control 1/day following NH ₃ addition 1/batch if NH ₃ added for pH control
7	B in: Purge slurry Makeup CuSO ₄ CuSO ₄ storage Slurry storage Demister wash	Offsite. Argon plasma emission spectroscopy.	10 10 10 10 10, 44	1/day 1/day 1/week 1/week 1/week

TP4-2

Anal. No.	Measurement	Analytical Technique	Used in Determination No.	Routine Frequency
8	H ⁺ in: Purge slurry Makeup CuSO ₄ CuSO ₄ storage Slurry storage Leach Neutralization Cu removal.	Titration with NaOH	10 10 10 10, 24 27, 31 35, 44 38	2/shift 1/shift 1/day following leach 1/day prior to leach (except during preleach) As required (3/batch) 1/day following NH ₃ addition 1/batch following Cu removal
9	SO ₄ ⁼ in: Purge slurry Makeup CuSO ₄ Slurry storage Leach Demister wash	Titration with Pb(ClO ₄) ₂ (Pb-ion specific electrode) following Cu ⁺⁺ removal by ion exchange.	10 10 10, 24 27, 31, 44 10, 44	1/day 1/day 1/day (if preleaching, 1/batch) 1/batch following leaching 1/week
10	Total solution analysis, selected samples	Offsite. Refereed analysis for Cu, NH ₄ ⁺ , B, H ⁺ , SO ₄ ⁼		Infrequent, as required.
11	pH in: Steam, in/out Purge slurry Makeup CuSO ₄ CuSO ₄ storage Slurry storage Leach Neutralization Cu removal	pH electrode, condensate samples. pH electrode, cooled slurry purge.	10 10 10 10 24 27 35 38	Inlet 1/day, outlet 1/shift. 2/shift (more if required for calibration) 1/shift 1/day following leach 1/day prior to leach (except during preleach) 1/batch following leach As required during NH ₃ addition 1/batch following Cu removal
12	Solids composition - % Cu Purge slurry Slurry storage Leach Cu removal	Wash with strong H ₂ SO ₄ for removal of solubles. Digest dried solids in conc. HNO ₃ . Cu ⁺⁺ by direct spectrophotometry.	10, 19 24 27, 31, 44 38, 44	1/shift 1/day except during preleach 1/day on composite residues 1/day on composite batch

Anal. No.	Measurement	Analytical Technique	Used in Determination No.	Routine Frequency
13	Solids composition, selected samples	Offsite. Refereed analysis for Cu, S, insols. (SiO_2 , Al_2O_3 , etc.), including petrographic examination		1/week initially, then less frequently.
14	Tracer in: Steam out Demister wash Purge slurry Makeup CuSO_4	Offsite. K^+ by flame photometry or atomic emission	8 8 8 8	2/shift during tracer tests 1/day during tracer tests 1/shift during tracer tests 1/day during tracer tests
15	Cl^- in: Steam, in/out Demister wash CuSO_4 makeup and storage Slurry storage	Offsite. Ag^+ titration	43 43 43 43	1/week 1/week 1/week 1/week
16	S^{2-} in: Steam, in/out Demister Slurry storage Leach	Offsite. As appropriate: org. liq. extraction and U.V. anal., coagulation/filtration, or thiocyanate formation.	10, 44 10, 44 10, 37 27	1/day 1/week 1/day if preleaching 1/week on composite residues
17	Basic copper sulfate in solid residues on process equipment	Dissolve in standard HClO_4 . Analyze for Cu^{2+} , OH^- (by back titration) and SO_4^{2-} .		As required upon appearance
18	Trace elements in: Purge slurry Makeup CuSO_4 Demister wash Process supplies	Offsite. Emission spectroscopy	43 43 43 43	1/week 1/week 1/week As required
19	Solids content (wt %) in: Purge slurry Slurry storage Leach Cu removal Decanter overflow Leach effluent	Filter slurry or weighed filter element. Dry in N_2 or vacuum oven.	10, 19, 20 10, 19, 20, 24 27, 31 38, 44 10, 19, 20, 44 27, 31, 44	1/shift 1/day prior to leach (except during preleach) As required (3/batch) 1/batch 1/day 1/day following leach

TEST PLAN

SECTION 5

DATA ACQUISITION LOGS

SECTION 5

DATA ACQUISITION LOG SUMMARY
EQUIPMENT, FUNCTIONS, FREQUENCY

<u>Equipment Item</u>	<u>Functions Observed</u>	<u>Frequency for Routine Observation</u>
Process Water Tank (T304)	Liquid level.	Hourly.
Process Water Flow Control Valve (FCV302)	Visual inspection of valve operation.	Occasionally.
Process Water Filter (F301)	Pressure (PI327)	Periodically to establish criteria for frequency of replacement.
Demister Wash Water Pump (P304)	Pressure (PI325) Flow (FI363) Pump Rotation.	Hourly.
Cycle Timer (KC301)	Cycling of demister wash solenoid valves.	Hourly.
Seal Flush Pump (P305)	Pressure (PI326) Flow (FI364-367) Pump Rotation.	Continuously, to insure high pressure seal water for circulating pumps.
Scrubbing Column (C101)	Sump Level (LI104) Column Pressure (PI120, PI121, PI123) Column Temperatures (TI140, 141)	Hourly. Occasionally. Occasionally.
Demister Element	Differential Pressure (DPI109)	Hourly.
Scrub Column Tray	Differential Pressure (DPR103)	Continuously.
Steam Flow Control Valve (FCV101)	Pressure (PI122) Flow (FR101)	Hourly.
Scrub Circulating Pumps (P101, 101A)	Pressure (PI124, 125) Flow FR103 Pump Rotation.	Hourly.
Makeup CuSO ₄ Pump (P102, 102A)	Pressure (PI131, 132) Flow (FR105) Pump Rotation.	Continuously, to insure flow of makeup CuSO ₄ .

DATA ACQUISITION LOG SUMMARY
EQUIPMENT, FUNCTIONS, FREQUENCY

<u>Equipment Item</u>	<u>Functions Observed</u>	<u>Frequency for Routine Observation</u>
Heat Exchanger (HX101)	Temperature (TI142, 145, 146). Pressure (PI126, 133) Flow (FR105, 107, 108)	Hourly.
Heat Exchanger (HX102)	Temperature (TI143, 147, 148) Pressure (PI126, 127)	Hourly.
Heat Exchanger (HX103)	Temperature (TI144, 145, 149) Pressure (PI131, 132, 133).	Hourly.
Sample Line Filter (F101, F101A)	Flow Indicator (FI160, 160A) Pressure (PI127, 134)	Occasionally.
Decanter (C102)	Flow (FR107, 108) Overflow clarity (SFG161) Pulp Height (in level glass).	Continuously, to insure adequate overflow clarity and underflow rate.
Decanter Overflow Filter (F102)	Pressure (PI129, 130) Flow (FR108)	Occasionally, to establish a filter replacement cycle.
Underflow Slurry Flow Control Valve (FCV107)	Valve Operation Position	Continuously, to insure solids plug does not develop.
Copper Analyzer (AIT105)	Copper Concentration, indicated and measured off line.	Hourly, daily for off line check.
pH Analyzer (PHI106)	pH, indicated and measured off line.	Hourly, daily for off line check.
Copper Sulfate Storage Tank (T102)	Level.	Daily.
Slurry Circulating Pumps (P103, 103A)	Pressure (PI220, 221) Pump Rotation.	Hourly, except continuously during ambient leaching.

DATA ACQUISITION LOG SUMMARY
EQUIPMENT, FUNCTIONS, FREQUENCY

<u>Equipment Item</u>	<u>Functions Observed</u>	<u>Frequency for Routine Observation</u>
Slurry Storage Tank and Agitator (T101, A101)	Liquid Level (LI201). State of suspensions of solids. Agitator rotations.	Hourly, except continuously during ambient leaching.
Heat Exchanger (HX201)	Temperature (TI240, 241) Flow (PI221, 229) Drip rate from steam trap.	Hourly.
Ambient Air Leach Contactor	Air Flow Rate (FI209)	Continuously during ambient leach.
Regeneration Reactor and Agitator (V201, A201)	Pressure (PI222, PR205) Temperature (TI242, TR202) Level (LI203) Agitator Power (JR209)	Fifteen minute intervals during operation (more frequently if required).
Temperature Control Valve (TCV209)	Pressure (PI227, 222) Steam Flow (valve position)	Continuously during heat up.
Cooling Water Flow Control Valve (TCV202)	Temperature (TI147, 247)	Fifteen minute intervals during operation.
Air Compressor and Flow Control (P401)	Pressure (PI223) Flow (FR208) Compressor Controls	Half hour intervals during operation.
Oxygen Flow Controls (PCV205A)	Pressure (PI224, 225) Flow (FR207) Level, pressure in Tank T305.	Fifteen minute intervals during operation.
Vent Scrubber (V202)	Drip rate to drain.	Fifteen minute intervals during operation.
Heat Exchanger (HX202)	Temperature (TI242, 245, 246) Flow (LI203)	Fifteen minute intervals when draining reactor.

DATA ACQUISITION LOG SUMMARY
EQUIPMENT, FUNCTIONS, FREQUENCY

<u>Equipment Item</u>	<u>Functions Observed</u>	<u>Frequency for Routine Observation</u>
Holding Tank (T201)	Liquid Level.	Fifteen minute intervals when draining reactor.
Transfer Pump (P201)	Pressure (PI226) Pump Rotation.	Fifteen minute intervals when draining reactor.
Polishing Filter (F201)	Pressure (PI226) Flow (level change, Tank T201)	Fifteen minute intervals or as frequency as required to establish criteria for filter cleaning.
Oxygen Storage Tank (T305)	Level, Pressure.	Daily.
Neutralization Tank and Agitator (T302, A302)	Temperature (TI340) Liquid Level Agitator Rotation	Hourly.
Circulating Pump (P302)	Pressure (PI320) Pump Rotation.	Hourly.
Ammonia Flow Control (FCV321)	Pressure (PI321, 322) Flow (FI360) Level, pressure in Tank T306.	Hourly during neutralization.
Circulating Pump (P301)	Pressure (PI323) Pump Rotation.	Hourly.
H ₂ S Addition System (FI368)	Flow (FI368) Condition of H ₂ S Alarm System	Continuously during use of H ₂ S for decopperization.
Polish Filters (F302)	Pressure (PI323) Flow (level change, Tank T301).	As frequently as required to establish criteria for filter cleaning.

DATA ACQUISITION LOG SUMMARY
EQUIPMENT, FUNCTIONS, FREQUENCY

<u>Equipment Item</u>	<u>Functions Observed</u>	<u>Frequency for Routine Observation</u>
Makeup Ammonia Tank (T306 and T306A)	Level, Pressure.	Daily.
Transfer Pump (P303)	Pressure (PI324) Flow (FI361)	Fifteen minute intervals during use.
Acid Storage Tank (T303)	Level (LI362)	Daily.

TEST PLAN

SECTION 6

SCHEDULE OF OPERATIONS FOR FIELD TEST WORK

SECTION 6

TEST PLAN, TASK 8

WATER TESTING AND OPERATOR TRAINING

<u>Day Into Task Effort</u>	<u>Shifts Operated</u>	<u>Operations Carried Out</u>	<u>Comments</u>
1	1	-	Cold System Walk Through
2	1	-	System Start Up, Shut Down
3	1	21, 22, 23, 24	Instrumentation Checks
4	1	4, 6, 39, 17	Column, Filter Testing
5	1	As required.	Repeat, Revision, Repair
8	1	11, 13, 25, 32, 15	Heat Exchanger Testing
9	1	11, 13, 30	Heat Exchanger Testing
10	1	4, 6, 8, 42	Miscellaneous
11	2	As required.	Simulation of System Operation, Final Instrumentation Checks.
12	1	As required.	Repeat, Revision, Repair Prepare System for Task 9.
6, 7, 13, 14	-	-	Free Days

TEST PLAN, TASK 9
OPEN CIRCUIT SCRUBBING/REGENERATION TESTING

<u>Day Into Task Effort</u>	<u>Shifts Operated</u>	<u>Operations Carried Out</u>	<u>Comments</u>
1	1	1, 2, 5, 7, 9, 10, 40	Scrubbing Column Tests
2, 3	2	1, 2, 3, 5, 7, 9, 10, 40 12, 14, 16, 18, 19, 20	Scrubbing Column and Auxiliaries Tests
4	2	24, 26, 35, 36	Ambient Leach and Neutralization Tests
5	1	27, 28, 29, 31, 33, 41 4, 6, 11, 13, 15	Pressure Leach, Column and Auxiliaries Water Test
8	1	As required.	Inspect, Revise, Repair, Prepare for Additional Tests
9	3	1, 2, 3, 5, 7, 9, 10, 40 12, 14, 16, 18, 19, 20	Scrubbing Column and Auxiliaries Tests
10	1	1, 2, 3, 5, 7, 9, 10, 40 12, 14, 16, 18, 19, 20	Scrubbing Column and Auxiliaries Tests
10	1	4, 6, 11, 13, 15	Column and Auxiliaries Water Testing
11	3	24, 26, 35, 36 27, 28, 29, 31, 33, 41 25, 30, 32	Ambient Leach and Neutralization, Pressure Leach and Water Tests
12	1	As required.	Inspect, Revise, Repair, Prepare System for Task 10.
6, 7, 13, 14	-	-	Free Days.

TEST PLAN, TASK 10

CLOSED CIRCUIT, SHORT TERM TESTING

<u>Day Into Task Effort</u>	<u>Shifts Operated</u>	<u>Operations Carried Out</u>	<u>Comments</u>
1	2	1, 2, 5, 7, 9, 10, 40 12, 14, 16, 18, 19, 20	Scrubbing Column and Auxil- iaries Tests for Rangeability Determination
2	2	24, 26, 35, 36 27, 28, 29, 31, 33, 41	Ambient and Pressure Leach Tests for Rangeability Determination
3, 4	3	Suite 1	Closed Circuit Operability Tests, Nominal Conditions
5	2	4, 6, 11, 13, 15 25, 30, 32	Water Tests, All Components
8	2	Suite 4	Inspect, Revise, Repair
9, 10	3	Suite 1	Closed Circuit Tests, Mini- mum Purge Flow Conditions
11	2	Suite 2	Closed Circuit Tests, Mini- mum Purge Flow Conditions
12	2	Suite 3	Water Tests, All Components
15	2	Suite 4	Inspect, Revise, Repair
16, 17	3	Suite 1	Closed Circuit Tests, Mini- mum Solids Alteration Con- ditions.
18	2	Suite 2	Closed Circuit Tests, Mini- mum Solids Alteration Con- ditions.
19	2	Suite 3	Water Tests, All Components
22, 23	3	Suite 1	Closed Circuit Tests, Maxi- mum Purge and Solids Altera- tion.

TEST PLAN, TASK 10
(continued)

<u>Day Into Task Effort</u>	<u>Shifts Operated</u>	<u>Operations Carried Out</u>	<u>Comments</u>
24	3	Suite 1	Closed Circuit Tests, Con- ditions to be Defined.
25	2	Suite 3	Water Tests, All Components.
25	1	Suite 4	Prepare for Inspection.
20	2	Suite 4	Inspect, Revise, Repair.
6, 7, 13, 14 20, 21, 27, 28	-	-	Free Days.

Suite 1: All operations normally used for monitoring, control, and evaluation; Nos. 1, 2, 3, 5, 7, 9, 10, 12, 14, 16, 18, 19, 20, 24, 26, 27, 28, 29, 31, 33, 35, 36, 37, 40, 41, 42, 44.

Suite 2: All Suite 1 operations, plus calibrations, entrainment, copper removal, and trace element tests; Nos. 8, 21, 22, 23, 34, 38A, 38B, 43.

Suite 3: All operations normally used for water testing to verify rates of fouling or approach to clean service conditions; Nos. 4, 6, 11, 13, 15, 17, 25, 30, 32, 39.

Suite 4: Disassembly of components of the system to the extent required for inspection and minor mechanical revision and repair.

TEST PLAN, TASK 11

CLOSED CIRCUIT, LONG TERM TESTING

<u>Week Into Task Effort</u>	<u>No. of Shifts Allowed for Operations Involving:</u>				
	<u>Suite 1</u>	<u>Suite 2</u>	<u>Suite 3</u>	<u>Suite 4</u>	<u>Suite 5</u>
1	12	1	2	1	5
2	11	3	-	2	5
3	15	1	-	1	4
4	11	6	-	-	4
5	13	1	2	1	4
6	13	3	-	1	4
7	16	1	-	-	4
8	11	6	-	-	4
9	14	1	2	1	3
10	14	3	-	1	3
11	18	1	-	-	2
12	13	6	-	-	2
13	15	1	2	1	2
14	15	3	-	1	2
15	18	1	-	-	2
16	13	6	-	-	2
17	12	6	2	1	0

Suite 5: Free shifts, unscheduled downtime, major mechanical revision and repair.

OPERATING INSTRUCTIONS

SECTION 1

PROCESS FLOW DIAGRAMS, DEMONSTRATION PLANT

OPERATING INSTRUCTIONS

SECTION 2

OPERATIONS TO BE CARRIED OUT DURING TEST OPERATIONS

SECTION 2

OPERATION NO. 1

FUNCTION TO
BE DETERMINED:

Scrubbing efficiency for removal of hydrogen sulfide.

TEST
CONDITIONS:

	<u>Nominal</u>	<u>Min/Max</u>
a) Scrub liquid to steam flow rate ratio (nominal steam flow)	1	0.5/4
b) Steam flow rate, MPPH	100	50/120
c) Scrub solution pH, g/l Cu	1.2, 2	1.0, 1/1.6, 4
g/l (NH ₄) ₂ SO ₄ , MPPM B	100, 3	50, 1/125, 5
d) Froth height, ft, tray DP, in.	6, 18	3, 7/9, 36
e) Solids content, w/o, residence time, hr.	2, 2, 4	1.1, 2/3.3, 6
f) Tray design, vapor area, %	20	As required
Downcomer flow, GPM/ft ² .	300	As required

MEASUREMENTS
TO BE MADE:

- Collect inlet and outlet steam (condensate) samples, H₂S content by analysis No. 1.
- Record: Steam flow rate, FR101
System pressure, PR110.
Scrub liquid recirculation rate, FR103
Tray DP, DPR103 (froth height if visible)
Sump level, LI104.
- Collect purge slurry sample at indicated frequencies, composition by analyses No. 5, 6, 7, 8, 11, 12 and 19.

EVALUATION OF
OPERATING DATA:

- Percent H₂S removal determined directly from inlet and outlet steam composition.
- Other data recorded for establishing correlation(s) with operating conditions. Anticipate dependence on superficial contact time (froth height or tray DP/steam velocity), pH, copper content below a critical value.

OPERATION NO. 2

FUNCTION TO
BE DETERMINED:

Scrubbing efficiency for removal of ammonia.

TEST
CONDITIONS:

Nominal Min/Max

Same as Operation No. 1.

MEASUREMENTS
TO BE MADE:

- a) Collect inlet and outlet steam (condensate) samples, NH₃ content by analysis No. 2.
- b) Record steam flow rate, scrub recirculation rate, tray DP, sump level same as Operation No. 1.
- c) Subject purge slurry sample to analyses same as Operation No. 1.

EVALUATION OF
OPERATING DATA:

- a) Percent NH₃ removal determined directly from inlet and outlet steam composition.
- b) Other data recorded for establishing correlation(s) with operating conditions. Anticipate dependence on superficial contact time (froth height or tray DP/steam velocity), pH, ammonium sulfate content.

OPERATION NO. 3

FUNCTION TO
BE DETERMINED:

Scrubbing efficiency for removal of boron.

TEST
CONDITIONS:

Same as operation No. 1. Nominal Min/Max

MEASUREMENTS
TO BE MADE:

- a) Collect inlet and outlet steam (condensate) samples, B content by analysis No. 3.
- b) Record steam flow rate, scrub recirculation rate, tray DP, sump level same as Operation No. 1.
- c) Subject purge slurry sample to analyses same as Operation No. 1.

EVALUATION OF
OPERATING DATA:

- a) Percent B removal determined directly from inlet and outlet steam composition.
- b) Other data recorded for establishing correlation(s) with operating conditions. Anticipate dependence on superficial contact time (froth height or tray DP/steam velocity), pH, boron content.

OPERATION NO. 4

**FUNCTION TO
BE DETERMINED:**

Contacting tray differential pressure under clean conditions.

**TEST
CONDITIONS:**

	<u>Nominal</u>	<u>Min/Max</u>
a) Scrub liquid to steam flow rate ratio (nominal steam flow)	1	0.5/4
b) Steam flow rate, MPPH	100	50/120
c) Froth height, ft, tray DP, in.	3, 18	1.5, 7/4.5, 36
d) Tray design, vapor area, %	20	As req'd.
Downcomer flow GPM/ft ²	300	As req'd.

**MEASUREMENTS
TO BE MADE:**

- a) Record: Steam flow rate, FR101
System pressure, PR110
Scrub liquid (water) recirculation rate, FR103
Makeup water or demister wash flow rates, FR105, FI363 if applicable.
Time tray has been in service, hr.
- b) Observe froth height and record level if visible.

**EVALUATION OF
OPERATING DATA:**

- a) Data recorded for establishing correlation(s) with operating conditions. Anticipate dependence on superficial steam velocity, percent active area on tray, time tray has been in service (if solids build-up constricts holes), liquid recirculation rate, and downcomer area.
- b) Record also dry hole pressure drop (i.e., without liquid circulation).
- c) If top of froth is visible, record froth height and compute ratio of tray DP to froth height.
- d) Note tray's previous history, particularly extent of fouling and methods taken to clean it.

OPERATION NO. 5

FUNCTION TO
BE DETERMINED:

Contacting tray differential pressure under operating conditions.

TEST
CONDITIONS:

Same as operation No. 1.

Nominal Min/Max

MEASUREMENTS
TO BE MADE:

- a) Record: Steam flow rate, FR101.
System pressure, PR110.
Scrub liquid recirculation rate, FR103.
Makeup CuSO_4 flow rate, FR105.
Demister wash rate, FI363.
Sump level, LI104.
Tray DP, DPR103.
Time tray has been in service, hr.
- b) Observe froth height and record level if visible.
- c) Collect purge slurry sample at indicated frequencies, composition by analyses No. 5, 6, 7, 8, 11, 12 and 19.

EVALUATION OF
OPERATING DATA:

- a) Data recorded for establishing correlation(s) with operating conditions. Anticipate dependence on superficial steam velocity, percent active area on tray, time tray has been in service (if solids build up constricts holes), liquid recirculation rate, downcomer area, sump level (if froth collapse controls downcomer hydraulics).
- b) Average solid's residence time (measured by sump level), slurry solids content, solids composition, and scrub solution composition (particularly pH and copper content) are also anticipated to be key variables.
- c) If top of froth is visible, record froth height and compute ratio of tray DP to froth height.
- d) If testing is terminated inspect tray and record extent and nature of solid build up, if any.

OPERATION NO. 6

FUNCTION TO
BE DETERMINED:

Demister differential pressure under clean conditions.

TEST
CONDITIONS:

	<u>Nominal</u>	<u>Min/Max</u>
a) Steam flow rate, MPPH	100	50/120
b) Demister wash rate (total area) GPM	30	15/60
c) Demister wash frequency, % total time	15	5/50
d) Disengaging space below demister, ft	6	3/9
e) Demister style	8" knit mesh	As req'd.

MEASUREMENTS
TO BE MADE:

- a) Record: Steam flow rate, FR101
System pressure, PR110
Demister wash rate, FI363
Demister wash frequency, KC301
Demister wash sequence (e.g., total, sequential,
etc.)
Tray DP, DPR103
Demister DP, DPI109
Time demister has been in service, hr.
- b) Observe froth height and record level if visible.
- c) Record rate of change of demister DP following
initiation of wash cycle(s).

EVALUATION OF
OPERATING DATA:

- a) Data recorded for establishing correlation(s) with
operating conditions. Anticipate dependence on super-
ficial steam velocity, wash rate, and time demister
has been in service and previous operating history (if
entrainment causes progressive plugging).
- b) Compare observed (unirrigated) pressure drop with
manufacturer's correlations.
- c) Estimate entrained liquid load to demister using tray
entrainment correlations (for effects of gas velocity,
liquid physical properties, and disengaging distance).
- d) Note demister's previous history, particularly extent
of fouling, upset operations resulting in high froth
heights, previously utilized demister wash rates and
frequencies, and methods taken to clean it.

OPERATION NO. 7

FUNCTION TO BE DETERMINED:

Demister differential pressure under operating conditions.

TEST CONDITIONS:

Same as Operation No. 6.

Nominal Min/Max

MEASUREMENTS TO BE MADE:

- a) Record: Steam flow rate, PR101.
System pressure, PR110.
Demister wash rate, FI363.
Demister wash frequency, KC301.
Demister wash sequence (e.g., total, sequential, etc.)
Tray DP, DPR103.
Demister DP, DPI109.
Time demister has been in service, hr.
- b) Collect purge slurry sample at indicated frequencies, composition by analyses No. 5, 6, 7, 8, 11, 12 and 19.
- c) Observe froth height and record level if visible.
- d) Record rate of change of demister DP following initiation of wash cycle(s).

EVALUATION OF OPERATING DATA:

- a) Data recorded for establishing correlation(s) with operating conditions. Anticipate dependence on superficial steam velocity, wash rate, and time demister has been in service and previous operating history (if entrainment causes progressive plugging).
- b) Anticipate scrub solution composition and solids characteristics (slurry density, particle size) and cleaned steam composition (determination No. 1, 2, 3) will effect rate of fouling.
- c) Estimate entrained liquid (slurry) load to demister using tray entrainment correlations (for effects of gas velocity, liquid physical properties and disengaging distance).
- d) Compare observed (unirrigated) pressure drop with manufacturer's correlation. Note maximum pressure drop observed when washing, rate of return to unirrigated condition, and rate of increase of maximum/decrease in rate of return to unirrigated condition.
- e) If testing is terminated inspect demister and record extent and nature of solid build up, if any.

OPERATION NO. 8

FUNCTION TO
BE DETERMINED:

Demister disentrainment efficiency.

TEST
CONDITIONS:

Same as Operation No. 6.

Nominal Min/Max

MEASUREMENTS
TO BE MADE:

- a) Record: Steam flow rate, FR101.
System pressure, PR110.
Demister wash rate, FI363.
Demister wash frequency, KC301.
Demister wash sequence (e.g., total, sequential, etc.)
Tray DP, DPR103.
Demister DP, DPI109.
Time demister has been in service, hr.
- b) Collect outlet steam (condensate), purge slurry and demister wash water samples at indicated frequencies, composition by analysis No. 14.
- c) Observe froth height and record level if visible.

EVALUATION OF
OPERATING DATA:

- a) Data recorded for establishing correlation(s) with operating conditions. Tracer added to system in both clean (steam-water) condition and while scrubbing.
- b) Anticipate dependence on superficial steam velocity, wash rate and frequency, and time demister has been in service and previous operating history (if partial plugging reduces efficiency). May be correlation between (unirrigated) pressure drop and efficiency.
- c) Estimate entrained liquid or slurry load demister using tray entrainment correlations (for effects of gas velocity, liquid physical properties, and disengaging distance).
- d) Compute removal efficiency from tracer content in cleaned steam and calculated entrainment rate to demister and compare with manufacturer's correlation.
- e) If testing is terminated inspect demister and record extent and nature of solid build up, if any.

OPERATION NO. 9

FUNCTION TO BE DETERMINED:

Total material and energy balance around scrubbing column.

TEST CONDITIONS:

	<u>Nominal</u>	<u>Min/Max</u>
a) Steam flow rate, MPPH	100	50/120
b) Demister wash rate (total area) GPM	30	15/60
c) Demister wash frequency, % total time	15	5/50
d) Makeup CuSO ₄ flow rate, GPM	5.7	4/7
e) Purge slurry flow rate, GPM	7	5/9.5

MEASUREMENTS TO BE MADE:

- a) Collect inlet and outlet steam (condensate) samples at indicated frequencies, H₂S, NH₃, B, and S^o contents by analyses No. 1, 2, 3 and 16.
- b) Collect makeup CuSO₄, purge slurry, and demister wash samples at indicated frequencies, composition by analyses No. 5, 6, 7, 8, 9, 12 and 19.
- c) Record: Steam flow rate and pressure, FR101, PI122.
System pressure, PR110.
Sump and scrubbed steam temperatures, TI140, 14
Makeup CuSO₄ flow rate and temperature, FR105,
TI146.
Demister wash flow rate and temperature, FI363,
TI147.
Demister wash frequency, KC301.
Sump level, LI104.
Total purge flow rate, FR107, plus FR108.
Scrub liquid recirculation rate, FR103.
Tray DP, DPR103 (froth height if visible).

EVALUATION OF OPERATING DATA:

- a) Total material/energy balance around scrubber cannot be independently closed since flow of steam out cannot be measured with sufficient accuracy. Therefore, convention is adopted of assuming all measured liquid (slurry) and steam inlet flow rates are correct with sump liquid conditions taken as reference for temperature. Then expected flow rates of cleaned steam will be calculated and compared with inlet rate. Magnitude and source of deviation will be day-to-day indicator of consistency of data.

OPERATION NO. 9
(continued)

EVALUATION OF
OPERATION DATA:

- b) Compute total direct liquid inputs to the column; make-up CuSO_4 solution, plus demister wash rate times wash frequency, plus moisture in inlet steam (see Operation No. 39).
- c) Compute indirect liquid inputs due to condensation from; heating inlet steam (and moisture) to operating temperature, plus heating makeup CuSO_4 solution and demister wash flows to operating temperature, plus condensation due to convective heat losses (see Operation No. 39).
- d) Compute indirect liquid outputs due to evaporation from; heat of reaction from removing H_2S by precipitating and oxidizing sulfides (see Operations No. 1, 10, 40), plus heat of reaction from removing NH_3 (see Operations No. 2, 10, 40).
- e) Correct measured purge rate for unsteady state operation; subtract excess purge if sump level is decreasing, add additional purge if sump level is rising.
- f) Compute expected change in steam flow rate on passing through the scrubber as the difference between (e) and (b) plus (c) minus (d).

OPERATION NO. 10

FUNCTION TO
BE DETERMINED:

Component material balances around the scrubber column.

TEST
CONDITIONS:

Same as Operations No. 1 and 9.

Nominal Min/Max

MEASUREMENTS
TO BE MADE:

Same as Operation No. 9.

EVALUATION OF
OPERATING DATA:

- a) For ammonia and boron, component balances will be used to check consistency of data. For copper, acidity, and sulfide (sulfur, sulfate) component balances will also be used to determine reaction stoichiometry.
- b) Ammonia balance; total input equals flow rate times concentration of inlet steam plus makeup copper sulfate solution plus demister wash. Total output equals flow rate times concentration of outlet steam plus total purge solution (slurry).
- c) Boron balance; same as (b).
- d) Copper balance; total input equals flow rate times concentration of makeup copper sulfate solution. Total output equals flow rate times concentration of total purge solution (slurry) plus total purge solution flow rate times slurry density times solids percent copper.
- e) Sulfur balance; total input equals steam inlet flow rate times sulfide concentration plus demister wash rate times sulfide plus sulfate concentrations plus makeup copper sulfate rate times sulfate concentration. Total output equals steam flow rate times sulfide concentration plus solution (slurry) flow rate times sulfate concentration plus total purge solution flow rate times slurry density times solids percent sulfide.
- f) Reaction stoichiometry check:
 - (1) Compute ratio of copper consumed (total purge solution flow rate times slurry density times solids percent copper) to hydrogen sulfide scrubbed (steam flow rate times hydrogen sulfide inlet minus outlet concentrations). Given measured solids composition, find extent of elemental sulfur formation from general reaction stoichiometry. Compare with measured sulfur formation rate (steam flow rate times sulfur content plus total purge solution (slurry) times sulfur content less demister wash rate times sulfur content).

OPERATION NO. 10
(continued)

EVALUATION OF
OPERATING DATA:

- (ii) Given measured solids composition and (rationalized) extent of sulfur formation (i), find extent of sulfate formation from general reaction stoichiometry. Compare with measured formation rate (total purge solution times sulfate content less makeup copper sulfate plus demister wash rates times sulfate contents).
 - (iii) Given measured solids composition and (rationalized) extent of sulfur formation (i, ii) find extent of acidity formation from general reaction stoichiometry. Compare with measured formation rate (total purge solution times acidity content less makeup copper sulfate plus demister wash rates times acidity contents plus steam flow rate times ammonia inlet minus outlet concentrations).
- g) Note that those balances ignore effect of entrainment. Use data from Operation No. 8 to correct balances if required.

OPERATION NO. 11

FUNCTION TO
BE DETERMINED:

Clean service heat transfer coefficient, energy recovery exchanger.

TEST
CONDITIONS:

	<u>Nominal</u>	<u>Min/Max</u>
a) Purge slurry (water) flow rate, GPM	7	3/15
b) Makeup CuSO ₄ (water) flow rate, GPM	5.7	3/15
c) Purge slurry (water) inlet temperature, °F	350	340/360
d) Makeup CuSO ₄ (water) inlet temperature, °F	100	80/120

MEASUREMENTS
TO BE MADE:

- a) Purge slurry (water) flow rate, FR107 plus FR108.
- b) Makeup CuSO₄ (water) flow rate, FR105.
- c) Purge slurry (water) inlet, outlet temperatures, TI141, 142.
- d) Makeup CuSO₄ (water) inlet, outlet temperatures, TI145, 146.

EVALUATION OF
OPERATING DATA:

- a) Compute heat transferred, average of purge slurry flow rates times inlet minus outlet temperatures and makeup CuSO₄ flow rate times outlet minus inlet temperatures.
- b) Compute log mean temperature difference from terminal temperature differences, purge slurry inlet minus makeup CuSO₄ outlet and purge slurry outlet minus makeup CuSO₄ inlet.
- c) Compute overall heat transfer coefficient and compare with manufacturer's predicted value.
- d) Rating tests: with purge slurry flow at nominal conditions, vary makeup CuSO₄ flow from minimum to maximum rate. Compute overall heat transfer coefficients and compare with value at nominal flow rates. Decrease (increase) is to be ascribed to decreased (increased) film coefficient on makeup CuSO₄ side; decrease (increase) manufacturer's predicted nominal value accordingly. Determine exponent of power law dependence of film coefficient on flow rate and compare with manufacturer's correlation.

OPERATION NO. 11
(continued)

EVALUATION OF
OPERATING DATA:

- e) Repeat (d) with variations in flow on purge slurry side, makeup CuSO_4 flow held constant.
- f) Fouling tests: for water testing following a period of service on process fluids, run tests as in (a, b, c). A decrease in overall heat transfer coefficient is to be ascribed to fouling.
- g) Record the time the exchanger has been in service, service history, time since last cleaning and method of cleaning if any. Upon termination of testing, disassemble and inspect, noting extent and location of deposits, if any. Recover solids materials for analysis.

OPERATION NO. 12

FUNCTION TO
BE DETERMINED:

Service heat transfer coefficient, energy recovery
exchanger.

TEST
CONDITIONS:

Nominal Min/Max

Same as Operation No. 11.

MEASUREMENTS
TO BE MADE:

- a) Purge slurry flow rate, FR107 plus FR108.
- b) Makeup CuSO₄ flow rate, FR105.
- c) Purge slurry inlet, outlet temperatures, TI141, 142.
- d) Makeup CuSO₄ inlet, outlet temperatures, TI145, 146.
- e) Collect purge slurry and makeup CuSO₄ samples at indicated frequencies, composition by analyses No. 5, 6, 7, 8, 11, 12, 17 and 19.

EVALUATION OF
OPERATING DATA:

- a) Compute heat transferred, average of purge slurry flow rate times inlet minus outlet temperatures plus heat of reaction for bisulfate-sulfate transformation and makeup CuSO₄ flow rate times outlet minus inlet temperatures plus heat of reaction for sulfate-bisulfate transformation.
- b) Compute log mean temperature difference and overall heat transfer coefficient as in operation No. 10, b and c.
- c) Correct calculated overall heat transfer coefficient to an equivalent value at nominal conditions by increasing (decreasing) calculated individual film coefficients if individual flow rates are lower (higher) than nominal. Flow rate-film coefficient correlation established in Operation No. 11.
- d) Compare (corrected) overall heat transfer coefficient with clean service value; a decrease is to be ascribed to fouling.
- e) Record time heat exchanger has been in service, service history, and time since last cleaning. Anticipate rate of fouling (increase in fouling resistance) will be particularly sensitive to makeup CuSO₄ stream composition and temperature.

OPERATION NO. 13

FUNCTION TO
BE DETERMINED:

Clean service heat transfer coefficient, auxiliary coolers.

TEST
CONDITIONS:

	<u>Nominal</u>	<u>Min/Max</u>
a) Purge slurry (water) flow rate, GPM	7	3/15
b) Makeup CuSO_4 (water) flow rate, GPM	5.7	3/15
c) Purge slurry (water) inlet temperature, °F	210	140/250
d) Makeup CuSO_4 (water) outlet temperature, °F	150	100/180
e) Cooling water flow rate, GPM	25	15/40
f) Cooling water temperature, °F	80	50/90

MEASUREMENTS
TO BE MADE:

- a) Purge slurry (water) flow rate, FR107 plus FR108.
- b) Makeup CuSO_4 (water) flow rate, FR105.
- c) Purge slurry (water) inlet, outlet temperatures, TI142, 143.
- d) Makeup CuSO_4 (water) inlet, outlet temperatures, TI144, 145.
- e) Cooling water inlet, outlet temperatures, TI147, 148 and 149.

EVALUATION OF
OPERATING DATA:

- a) Compute heat transferred, purge slurry and makeup CuSO_4 flow rates times inlet minus outlet temperatures.
- b) Compute cooling water flow rates from heat transferred and cooling water outlet minus inlet temperatures.
- c) Compute log mean temperature difference from terminal temperature differences (process stream outlet minus cooling water inlet and process stream inlet minus cooling water outlet) and MTD correction factor charts.
- d) Compute overall heat transfer coefficient and compare with calculated value. Calculated value derived from tube wall conductance plus values of tube side and shell side film coefficients calculated from Nusselt-Reynolds-Prandtl correlations.
- e) Rating tests: conduct in same manner as for Operation No. 11 d and e.
- f) Fouling tests: conduct in same manner as for Operation No. 11 f.
- g) Record exchangers conditions in same manner as for Operation No. 11 g.

OPERATION NO. 14

FUNCTION TO
BE DETERMINED:

Service heat transfer coefficient, auxiliary coolers.

TEST
CONDITIONS:

Same as Operation No. 13.

Nominal Min/Max

MEASUREMENTS
TO BE MADE:

- a) Purge slurry flow rate, FR107 plus FR108.
- b) Makeup CuSO_4 flow rate, FR105.
- c) Purge slurry inlet, outlet temperatures, TI142, 143.
- d) Makeup CuSO_4 inlet, outlet temperatures, TI144, 145.
- e) Cooling water inlet, outlet temperatures, TI147, 148, 149.
- f) Collect purge slurry and makeup CuSO_4 samples at indicated frequencies, composition by analyses No. 5, 6, 7, 8, 11, 12, 17 and 19.

EVALUATION OF
OPERATING DATA:

- a) Compute heat transferred, cooling water flow rate, corrected log mean temperature difference and overall heat transfer coefficient in the same manner as for Operation No. 13 a, b, c and d.
- b) Correct calculated overall heat transfer coefficient to an equivalent value at nominal conditions in the same manner as for Operation No. 12 c.
- c) Compare (corrected) overall heat transfer coefficient with clean service value; a decrease is to be ascribed to fouling.
- d) Record time heat exchanger has been in service, service history, and time since last cleaning. Anticipate rate of fouling (increase in fouling resistance) will be sensitive to process stream compositions and temperatures.

OPERATION NO. 15

FUNCTION TO BE DETERMINED:

Clean service pressure drop in process heat exchangers.

TEST CONDITIONS:

	<u>Nominal</u>	<u>Min/Max</u>
a) Purge slurry (water) flow rate, GPM	7	3/15
b) Makeup CuSO ₄ (water) flow rate, GPM	5.7	3/15
c) Recirculated slurry (water) flow rate, GPM	100	50/150
d) Regenerated CuSO ₄ (water) flow rate, GPM	100	50/150

MEASUREMENTS TO BE MADE:

- a) Purge slurry (water) flow rate, FR107 plus FR108.
- b) Makeup CuSO₄ (water) flow rate, FR105.
- c) Rate of level decrease in reactor V201, LI203 vs. time.
- d) Purge slurry (water) pressures and temperatures, PI125, 126, 127, TI141, 142 and 143.
- e) Makeup CuSO₄ (water) pressures and temperatures, PI131, 133, 125, TI144, 145, 146.
- f) Recirculated slurry (water) pressure and temperature, PI221, PI229, TI241.
- g) Regenerated CuSO₄ (water) temperature TI242, 245.

EVALUATION OF OPERATING DATA:

- a) Calculate flow rate through exchanger X202 from rate at which level in reactor V201 drops.
- b) Estimate flow of recirculated slurry through X201 from pump P103 head-capacity curve.
- c) Vary flow rates through all exchangers from maximum to minimum, recording observed pressure drops. Determine exponent of power law dependence of pressure drop on flow rate and compare with manufacturer's correlation or published friction factor-flow rate correlations.
- d) Fouling tests: for water testing following a period of service on process fluids, run tests as in (a, b, c). An increase in pressure drop (friction factor) is to be ascribed to fouling.
- e) Record the time the exchanger has been in service, service history, time since last cleaning and method of cleaning, if any. Upon termination of testing, disassemble and inspect, noting extent and location of deposits, if any. Recover solids material for analysis.

OPERATION NO. 16

FUNCTION TO
BE DETERMINED:

Process side pressure drop of heat exchangers in service.

TEST
CONDITIONS:

Nominal Min/Max

Same as Operation No. 15.

MEASUREMENTS
TO BE MADE:

- a) Same as Operation No. 15.
- b) Also, collect purge slurry, makeup CuSO_4 , circulating slurry, and regenerated CuSO_4 samples at indicated frequencies, composition by analyses No. 5, 6, 7, 8, 11, 12, 17 and 19.

EVALUATION OF
OPERATING DATA:

- a) Determine flow rates through exchangers X201 and X202 in same manner as for Operation No. 15 a, b.
- b) Compare measured pressure drops with those found in clean service at equivalent flow rates (Operation No. 15); an increase is to be ascribed to fouling.
- c) Record time heat exchanger has been in service, service history, and time since last cleaning. Anticipate rate of fouling (increase in friction factor) will be sensitive to process stream compositions and temperatures and will correspond to decrease in heat transfer performance (Operations No. 12, 14, 26 and 33).

OPERATION NO. 17

FUNCTION TO
BE DETERMINED:

Pressure drop of process filters in clean service.

TEST
CONDITIONS:

	<u>Nominal</u>	<u>Min/Max</u>
a) Filtered scrub solution (water) purge, GPM	0.05	0.03/0.1
b) Decanted solubles (water) purge, GPM	1.3	1/2.5
c) Regenerated CuSO ₄ (water) return, GPM	80	40/100
d) Demister, seal flush water, GPM	50	1/2.5
e) Neutralized purge (water) flow, GPM	1.3	1/2.5

MEASUREMENTS
TO BE MADE:

- a) Purge slurry and filtrate (water) flow rates, FR107 plus 108, FI160.
- b) Decanted solubles (water) purge flow rate, FR108.
- c) Regenerated CuSO₄ (water) return flow rate, rate of change of level in Tank 201 (and/or 102) with time.
- d) Demister, seal flush water flow rate, rate of change of level in Tank 304.
- e) Consumption of demister wash and seal flush water, FI363, 364, 365, 366 and 367.
- f) Fill rate of Tank 201 (discharge rate of reactor V201), change of level in reactor V201 with time.
- g) Neutralized purge (water) flow rate, rate of change of level in Tank 302 (and/or 301) with time.
- h) Purge slurry and filtrate (water) pressures, PI127, 128, 134 and temperatures TI143.
- i) Decanted solubles (water) purge pressures, PI129 and 130.
- j) Regenerated CuSO₄ (water) return pressure PI226 and temperature, TI245.
- k) Demister, seal flush water pressure, PI327 and temperature, TI147.
- l) Neutralized purge (water) pressure, PI320 (323) and temperature, TI340 (342).

EVALUATION OF
OPERATING DATA:

- a) Compute flow rate through filter F201 by rate of change of level in Tank T201 plus rate of change of level in reactor V201.
- b) Compute flow rate through filter F301 by rate of change of level in Tank T304 plus demister wash and seal flush flow rates FI363, 364, 365, 366 and 367.

OPERATION NO. 17
(continued)

EVALUATION OF
OPERATING DATA:

- c) Compute flow rate through filter F302 by rate of change of level in Tank T302 (T301) plus soluble purge flow rate FR108.
- d) Vary flow rates over expected range and measure pressure drops. Compare with manufacturer's specification for clean service at nominal flow rate and establish exponent on pressure drop-flow rate correlation.
- e) Note style of filter element used, time filter has been in service, service history, and time since last cleaning and method of cleaning if the element is not new. For water tests following process use, remove and inspect element at conclusion of test, noting extent and nature of solids build up, cake thickness penetration of media (if any). Reserve sample of solids for analysis, remove cake, dry and weigh for material balance if required.

OPERATION NO. 18

FUNCTION TO
BE DETERMINED:

Pressure drop and particulate removal efficiency of
filters on process fluids.

TEST
CONDITIONS:

Nominal Min/Max

Same as Operation No. 17.

MEASUREMENTS
TO BE MADE:

- a) Same as Operation No. 17.
- b) Also, collect purge slurry, recirculated slurry, regenerated CuSO_4 , neutralized (decopperized) purge and makeup water samples at indicated frequencies, composition by analyses No. 5, 6, 7, 8, 11, 12, 16, 17 and 19.

EVALUATION OF
OPERATING DATA:

- a) Compute flow rates in F201, 301, 302 by same procedures as in Operation No. 17 a, b, and c.
- b) Record pressure drop and flow rate for all filters as well as style of element and time filter has been in service since cleaning.
- c) Compare pressure drop at flow rate with clean service value (Operation No. 17 d). If pressure drop becomes excessive and/or limits attainable flow, bypass filter and replace element.
- d) Remove elements from filters F102, 201, and 302, remove solids, dry, weigh, and analyze to complete material balances as required.
- e) Anticipate time filter can stay in service between cleanings will be function of solids properties, as well as solids loading (slurry density), including particle size distribution, solids composition, cake density (filtering DP), and solution temperature.

OPERATION NO. 19

FUNCTION TO
BE DETERMINED:

Decanter overflow solids content.

TEST		<u>Nominal</u>	<u>Min/Max</u>
CONDITIONS:	a) Purge slurry flow rate, GPM	7	3/15
	b) Decanter flow rate, GPM	1.3	1/2.5
	c) Thickened slurry flow rate, GPM	5.7	5/9.5
	d) Purge slurry density, w/o	2.2	1.1/3.3

MEASUREMENTS
TO BE MADE:

- a) Decantate flow rate, FR108.
- b) Thickened slurry flow rate, FR107.
- c) Slurry level in decanter - observe on sight glass.
- d) Weight of solids retained on filter F102 and time interval for this accumulation at required frequency.
- e) Observe decantate clarity, SFG161.
- f) Purge slurry temperature, TI143.
- g) Collect purge slurry and thickened slurry samples at indicated frequencies, composition by analyses No. 5, 6, 7, 8, 11, 12 and 19.

EVALUATION OF
OPERATING DATA:

- a) Compute average rate of accumulation of solids in filter F102 from total weight of solids retained and time interval for collection.
- b) Compute average overflow (decantate) solids content from average rate of solids accumulation and decantate flow rate.
- c) Other data recorded for establishing correlation(s) of decanter performance with operating conditions. Anticipate dependence on total flow rate and slurry density, decantate flow rate, slurry level in decanter, and stability of the purge operation.
- d) Compute solids residence time in decanter from pulp level (volume) and underflow rate. Compute decantate rise velocity and residence time in decanter from clear liquid height (volume) and decantate flow rate. Compare with settling data from litre cyclinder tests (if conducted) to establish correlation with operating conditions and solids properties.

OPERATION NO. 20

FUNCTION TO
BE DETERMINED:

Decanter total material balance.

TEST
CONDITIONS:

Same as Operation No. 19.

Nominal

Min/Max

MEASUREMENTS
TO BE MADE:

Same as Operation No. 19.

EVALUATION OF
OPERATING DATA:

- a) Compute average rate of accumulation of solids in filter F102 from total weight of solids retained and time interval for collection.
- b) Compute solids flow rate to decanter from measured inlet slurry density times total flow rate (decantate plus underflow rate).
- c) Compute solids flow rate from decanter from measured underflow slurry density times underflow rate plus average rate of accumulation in filter F102. Compare with computed solids input rate.

OPERATION NO. 21

FUNCTION TO
BE DETERMINED:

Instrument check, makeup copper sulfate flow rate.

TEST
CONDITIONS:

	<u>Nominal</u>	<u>Min/Max</u>
a) Makeup CuSO_4 flow rate, GPM	5.7	4/7
b) Regenerated CuSO_4 flow rate, GPM	80	40/100

MEASUREMENTS
TO BE MADE:

- a) Flow rate of makeup CuSO_4 , FR105.
- b) Rate of change of level in Tank T102.
- c) Rate of change of level in Tank T201.

EVALUATION OF
OPERATING DATA:

- a) Compute flow rate of makeup CuSO_4 from Tank T102 from decrease in level (volume) vs. time (plus decrease in level vs. time for Tank T201 if regenerated CuSO_4 is transferred in measuring interval).
- b) Compute average flow rate of makeup CuSO_4 by integrating instantaneous readings of FR105, and compare with average rate calculated from volume change of tank. Re-calibrate indicating/transmitting/recording instrumentation if required.

OPERATION NO. 22

FUNCTION TO
BE DETERMINED:

Instrument check, demister wash flow rate.

TEST

CONDITIONS:

	<u>Nominal</u>	<u>Min/Max</u>
a) Demister wash rate (total area) GPM	30	15/60
b) Demister wash frequency, % total time	15	5/50
c) Total seal flush flow rates, GPM	.5	0.1/13

MEASUREMENTS

TO BE MADE:

- a) Flow rate of demister wash water, FI363.
- b) Demister wash frequency (% of total time demister wash is on) KC301.
- c) Rate of change of level in Tank T304.
- d) Rate of consumption of seal flush water FI364, 365, 366 and 367.

EVALUATION OF
OPERATING DATA:

- a) Compute rate of consumption of water from Tank T304 from decrease in level (volume) vs. time with flow of makeup water stopped (PCV302 closed).
- b) Calculate rate of demister wash from rate of decrease in tank level less total rate of seal flush flow (if any).
- c) Compare calculated wash rate with wash rate computed from demister wash rate times wash frequency. Recalibrate flow indicator/timer if required.

OPERATION NO. 23

FUNCTION TO
BE DETERMINED:

Instrument check, purge scrub solution (slurry) flow rate.

TEST
CONDITIONS:

	<u>Nominal</u>	<u>Min/Max</u>
a) Purge slurry flow rate, GPM	7	3/15
b) Decantate flow rate, GPM	1.3	1/2.5
c) Decanter underflow rate, GPM	5.7	5/9.5

MEASUREMENTS
TO BE MADE:

- a) Decantate (solubles purge) flow rate, FR108.
- b) Decanter underflow (thickened slurry) flow rate, FR107.
- c) Level change in Tank T101 as a function of time, LI201.
- d) Level change in Tank T302 as a function of time.
- e) Level change in column sump vs. time, LI104.

EVALUATION OF
OPERATING DATA:

- a) Calculate solubles purge rate from rate of increase of level in Tank T302 with no neutralization (HVC 321 off) or disposal (P302 off) of purge. Compare with rate calculated by integrating readings of FR108 and recalibrate indicator/recorder if required.
- b) Calculate decanter underflow rate from rate of increase of level in Tank T101 with no transfer of slurry to leaching (P103 off). Compare with rate calculated by integrating readings of FR107 and recalibrate indicator/recorder if required.
- c) Check calibrations of Tanks T101 and/or T302 by comparing level increases with level decrease in column sump with other column makeup flows off (FCV301, FC105 off).

OPERATION NO. 24

FUNCTION TO BE DETERMINED:

Regeneration rate of sulfides at near ambient conditions.

TEST CONDITIONS:

	Nominal	Min/Max
a) Slurry density, %, temperature, °F	2.2, 120	1.1, 100/3.3, 190
b) Solution acidity, g/l H_2SO_4 , pH	24, 1.2	12, 1.0/30, 1.6
c) Slurry circulation rate, GPM	100	50/150
d) Air to slurry ratio, Fe^3/Fe^{2+} , (at nominal circulating rate)	10	5/20

MEASUREMENTS TO BE MADE:

- Rate of slurry input, FR107 (if any).
- Rate of slurry output, level change in reactor V201, LI203 (if any).
- Recirculation slurry pressure and temperature PI221, 229, TI240.
- Leaching air flow rate, FI260.
- Condensate flow rate from trap on heater X201.
- Level change in Tank TI01, LI201.
- Nature of slurry, e.g., propensity to form froth, settling rate in litre cylinder tests, occurrence of basic copper salts, etc.
- Collect purge slurry samples and samples of contents of circulating slurry at indicated frequencies, composition by analyses No. 5, 6, 7, 8, 11, 12 and 19.

EVALUATION OF OPERATING DATA:

- Basic kinetic data are to be obtained with no input (slurry purge from scrubber temporarily stopped) or output (between batches in leach reactor). Sample contents of tank to determine initial solids content and composition and solution composition. Calculate final solution composition (copper content, acidity) if all solids were to be leached.
- After initiating leaching at desired air-slurry ratio and temperature, sample contents of tank periodically. Check ammonium sulfate concentration (and tank level); if increasing (decreasing) correct measured concentrations to account for evaporation, bringing them back to initial dilution.
- Calculate fraction solids reacted (fraction of maximum attainable copper concentration obtained) and plot $\log [1 - (1 - F)^{1/3}]$ vs. $\log [time]$.

OPERATION NO. 24
(continued)

EVALUATION OF
OPERATING DATA:

- d) Calculate ratio of acidity consumed to copper solubilized to check anticipated leach reaction stoichiometry.
- e) Other data recorded for establishing correlation(s) with operating conditions. Anticipate dependence on air-slurry ratio (particularly for early stages of leaching), temperature, initial slurry density and solution composition, solids composition and physical properties, and method of gas-liquid contacting. Also seek correlation with nature of slurry.
- f) To evaluate leaching data with input/output to/from system; integrate input slurry density times flow rate times solids composition, add to initial tank slurry density times solids composition to obtain total solids input. Add to final tank slurry density times solids composition integrated output slurry density times output flow rate (if any) times solids composition. Output plus accumulation minus input is production (leaching) of solids, leach rate is obtained by dividing by time interval.
- g) Perform material balance check by correcting measured concentrations for evaporation (as b), determining soluble copper increase (and correspondence to leaching of solids) and consumption of acidity (as d).
- h) Seek correlation of leach rate with operating data (as e).

OPERATION NO. 25

FUNCTION TO
BE DETERMINED: Clean service heat transfer coefficient, slurry heater.

TEST CONDITIONS:		<u>Nominal</u>	<u>Min/Max</u>
a) Circulating slurry (water) flow rate, GPM		100	50/150
b) Circulating slurry (water) temperature, °F		120	100/190
c) Steam pressure, PSIG		25	10/50

MEASUREMENTS
TO BE MADE:

- a) Steam pressure, PI228.
- b) Rate of discharge of condensate from steam trap.
- c) Circulating slurry (water) inlet and outlet temperatures, TI241, 240.
- d) Circulating pump discharge pressure, PI221.

EVALUATION OF
OPERATING DATA:

- a) Estimate flow of recirculated slurry (water) through exchanger from pump P103 head-capacity curve.
- b) Compute heat transferred as average of condensate flow rate times latent heat and flow rate of circulated slurry (water) times outlet minus inlet temperature.
- c) Compute log mean temperature difference from temperature corresponding to steam pressures at saturation and slurry (water) inlet and outlet temperatures.
- d) Compute overall heat transfer coefficient and compare with calculated value. Calculated value derived from tube wall conductance plus values of tube side and shell side film coefficients calculated from Nusselt-Reynolds-Prandtl correlations.
- e) Rating tests: conduct in same manner as for Operation No. 11 d, e.
- f) Fouling tests: conduct in same manner as for Operation No. 11 f.
- g) Record exchanger's conditions in same manner as for Operation No. 11 g.

OPERATION NO. 26

FUNCTION TO
BE DETERMINED:

Service heat transfer coefficients, slurry heater.

TEST
CONDITIONS:

Same as Operation No. 25.

Nominal

Min/Max

MEASUREMENTS
TO BE MADE:

- a) Same as Operation No. 25.
- b) Also, collect circulated slurry samples at indicated frequencies, composition by analyses No. 5, 6, 7, 8, 11, 12, 17 and 19.

EVALUATION OF
OPERATING DATA:

- a) Compute recirculated slurry flow rate, heat transferred, log mean temperature difference, and overall heat transfer coefficient as in Operation No. 25 a, b, c and d.
- b) Correct calculated overall heat transfer coefficient to an equivalent value at nominal conditions in the same manner as for Operation No. 12 c.
- c) Compare (corrected) overall heat transfer coefficient with clean service value; a decrease is to be ascribed to fouling.
- d) Record time heat exchanger has been in service, service history, and time since last cleaning. Anticipate rate of fouling (increase in fouling resistance) will be sensitive to process stream compositions and temperatures.

OPERATION NO. 27

**FUNCTION TO
BE DETERMINED:**

Rate of leaching of sulfides in pressure leach reactor.

**TEST
CONDITIONS:**

	<u>Nominal</u>	<u>Min/Max</u>
a) Slurry volume/batch, gal, slurry density, %	3000, 2.7	2500, 2.3/3500, 3.2
b) Leach temperature, °F, total pressure, psig.	230, 55	160, 15/300, 120
c) Agitation speed, RPM	56	56/84
d) Agitation arrangement: dual turbines, adjustable height (0-108") and four adjustable tank wall baffles.		
e) Sulfuric acid consumption, gal/batch	0	0/15
f) Oxygen use, Mlb/day, or air use, CFM.	1, 230	0.5, 50/1.1, 250

NOTE: WHEN USING OXYGEN FOR LEACHING, OBSERVE ALL POSTED
SAFETY PRECAUTIONS. SEE INSTRUCTION (e) BELOW.

**MEASUREMENTS
TO BE MADE:**

- a) Initial slurry volume and temperature, LI203, TI242.
- b) Agitator speed and power draw JR209.
- c) Total pressure, PR205.
- d) Air or oxygen flow rate, FR208 or FR207.
- e) Temperature, level, and oxygen flow rates as function
of time from initiation of leach.
- f) Amount and composition of drips from reactor vent
scrubber column, if any.
- g) Collect samples of initial slurry and partially leached
slurry at indicated frequencies, composition by
analyses No. 5, 6, 7, 8, 9, 11, 12, 16, 17 and 19.

**EVALUATION OF
OPERATING DATA:**

- a) From initial sample of tank contents, compute final
copper concentration (initial dissolved copper plus
copper leached from solids) expected at 100% leaching
as well as maximum oxygen and acid requirements for
assumed leach stoichiometry. If insufficient acid is
present, transfer required additional amount from
Tank T303.
- b) After batch is brought to desired temperature and
leaching is initiated by supplying air or oxygen,
sample and note level at indicated frequencies, check
ammonium sulfate concentration, correct measured con-
centrations to bring them back to initial dilution.

OPERATION NO. 27
(continued)

EVALUATION OF
OPERATING DATA:

- c) Calculate fraction solids reacted (fraction of maximum attainable copper concentration obtained) and plot $\log [1-(1-F)^{1/3}]$ vs. $\log \{ \text{time} \}$.
- d) Calculate ratio of acidity consumed to copper solubilized and composition of residual solids to check anticipated leach reaction stoichiometry for oxygen leaching, also compare rate of consumption of oxygen with rate of solubilization of copper.
- e) Calculate oxygen partial pressure; for oxygen leaching, subtract water partial pressure (vapor pressure at leach temperature times activity for leach solution composition) from total system pressure. When air leaching, compute oxygen plus nitrogen partial pressure as above and compute oxygen and nitrogen input rates from air input rate. Calculate oxygen consumption rate from rate of solubilization of copper (from b, c above) and assumed leach reaction stoichiometry (check d above). Calculate oxygen partial pressure from oxygen plus nitrogen total times the fraction input consumed oxygen over total input minus consumed oxygen.

NOTE: USE OF OXYGEN PRESENTS AN OPERATING HAZARD SINCE IT LOWERS IGNITION TEMPERATURES AND INCREASES FLAME TEMPERATURES GREATLY. ALL SOURCES OF IGNITION MUST BE REMOVED FROM THE OPERATING AREA PRIOR TO INITIATION OF OXYGEN LEACHING. IF ANY MAINTENANCE WORK HAS BEEN CARRIED OUT ON THE REACTOR OR ITS ATTACHMENTS, THE EQUIPMENT SHOULD BE THOROUGHLY CLEANED AND INSPECTED TO INSURE THAT IT IS OIL AND GREASE FREE. ALWAYS LEAK TEST THE REACTOR AND PIPING WITH AIR PRIOR TO RESUMING OPERATION.

- f) Other data recorded for establishing correlation(s) with operating conditions. Anticipate dependence on oxygen partial pressure, temperature, agitation arrangement, preleaching of solids (if carried out), solids and solution composition (particularly pH), and solids properties (particularly size distribution). Attempt to conduct reactions isothermally and establish activation energy and normalize results for oxygen pressure.
- g) Calculate surface dissolution rate from initial particle size distribution, size distributions measured during the course of the run(s), and time (extrapolated if necessary) for complete leaching.

OPERATION NO. 28

FUNCTION TO
BE DETERMINED:

Leach reactor total material balance.

TEST
CONDITIONS:

Same as Operation No. 27.

Nominal Min/Max

MEASUREMENTS
TO BE MADE:

- a) Decrease in level in Tank T101 upon charging reactor, LI201.
- b) Amount of H_2SO_4 charged to reactor: level decrease in Tank T303, LI362.
- c) Initial and final level in leach reactor, LI203.
- d) Increase in level in Tank T201 upon discharge reactor.
- e) Flow rate of leaching air, leach total pressure and temperature, PR208, PR205, TR202.
- f) Temperature rise of reactor contents when sparging steam for initial heat up, TI242.

EVALUATION OF
OPERATING DATA:

- a) Compare level change in Tank T101 upon charging with initial reactor volume (level), level change in Tank T201 upon discharging with final reactor volume to verify tank and level indicator calibrations.
- b) Compute level increase in reactor upon initial heating due to decreased density and accumulation of condensate. Amount of condensate expected calculated from initial tank contents (volume times density) times heat capacity plus tank shell mass times heat capacity times temperature rise on heating divided by steam's heat of condensation.
- c) Compute level decrease due to evaporation of water during air leaching. Calculate flow of oxygen plus nitrogen in same fashion as Determination No. 27 e, and water content of vent gases by ratio of water partial pressure to total pressure (use integrated average temperature-pressure). Compute water content of inlet air, assuming saturation at compressor exhaust conditions. Calculate total amount of water evaporated from gas flow times outlet minus inlet water contents times leach time.

OPERATION NO. 28
(continued)

EVALUATION OF
OPERATING DATA:

- d) Compare calculated volume change (b & c + volume of H_2SO_4 added, if any) with difference between measured initial and final volumes. At completion of run, inspect reactor freeboard (and vent line/vent scrubber if appropriate) for evidence of accumulation of solids (or solids plus liquids).
- e) Observe indicated level in reactor during leach to insure excessive entrainment and/or loss of gassed density has not occurred.

OPERATION NO. 29

FUNCTION TO
BE DETERMINED: Component material balance around the regeneration reactor.

TEST
CONDITIONS: Same as Operation No. 27. Nominal Min/Max

MEASUREMENTS
TO BE MADE: a) Same as Operations No. 27 and 28.
b) Also, remove, weigh, and analyze solids content of filter F201 following leach cycles.

EVALUATION OF
OPERATING DATA: a) Use boron and ammonia as non reactive keys for establishing material balance, as in Operation No. 27 b, to correct measured concentrations to initial dilution. If ratio of ammonia to boron decreases during the course of the run and the pH of the leach solution rises above 2, add additional H_2SO_4 and check solid residues at end of run for presence of basic copper sulfates.
b) Establish slurry density at completion of leach; average of direct and inferred measurements. Inferred slurry density estimated by weighing solids removed in filter F201 following leach cycle divided by total volume passed from holding Tank T201 through filter. If post run inspection of reactor shows a significant amount of solids adhering to freeboard and top head (or wetted sides), remove mechanically, weigh and analyze.
c) Copper balance; total input equals initial reactor volume times soluble copper concentration plus initial slurry density times solids copper content. At any time, total (output) equals reactor volume times soluble copper concentration plus (average) slurry density times solids copper content.
d) Sulfur balance; total input equals initial reactor volume times sulfate plus sulfuric acid concentrations plus initial slurry density times solids sulfide content. At any time, total (output) equals reactor volume times sulfate plus sulfuric acid concentrations plus (average) slurry density times solids sulfide content.

OPERATION NO. 29
(continued)

EVALUATION OF
OPERATING DATA:

- e) Check amount and composition of drips from vent scrubber for entrainment and/or distillation of elemental sulfur from leach reactor. Correct balances a, c, d as required.
- f) Oxygen consumption; total input at any time established by integrating instantaneous flow rate readings from FR207. Compute ratio of oxygen consumed to sulfide oxidized, the latter from difference between initial slurry volume times density times solids sulfide content minus this product at any time.

OPERATION NO. 30

FUNCTION TO BE DETERMINED:

Clean service heat transfer coefficient, regeneration reactor

TEST CONDITIONS:

	<u>Nominal</u>	<u>Min/Max</u>
a) Initial reactor volume (water) gal	3000	2500/3500
b) Initial batch temp., °F	230	160/300
c) Agitator speed, RPM	56	56/84
d) Reactor pressure, psig	55	15/120
e) Oxygen use, Mlb/day, or air use, CFM	1,230	.5, 50/1.1, 250
f) Agitator arrangement: dual turbines, adjustable height (0-108") and four adjustable tank wall baffles.		

MEASUREMENTS TO BE MADE:

- Initial reactor volume (level) LI203, indicated level with agitation, and indicated level with agitation under gassed conditions.
- Agitator speed and arrangement.
- Air flow rate, FR208.
- Reactor pressure, PR205, and temperature TR202.
- Jacket cooling water outlet pressure and temperature, PI230, TI247 and position of control valve TCV202.

EVALUATION OF OPERATING DATA:

- Compute mass times heat capacity for tank hardware and contents; for hardware from estimated shell plus agitator weight times heat capacity of steel, for contents from initial volume times density.
- With tank contents at steady, initial temperature, introduce flow of cooling water to jacket and record rate of decrease in temperature of tank contents. Record times required to reach 63%, 86%, and 95% of the difference between the initial tank temperature and (average) cooling water temperature. Compute average overall heat transfer coefficient from unsteady state energy balance for one, two, and three time constants, given jacket area, times, and total system mass-heat capacity.
- Calculate overall heat transfer coefficient and compare with computed value. Calculated value derived from vessel wall conductance plus values of jacket side and process side film coefficients calculated from Nusselt-Reynolds-Prandtl correlations. Jacket cooling water flow rate estimated from position of control valve TCV202 and pressure drop across the valve. Check estimate by balance; rate of temperature drop of tank contents and temperature increase of cooling water.

OPERATION NO. 30
(continued)

EVALUATION OF
OPERATING DATA:

- d) Rating tests: Repeat above procedures for maximum and minimum agitator speeds, initial tank volumes, agitation arrangements, degrees of aeration, and cooling water flows. With agitation (or coolant flow) held at nominal conditions, increase in heat transfer coefficient with increase in coolant flow (or agitation) is to be ascribed to increased film coefficient. Determining exponent of power law dependence of film coefficient with flow rate (or agitator speed) and compare with literature values.
- e) Seek correlation of inside film heat transfer coefficient with agitation arrangement, degree of aeration, and agitator power input to determine "optimum" conditions (note: final selection will, however, be based on mass transfer and kinetic considerations. See Operation No. 27).
- f) Fouling tests: conduct in the same manner as for Operation No. 11 f.
- g) Record condition of heat transfer surface in same manner as for Operation No. 11 g.

OPERATION NO. 31

FUNCTION TO
BE DETERMINED:

Service heat transfer coefficient, regeneration reactor.

TEST
CONDITIONS:

Same as Operation No. 27. Nominal Min/Max

MEASUREMENTS
TO BE MADE:

- a) Same as Operation No. 27.
- b) Also, jacket cooling water outlet temperature, TI247.

EVALUATION OF
OPERATING DATA:

- a) Calculate heat released in regeneration reactor (which will vary over the course of the reaction) from rate of dissolution of solids times heat of reaction (see Operation No. 41).
- b) Calculate heat transferred from reaction heat released minus (plus) mass times heat capacity for tank hardware plus contents times rate of increase (decrease) of reactor temperature. Check calculated heat transferred against product of jacket water flow rate, estimated from position of control valve TCV202 and valve pressure drop, and jacket water outlet minus inlet temperature.
- c) Compute average temperature difference from (average) temperature within reactor minus average of jacket cooling water inlet and outlet temperatures. Calculate overall (average) heat transfer coefficient.
- d) Correct calculated overall heat transfer coefficient to an equivalent value at nominal conditions in the same manner as for Operation No. 12 c.
- e) Compare (corrected) overall heat transfer coefficient with clean service value, a decrease is to be ascribed to fouling.
- d) Record the number of batches leached, the service history, and the time since last cleaning. Anticipate rate of fouling (increase in fouling resistance) will be sensitive to leach temperature and, particularly, final composition of leach solution.

OPERATION NO. 32

FUNCTION TO
BE DETERMINED:

Clean service heat transfer coefficient, regenerated copper sulfate cooler.

TEST
CONDITIONS:

	<u>Nominal</u>	<u>Min/Max</u>
a) Copper sulfate (water) flow rate, GPM	80	40/100
b) Copper sulfate (water) temp., °F	230	190/300

MEASUREMENTS
TO BE MADE:

- a) Rate of level change in Tank T201 and reactor V201, LI203.
- b) Copper sulfate (water) inlet and outlet temperatures, TI242, 245.
- c) Cooling water inlet and outlet temperatures, TI147, 246.

EVALUATION OF
OPERATING DATA:

- a) Compute copper sulfate flow rate from rate of level decrease (increase) in reactor V201 (Tank T201 if pump P201 is off).
- b) Compute heat transferred, copper sulfate flow rate times inlet minus outlet temperatures. Note: increase cooling water flow and/or decrease flow of copper sulfate to insure outlet temperature remains always below 210°F.
- c) Compute cooling water flow rate in same manner as for Operation No. 13 b.
- d) Compute log mean temperature dependence and MTD correlation factor in same manner as for Operation No. 13 c.
- e) Compute overall heat transfer coefficient and compare with calculated value in same manner as for Operation No. 13 d.
- f) Rating tests: Conduct in same manner as for Operation No. 11 d, e.
- g) Fouling tests: conduct in same manner as for Operation No. 11 f.
- h) Record exchangers condition in same manner as for Operation No. 11 g.

OPERATION NO. 33

FUNCTION TO
BE DETERMINED:

Service heat transfer coefficient, regenerated copper sulfate cooler.

TEST
CONDITIONS:

Same as Operation No. 32.

Nominal Min/Max

MEASUREMENTS
TO BE MADE:

- a) Same as Operation No. 32.
- b) Also, sample regenerated CuSO_4 at end of leach regeneration run, composition by analyses No. 5, 6, 7, 8, 11, 12, 17 and 19.

EVALUATION OF
OPERATING DATA:

- a) Compute copper sulfate and water flow rates, heat transferred, corrected log mean temperature difference, and overall heat transfer coefficient in the same manner as for Operations No. 32 a, b, c, d, and e.
- b) Correct calculated overall heat transfer coefficient to an equivalent value at nominal conditions in the same manner as for Operation No. 12 c.
- c) Compare (corrected) overall heat transfer coefficient with clean service value; a decrease is to be ascribed to fouling.
- d) Record time heat exchanger has been in service, service history, and time since last cleaning. Anticipate rate of fouling (increase in fouling resistance) will be sensitive to process stream composition and temperature.

OPERATION NO. 34

FUNCTION TO
BE DETERMINED:

Instrument check, consumption of sulfuric acid.

TEST
CONDITIONS:

Sulfuric acid consumption in leach,
gal/batch

Nominal

Min/Max

0

0/15

MEASUREMENTS
TO BE MADE:

- a) Flow rate of makeup H_2SO_4 , FI361.
- b) Rate of decrease in level in Tank T203, LI362.
- c) Rate of increase in level in reactor V201, LI202.

EVALUATION OF
OPERATING DATA:

- a) Compute flow rate of makeup H_2SO_4 from Tank T303 from decrease in level (volume) vs. time (and increase in level vs. time for reactor V201, although this will be a small change).
- b) Compute average flow rate of H_2SO_4 by integrating instantaneous readings of FI361 and compare with average rate calculated from volume change in tank. Apply correlation factor to flow indicator's scale if required.

OPERATION NO. 35

FUNCTION TO
BE DETERMINED:

Extent of neutralization of solubles purge.

TEST
CONDITIONS:

	<u>Nominal</u>	<u>Min/Max</u>
a) Soluble purge rate, GPM	1.3	1/2.5
b) Purge stream acid content, g/l	24	12/30
c) Purge stream pH, (NH ₄) ₂ SO ₄ , g/l	1.2, 100	1.0, 50/1.6, 125

MEASUREMENTS
TO BE MADE:

- a) Flow rate of solubles purge, FR108.
- b) Level change in Tank T302.
- c) Flow rate of ammonia, FI360.
- d) Level change in Tank T306.
- e) Tank temperature, TI340, circulation, PI320, and degree of agitation.
- f) Collect solubles purge and circulating (neutralized) purge samples at indicated frequencies, composition by analyses No. 5, 6, 7, 8, 9, 11 and 17.

EVALUATION OF
OPERATING DATA:

- a) For continuous neutralization, calculate ammonia use rate requirements from product of solubles purge flow rate times purge acidity.
- b) At indicated frequency, check pH of circulating solution; if decreasing (increasing), increase (decrease) flow of ammonia.
- c) For batch (or semibatch) neutralization calculate ammonia requirements from product of volume of solution in neutralization tank times free acidity. Set required flow rate of ammonia to achieve neutralization in desired time.
- d) At indicated frequency, check pH of circulating solution; if increasing too slowly (rapidly) increase (decrease) flow of ammonia.
- e) Periodically verify efficiency of ammonia utilization: If ratio of ammonia fed to acid neutralized is too high (>100% stoichiometric) check for high tank temperature, insufficient circulation and/or agitation, and odor of ammonia above tank.
- f) Periodically examine sample of neutralized purge for evidence of precipitated solids. If any precipitation occurs, reserve solids for analysis and discontinue neutralization to allow pH to drop, observing point at which solids redissolve.

OPERATION NO. 36

FUNCTION TO
BE DETERMINED:

Neutralization material balance and instrument check.

TEST
CONDITIONS:

Same as Operation No. 35.

Nominal Min/Max

MEASUREMENTS
TO BE MADE:

Same as Operation No. 35.

EVALUATION OF
OPERATING DATA:

- a) Integrate product of solubles purge stream flow rate times acidity over a day's cycle of operation and calculate the amount of ammonia required for neutralization.
- b) Add to this integrated product of solubles purge stream flow rate times inlet ammonia (ammonium sulfate) concentration.
- c) Subtract product of volume of Tank T302 times ammonia (ammonium sulfate) concentration at start of cycle from that at end of cycle.
- d) If no neutralized purge has been transferred to waste disposal, accumulation of total ammonia (c) should equal input (a + b).
- e) Integrate product of ammonia flow rate by time over a day's cycle of operation, and compare total with calculated requirement for neutralization (a).
- f) Observe level decrease in Tank T306 and compare with volume calculated from integrated flow rate (e). Recalibrate flow indicator as required.

OPERATION NO. 37

FUNCTION TO
BE DETERMINED:

Instrumentation check, oxygen consumption.

TEST
CONDITIONS:

	<u>Nominal</u>	<u>Min/Max</u>
a) Oxygen flow rate (average), SCFM	40	20 80

NOTE: INSTANTANEOUS USE RANGES FROM ZERO TO 80 SCFM DURING THE COURSE OF A BATCH RUN. SEE SAFETY NOTE, OPERATION NO. 27.

MEASUREMENTS
TO BE MADE:

- a) Oxygen flow rate to regeneration, FR207.
- b) Level change in oxygen tank T305.
- c) Metered oxygen pressure, temperature, PI225, TI244.

EVALUATION OF
OPERATING DATA:

- a) Record rate of level decrease in oxygen Tank T305 over a period of days in which no oxygen is consumed for process use. Compare vent loss with manufacturer's estimates for heat leak.
- b) Integrate oxygen flow rate recorded by FR207 over course of a leach run to calculate total mass of oxygen consumed. Compare with use indicated by decrease in level in Tank T305 and, after correcting for heat leak, recalibrate flow indicator/recorder if required. Note: it may be necessary to run several leach tests to obtain a significant level change in the oxygen storage tank. If oxygen consumption rate changes so rapidly that integration is difficult, instrument calibration can be carried out by passing oxygen through the reactor (empty) and venting.

OPERATION NO. 38A

FUNCTION TO
BE DETERMINED:

Rate and extent of removal of copper from solution by displacement on iron.

TEST
CONDITIONS:

	<u>Nominal</u>	<u>Min/Max</u>
a) Purge solution copper content, g/l	2	1/4
b) Neutralized purge solution pH	4	1.2/8
c) Neutralized purge solution temp., °F	100	80/150

MEASUREMENTS
TO BE MADE:

- a) Initial and operating level of solution in Tank T301.
- b) Discharge pressure on Pump P301, PI323.
- c) Rate of change of level in Tank T302 and solubles purge flow rate, FR108.
- d) Weight and size distribution of initial charge of scrap to Tank T301, weight and size distribution of additional scrap charged and of scrap residues at termination of run.
- e) Weight of precipitate copper in Tank T301 and of solids removed from filter F302 at termination of run.
- f) Collect samples of neutralized purge fed to decopperization Tank T301 (if any), initial and final tank contents, and decopperized purge from Tank T301 (if any) at indicated frequencies, composition by analyses No. 5, 6, 8, 11, 12 and 19.

EVALUATION OF
OPERATING DATA:

- a) Calculate decopperized purge flow rate from solubles purge flow rate plus (minus) rates of decrease (increase) in volumes of solution in Tanks T302 and T301 (correct increase in level in Tank T301 for addition of scrap if appropriate).
- b) Calculate iron consumption from initial less final weight of scrap retrieved from tank after mechanically dislodging residual copper plated on surface. Check iron consumption from product of final tank volume times solution iron content plus integrated product of decopperized purge flow rate (if any) times solution iron content times run duration.

OPERATION NO. 38A
(continued)

EVALUATION OF
OPERATING DATA:

- c) Calculate copper removed from product of initial less final solution volume (Tank T301) times copper concentration plus integrated product of decopperized purge flow rate times copper concentration of purge solution less decopperized purge concentration times run duration. Check copper removal against weights of copper retrieved from Tank T301 and Filter F302 at termination of run.
- d) Calculate acid consumption as in (c).
- e) Compute liquid circulation rate from head capacity curve of Pump P301 and note condition of agitation, A301.
- f) Compute iron factor from ratio of (rationalized) iron consumed to copper removed. Check consumption of iron by acid by comparing excess over stoichiometric iron factor with consumption of acid.
- g) Anticipate dependence of rate and extent of decopperization on solution composition, temperature, degree of agitation/mixing, amount of excess scrap used, scrap composition and physical properties.

OPERATION NO. 38B

FUNCTION TO
BE DETERMINED:

Rate and extent of removal of copper from solution by precipitation with H_2S .

TEST
CONDITION:

	<u>Nominal</u>	<u>Min/Max</u>
a) Purge solution copper content, g/l	2	1/4
b) Neutralized purge solution pH	4	1.2/8
c) Neutralized purge solution temp., °F	100	80/150
d) Rate of addition of H_2S , CFM	0.1	0.1/1

NOTE: ADDITION OF H_2S AT A RATE HIGHER THAN IT CAN BE ABSORBED IN SOLUTION COULD CREATE A HAZARDOUS CONDITION, SEE INSTRUCTION (b) BELOW.

MEASUREMENTS
TO BE MADE:

- Initial and operating level of solution in Tank T301.
- Discharge pressure on Pump P301, PI323.
- Rate of change of level in Tank T302 and solubles purge flow rate FR108.
- Rate of addition of H_2S , FI368.
- Weight of precipitated sulfides in Tank T301 and of solids removed from Filter F302 in termination of run.
- Collect samples of neutralized purge fed to decopperization Tank T301 (if any), initial and final tank contents, decopperized purge from tank (if any), and solids precipitated at indicated frequencies, composition by analyses No. 5, 6, 8, 11, 12 and 19.

EVALUATION OF
OPERATING DATA:

- Calculate decopperized purge flow rate, copper removal, and acid generation in the same manner as for Operation No. 38A, a, c, and d.
- Calculate the consumption of H_2S from the integrated product of flow rate times run duration.

NOTE: IF ATTEMPTS ARE MADE TO INTRODUCE H_2S INTO THE DECOPPERIZATION SYSTEM AT A RATE FASTER THAN IT CAN BE REMOVED BY REACTION, THE EXCESS COULD BE VENTED INTO THE WORKING AREA AT TOXIC CONCENTRATIONS. ALWAYS INSURE THAT THE H_2S SUPPLY, METERING, AND INJECTION SYSTEM HAS BEEN THOROUGHLY LEAK CHECKED, THE H_2S ALARM SYSTEM IS OPERABLE, AND THAT A HEEL OF COPPER RICH SOLUTION IS PRESENT IN THE DECOPPERIZATION TANK PRIOR TO INITIATING THIS OPERATION. ALWAYS INITIATE H_2S FLOW AT THE LOW RANGE OF FLOW RATES AND INCREASE CAREFULLY. IF THE H_2S ALARM SOUNDS, CLEAR THE WORKING AREA IMMEDIATELY AND DO NOT RE-ENTER WITHOUT PROPER PROTECTION.

OPERATION NO. 38B
(continued)

EVALUATION OF
OPERATING DATA:

- c) Compute liquid circulation rate from head capacity curve of Pump P301 and note condition of agitation A301.
- d) Check copper removal calculated in (a) against product of weight of sulfides collected from tank and filter at run termination times solids copper content.
- e) Calculate sulfide consumption from (rationalized) copper removal and solids sulfide-to-copper composition. Compare with total consumption of sulfide calculated from (b). If simple sulfides are not obtained, check reaction stoichiometry in the same manner as for Operation No. 10 f.
- f) Anticipate dependence of rate and extent of decopperization on solution composition, temperature, degree of agitation, method of mixing, and rate of addition of H_2S .

OPERATION NO. 39

**FUNCTION TO
BE DETERMINED:**

Rate of heat loss from the scrubbing column and inlet steam moisture content.

TEST

CONDITIONS:

	<u>Nominal</u>	<u>Min/Max</u>
a) Steam flow rate, MPPH	100	50/120
b) System pressure, psig	120	105/135
c) Ambient conditions, as appropriate. Note recalibration may be required if ambient conditions (and steam source, or insulation) change greatly.		

**MEASUREMENTS
TO BE MADE:**

- a) Steam flow rate, PR101.
- b) System pressure and temperature, PR110, TI141
- c) Liquid level in scrubber sump, LI104.
- d) Ambient conditions: temperature, wind speed, precipitation if any.
- e) Integrity of system insulation (qualitatively) and time insulation has been at temperature.
- f) Surface temperature of insulation material at various locations on the system.

**EVALUATION OF
OPERATING DATA:**

- a) Bring the system to operating pressure and temperature, by admitting steam at a relatively low flow rate, without introduction of CuSO_4 and leave at this condition until insulation has thoroughly dried and is at a steady temperature as measured by replicated surface temperature readings. Adjust circulating water (scrub solution) flow rate to obtain minimum froth height. Demister wash flow, makeup water (copper sulfate) flows are to be off.
- b) At the start of the test period, record the sump level with water circulation temporarily stopped, and record the increase in level with time with a constant steam rate. Repeat this test for a series of steam flow rates from minimum to maximum, recording ambient conditions for each test and the insulation integrity if changed.
- c) Plot rate-of-level-increase vs. steam flow rate and extrapolate to zero steam flow. This rate of increase represents condensation due to heat loss; calculate heat loss from mass rate of accumulation times steam heat of condensation. The slope of the rate of level increase with steam flow rate represents moisture carried in with the steam and disentrained in the scrubber. Calculate inlet steam moisture from mass rate of accumulation divided by steam flow rate.

OPERATION NO. 39
(continued)

EVALUATION OF
OPERATING DATA:

- d) Calculate expected rate of heat loss from calculated (summed) product of area times overall heat loss coefficient times system minus ambient temperature for all components. Overall heat loss coefficients from manufacturers' insulation R values and calculated process and air side convective coefficients, the later being a function of ambient conditions. Rationalize calculated and measured rates of heat loss.
- e) Repeat heat loss calibration if source of steam, integrity of insulation, or ambient conditions change significantly. If unusually high (>.5%) steam moisture contents are calculated, make a direct reading on the inlet steam with a throttling calorimeter and rationalize the results.

OPERATION NO. 40

FUNCTION TO
BE DETERMINED:

Scrubbing column energy balance, heats of reaction.

TEST
CONDITIONS:

Same as Operations No. 1 and 9.

Nominal Min/Max

MEASUREMENTS
TO BE MADE:

Same as Operation No. 9.

EVALUATION OF
OPERATING DATA:

- a) Determine rate of removal of H_2S (Operations No. 1 and 10 e) and scrubbing reaction stoichiometry (Operation No. 10 f). Compute the heat of reaction from the product of heats of formation times rate of formation for each compound (element) formed minus those consumed.
- b) Determine rate of removal of NH_3 (Operations No. 2 and 10 b) and compute the heat of reaction as in (a).
- c) Use total heats of reaction to calculate water evaporated from system (see Operation No. 9 d).

OPERATION NO. 41

FUNCTION TO
BE DETERMINED:

Regeneration reactor energy balance.

TEST
CONDITIONS:

Same as Operation No. 27.

Nominal Min/Max

MEASUREMENTS
TO BE MADE:

Same as Operation No. 27.

EVALUATION OF
OPERATING DATA:

- a) Determine rate of dissolution of solids during regeneration reaction (Operations No. 27 a-c) and leach reaction stoichiometry (Operations No. 29 a-e). Note that reaction rate will and stoichiometry may vary greatly over the course of the reaction.
- b) Compute the heat of reaction from the product of heats of formation time rate of formation for each compound (element) formed minus those consumed.
- c) Use total heat of reaction to determine rate of heat transfer in regeneration reactor (see Operation No. 31).

OPERATION NO. 42

FUNCTION TO
BE DETERMINED:

Power consumption of process agitators.

TEST
CONDITIONS:

	<u>Nominal</u>	<u>Min/Max</u>
a) Level in Tank T101, ft	7	2/13
b) Slurry Density in Tank T101, w/o	2.7	1.2/5.2
c) Levels in Tanks T301, 302, ft	2, 3	1.5/3.8
d) Level in reactor V201, ft	6	1/8
e) Gas rate to reactor, SCFM	230	0/250
f) Reactor agitation speed, RPM	56	56/84
g) Agitation arrangements	As required	

MEASUREMENTS
TO BE MADE:

- Power draw on all agitators: JR209 on reactor V201, temporary instrumentation all others.
- Level in all tanks: LI203 on reactor V201, LI201 on T101, visual all others.
- Gas rate to reactor V201, FR207 or FR208 and reactor pressure, PR205.
- Agitation speed and arrangement, all tanks and agitator (No. and position of agitators, baffle extension, etc.)
- Collect slurry samples from slurry surge tank, regeneration reactor, decopperization tank at indicated frequencies, slurry density by analysis No. 19.

EVALUATION OF
OPERATING DATA:

- For slurry surge Tank T101, observe effectiveness of agitator in maintaining solids suspension under varying conditions of tank level, agitator height, slurry density, and solids properties. Record agitator power draw as appropriate, and withdraw slurry samples for litre cylinder settling tests if results appear anomalous.
- Evaluate effectiveness of agitators in Tanks T301 and 302 in same manner as for (a).
- Determine gassed density - power draw correlation for reactor V201 - Agitator A201 in air water tests. Charge water to reactor V201 to predetermined level(s), start agitation without air flow and record level and agitator power at minimum and maximum speeds. Initiate air flow over range of expected rates and pressures, recording level and power draw at each, and repeat test series for all agitation and baffling arrangements to be used. Compute power numbers and compare with manufacturers correlation.
- When leaching, record power draw during course of run. Anticipate dependence on extent and rate of leaching as well as air flow, baffling, level, etc. (Note: Power input may be an important parameter in determining leach rate, see Operation No. 27).

OPERATION NO. 43

FUNCTION TO
BE DETERMINED:

Build up of trace elements in the system.

TEST
CONDITIONS:

	<u>Nominal</u>	<u>Min/Max</u>
a) Steam flow rate, MPPH	100	50/120
b) Solubles purge rate, GPM	1.3	1/2.5
c) Demister wash rate GPM, frequency, %	30,15	15,5/60,50
d) Makeup CuSO_4 requirements, lb/day	75	0/150
e) Additional H_2SO_4 requirement, gal/day	0	0/25
f) Additional NH_3 requirement, lb/day	0	0/250

MEASUREMENTS
TO BE MADE:

- a) Steam flow rate, FR101.
- b) Solubles purge rate, FR108.
- c) Demister wash rate, FI363, KC301.
- d) Makeup rates for CuSO_4 , direct weight, H_2SO_4 , FI361, NH_3 , FI360.
- e) Level in column sump, LI104, slurry surge tank, LI201, Makeup CuSO_4 and neutralization tanks.
- f) Collect samples of inlet and outlet steam (condensate), solubles purge, slurry and makeup CuSO_4 surge tank contents, process solids residues (from Filters F102, 201, 302) and makeup chemicals at indicated frequencies, composition by analyses No. 4, 13, 14, and 18.

EVALUATION OF
OPERATING DATA:

- a) Verify the process material balance for trace elements (i.e., elements or compounds not participating in expected reactions): total input of each element derived from steam flow rate times its inlet minus outlet concentration plus flow rate times its concentration in demister wash plus process makeup streams. Total output of each element from flow rate of solubles purge times its concentration for each element, plus rate of generation of process solid residues times its concentration.
- b) Correct balance, if necessary, for in process inventory changes; accumulation (depletion) due to increase (decrease) in level (or slurry density) in column sump and process tankage, and entrainment if significant.
- c) Steady state will have been presumed to be obtained when the (liquid) contents of the system have been turned over twenty times. If process conditions have not changed and concentrations are still changing monotonically, review operating data for consistency and/or determine source (sink) for the element in question. Special emphasis should be directed to elements incorporated in solid residues which may be accumulating in process equipment and/or entrained from the scrubber.

OPERATION NO. 43
(continued)

EVALUATION OF
OPERATING DATA:

- d) Establish correlation for rate of build up of trace element as function of operating conditions. Anticipate dependence on demister wash rate, solubles purge rate, and extent of leaching.

OPERATION NO. 44

FUNCTION TO
BE DETERMINED:

Process total and major component material and energy balance.

TEST
CONDITIONS:

Same as Operation No. 43.

Nominal Min/Max

MEASUREMENTS
TO BE MADE:

Same as Operation No. 43, compositions by analyses No. 5, 6, 7, 8, 9, 12, 14, 16 and 19.

EVALUATION OF
OPERATING DATA:

- a) Determine reaction stoichiometry and total material balances in scrubber and regeneration reactor (see Operations No. 10, 29, 9 and 28).
- b) Verify the process water balance: total input equals demister wash plus inlet steam moisture plus (net) indirect inputs to scrubbing column plus steam sparged to regeneration reactor, if any. Total output equals solubles purge plus evaporation from regeneration reactor. Estimate amount lost due to process spills and evaporation from storage tanks and correct for inventory change due to increase/decrease in column sump and process tankage and makeup water added to system, if any.
- c) Verify process ammonia and boron balances: total input equals steam flow rate times inlet minus outlet concentrations plus demister wash rate times concentration. Total output equals solubles purge rate times concentration (prior to neutralization) plus rate of accumulation of solid residues times concentration (if any). Correct for process inventory changes as appropriate.
- d) Verify process copper balance: total makeup required (output) equals steam flow times outlet concentration plus solubles purge times concentration after decopperization plus rate of accumulation of solid residues times concentration. Correct for process inventory changes as appropriate.
- e) Verify process sulfur (sulfide, sulfate) balance: total input equals steam flow rate times inlet minus outlet concentration plus demister wash rate times concentration plus makeup rate of H_2SO_4 and $CuSO_4$. Total output equals solubles purge rate times concentration plus rate of accumulation of solid residues times concentration. Correct for process inventory changes as appropriate.

OPERATION NO. 44
(continued)

EVALUATION OF
OPERATING DATA:

- f) Verify process acidity balance: establish net rate of generation from scrubbing and regeneration reaction stoichiometries. Net output, solubles purge rate times concentration prior to neutralization, equals net rate of generation minus rate of neutralization by ammonia scrubbed from steam and rate of accumulation of solid residues times concentration. Correct for process inventory changes as appropriate.
- g) Review operating data for consistency and rationalize the data. If the total process balance does not close, review operating data for consistency and/or determine the source (sink) for the elements in question. Special emphasis should be directed to elements incorporated in solid residues which may be accumulating in process equipment and/or entrained in steam from the scrubber. Also, if apparent discrepancies can be correlated with operating conditions such as extent of demister washing, scrubbing liquid pH, use of air vs. oxygen, etc.

OPERATION NO. 45

FUNCTION TO
BE DETERMINED:

Suitability of materials of construction under various
process conditions.

TEST CONDITIONS:	In Appropriate <u>Equipment Item</u>	Same as <u>Operation No.</u>	<u>Nominal</u>	<u>Min/Max</u>
	Scrubber	1		
	Slurry Storage	24		
	Regeneration Reactor	27		
	Neutralization Tank	35		

MEASUREMENTS
TO BE MADE:

- Initial weight, dimensions, surface condition, mechanical strength, and previous history of test coupons and resistance of corrosion measuring elements
- Same measurements at conclusion of test.
- Test duration.
- Average and extremes of operating conditions during test.
- Stream compositions as reported in Operations No. 1, 24, 27 and 35.
- State of process equipment in environment in which test coupons or elements are suspended.

EVALUATION OF
OPERATING DATA:

- Calculate corrosion rate of test coupons from weight loss, test duration, area, and density. Mills per year equals 535 times milligram weight loss divided by product of test time, hours, times area, sq inches, times density gm/cc.
- Measure mechanical strength of composite materials tested by procedures described in Task Report B.1. (This may be done offsite and infrequently).
- Observe test coupons surfaces for incidence of pitting, stress or weld corrosion, and crevice corrosion. If significant pitting or crevice corrosion has occurred, measure depth of metal loss.
- Observe state of process equipment in vicinity of location of test coupons. Seek correlation with changes in equipment surfaces with measured condition of test coupons.

NOTE: ROUTINE INSPECTIONS OF THE CONDITION OF PROCESS EQUIPMENT WILL ALSO BE MADE AT LOCATIONS REMOVED FROM TEST COUPON RACKS. CHANGES IN THE STATE OF THE EQUIPMENT AT THESE SITES WILL ALSO BE CORRELATED WITH TEST COUPON RESULTS AND OPERATING CONDITIONS.

OPERATION NO. 45
(continued)

EVALUATION OF
OPERATING DATA:

- e) Test coupons will be installed in the following locations.
 - i) Column sump below normal liquid level.
 - ii) Column sump above liquid level, below tray.
 - iii) Column within normal froth zone
 - iv) Column above normal froth, below demister.
 - v) Column above demister.
 - vi) Within decanter above normal pulp level.
 - vii) Slurry surge tank.
 - viii) Regenerated CuSO_4 tank.
 - ix) Regeneration reactor below liquid level.
 - x) Regeneration reactor freeboard.
 - xi) Neutralization tank.
 - xii) Decopperization tank.
- f) Other data recorded for establishing correlation(s) with operating conditions. Anticipate dependence on solution composition (particularly pH and copper content below critical values), temperature, velocity, extent of wetting, condition of test coupon, e.g., creviced, stressed.

OPERATING INSTRUCTIONS

SECTION 3

START UP INSTRUCTIONS

SECTION 3
START UP INSTRUCTIONS

Services and General Procedures

1. Verify availability and functionality of all required safety gear (see Section 11) and that housekeeping in the area is proper.
2. Open main shut off and insure adequate flow of cooling water to all skids and use points.
3. Open main instrument air line and insure adequate air pressure to main control panel, all skid manifolds, and all valve actuators.
4. Close main circuit breaker and insure power supply to main control panel, all skid J boxes, process air compressor, and other process use points. Start up process air compressor P401.
5. Insure that sufficient supplies of all required process materials are available and that storage tanks T305 and 306 contain sufficient oxygen and ammonia.
6. Insure that sufficient analytical supplies and materials are available and that analytical instrumentation is operable (see Section 7).
7. Recheck calibration of process instrumentation if required (see Section 10).
8. Check test plan for days operation to determine start up sequence, determinations to be carried out, and analytical requirements (see Section 6 of Test Plan).

Makeup of Process Materials

1. Fill process water Tank T304 and start pump P305. Establish flow to all seal coolant chambers.

NOTE: Failure to pressurize seal coolant chambers on pumps P101 and P101A prior to pressurizing scrubber C101 with steam or to pressurize agitator A201 seal chamber prior to pressurizing reactor V201 with air or oxygen may unseat the mechanical seals causing significant damage and subsequently forcing unscheduled shutdowns. Always establish seal coolant flow as the first operation at start up.

2. Fill reactor V201 with water. This may be done directly by means of a temporary water line from process water storage or through the normal process flow piping. In the latter case, water is introduced to scrubber C101 by demister wash pump P304, transferred from the sump to Tank T101 through heat exchangers and decanter underflow by circulating pump P101, and thence to reactor V201 by circulating pump P103.
3. Turn on agitator A201, set TCV209 to 120°F, and open steam block valves, bringing reactor contents to the desired temperature.
4. Weigh out the required amount of solids and charge them to the reactor through the manhole on the top head. Pump the required amount of liquids to the reactor through the H₂SO₄ addition line. Re-close manhole and continue agitation until solids are dissolved. Close heating steam block valves and turn off agitator A201.
5. Set pressure control PIC205 to 15 psig and establish air flow at minimum rate, FR208. Transfer contents of reactor to surge tank T201 by opening valve HCV222. At completion of transfer, reset PIC205 to zero and shut off air flow, FR208.
6. Start pump P201, and transfer contents of Tank T201 through filter F201 to surge Tank T102. The contents of Tank T201 can also be transferred to either Tank T101 or T302 by means of temporary lines if required.
7. Repeat procedure as many times as required.

Start Up of Scrubbing Column and Auxiliaries

1. Insure flow of seal water has been established to pumps P101 and P101A, power to skids No. 1 and 2, instrument air to all indication and control loops, and cooling water flow to exchangers HX102, 103.
2. Set FIC101 loop to actuate valve FCV101B which will vent steam to the mufflers. Open valve to maximum position on manual control.
3. With main steam block valve closed, open low flow bypass. Steam will pass to column driving out air and condensing at near atmospheric pressure while heating components of the system.

4. Start circulating pump P101 with HCV 122 open as soon as sufficient level of condensate accumulates in the sump, LI104. Then start circulating pump P101A with FIC103 at a minimum value. Excess condensate can be removed from the sump by transferring it with pump P101A through the heat exchangers and decanter overflow - FCV108 open, FCV107 closed - to Tank T302, and thence to the tower sumps with pump P302.
5. When steam is seen issuing from the mufflers, start reducing the set point on FIC101. This will cause the pressure in the system to rise, PR110, and increase the rate of condensation. When the system pressure has reached steam main pressure, open the main steam block valve and close the low flow bypass. Allow the system to idle in this manner until heat up has occurred as measured by reduced condensation rate and high insulation temperatures.
6. Increase steam flow rate to desired value gradually, and then increase circulating rate FIC103. Verify system integrity and tray and demister operation. Start demister wash pump P304 and cycle timer KC301 and verify operation - FI363.
7. Carry out water testing or heat loss calibration if required.
8. Reduce steam flow to minimum value while keeping system at (near) line pressure. Change actuation on FIC101 to operate valve FCV101A.* Remove excess condensate from the system with pump P101A, adjusting sump level LI104 to its nominal operating level. Open valve HCV122 for maximum circulation and stop recirculation flow, FIC103, bypassing flow to the sump.
9. Turn on Pump P102 and set flow controller FIC105 on manual, adjusting set point to maximum value. Withdraw samples of circulating fluid to check copper concentration at intervals. When concentration has reached desired value, reduce set point on FIC105 to nominal value, close bypass on recirculating line, and increase set point on FIC103 to nominal value on manual control.
10. Slowly increase steam flow rate, FIC101, to its nominal value noting tray DP and froth height.* When tray DP has reached its nominal value and/or has stabilized, switch flow control FIC103 from manual to automatic on DPIC. Institute flow of demister wash water at desired flow and frequency. Continue to monitor sump copper concentration and level.
11. After tray DP has stabilized, allow system to run without purge until desired level is obtained, LI104. Then, slowly increase set point on decanter under flow valve, FCV107, to purge required volume of liquid. After condensate has been purged from lines and decanter and slurry is being discharged into Tank T101, slowly increase set point on decanter overflow valve FCV108 to about half the nominal value and decrease set point on underflow FCV107 by a corresponding amount. Carefully observe the overflow clarity in SFG161 and decanter slurry level. Start circulating pump P103 and agitator A101 when sufficient level has built up in Tank T101, LI207.

*See Start Up/Operating Instructions for conditions when turbines are down. (Page 9 this Section).

12. Insure that operation of sample filter FI01 is proper and set desired purge rate on FI160. Check zero and span on AIT105 and withdraw a sample of solution for off line analysis to verify calibration. Also, check calibration of PHE106 against off line sample.
13. When the scrubber has been in operation for a sufficient period of time to insure stable operation, switch the operation of flow controller FIC105 from manual to automatic on AIT105.
14. Readjust set points on decanter over and underflow control valves, FCV108 and 107, to obtain the nominal values. Observe sump level LI104; if increasing, increase both flows and vice versa.
15. If energy recovery exchanger HX101 is operating normally and make-up and purge flow rates have stabilized, turn off cooling water on exchangers HX102 and 103.
16. Withdraw samples and record data at indicated frequencies to monitor steady state operation of the scrubber.
17. Changes in scrub solution composition can be made by adjusting the relative rates of demister wash (FI363, KC301) and makeup CuSO_4 flow (FR105) with the purge flow (FR107 plus FR108) adjusted to maintain the proper total material balance. Adjusting the ratio of decanter over-to-underflow (FR108, FR107) will, after regeneration of solids, fix the composition of the makeup copper sulfate stream.
18. Sufficient copper sulfate must be made up to the scrubber to precipitate the hydrogen sulfide entering and provide an excess for the purge stream. The excess not only provides a driving force for H_2S removal, but provides corrosion protection. A low copper alarm on AIT105 is cause for immediate shutdown (see Section 4).

Start Up of Regeneration Reactor and Auxiliaries

1. Insure flow of seal water has been established to agitator A201, water to reactor jacket and exchanger X202, power to skid No. 3, instrument air to all indication and control loops, and that compressor P401 is on for air leach tests.
2. If leaching is to be carried out with oxygen, insure that all components are clean, grease and oil free, and all piping has been leak checked with air.

3. Insure that circulating pump P103 is operating and apply steam to HX201 (if not already on) at nominal pressure.
4. Vent reactor (manually open PCV 205B), then open transfer and close recirculation valves, charging reactor V201 to desired level. Turn on agitator A201 at minimum speed.
5. Withdraw a sample from the reactor and measure its slurry density, acidity, ammonia, and copper contents. If solids composition is not known from previous analyses of the contents of tank T101, estimate its composition and reserve a sample for future analysis.
6. Calculate the final solution composition if all solids were to be leached, based on assumed solids composition and leach reaction stoichiometry.
7. If complete leaching would result in an unacceptably high final solution copper content, add water to the reactor by way of a temporary water line from the process water supply. If complete leaching would result in too dilute a final copper content, turn off agitator A201 and allow solids to settle. Decant excess liquid through SFG260 by way of a temporary line to neutralization Tank T302.
8. In the former case, either the ratio of decanter over-to-underflow (FR208/FR207) should be decreased or more water should be added to the system by the demister wash (FI363, KC301). For the latter case, either decrease demister wash flow or increase the ratio of decanter over-to-underflow. Note: The final balance between water addition and decanter over-to-underflow ratio will be fixed by the process acid balance.
9. If the calculated final solution composition is too low in acidity, transfer the additional acid required from tank T303 by pump P303 to reactor V201. If the final solution would be too high in acidity, shut off agitator A201 and decant excess liquid through SG260 to tank T302.
10. In the former case either the ratio of decanter over-to-underflow (FR208/FR207) should be decreased or less water should be added to the system by decreasing demister wash (FI363, KC301). For the latter case the reverse is true, subject to the limitations of obtaining the proper acid balance in the system.
11. Once the desired slurry composition has been obtained, set temperature control TCV209 to the desired initial leach temperature and open steam block valves. Set temperature control TIC202 above the desired temperature. For oxygen pressure leaching, the set point should be at least 220°F, and steam sparging should continue until steam vapors pass through the vent line to scrubber V202, insuring all air has been displaced from the system. Note that use of direct steam will dilute the solution concentrations if the initial batch temperature was too low, and this must be accounted for in Steps No. 6-10 above.

12. When the desired initial temperature has been reached, or the solution's normal boiling point, the system pressure required for leaching is set: The signal from pressure controller PIC205 directed to valve PCV205A for oxygen leaching or to valve PCV205B for air leaching. Temperature control set point TCV209 is then reset to ambient temperature, and temperature control TIC202 reset to the desired leach temperature.
13. Agitator A201 is then shut off and the flow of air or oxygen for leaching is initiated. When leaching with air, the main block valve is opened slowly and air flow rate, FIT208, is controlled by obtaining the proper set point on compressor P401 for the desired leach pressure, set by PIC205. When the desired air flow has been established and it is verified that the operating level is proper, LI203, and no liquid is being entrained into the vent scrubber V201, restart agitator A201 at minimum speed. After insuring that operating level and disengagement are still acceptable the agitator speed may be increased if desired. When leaching with oxygen flow control valve PCV206 is actuated and the system allowed to come to pressure as an initial charge of oxygen is bled in. Then, the agitator is restarted at minimum speed, and the flow - automatically controlled by PCV205A - can be throttled if desired by HCV226. Agitator speed can be increased, if desired, to obtain higher gas phase mass transfer rates.
14. Withdraw samples and record data at indicated frequencies to monitor regeneration rate in the reactor. Continuously monitor indicated level, LI203, reactor power draw, JR209, and drip rate from vent scrubber V202 to insure operation is within normal limits.
15. Regeneration rate can be increased, if desired, by increasing leach temperature, TIC202, oxygen pressure, PIC205 and/or air flow FIT208, and agitator speed (and power JR209). Note that if temperature is increased, total pressure must increase by an amount which exceeds the increase in water vapor pressure to maintain oxygen partial pressure.

Start Up of Neutralization and Decopperization Tanks and Auxiliaries

1. Start circulating pump P302, throttling flow with recycle valve to obtain a discharge pressure, PI320, which corresponds to the desired flow rates from the pumps head-capacity curve. Start agitator A302 if a sufficient liquid level is present in neutralization tank T302.
2. Withdraw samples of the tanks contents and of solubles purge stream, analyze for free acidity, and note purge streams flow rate, FR108, and tank level.

3. If neutralization is to be carried out in a continuous manner, calculate the flow rate of ammonia required to neutralize the acid carried in solubles purge stream. For batch neutralization, calculate the amount required to neutralize the tank contents, fix a neutralization time thereby setting ammonia flow rate, and increase this by the flow rate required to neutralize acidity in the incoming solubles purge.
4. Check pressure and level on tanks T306, 306A to insure sufficient ammonia is available. If pressure is low activate tank heater.
5. Open block valve on ammonia feed line and slowly increase flow to desired rate with HCV321. Check TI340 to insure excessive temperature rise does not occur and for odor of ammonia above tank T302 which would indicate incomplete absorption. Increase circulation rate by opening bypass valve to promote absorption.
6. For continuous neutralization, adjust purge flow valve HCV326 to maintain essentially constant level in tank T302. Withdraw samples at indicated frequencies to insure that neutralization is proceeding as desired. If either acidity or flow rate of solubles purge increases or decreases, a compensating increase or decrease must take place in the ammonia flow rate FI360.
7. At the completion of neutralization of a batch of purge solution, or a days campaign, increase purge rate from tank T302, pumping it out to minimum level and then turn off liquid and ammonia flow. Then, clean filter F302, and reserve solids for weight and analysis. Inspect tank to insure no solids have accumulated during neutralization; if any are present, estimate amount and obtain samples for analysis. Note rate and extent to which they redissolve as tank refills with acid purge.
8. Transfer purge, neutralized or unneutralized, to tank T301 for decopperization. Start circulating pump P301, obtaining desired circulation rate by throttling recycle valve to obtain proper pressure, PI323. Start agitator A301 when level is adequate if required for process use.
9. Sample tank contents and analyze for copper content. Estimate total volume of tank. For decopperization by displacement on scrap iron, weigh out amount of scrap desired for estimated iron factor plus excess, estimate its specific surface, and manually charge to tank T301. Continue circulation and agitation if desired, and sample at indicated frequencies to measure residual copper concentration.
10. At completion of run, close recycle valve and open discharge line, pumping tank to minimum level and then stop pump P301. Retrieve and weigh unconsumed scrap in tank T301. Wash down tank with water from temporary line. Collect solids from bottom drain, and retrieve solids from filter F302. Weigh and analyze solids, clean and replace filter.

11. For decopperization by precipitation with hydrogen sulfide, calculate the amount required to precipitate copper content of tank T301 for the assumed stoichiometry and rate of addition required for desired reaction time.
12. Activate H₂S alarm and check calibration. Insure circulation, pump P301, and agitation, A301, are adequate, and slowly open H₂S flow control, bringing flow rate to desired level, FI368. Sample at indicated frequencies to measure residual copper concentration, being especially watchful towards the end of a run as copper becomes depleted.
13. At the completion of a run, shut off flow of H₂S, close recycle valve and open discharge line, pumping tank to minimum level and stop pump P301 and agitator A301. Wash down tank and collect solids from bottom drain, retrieve solids from filter F302, weigh and analyze solids, clean and replace filter.

Start Up/Operating Instructions with Turbines Down

1. It is possible to operate the scrubbing column and auxiliaries when the turbines are down, and operation may continue following unscheduled turbine outages although a system upset will occur. This will result from a loss of steam flow through the restricting orifice in the main line which provides pressure drop in normal operations. Start up, or restart, instructions for such a condition follow.
2. Close the main block valve downstream of FCV101A. Insure that FCV101B is closed, then change actuation on FIC101 to operate valve FCV101B. Set FIC101 on manual control.
3. Open valve HCV122 for maximum circulation and stop recirculation flow, FIC103, bypassing flow to the sump.
4. Slowly open FCV101B. System pressure will start to decrease; continue opening valve while observing level in sump, LI104, to insure superheated liquid does not boil too rapidly. When steam rate is at desired value, set FIC101 to automatic control.
5. Continue with normal start up procedures, steps 8-18 of column and auxiliaries start up instructions, as appropriate.

OPERATING INSTRUCTIONS

SECTION 4

SHUT DOWN INSTRUCTIONS

SECTION 4

SHUT DOWN INSTRUCTIONS

Shut Down of Scrubbing Column and Auxiliaries

1. Open recirculating valve HCV122 and stop flow of circulating scrub solution by resetting FIC103 to zero flow, manual control. Set steam flow, FIC101, and demister wash flow, FI363, KC301, to minimum values.
2. When froth on tray has dumped, DPIC returning to dry tray value, stop flow of makeup copper sulfate by closing block valve to recirculating line; leave pump P102 operating. Turn on cooling water flow to auxiliary cooler HX102.
3. Continue purging contents of sump. Increase flow of purge stream, FIC107 and FIC108, to maximum value consistent with stable operation of decanter C102.
4. When sump level has been decreased to minimum level possible without cavitation of circulating pump P101, reduce purge rate to normal value, resume flow of makeup copper sulfate, and switch FIC105 to manual control, feeding at maximum possible rate. Turn on flow of demister wash, FI363, KC301, at maximum rate and resume flow of scrubbing solution, FIC103, at maximum rate. Continue operating in this mode until liquid level in sump, LI104, returns to normal level, then shut off flow of demister wash and makeup copper sulfate.
5. Again pump sump to minimum level at maximum purge rate, increasing ratio of decanter over-to-underflow to maximum extent possible consistent with stable decanter operation.
6. Repeat Steps No. 4 and 5 as many times as required to purge solids and residual acidity from the system. If water testing is to follow, a few cycles will suffice and additional cleaning/purging will take place during water testing. If the equipment is to be shut down for inspection involving disassembly and entrance, repeat procedures until analysis of purge stream indicates negligible residual acidity. The flow of makeup copper sulfate need not be resumed on each fill cycle when the pH of the purged wash solution exceeds about 4.
7. If water testing is scheduled, fill sump with demister wash to normal level, LI104, return scrub solution flow to automatic control DPIC103, increase steam flow to nominal value, FIC101, and carry out tests. Purge any liquid accumulating in the sump entirely through the decanter overflow, FIC108. At the completion of water testing, turn off recirculating slurry and demister wash flows, return steam flow to minimum value, and pump sump level to minimum value before turning off circulating pumps, P101. Also turn off makeup copper sulfate pump P102.

8. Close main steam block valves and switch steam flow control from FCV101A to FCV101B. Allow system to depressurize by bleeding steam to mufflers. When system has reached atmospheric pressure, resume flow of demister wash water at maximum rate. When sump level reaches operating level, restart circulating pump and set circulating flow to maximum value to cool column components. Accumulated sump water may be removed either by pumping through decanter overflow or from a sample point through a temporary line to the drain.
9. When the system has cooled down, stop flow of demister wash, pump sump water to minimum level, stop recirculation of scrub solution (water), and shut down circulating pump P101. Shut down demister wash pump P304, and seal flush water pump P305 only if regeneration reactor is not operating. Turn off power to skids No. 1, 2 and 5, shut off instrument air. Open vent and drain lines in all piping. Insure that all solids have been flushed from slurry lines; use temporary lines and process water for additional flushing if required. Open lower and upper manholes on scrubber to promote air circulation for cooling if entry is required for inspection. Disassemble other components as required.
10. Prior to entry, lock out power to pumps P101, P102 and P304, set FCV101B open in manual operation, and insure that both main steam block valves and low flow bypass are closed and tagged.

Shut Down of Regeneration Reactor and Auxiliaries

1. When sample analyses indicate reaction has been completed to degree desired, decrease agitation speed and air flow, FIT208, to minimum rates and reset temperature control TIC202 to near ambient temperature. Reduce set point for system pressure, PIC205, to 15 psig. Check to verify clean elements in filter F201.
2. Insure water flow to exchanger HX202 is adequate, and slowly open flow control valve HCV222 to drain reactor. If flow rate is so high that exchanger HX202 is unable to cool effluent to below 210°F, TI245, decrease flow rate further by throttling HCV222 and/or reducing pressure PIC205. If flow rate is lower than desired, open HCV222 further and/or increase pressure PIC205.
3. As soon as sufficient level has accumulated in holding tank T201, start transfer pump P201. Adjust setting on recirculation valve to obtain pressure required, PI226, to transfer regenerated copper sulfate to surge tank T102. Control rate of reactor draining with HCV222/PIC205 to insure that level in tank T201 does not rise too high. If transfer rate from T201 to T102 is too low, close recir-

ulation valve to increase pressure on filter F201, PI226. If rate is still not sufficient, switch to auxiliary filter and clean or replace element.

4. As reactor level, LI203, drops below agitator blade level, turn off agitator A201 and cooling water flow to jacket, TIC202. As level drops towards zero, stop flow of air or oxygen by closing block valves and shutting off air compressor if required. As residual liquid is blown out of transfer line and air/liquid mixture issues from discharge pipe to tank T201, close flow control valve HCV222. Reduce set point on pressure control PIC205 to zero, switch to manual control and set valve to open position.
5. Open manhole on reactor head and inspect interior. If substantial amounts of unregenerated solids are retained on walls or agitator, wash them down with process water from temporary line. Do not use excessive amounts of water; solids may be left in place for subsequent regeneration run if not excessive or if entry is not required for inspection or revision. Replace manhole, reset pressure control PIC205 to 15 psig, repressurize reactor with air at minimum flow, FI208, and transfer washed down solids to tank T201 by opening valve HCV222.
6. When level in tank T201 has reached minimum value prior to onset of cavitation by pump P201, turn off transfer pump, remove filter elements, F201, and reserve solids for weight and analysis. Turn off flow of cooling water to exchanger HX202. Inspect vent scrubber V202 for presence of solids.
7. Turn off power to skid No. 3 and if reactor V201 is to be entered for inspection or repair, lock out power to agitator A201, pump P103, compressor P401, and oxygen flow valve FV206, and reset TCV209 to minimum temperature, PRV221 to minimum pressure, and insure steam block valves are closed and tagged.

Shut Down of Neutralization and Decopperization Tanks and Auxiliaries

1. Shut off flow of ammonia, HCV321, and close block valve. Turn off heater vaporizer on storage tank T306.
2. Close recirculation valve and pump contents of tank T302 through filter F302 to waste. Draw tank to minimum level, turn off agitator A302 and circulating pump P302. If tank is to be entered, wash

down with water from process water supply by means of a temporary line, restart pump P202, and drain tank contents through filter F302.

3. Remove elements from filter F302, remove and retain solids for weight and analysis, replace filter.
4. Draw and wash down decopperization tank T301 in same manner as neutralization tank T302. Insure that hydrogen sulfide supply is valved off and secured.

OPERATING INSTRUCTIONS

SECTION 5

EMERGENCY SHUT DOWN INSTRUCTIONS

SECTION 5

EMERGENCY SHUT DOWN INSTRUCTIONS

General

1. These emergency shut down procedures are directed towards situations where failure of a system component is so serious that it can not be bypassed or repaired quickly enough to permit normal shut down procedures to be used without still further damage or other serious consequences. THEY ARE NOT INTENDED TO APPLY WHEN CATASTROPHIC FAILURES HAVE OCCURRED OR IN SITUATIONS IN WHICH PERSONAL INJURY HAS OR COULD OCCUR.
2. For catastrophic failure or where personal injury has occurred, the emergency system shut down procedure is to:
 - i) Disconnect main process power relay and activate emergency alarm.
 - ii) Evacuate the operating area at once. Notify plant personnel if failure could have harmed turbines or if personnel injury is involved.
 - iii) Determine immediate cause of failure if possible. Return to operating area to assist disabled personnel and/or repair damage only when protected by adequate safety gear and in accordance with plant safety standards.

Scrubbing Column

1. Shut off main steam block valves as rapidly as possible and insure low flow bypass is closed.
2. Switch flow control FIC101 from FCV101A to FCV101B, set FCV101B to manual control and open valve slightly to start depressurizing the system. Reduce set point on tray DP control to minimum value, DPIC-103.
3. If safe access to skid No. 2 is possible, turn on cooling water to auxiliary cooler HX102. Increase decanter underflow to maximum possible, FCV107.
4. Observe tray DP, DPR103; as soon as it indicates that the froth has collapsed and the tray dumped, open FCV101B further to more rapidly depressurize the system.

5. Turn on demister wash to maximum rate, FI363, KC301, to cool system and dilute sump contents, as long as sump level is not excessive, LI104. Shut down pump P102.
6. If a system component fails, e.g., pump seal on P101, and safe access is possible, close blocks and open bypasses to permit continued operation if possible. Otherwise shut down as in Steps No. 1-5 subject to limitations of functionality of system components.
7. As soon as system has depressurized, return to normal shut down procedures as safety considerations permit and equipment serviceability allows.

Heat Exchangers and Decanter

1. If safe access to Skid No. 2 is possible:
 - i) For energy recovery exchanger HX101, turn on water flow to exchanger HX102 and bypass both makeup copper sulfate and purge flow, blocking off exchanger HX101.
 - ii) For decanter C102, bypass and block off decanter and flow control valve FCV107, throttle by hand to achieve approximately correct total purge rate to maintain sump level, LI104.
 - iii) Evaluate magnitude of repairs required. Shut down scrubber in normal manner if a long outage is indicated. Shut down with emergency procedures if continued safety hazard exists.
2. If safe access to Skid No. 2 is not possible:
 - i) Decrease set point on steam flow control FIC101 to minimum value.
 - ii) Close block valves on makeup copper sulfate flow and purge slurry flow on Skid No. 1 if safe access is possible. Turn off makeup copper sulfate pump P102.
 - iii) Open decanter underflow control valve FCV107 and reduce set points of pressure reducing valve PRV120 to depressurize equipment.
 - iv) As soon as safe access is possible, inspect equipment and evaluate possibility of continued operation in modes of Step No. 1 i, ii. Shut down scrubber in normal or emergency mode if continued operation is not possible or a continued hazard exists.

Regeneration Reactor

1. Turn off air compressor P401 if air leaching or activate solenoid shutting off oxygen flow, HS206. Valve off oxygen supply at tank T305.
2. Turn off agitator A201 and reset temperature control TIC202 to ambient temperature.
3. Switch pressure control PIC205 to activate valve PCV205B. Reduce pressure set point to a pressure corresponding to the vapor pressure of water at leach temperature TR202. Then, slowly reduce set point of PIC205 to depressurize system; too rapid depressurization could transfer large amounts of flashing liquid/vapor to vent scrubber V202 exceeding its capacity to disengage it.
4. As soon as safe access is possible, shut off air and oxygen block valves on feed lines and open drain valve HCV222.
5. As soon as system has depressurized, return to normal shut down procedures as safety considerations and equipment serviceability allows.

Neutralization and Decopperization

1. Shut off ammonia at tank T306 and turn off heater vaporizer. As soon as safe access to Skid No. 4 is possible, turn off ammonia flow, HCV321.
2. Do not enter area of Skid No. 4 to shut down decopperization when hydrogen sulfide is in use without proper personnel protection. Shut off and secure H₂S supply, after evacuating area, if required.

Other Equipment and Auxiliary Items

1. Other system components which, malfunctioning, present safety hazards include:
 - 1) All piping and components of the scrubbing column which are under full system pressure. This includes demister wash system, purge system upstream of flow control valve FCV107 and filter F102 (and downstream if lines are blocked), and makeup copper sulfate system.

- ii) All piping and components of the regeneration reactor which could be pressurized. This includes the slurry fill system, steam heating system, oxygen and air supply systems, vent lines (and scrubber if downstream lines are plugged), and reactor drain and cooling system.
 - iii) Oxygen, hydrogen sulfide, ammonia, and sulfuric acid storage and feeding systems.
 - v) Process utility lines; steam, power, and air.
2. Emergency shut down procedures to correct malfunctions in these components must be evaluated on a case by case basis. However, the first action to be considered in all cases is to disconnect main process power and evacuate the area.

OPERATING INSTRUCTIONS

SECTION 6

TROUBLESHOOTING GUIDE (DRAFT)

SECTION 6

TROUBLESHOOTING GUIDE (DRAFT)

<u>Observation (Malfunction)</u>	<u>Possible Cause</u>	<u>Ancillary Observation</u>	<u>Corrective Action</u>
Falling level in tower sump, decreasing copper concentration.	Loss of makeup copper sulfate, pump failure. A	Low readings or no reading PI132 or PI131.	Switch PI102 or PI102A into service, repair broken pump.
Falling level in tower sump, decreasing copper concentration.	Excessive by-passing in pressure control valve.	PI131, PI132 reading properly, FR105 low. Increase of TI142, TI146.	Check PRV's 120 or 121 see that they are not operating below set pressures.
Falling level in tower sump, decreasing copper concentration.	Plug in line or heat exchanger.	PI131, 132 reading properly, TI142, 146 increasing, FR105 low.	By-pass blocked section if possible, otherwise shutdown in orderly manner and remove blockage.
Falling level in tower sump, decreasing copper concentration.	Malfunction of copper analyzer.	Loss of automatic calibration function on analyzer.	Use sample of purge copper to manually adjust makeup flow. Repair analyzer.
Falling level in tower sump, decreasing copper concentration.	Excess flow in purge stream, high demister wash flow.	Changed level in decanter, increase of FR108 and 107.	Decrease purge discharge rate to return FR107 and 108 to normal operating conditions, decanter to proper liquid level. Readjust demister wash ratio.
Increasing sump level decreasing copper concentration.	Demister wash cycle not operating properly.	Continuous flow through FI363.	Check for a stuck open solenoid valve or electrical malfunction in the cycle timer.
Increasing sump level decreasing copper concentration.	High demister wash rate and/or low makeup CuSO_4 rate, low purge rate.	High flow through FI363, low flow through FR105, FR107, FR108.	Readjust demister wash cycle timer, increase set points, FR105, 107, 108.

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TROUBLESHOOTING GUIDE

<u>Observation (Malfunction)</u>	<u>Possible Cause</u>	<u>Ancillary Observation</u>	<u>Corrective Action</u>
Increasing of sump level, increasing solids, copper concentration steady.	Insufficient flow in purge line, blockage prior to decanter.	Low TI146, TI142, PI128, 129 readings. High readings PI126 (127). FR107 and 108 low.	Bypass heat exchangers and clean as required. If blockage not removed, shut down in orderly manner.
Increasing of sump level, increasing solids, copper concentration steady.	Insufficient purge flow, plug in underflow line or decanter.	Low TI146, 142, FR107 reading, pressure reading normal, decanter level high.	Cycle flow control valve FCV107 over range. If plug is not removed, bypass decanter and clean lines. If blockage not removed, shut down in orderly manner.
Sump level steady, copper concentration decreasing.	Cu analyzer not operating properly, high demister flow.	FI363 flow high.	Readjust cycle timer, external analysis and manual adjustment for makeup flow.
Rapid buildup of sump level, Cu concentration increasing.	Failure of P101 or 101A.	Low reading DPR103. Low flow FR103, pressure PI124, 125. Loss of H ₂ S removal efficiency.	Switch P101 or 101A into service, repair broken pump.
Rapid buildup of sump level, Cu concentration increasing.	Blockage in recirculating line or valve.	Low reading DPR103, FR103. Normal pressure PI124, 125.	Cycle flow control valve FCV103 over range, close bypass HCV122. If blockage not removed, shut down in orderly manner.
High and/or rising pressure drop across the demister unit.	Malfunction of cycle timer.	High flow through FI363.	Correct malfunction in timer or shut demister wash flow off.
High and/or rising pressure drop across the demister unit.	Demister fouled.	Steam flow FR101 and demister wash flow FI363 normal.	Decrease demister wash flow and/or steam flow and schedule shut down to clean demister.

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TROUBLESHOOTING GUIDE

<u>Observation (Malfunction)</u>	<u>Possible Cause</u>	<u>Ancillary Observation</u>	<u>Corrective Action</u>
High or rising pressure drop across contact tray.	Excessive recirculation of scrub solution.	High reading FR103, low or normal sump level LI104.	Reduce set point on DPIC103.
High or rising pressure drop across contact tray.	Entrainment of sump liquid to tray.	Normal or low reading FR103, high and fluctuating level LI104.	Increase purge rates FR107, 108; temporarily decrease demister wash rate FI363.
High or rising pressure drop across contact tray.	Downcomer or tray fouled.	Normal or low reading FR103, normal steam flow FR101 and normal or decreasing sump level LI104.	Cycle flow control valves FCV101 and 103 over range; dump tray contents and reestablish normal froth if possible. Otherwise, schedule shut down to clean tray.
Loss of scrubbing efficiency.	Loss of froth on tray.	Low flow FR103, pressure drop DPR103.	Increase set point on tray DP control.
Loss of scrubbing efficiency.	Solution copper content, pH too low.	AIT105, PHI106 readings low, scrub flow and tray DP readings normal.	Increase set point on makeup CuSO ₄ flow. Increase purge rate (FR107, 108) and demister wash rate to flush excess acid from system.

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TROUBLESHOOTING GUIDE

<u>Observation (Malfunction)</u>	<u>Possible Cause</u>	<u>Ancillary Observation</u>	<u>Corrective Action</u>
Rapidly changed temperature or pressure in heat exchanger 101, 102 and 103.	Loss or stoppage of flow of process stream.	TI146 decreasing, TI142 decreasing, LI104 increasing.	Check to insure adequate purge flow (FR107, 108). Cycle flow control valves to free stoppage if possible, otherwise shut down.
Rapidly changed temperature or pressure in heat exchanger 101, 102 and 103.	Loss or stoppage of flow of process stream.	TI146, 142 increasing, LI104, AR105 decreasing.	Check to insure adequate makeup CuSO_4 flow (FR105). Reset PRV120, 121 if required, otherwise shut down.
Erratic operation or response, AIT105.	Filters 101 or 101A blocked.	Drop in pressure of PI134, low reading PI160, 160A.	Switch to alternate filter and replace element.

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TROUBLESHOOTING GUIDE

<u>Observation (Malfunction)</u>	<u>Possible Cause</u>	<u>Ancillary Observation</u>	<u>Corrective Action</u>
Solids in SFG161	Total flow through decanter too high.	Flows FR107, 108 high.	Reduce total purge rate, insure column sump level is acceptable.
Rising solids level.	Total flow rate too high.	Ratio of FR108/107 within acceptable limits, level LI104 dropping.	Decrease total flow, insure column sump level is acceptable.
Solids in SFG161	Solubles purge rate too high.	Ratio of FR108/107 excessive. Slurry level too high.	Reduce solubles purge rate; decrease FR108, increase FR107.
Solids in SFG161	Blockage in underflow line or flow control valve.	FR107 reading low, valve position open.	Cycle valve over range, and/or temporarily bypass decanter to clear blockage.
Loss of pressure (PI126).	Blockage in heat exchanger.	Low pressure PI128, low flow FR107, 108. Increasing level LI104.	Bypass exchanger to reestablish flow.
Loss of pressure (PI126).	Excessive underflow rate.	Normal pressure, level readings, high flow FR107.	Reduce set point, FR107.
Solubles flow rate decreasing (FR108).	Filter F102 becoming blocked.	Pressure PI129 increasing, valve position open FCV-108.	Bypass filter and clean, replace element.
Rising solids level in decanter.	Underflow rate too low.	Total purge flow, FR107 and 108 acceptable, ratio FR107/108 too low.	Increase set point FR107, decrease FR108 if required.
Falling solids level in decanter.	Underflow rate too high.	Rate FR108/102 too low, total flow acceptable.	Decrease set point FR107, increase FR108 if required.

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<u>Observation (Malfunction)</u>	<u>Possible Cause</u>	<u>Ancillary Observation</u>	<u>Corrective Action</u>
Terminal temperature differences in heat exchangers changing.	Loss of flow of fluid on one side.	FR105, 107 or 108 too low.	Cycle control valves, check pumps, reset FC's as required to reestablish flows. If blockages are not cleared, shut down.
Terminal temperature differences in heat exchangers changing.	Fouling of heat exchanger surfaces.	Flows within normal range. Pressure drops may be increasing.	If pressure drops are not excessive, continue operation as long as loss of energy recovery does not cause process problems. Otherwise bypass and clean heat exchangers.

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Observation (Malfunction)	Possible Cause	Ancillary Observation	Corrective Action
Abnormal (too high or low) rate of change of level, CuSO_4 storage tank.	Pump failure.	FR105 not recording, pumps P102, 201 not operating.	Switch to alternate pump and repair as required. Bypass tank T201 with temporary piping if required to repair P201.
Abnormal (too high or low) rate of change of level, CuSO_4 storage tank.	Makeup flow rate too high/low.	FR105 out of normal range. Sump level LI104 or copper content changing.	Reset control point, FC105.
Abnormal (too low) rate of change of level, slurry storage tank.	Blockage in slurry transfer line.	Slurry level in decanter increasing, FR107 not reading.	Cycle FCV107 over range to clear blockage, bypass decanter if required. If blockage is not cleared shut down.
Abnormal (too high or low) rate of change of level, slurry storage tank.	Slurry purge rate too high/low.	FR107 out of normal range, slurry level in decanter changing.	Reset control point, FC107, insure sump level is acceptable.
Abnormal (too high) rate of change of level, slurry storage tank.	Transfer rate to reactor too high.	Slurry level in regeneration reactor rising too rapidly, temperature TI240 too low.	Readjust flow control valve to reduce transfer rate.
Abnormal (too high) rate of change of level, slurry storage tank.	Excessive evaporation losses.	High reading TI240, FI228, FI209. High drip rate from HX201 trap.	Reduce air flow FI209, steam pressure PI228.
Tank level (visual) not corresponding to indication on LI201.	Loss of supply air, plugged dip tube.	Low (or high) air pressure.	If low air pressure, restore service, if high air pressure, clear blockage in dip tube.
Loss of solid suspension.	Failure of agitation.	No rotation, physical loss of baffle or turbine blade.	Increase circulation rate of pumps P103, 103A, adjust tank level or slurry density to improve suspension, schedule shut down for repairs.

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<u>Observation (Malfunction)</u>	<u>Possible Cause</u>	<u>Ancillary Observation</u>	<u>Corrective Action</u>
Slurry temperature too high.	High steam pressure, HX201.	Pressure PI228 too high.	Change set point PRV220, throttle steam manually, repair if required.
Slurry temperature too high.	Loss of leaching air and/or circulating flow.	FI209 reading too low. PI221, 229 too high.	Readjust set point FCV226, clear blockage if required, increase circulating flow rate.
Slurry temperature too low.	Low steam pressure HX201.	Pressure PI228 too low.	Check trap operations. Increase set point PRV220 if required.
Slurry temperature too low.	Excessive evaporation.	FI209 reading too high.	Decrease flow rate of leaching air.
Slurry temperature too low.	Fouling of heat exchanger HX201.	Pressure PI228 acceptable or high, circulating flow, air flow normal.	Increase circulating flow, steam pressure to maximum possible, decrease air flow rate, schedule shut down for cleaning.

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<u>Observation (Malfunction)</u>	<u>Possible Cause</u>	<u>Ancillary Observation</u>	<u>Corrective Action</u>
Low fill rate for reactor.	Line blockage	PI220, 221 pressure normal.	Check valve positions. Cycle flows to remove blockage if possible, otherwise isolate plug and shut down to clean.
Low fill rate for reactor.	Pump failure	PI220, 221 too low.	Switch to alternate pump and repair as required.
Initial batch temperature cannot be increased or increases slowly.	Malfunction of temperature control valve TCV-209	PI227 pressure normal. TCV202 closed.	Readjust set point on TCV209. Increase set point on PRV221. Repair valve if required.
Initial batch temperature cannot be increased or increases slowly.	Set point of TIC202 too low.	Valve TCV open.	Increase set point above desired initial temperature.
Excessive temperature rise during reaction.	Insufficient cooling water flow.	Pressure PI230 low, temperature TI247 high, valve TCV202 open.	Check cooling water supply and valving. Restore service.
Excessive temperature rise during reaction.	Malfunction TCV209 or set point too high.	PI227 normal, valve 209 open.	Decrease set point on TCV209 below desired temperature. Close steam block valve.
Excessive temperature rise during reaction.	Fouled heat transfer surface.	TCV209 closed, TCV202 open, pressure PI230 normal.	Decreases reaction rate by limiting air or oxygen supply or reducing pressure PR205. Schedule cleaning on shut down.
Reactor fails to pressurize.	Mechanical seal failure, A201.	Liquid and/or gas vapor flow past seal.	Shut down and repair seal.
Reactor fails to pressurize.	Burst disk and safety valve opened.	Liquid and/or gas vapor flow out discharge pipe.	Shut down, replace PSE, reset PSV.

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<u>Observation (Malfunction)</u>	<u>Possible Cause</u>	<u>Ancillary Observation</u>	<u>Corrective Action</u>
Reactor fails to pressurize.	Pressure control systems failure.	FR207 or 208 normal, no evidence of seal or pressure relief failure.	Readjust set point on PIC205. Manually adjust valve position on PCV205B.
Reactor fails to pressurize.	Gas supply system failure.	FR207 or 208 reading low and/or pressures PI223, 224 and 225 low.	Check valve positions. Check operation of PRV225 and compressor P401. Verify supply of oxygen in Tank T305.
Low power draw on agitator.	Mechanical failure - loss of turbine or baffling.	Normal air or somewhat low oxygen flow (FR207, 208), normal liquid level, low leach rate.	Increase agitation speed. Shut down and inspect agitator and baffling. Repair as required.
Low power draw on agitator.	Low gassed density.	High air or oxygen flow rate, high liquid level LI203.	Decrease air/oxygen flow rate, increase pressure set point. Stop and restart agitator.
High power draw on agitator.	Improper baffling, turbine position.	Normal air or oxygen flow (FR207, 208) normal liquid level.	Change turbine position(s) on shaft, adjust baffle extension, reduce agitator speed.
High power draw on agitator.	High gassed density.	Low flow air or oxygen (FR207, 208). High pressure (PR205), level LI203.	Increase air flow rate, reduce pressure and agitator speed. Partially discharge tank contents (HGV222). Turn off agitator.
Excessive operating liquid level.	Initial slurry charge too high.	High level, LI203, high power draw.	Turn off agitator and decant excess clear liquid (SPG260).
Excessive operating liquid level.	Gassed density too low.	High air flow rate FR208, level LI203. Low power draw.	Decrease air flow rate (FR208), increase pressure (PR205), decrease agitator speed. If not effective shut down and decant liquid.

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Observation (Malfunction)	Possible Cause	Ancillary Observation	Corrective Action
Unacceptably low leaching rate.	Low oxygen partial pressure.	Low total pressure (PR205), air flow rate (FR208). High temperature TR202.	Increase pressure set point and/or air flow rate. Decrease temperature set point.
Unacceptably low leaching rate.	Low leach temperature.	Low reading TR202.	Increase set point on TIC202, TCV209 to raise temperature to desired level.
Unacceptably low leaching rate.	Agitator not operating properly.	Low agitator power draw.	Increase agitator speed. Stop and restart agitator, check baffling arrangement.
Unacceptably low leaching rate.	Insufficient solids suspension.	Visual observation.	Adjust slurry density, agitator speed or position baffling arrangement as required.
Unacceptably low leaching rate.	Insufficient solution acidity.	pH of leach solution >2.	Interrupt leach, add sufficient acid to complete reaction and resume.
Regenerated copper sulfate temperature too high.	Reactor discharge rate too high.	Rapid level increase, T201. Rapid level decrease LI203.	Decrease flow; throttle HCV222 or decrease pressure PIC205.
Regenerated copper sulfate temperature too high.	Inadequate cooling water flow.	Temperature TI246 too high.	Increase cooling water flow.
Regenerated copper sulfate temperature too high.	Fouled heat transfer surface.	Normal reactor discharge rate and cooling water flow.	Decrease discharge rate further, schedule cleaning for exchanger.
High level in Tank T201.	Plugged polish filter.	High pressure, PI226.	Switch to alternate filter and clean/replace element.
High level in Tank T201.	Pump failure.	Low pressure, PI226.	Use auxiliary, portable pump to transfer regenerated CuSO_4 .

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Observation (Malfunction)	Possible Cause	Ancillary Observation	Corrective Action
High acid concentration in Tank T302.	Insufficient purge rate.	High ammonia concentration. Low purge rate PR108.	Increase solubles purge rate FC108. Decrease underflow rate FC107 if required.
High acid concentration in Tank T302.	Inadequate supply of ammonia.	Normal purge rate. Low ammonia flow FI360.	Increase set point, HCV321 and pressure PRV320 if required. Check contents of storage Tank T306.
High acid concentration in Tank T302.	Insufficient contact of ammonia with solution.	Normal purge rate and ammonia flow. Low circulation.	Check operation of circulating pump, contactor and agitator.
Over neutralization in Tank T302.	Ratio of ammonia to purge flow too high.	High ammonia flow, FI360, and/or low purge flow PR208.	Readjust flow rates to obtain proper ratio.
Insufficient decopperization of purge stream.	Excess consumption of iron by acid or lack of absorption of H ₂ S in low pH solution.	High acidity in neutralization tank. Excess consumption of iron. H ₂ S alarm response at normal flow rates FI368.	Increase flow of ammonia (FI360) to neutralization tank.
Insufficient decopperization of purge stream.	Ineffective contact of solution with iron on H ₂ S.	Low circulation (high PI323). Ineffective agitation, A301.	Increase circulation rate, readjust agitator/baffling arrangement. Add more iron or increase H ₂ S addition rate.

OPERATING INSTRUCTIONS

SECTION 7

ANALYTICAL PROCEDURES FOR FIELD TEST WORK

SECTION 7

FIELD TEST - CHEMICAL ANALYSIS PROCEDURES

<u>Designation</u>		<u>Used in Analyses No.</u>
A	Hydrogen sulfide in steam condensate	1
B	Ammonia in steam condensate	2
C	Boric acid in condensate and solution samples	3 (7)
D	Copper in solution samples - direct photometric	5, (10)
D (alt.)	Copper in solution samples - electrogravimetric	(10)
E	Copper in solution samples - neocuproin method	
F	Ammonium ion in solution samples - semiquantitative	
G	Ammonium ion in solution samples - quantitative	(10)
H	Sulfuric acid in solution samples	8, (10)
J	Total sulfate in solution samples - titrimetric	9
J (alt.)	Total sulfate in solution samples - gravimetric	(10)
K	Copper in scrubber solids	12
L	Total analysis of scrubber solids	(13)
M	Chemical tracer in solution samples	(14)
N	Chloride in solution samples	(15)
P	Elemental sulfur in steam condensate	(16)
Q	Elemental sulfur in solid residues	(16)
R	Analysis of basic copper sulfate residues	17
S	Solids content of various process streams	19
T	Preparation of condensate samples for offsite analysis.	4

Anal. No.	Procedure	Equipment Required
(1)	A H ₂ S in condensate	Ag/Ag ₂ S and reference electrodes, p-Ion meter, recorder, automatic titrator and printer.
(2)	B NH ₃ in condensate	pH and reference electrodes, pH meter, recorder, automatic titrator and printer.
(3)	C H ₃ BO ₃ in condensate	Argon plasma emission spectrograph (off-site).
(4)	T + various H ₂ S, NH ₃ , H ₃ BO ₃ in condensate	(Offsite).
(5)	D, E Cu ²⁺ in solution	Visible spectrophotometer w/near-IR detection and temperature-controlled cuvette holder.
(6)	F NH ₄ ⁺ in solution	NH ₃ and reference electrodes, p-Ion meter, recorder
(7)	C H ₃ BO ₃ in solution	(Offsite)
(8)	G, H H ₂ SO ₄ in solution	pH and reference electrodes, pH meter, recorder, automatic titrator and printer.
(9)	H SO ₄ ²⁻ in solution	Pb-ion and reference electrodes, p-Ion meter, recorder automatic titrator and printer, ion exchange columns.
(10)	D or D (alt.) Total solution analysis G, H, J (alt.)	(Offsite)
(11)	- pH of solutions.	pH and reference electrodes, pH meter.
(12)	K % Cu in solids	Same as 5.
(13)	L Total solids analysis	Offsite.
(14)	M Entrained tracer (K ⁺ or Li ⁺)	Offsite.
(15)	N Cl ⁻ in solution.	Silver coulometric titrator (offsite).
(16)	P, Q Elemental sulfur (dispersion)	Soxhlet extractor, UV spectrophotometer, pH and reference electrode, pH meter, recorder.
(17)	R Basic copper salts	Same as No. 5 (Cu ²⁺) + No. 2 (NH ₃ in condensate) + No. 9 (SO ₄ ²⁻)

<u>Anal. No.</u>	<u>Procedure:</u>	<u>Equipment Required</u>
(18)	- Trace elements	Offsite
(19)	S % solids	Filtration rig, controlled atmosphere, or vacuum oven.

Summary of Onsite Equipment Requirements

- (1) pH meter, with spare pH and reference electrodes, if not combination
- (1) Combination pH, p-Ion meter (i.e., with expanded mV range).
- (1) Chart Recorder for same.

Specific electrodes, including one spare of each and reference electrodes.

Silver/silver sulfide electrode
Ammonia membrane electrode
Lead-ion specific electrode

- (2) Automatic titrators with printout.
- (1) Spectrophotometer, visible with near-IR capability and with temperature-controlled cuvette holder.
- (1) Controlled-atmosphere or vacuum oven
- (2) Millipore filtration apparatus
- (1) Soxhlet extractor, Pyrex with heating mantle and extraction thimbles
- (2) Ion-exchange columns, ca. 5 ml capacity.

Section 7

(Analytical Techniques will be furnished when equipment purchases are made).

OPERATING INSTRUCTIONS

SECTION 8

EQUIPMENT PERFORMANCE FOR DATA REDUCTION AND ANALYSIS

SECTION 8

OUTSIDE INFORMATION REQUIRED FOR
DATA REDUCTION AND ANALYSIS

Equipment Performance, Rating Data

Page

Demister pressure drop vs. flow rate, clean service

1

Demister disentrainment efficiency, clean service.

Head-capacity curves; pumps P101, 102, 103, 201, 30P, 302, 303,
304, 305.

Valve position - CV data; valves FCV101A, B, FCV103, FCV105,
FCV107, FCV108, TCV202, PCV205A, B, TCV209, PRV120, 121,
220, 221, 225, 320, HCV122, 222, 321, 322, FCV301A, B, C.

Clean service rating, energy recovery exchanger.

Filter pressure drop vs. flow rate, water service F101, A, F102, F201,
F301, F302.

Leach agitator power number.

Oxygen storage tank heat loss rate.

Insulation R values.

Demister Pressure Drop vs. Flow Rate

(This and other equipment performance data will be furnished by manufacturers when equipment purchases are made).

OPERATING INSTRUCTIONS

SECTION 9

PERFORMANCE CORRELATIONS AND THERMOCHEMICAL DATA

SECTION 9

OUTSIDE INFORMATION REQUIRED FOR DATA REDUCTION AND ANALYSIS

<u>Generalized Performance Correlations and Thermochemical Data</u>	<u>Page</u>
Tray entrainment correlations	1
Heat transfer rate correlations; tube side convective	2
shell side convective	3
tank wall convective	3
condensing	3
ambient convective	4
Mean temperature difference correction factor	4
Pressure drop correlations; tube side flow	5
shell side flow	5
Unsteady state heat transfer data evaluation	7
Agitator power number correlations	7
Generalized scrubbing reaction stoichiometry	8
Generalized regeneration reaction stoichiometry	8
Heats of formation	12

Tray Entrainment Correlations

Compute entrainment by both correlations shown below and use average.

Correlation No. 1

Correlation No. 2

Fig. 1.

where:

L = scrubbing liquid rate, lb/hr

G = steam flow rate, lb/hr

ρ_g, ρ_l = steam, liquid density, lb/ft³

$\phi = e/(L + e)$

e = liquid entrainment, lb/hr

$\hat{e}$ = entrainment, lb liquid/lb vapor

% of flood: use sieve tray curves. Define flooding velocity from correlation below. Spacing parameter is distance between top of froth and bottom of demister.

Correlation No. 3

Fig. 3

σ = liquid surface tension, dyne/cm

U_{nf} = flooding velocity, ft/sec, based on tray hole area

Tube Side Convective Heat Transfer Coefficient

Compute tube side convective heat transfer coefficient from:

$$Nu = 0.023 Re^{.8} Pr^{.33}$$

where: $Nu = hD/k$

$Re = DV\rho/u$

$Pr = Cu/k$

h = heat transfer coefficient, BTU/hr/ft²/°F
 D = tube inside diameter, ft
 k = liquid thermal conductivity, BTU-ft/hr/ft²/°F
 V = liquid velocity, ft/hr
 ρ = liquid density, lb/ft³
 u = liquid viscosity, lb/ft hr, cps $\times 2.42$
 C = liquid heat capacity, BTU/lb/°F

Note: Any set of consistent units may be used.

Shell Side Convective Heat Transfer Coefficient

Compute shell side convective heat transfer coefficient from:

$$Nu = 0.2 Re_{mx}^{.6} Pr^{.33}$$

$$Re_{mx} = DV_{mx} \rho / u$$

D = tube outside diameter, ft

V_{mx} = liquid velocity, ft/hr, through minimum clearance area between tubes. Others as previously defined.

Tank Wall Convective Heat Transfer Coefficient

Compute convective heat transfer to regeneration reactor inside wall from:

$$NU_T = 0.54 Re_T^{.66} Pr^{.33}$$

where:

$$NU_T = h D_T / k$$

$$Re_T = L_p^2 N_R \rho / u$$

D_T = tank inside diameter, ft

L_p = agitator blade diameter, ft

N_R = agitator speed, revolutions/hr

Others as previously defined.

Condensing Heat Transfer Coefficient

Compute condensing steam film heat transfer coefficient on vertical tubes from:

$$NU_L = .92 (L^3 \rho_g^2 g / u T')^{1/3}, \text{ or}$$

$$h_L = 1000 (Dk^3 \rho_g^2 / u \dot{w})^{1/3}$$

where: $\dot{w}$ = condensate flow rate, lb/hr/tube.

Others as previously defined.

Ambient Convective Heat Transfer Coefficient

Compute convective (plus radiative) heat transfer coefficient to ambient air from:

$$h_L = 0.5 U^{1/2} + 1$$

where: U = wind velocity, mph.

Others as previously defined.

Mean Temperature Difference Correction Factor

Compute mean temperature difference correction factor from curves shown below for exchanger of appropriate configuration.

Fig. 4.

where: Y = MTD correction factor

T_1' = shell side fluid inlet temperature, °F

T_1'' = tube side fluid inlet temperature, °F

T_2' = shell side fluid outlet temperature, °F

T_2'' = tube side fluid outlet temperature, °F

Pressure Drop, Tube Side Fluid Flow

Total pressure drop on tube side of heat exchanger is composed of entrance and exit nozzle losses, bonnet-to-tube entrance and exit losses, and tube friction losses.

$$\Delta P_T = \Delta P_N + \Delta P_{TS} + \Delta P_{TF}$$

where:

- ΔP_T = total pressure drop, psi
- ΔP_N = entrance plus exit pressure drop, psi
- $\Delta P_N = .0001 \rho V_N^2$
- ΔP_{TS} = tube sheet entrance plus exit pressure drop, psi
- $\Delta P_{TS} = .0001 N \rho V_T^2$
- ΔP_{TF} = tube friction loss
- $\Delta P_{TF} = .00003 N L \rho V^2 / D Re^{.2}$
- ρ = fluid density, lb/ft³
- V_N = entrance, exit nozzle velocity, ft/sec
- V_T = fluid velocity in tubes, ft/sec
- N = number of tube passes.
- L = tube length, ft
- D = tube inside diameter, inches
- Re = fluid tube Reynolds number, $DV\rho/\mu$ (consistent units).

Pressure Drop, Shell Side Fluid Flow

Total pressure drop on shell side of heat exchanger is composed of entrance and exit nozzle losses plus tube bank friction losses.

$$\Delta P_T = \Delta P_N + \Delta P_{TB}$$

where:

- ΔP_T = total pressure drop, psi
- ΔP_N = entrance plus exit pressure drop, psi
- $\Delta P_N = .0001 \rho V_N^2$
- ΔP_{TB} = tube bank friction losses, psi
- $\Delta P_{TB} = .0004 f N_R \rho V_{mx}^2$
- V_{mx} = fluid velocity through minimum flow area, ft/sec
- N_R = total number of rows of tubes in the direction of flow;
number of rows per shell pass times number of passes
- f = tube bank friction factor.

Others as previously defined.

Friction factor is determined as a function of Reynolds number for various shell side configurations from correlations shown below.

Minimum Flow Area Traverse Staggered

Minimum Flow Area Diagonal

Fig. 5

In-Line Tubes

Fig. 6.

Unsteady State Heat Transfer Data Evaluation

Calculate heat transfer coefficient from unsteady state rate of cooling (or heating) of a batch of fluid from the relation

$$\frac{T_o - T_c}{T - T_c} = \exp \left(\frac{UA}{mC_p} t \right)$$

where:

- T = batch temperature at time t , °F.
- T_o = initial batch temperature, °F
- T_c = (average) coolant temperature, °F
- t = time into run, hours
- mC_p = total mass times heat capacity being cooled, BTU/°F
- A = heat transfer area, ft²
- U = overall heat transfer coefficient, BTU/hr/ft²/°F

Agitator Power Number Correlations

Calculate power draw expected for agitator of given configuration from power number as a function of agitator geometry and Reynolds number. Correlations are shown below.

Fig. 7.

Curve 2, propeller, pitch equal to diameter, four baffles, each 0.1 D_t ;
 Curve 4, propeller, pitch twice the diameter, four baffles, each 0.1 D_t ;
 Curve 6, flat six-blade turbine, four baffles, each 0.1 D_t ; Curve 7, six-blade turbine, four baffles each, 0.1 D_t ; Curve 8, arrowhead six-blade turbine, four baffles each, 0.1 D_t ; Curve 9, eight-blade fan turbine, four baffles, each 0.1 D_t ; Curve 10, two-blade flat paddle, four baffles, each 0.1 D_t ; Curve 11, shrouded six-blade turbine, four baffles, each 0.1 D_t ; Curve 12, shrouded six-blade turbine, stator ring with 20 blades.

where D_a = agitator diameter, ft
 N = agitator speed, revolutions per hour
 ρ = fluid density, lb/ft³
 u = fluid viscosity, lb/ft hr, CPS $\times 2.42$
 g_c = force-mass conversion factor 4.18×10^8 lb/ft/hr
 P = power draw, ft lb/hr, HP $\times 33,000$

Generalized Scrubbing Reaction Stoichiometry

The generalized stoichiometry for the removal of H₂S by precipitation with CuSO₄ at geothermal conditions is:

The ratio of copper consumed, acidity, and sulfate generated is shown as a function of precipitated solids composition and extent of oxidation of sulfide to elemental sulfur in the following graphs.

Generalized Regeneration Reaction Stoichiometry

The generalized stoichiometry for regeneration of copper sulfate from sulfide by pressure leaching is:

Heats of Formation

The heats of formation of compounds and elements of interest in this system are summarized below as functions of temperature within the range of interest. Heats of solution are also given where appropriate. Units are 10³ BTU/lb mole.

RELATION BETWEEN SULFIDE STOICHIOMETRY AND EXTENT OF
SULFUR OXIDATION AND COPPER REQUIREMENT

Fig. 8.

RELATION BETWEEN SULFIDE STOICHIOMETRY AND EXTENT OF
SULFUR OXIDATION AND ACID GENERATION

Fig. 8 (cont'd)

Relation between Sulfide Stoichiometry
and Extent of Oxidation to Sulfur and Sulfate

Fig. 8 (cont'd)

Heats of Formation

Compound or Element	State		77°F (298°K)	260°F (400°K)	440°F (500°K)
CuS	c	ΔH_{fT}	- 50.29	- 48.15	- 45.93
Cu ₂ S	c	ΔH_{fT}	- 62.53	- 57.25	53.07
CuSO ₄	c	ΔH_{fT}	-358.27	-353.55	-348.33
CuSO ₄	aq	ΔH_{soln}	- 31.52		
Cu _n S	c	ΔH_{fT}	- 50.29-(n-1)12.24	- 48.15-(n-1)9.1	- 45.93-(n-1)7.14
H ₂ S	g	ΔH_{fT}	- 36.54	- 35.01	- 33.45
S ₂	g	ΔH_{fT}	0	+ 1.46	+ 2.95
H ₂ SO ₄	l	ΔH_{fT}	-377.94	-371.51	-364.71
H ₂ SO ₄	aq	ΔH_{soln}	- 39.59		
	~.1g/l		- 35.72		
	~ 1g/		- 33.71		
	~ 5g/		- 32.91		
	~10g/		- 31.68		
	~50g/				
NH ₃	g	ΔH_f	- 19.75	- 18.12	- 16.39
NH ₃	aq	ΔH_{soln}	- 14.9		
(NH ₄) ₂ SO ₄	c	ΔH_f	-535.77	-526.82	-517.16
(NH ₄) ₂ SO ₄	aq,∞	ΔH_{soln}	+ 2.66		
NH ₄ HSO ₄	c	ΔH_f	-469.12		
NH ₄ HSO ₄	aq	ΔH_{soln}	- 1.39		
O ₂	g	ΔH_f	0	+ 1.30	+ 2.62
H ₂ O	g	ΔH_f	-104.04	-102.55	-101.06
H ₂ O	l	ΔH_f	-123.01	-119.45	-115.20

SECTION 10

INSTRUMENTATION CALIBRATION PROCEDURES

(Instrumentation Calibration Procedures will be furnished by manufacturers when equipment purchases are made).

OPERATING INSTRUCTIONS

SECTION 11

SAFETY POLICY AND PROCEDURES

SECTION 11

SAFETY POLICY AND PROCEDURES

General

Operations in this demonstration plant will be carried out subject to work rules and procedures specified in PG & E Standard Operating Procedures.

Special Considerations

Three general types of hazards will be encountered during the operation of the demonstration plant. They are:

- Potential release of steam and hot water from equipment under pressure.
- Hazards attending the operation of rotating machinery and other process equipment.
- Potential release of hazardous or toxic materials from process upsets.

The first two general types of hazards are encountered in the day-to-day operation of the power plant, and safety procedures will be covered in operating SOP's.

The hazardous or toxic material which might be released during a process upset include:

- Hydrogen sulfide gas
- Gaseous ammonia
- Oxygen gas
- Concentrated liquid sulfuric acid
- Hot, dilute sulfuric acid solutions.

Information describing the properties of these materials and special handling requirements is summarized below.

OXYGEN

General Information

Colorless, odorless, tasteless gas or liquid hexagonal crystals.

Formula: O_2 .

Mol wt: 32.00, mp: $-218.4^{\circ}C$, bp: $-183.0^{\circ}C$, d: liquid: 1.14 at $-183.0^{\circ}C$, solid: 1.426 at $-252.5^{\circ}C$, vap. d.: 1.429 at $0^{\circ}C$.

Hazard Analysis

Toxicity: None, as gas. In liquid form it can cause severe "burns" and tissue damage on contact with the skin.

Fire Hazard: Though itself nonflammable, it is essential to combustion. Exclusion of oxygen from the neighborhood of a fire is one of the principle methods of extinguishment.

Explosion Hazard: Liquid oxygen can explode on contact with readily oxidizable material, especially at high temperature.

Disaster Hazard: Compressed oxygen is stored in steel cylinders under high pressure. If these containers are broken due to shock or exposed to high temperature, an explosion and fire may result.

Countermeasures

Storage and Handling: Section 7. (of Sax, Handbook of Dangerous Materials)
Shipping Regulations: Section 11.
Regulated by CG, DOT, IATA.

Liquid Oxygen: Though not by itself explosive, liquid oxygen can be dangerous when blended with highly flammable or carbonaceous materials.

AMMONIA, ANHYDROUS

General Information

Synonym: ammonia gas.

Colorless gas, extremely pungent odor, liquefied by compression.

Formula: NH_3 .

Mol wt: 17.03, mp: -77.7°C , bp: -33.35°C , lel = 15%, uel = 28%,
d: 0.771 g/liter at 0°C , 0.817 g/ml at -79°C , autoign. temp.:
 1204°F , vap. press.: 10 atm at 25.7°C , vap. d.: 0.6.

Hazard Analysis

Toxic Hazard Rating:

Acute Local: Irritant 3; Ingestion 3; Inhalation 3. (see Sax for definitions).
Acute Systemic: U.
Chronic Local: Irritant 1.
Chronic Systemic: U.

Toxicology: Irritating to eyes and mucous membranes of respiratory tract. Signs and symptoms of exposure are irritation of the eyes, conjunctivitis, swelling of the eyelids, irritation of the nose and throat, coughing, dyspnoea and vomiting. Irritation of the skin may be experienced, especially if it is moist. Corneal ulcers have been reported following splashing of ammonia water in the eye. A common air contaminant.

Fire Hazard: Moderate, when exposed to heat or flame.

Spontaneous Heating: No. Requires high concentrations in air before it catches fire.

Explosion Hazard: Moderate, when exposed to flame. Forms explosive compounds in contact with Ag or Hg (Section 7).

Disaster Hazard: Moderately dangerous; exposed to heat, it emits toxic fumes.

Countermeasures

Ventilation Control: Section 2.

To Fight Fire: Stop flow of gas, carbon dioxide, dry chemical or water spray (Section 7).

Personnel Protection: Section 2.

Personal Hygiene: Section 2.

Storage and Handling: Section 7.

Shipping Regulations: Section 11.

Regulated by CG, DOT, IATA.

AMMONIA SAFETY

Ammonia gas is not harmful at low concentrations. The pungent odor of the gas gives adequate warning, and it is unlikely that an individual would stay in a room with a concentration of ammonia great enough to overcome him unless he was trapped. The following table gives the physiological effects of various concentrations of ammonia in air (Henderson and Haggard):

	Parts of Ammonia per million parts of air <u>(by volume)</u>
Least detectable odor	53
Maximum concentration allowable for prolonged exposure	100
Maximum concentration allowable for short exposure (1/2 to 1 hr)	300 to 500
Least amount causing immediate irritation to the eye	698
Least amount causing coughing	1720
Dangerous for even short exposure (1/2 hr)	2500--4500
Rapidly fatal for short exposure	5000--10,000

Ammonia represents a possible panic hazard. Because of the discomfort resulting from even traces of ammonia in the air, care should be taken in setting up equipment and in keeping valve packing glands and union joints tight.

Goggles recommended for anhydrous ammonia service should be worn by all personnel dealing directly with anhydrous ammonia. There should be no exceptions to this rule.

For users connecting and disconnecting ammonia cylinders regularly, an ammonia gas mask should be kept where it will be available in case of a leak. It should be noted that most cannister type ammonia gas masks are limited to a maximum concentration of 3% in air. For concentrations exceeding 3%, a self-contained breathing apparatus should be used.

If a bad ammonia leak should develop, spray water around the leaking section until the cylinder can be turned off. Ammonia reacts chemically with water to form ammonium hydroxide (aqua ammonia). If a mask is not available, a sponge or cloth soaked in water and placed over the nose and mouth will offer temporary protection. Since ammonia is lighter than air, the area closest to the floor will be the lowest in ammonia concentration in case a leak should develop.

If liquid ammonia has been released, it should be flooded with large volumes of water. Under no conditions should liquid ammonia be neutralized with an acid.

Liquid ammonia on the skin usually results in severe burns due to a freezing, dehydrating, and caustic effect. For this reason care should be taken in breaking unions on lines containing liquid ammonia. Before breaking a union such lines should be vented with the vent line open to the atmosphere until all frost has left the line.

Any person who has been overcome or burned by ammonia should be placed under a physician's care immediately. As a guide, the following first aid procedure in case of ammonia accidents is suggested:

1. REMOVE the affected PERSON to a place where there is FRESH AIR, CALL A PHYSICIAN. Place the patient flat on his back, in a relaxed position, and keep him WARM to prevent chilling, guarding against exposure to drafts.
2. ASPHYXIATION: If breathing has ceased, start artificial respiration immediately. Artificial respiration, when administered by an inexperienced person is definitely hazardous following exposure to ammonia and should be avoided where possible. The use of a pulmator is definitely not recommended as its more violent action will irritate and may severely injure the lungs. However, a resuscitator used with oxygen and operated by a trained person is recommended.
3. EYES: Hold the lids open and pour clean water over the eyeball and lids (or use eye irrigation fountain). Wash thoroughly in this way for 15 minutes. A doctor, preferably an eye specialist, should be summoned immediately.

4. SKIN: Speed is essential. Strip the ammonia-saturated clothing from the body immediately. Flood affected area continuously with clean water for at least 15 minutes. Do not cover burns with clothing or dressings. Allow them to remain open to the air.
5. NOSE AND THROAT: Irrigate nose and mouth with water continuously for 15 minutes. If the patient can swallow, encourage him to drink large quantities of 1/2% citric acid solution or lemonade. Summon physician immediately.
6. Although 2500 parts per million of ammonia in air is dangerous for exposure of 1/2 hour duration, it would be very difficult for a person to remain in this high a concentration of ammonia gas even for a short period of time, because of the severe irritation to eyes and throat. In other words, air containing amounts of ammonia which a person can stand is not particularly dangerous, although care should be taken to prevent prolonged exposure to any atmosphere having an irritating effect.

HYDROGEN SULFIDE

General Information

Synonym: sulfureted hydrogen.

Colorless; flammable gas, offensive odor.

Formula: H_2S .

Mol wt: 34.08, mp: $-85.5^{\circ}C$, bp: $-60.4^{\circ}C$, lel = 4.3%, uel = 46%, autoign temp.: $500^{\circ}F$, d: 1.539 g/liter at $0^{\circ}C$, vap. press.: 20 atm at $25.5^{\circ}C$, vap. d.: 1.189.

Hazard Analysis

Toxic Hazard Rating:

Acute Local: Irritant 3.

Acute Systemic: Inhalation 3.

Chronic Local: U.

Chronic Systemic: Inhalation 3.

Toxicology: Hydrogen sulfide is both an irritant and an asphyxiant. Low concentrations of from 20 to 150 ppm cause irritation of the eyes; slightly higher concentrations may cause irritation of the upper respiratory tract, and if exposure is prolonged, pulmonary edema may result. The irritant action has been explained on the basis that H_2S combines with the alkali present in moist surface tissues to form sodium sulfide, a caustic.

With higher concentrations the action of the gas on the nervous system becomes more prominent, and a 30-minute exposure to 500 ppm results in headache, dizziness, excitement, staggering gait, diarrhea and dysuria, followed sometimes by bronchitis or bronchopneumonia. The action on the nervous system is, with small amounts, one of depression; in larger amounts, it stimulates, and with very high amounts the respiratory center is paralyzed. Exposures of 800 to 1000 ppm may be fatal in 30 minutes, and high concentrations are instantly fatal. Fatal hydrogen sulfide poisoning may occur even more rapidly than that following exposure to a similar concentration of hydrogen cyanide. H_2S does not combine with the hemoglobin of the blood; its asphyxiant action is due to paralysis of the respiratory center.

With repeated exposures to low concentrations, conjunctivitis, photophobia, corneal bullae, tearing, pain and blurred vision are the commonest findings. High concentrations may cause rhinitis, bronchitis, and occasionally pulmonary edema. Exposure to very high concentrations results in immediate death. Chronic poisoning results in headache, inflammation of the conjunctivae and eyelids, digestive disturbances, loss of weight and general debility. It is a common air contaminant.

Fire Hazard: Dangerous, when exposed to heat or flame.

Explosion Hazard: Moderate, when exposed to heat or flame.

Disaster Hazard: Highly Dangerous; when heated to decomposition, it emits highly toxic fumes of oxides of sulfur; can react vigorously with oxidizing materials.

Countermeasures

Ventilation Control: Section 2.

Personnel Protection: Section 2.

Storage and Handling: Section 7.

To Fight Fire: Carbon dioxide, dry chemical or water spray) Section 7).

Shipping Regulations: Section 11.

Regulated by CG, DOT, IATA.

Safety Considerations in Handling Hydrogen Sulfide

Toxicity

Hydrogen sulfide is perhaps responsible for more industrial poisoning accidents than any other single chemical. A number of these accidents have been fatal. Hydrogen sulfide should be handled with caution and any experiments using it planned carefully. The maximum allowable concentration in the air for an 8-hour work day is 10 ppm, well above the level detectable by smell. However, the olfactory nerves can become deadened to the odor after exposure of 2 to 15 minutes, dependent on concentration, so that odor is not a completely reliable alarm system.

Briefly, the following are some of the human physiological reactions to various concentrations of hydrogen sulfide. Exposure to concentrations in the range of 150 ppm to 200 ppm for prolonged periods may cause edema of the lungs. Nausea, stomach distress, belching, coughing, headache, dizziness and blistering are other signs and symptoms of poisoning in this range of concentration. Pulmonary complications, such as pneumonia, are strong possibilities from such sub-acute exposure. At 500 ppm unconsciousness usually results within 30 minutes and results in acute toxic reactions. In the 700 to 1000 ppm range, unconsciousness may occur in less than 15 minutes and death occur within 30 minutes. At concentrations above 1000 ppm, a single lungfull may result in instantaneous unconsciousness, with death quickly following due to complete respiratory failure and cardiac arrest.

Additional information on the toxicity of hydrogen sulfide can be obtained from the "Chemical Safety Data Sheet SD-36," adopted January, 1950, available from the Manufacturing Chemists Association, 1825 Connecticut Avenue, N.W., Washington, D. C. 20009.

Fire and Explosion Hazards

Hydrogen sulfide is a flammable gas, yielding poisonous sulfur dioxide as a combustion product. In addition its explosive limits range from 4 to 46% in air. Appropriate precautions should be taken to prevent these hazards from developing.

Experimental Suggestions

All tests should be performed in a hood or with adequate ventilation to exhaust all the H_2S . The H_2S flow rates should be kept low to minimize the quantity exhausted. Suitable safety equipment should be used. Particular attention should be given to the output pressure on the pressure regulators as the downstream pressure frequently will rise as corrosion product, debris, etc., interfere with regulation at low flow rates. Gas cylinders should be securely fastened to prevent tipping and breakage of the cylinder head. Because hydrogen sulfide is in liquid form in the cylinders, the high pressure gage should be checked frequently, as relatively little time will elapse after the last liquid evaporates until the pressure drops from 250 psi to atmospheric pressure. The cylinder should be replaced by the time it reaches 75 to 100 psi because the regulator control may become erratic. Flow should not be allowed to stop without closing a valve or disconnecting the tube at the test vessel because the solution will continue to absorb H_2S and move upstream into the flowline, regulator, and even the cylinder. A check valve in the line should prevent the problem if the valve works properly. However, if such an accident occurs, the remaining hydrogen sulfide should be vented as rapidly and safely as possible and the manufacturer notified so that the cylinder can receive special attention.

SULFURIC ACID

General Information

Synonyms: oil of vitriol; dipping acid.

Colorless, oily liquid.

Formula: H_2SO_4

Mol wt: 98.08, mp: 10.49, bp: 330°C, d: 1.834 vap. press.: 1 mm at 145.8°C.

Hazard Analysis

Toxic Hazard Rating:

Acute Local: Irritant 3; Ingestion 3; Inhalation 3.

Acute Systemic: U.

Chronic Local: Irritant 2; Inhalation 2.

Chronic Systemic: U.

Toxicology: Contact with the body results in rapid destruction of tissue, causing severe burns. No systemic effects due to continual ingestion of small amounts of this material have been noted. There are systemic effects secondary to tissue damage caused by contact with it. However, repeated contact with dilute solutions can cause a dermatitis, and repeated or prolonged inhalation of a mist of sulfuric acid can cause an inflammation of the upper respiratory tract leading to chronic bronchitis. Sensitivity to sulfuric acid or mists or vapors varies with individuals. Normally 0.125 to 0.50 ppm may be mildly annoying and 1.5 to 2.5 ppm can be definitely unpleasant. 10 to 20 ppm is unbearable.

Workers exposed to low concentrations of the vapor gradually lose their sensitivity to its irritant action. Inhalation of concentrated vapor or mists from hot acid or oleum can cause rapid loss of consciousness with serious damage to lung tissue. In concentrated form it acts as a powerful caustic to the skin destroying the epidermis and penetrating some distance into the skin and subcutaneous tissues, in which it causes necrosis. This causes great pain and if much of the skin is involved, it is accompanied by shock, collapse and symptoms similar to those seen in severe burns. The fumes or mists of this material cause coughing and irritation of the mucous membranes of the eyes and upper respiratory tract. Severe exposure may cause chemical pneumonitis; erosion of the teeth due to exposure to strong acid fumes has been recognized in industry.

Used as a general purpose food additive; it migrates to food from packaging materials (Section 10). It is a common air contaminant.

Fire Hazard: Moderate, by chemical reaction; a powerful oxidizer; can ignite upon contact with combustibles.

Disaster Hazard: Dangerous; when heated, it emits highly toxic fumes; will react with water or steam to produce heat; can react with oxidizing or reducing materials.

Countermeasures

Ventilation Control: Section 2.

Treatment and Antidotes: Speed in removing this material from contact with the body is of primary importance. Start first aid at once. In all cases of contact in any form, delay can result in serious injuries and all persons injured should be referred to a physician. However, immediately give prolonged applications of running water to wash the material off the body. Remove contaminated clothing. Subject patient to a deluge type of shower if this is available. Do not attempt to neutralize the acid in contact with the skin until all areas of contact have been thoroughly irrigated with running water. Then applications of mild alkali solutions may be in order. Shock symptoms will often be noted in cases of severe or extensive burns. In such a case, put patient on his back, keep him warm but not hot until physician arrives. Do not apply oils or ointments to burned area without instructions from a physician. If eyes are involved, they should immediately be irrigated with copious quantities of warm water for at least 15 minutes.

If the material has been taken internally, it causes burns of the mucous membrane of the throat, esophagus, and stomach. Do not attempt to induce vomiting in patients who have swallowed strong solutions of sulfuric acid. Do not give anything by mouth to an unconscious patient. If he is conscious, encourage him to wash out his mouth with copious amounts of water, then have him drink milk mixed with whites of eggs. If this is not available, have him drink as much water as possible. Get medical help.

Personnel Protection: Section 2.
Storage and Handling: Section 7.
Shipping Regulations: Section 11.
Regulated by CG, DOT, IATA.

OPERATING INSTRUCTIONS

SECTION 12

OPERATING LOGS

OPERATING LOG

SCRUBBING COLUMN AND AUXILIARIES

Page 1

DATE _____ SHIFT _____ TASK _____ CAMPAIGN _____

MEASUREMENT	Time INSTRUMENT								
<u>Panel Readings</u>									
Steam Flow Rate	FIC101								
System Pressure	PR110								
Makeup CuSO ₄ Rate	FIC105								
Purge Slurry Rate	FIC107								
Soluble Purge Rate	FIC108								
Scrub Solution Rate	FIC103								
Scrub Tray DP	DPIC103								
Demister DP	DPI109								
Sump Level	LI104								
Purge Solution Cu	AIC105								
Purge Solution pH	PHI106								
<u>Local Readings, Water Supply</u>									
Supply Pressure	PI327								
Pump Pressure	PI325,6								
Pump Seal Flow	FI364,5								
Agitator Seal	FI366								
Analyzer Flush	FI367								
Demister Wash	FI363.KC301								
Level, Tank T304									
<u>Scrubber Column Condition</u>									
Scrubber Temp.	TI140,1								
Scrubber Pressure	PI120,1								
Line Pressure	PI122,3								
Pump Pressure	PI124,5								
Sump Level									
Froth Height									

Comments:

OPERATING LOG
SCRUBBING COLUMN AND AUXILIARIES

Page 2

DATE _____ SHIFT _____ TASK _____ CAMPAIGN _____

MEASUREMENT	Time								
<u>Local Readings,</u>	<u>INSTRU-</u>								
<u>Purge Flow</u>	<u>MENT</u>								
Exchanger 101 DP	PI125/126								
Exchanger 102 DP	PI126/127								
Filter 101 DP	PI127/128								
Filter 102 DP	PI129/130								
Exchanger 101 AT	TI141/142								
Exchanger 102 AT	TI142/143								
Decanter Level									
Overflow Clarity	SFG161								
Makeup CuSO ₄ Flow									
Level, Tank 102									
Pump Pressure	PI131,2								
Exchanger 101 DP	PI133/125								
Exchanger 103 AT	TI145/144								
Exchanger 101 AT	TI146/145								
<u>Miscellaneous</u>									
Water Inlet Temp.	TI147								
Water Out, X102	TI148								
Water Out, X103	TI149								
Analyzer Flow	FI160,A								
Scrub Solution, g/t Cu									
Scrub Solution, pH									
Filter 102 Solids									
Steam Out, ppm H ₂ S									

Comments:

OPERATING LOG
REGENERATION REACTOR

Page 1

DATE _____ SHIFT _____ TASK _____ CAMPAIGN _____

	Time								
<u>MEASUREMENT</u>	<u>INSTRUMENT</u>								
<u>Panel Readings</u>									
Leach Temperature	TIC202								
Leach Pressure	PIC205								
Operating Level	LI203								
Oxygen Flow Rate	FR207								
Air Flow Rate	FR208								
Agitator Power	JR209								
<u>Local Readings</u>									
<u>Agitator Speed</u>									
Jacket Water Out	TI247								
Jacket Water Out	PI230								
Leach Temperature	TI242								
Leach Pressure	PI222								
Compressor Press.	PI223								
O ₂ Tank Press.	PI224								
O ₂ Tank Level									
<u>Miscellaneous</u>									
H ₂ SO ₄ Added									
Initial Level	LI203								
Initial Temp.	TI242								
Initial, g/l Cu									
Initial Solids									
Batch, g/l Cu									
Batch, pH									

Comments:

OPERATING LOG
REGENERATION REACTOR

Page 2

DATE _____ SHIFT _____ TASK _____ CAMPAIGN _____

	Time								
<u>MEASUREMENT</u>	<u>INSTRUMENT</u>								
<u>Slurry Store/</u>									
<u>Amb. Leach</u>									
<u>Level, Tank T101</u>	<u>LI201</u>								
<u>Pump Pressure</u>	<u>PI220,1</u>								
<u>Tank Temperature</u>	<u>TI240</u>								
<u>Circulating Temp.</u>	<u>TI241</u>								
<u>Steam Pressure</u>	<u>PI228</u>								
<u>Eductor Pressure</u>	<u>PI229</u>								
<u>Leach Air Flow</u>	<u>FI209</u>								
<u>Trap Drip Rate</u>									
<u>Agitator A101</u>									
<u>Batch, g/l Cu</u>									
<u>Batch, pH</u>									
<u>Surge Tank</u>									
<u>Level, Tank T201</u>									
<u>Tank Temperature</u>	<u>TI245</u>								
<u>Water Out, X202</u>	<u>TI246</u>								
<u>Pump Pressure</u>	<u>PI226</u>								
<u>Tank, g/l Cu</u>									
<u>Tank, pH</u>									
<u>Filter 201 Solids</u>									

Comments:

OPERATING LOG
NEUTRALIZATION, DECOPPERIZATION

DATE _____ SHIFT _____ TASK _____ CAMPAIGN _____

MEASUREMENT	Time								
<u>Neutralization</u>	<u>INSTRUMENT</u>								
Level, Tank T302									
Pump Pressure	PI320								
Tank Temperature	TI340								
NH ₃ Flow Rate	FI360								
NH ₃ Tank Press.	PI321								
NH ₃ Tank Level									
Agitator A302									
Tank, pH									
Filter F302 Solids									
<u>Decopperization</u>									
Level, Tank T301									
Pump Pressure	PI323								
Tank Temperature	TI342								
Agitator A301									
H ₂ S Flow Rate	FI368								
Initial Fe Charge									
Tank, g/l Cu									
Filter F302 Solids									
<u>Miscellaneous</u>									
Level, Tank T303	LI362								
Acid Flow	FI361								

Comments:

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OPERATING INSTRUCTIONS

SECTION 13

SPARE PARTS LISTS AND MAINTAINING INSTRUCTIONS

(Spare Parts Lists and Maintaining Instructions will be furnished by manufacturers when equipment purchases are made).

OPERATING INSTRUCTIONS

SECTION 14

MANUFACTURERS LITERATURE

(Manufacturers Literature will be furnished by manufacturers when equipment purchases are made).

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