DOE/RA/50351-1300

CROW TRIBE
OF
INDIANS

SYNFUELS FEASIBILITY STUDY

VOLUME II

PROCESS DESIGN AND COST ESTIMATE
BOOK II: SECTIONS 6.3 AND 6.4

AUGUST, 1982

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PREFACE

Volume II, Process Design and Cost Estimate is a three book volume. Sections 1.0 through 6.2 are presented in Book I. This portion, Book II, contains Sections 6.3 and 6.4, the Base Case Utilities and Offsite Units Engineering Data and the Contents and Results of the Power Self-Sufficiency Case. Book III contains Sections 6.5 through 6.9, the Coproduction Case, Shell Coal Case, Process Studies, Design Plans and Drawings and Cost Estimates. The Table of Contents for Volume II is presented in total in each of the three books.

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PRELIMINARY DESIGN AND COST ESTIMATE

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BOOK III

6.3 BASE CASE UTILITY AND OFFSITE UNITS - ENGINEERING DATA

6.3.1 OXYGEN PRODUCTION - UNIT 40

6.3.1.1 DESIGN BASIS

Purpose of Unit

The oxygen plant produces gaseous oxygen for use in coal gasification and partial oxidation of liquid hydrocarbons. The oxygen plant also produces high purity nitrogen and instrument air required by the process, utility, and off-site units within the plant.

Scope of Unit

The oxygen plant consists of facilities to compress air, separate air via autorefrigeration and compress the oxygen product, nitrogen and instrument air for delivery to plant battery limits.

General Design Criteria

The oxygen production facility consists of two 50 percent capacity parallel trains, each train having air compressor, a cold box with column/expander, and two 100 percent oxygen compressors and LP expanders.

Each train is designed for continuous operation at design product rates with minimum onstream time before deriming or planned shutdown of two years. The onstream factor is expected to be 100 percent due to the sparing of equipment.

Air compressor drivers are back pressure turbines using 1450 psig/925°F steam exhausting at 650 psig. Oxygen compressor drivers and all other drivers are motors.

6.3.1.1 (Continued)

Each train is capable of operating independently and at turn down rates of approximately 70 percent of design capacity.

Process Performance Objectives

The oxygen plant is designed to produce a total of 2925 ST/D of 98.5 percent volume purity oxygen based on atmospheric air feed. The oxygen plant also produces 14.5 MM SCFD of 99.99 percent volume purity nitrogen(1) and 4.4 MM SCFD of instrument air with a maximum dew point of -40°F (at 100 psig).

Feedstock

Inlet air for the design of the oxygen plant is atmospheric air with the following properties:

Pressure	13.0 psia
Temperature	88°F
Dew Point	64°F

Inlet flow rate of air is 347 MM SCFD

The possible contaminants in the intake air are the following: Light hydrocarbons, ammonia, sulfur dioxide, hydrogen sulfide, and nitrogen oxides.

(1) O_2 content less than 100 ppm volume

6.3.1.1 (Continued)

Products

The condition of the oxygen plant product streams are given below:

Product Stream	Temperature (°F)	Pressure (psig)	Phase
Oxygen	230 (max)	495	gas
Nitrogen	75	50	gas
Instrument Air	75	50	gas

Utilities

The oxygen plant consumes the utilities listed below:

1450 psig/925°F Steam	1.2 x 10^6 lb/hr (exits unit at 650 psig)
Cooling Water	10,400 gpm
Electrical Power	11,900 kW

The oxygen plant produces the utilities listed below:

Process Condensate	11,009 lb/hr
Electrical Power	600 kW

6.3.1.2 PROCESS DESCRIPTION

The utility flow sketch for the Oxygen Production unit is shown on Drawing No. 835704-40-4-101. The material balance (Table 6.3.1-1) for the unit follows the drawing. The plot plan is shown on Drawing No. 835704-40-4-050 and the equipment list (Table 6.3.1-2) follows.

6.3.1.2 (Continued)

The Oxygen Plant uses a low pressure cycle for air separation with reversing heat exchangers. The refrigeration requirements for the plant are covered by the expansion of air.

The process air is filtered, compressed (by an axial/radial centrifugal compressor) and cooled. The air stream is passed through a knockout drum where condensate is removed and sent to BFW and Condensate Treating Unit 45. The air stream then enters the reversing exchangers at near ambient temperature.

In the exchangers the air is cooled to near liquefaction temperature against separated cold product streams. Water and carbon dioxide contained in the air are deposited on the plate surface of the air passes during one half cycle. They are scavenged from there after flow reversal by waste nitrogen from the unit.

Flow reversal in the reversing heat exchangers is controlled by an electric switching device actuating valves located at the warm end of the heat exchangers. Flow reversal at the cold end of the exchangers is effected by means of automatically operating check valves.

The major portion of the process air, after leaving the cold end of the reversing exchangers, flows to the Air Separation unit. Within the Air Separation unit the process air is cryogenically separated into nitrogen and oxygen via autorefrigeration.

Pure nitrogen product is withdrawn from the Air Separation unit and flows to the reversing exchangers. The stream is warmed to ambient temperature in heat exchangers.

6.3.1.2 (Continued)

The gaseous oxygen product is warmed up in nonreversing passages of the main exchangers and leaves at ambient temperature and a pressure of approximately 24 psia. It then enters the suction of the oxygen product compressor system.

Deriming of the reversing exchangers is by heated plant air. Total deriming is required every two years, with downtime of approximately 80 hours.

Prevention of dangerous contaminants from entering the oxygen-rich section of the Air Separation Unit is provided by:

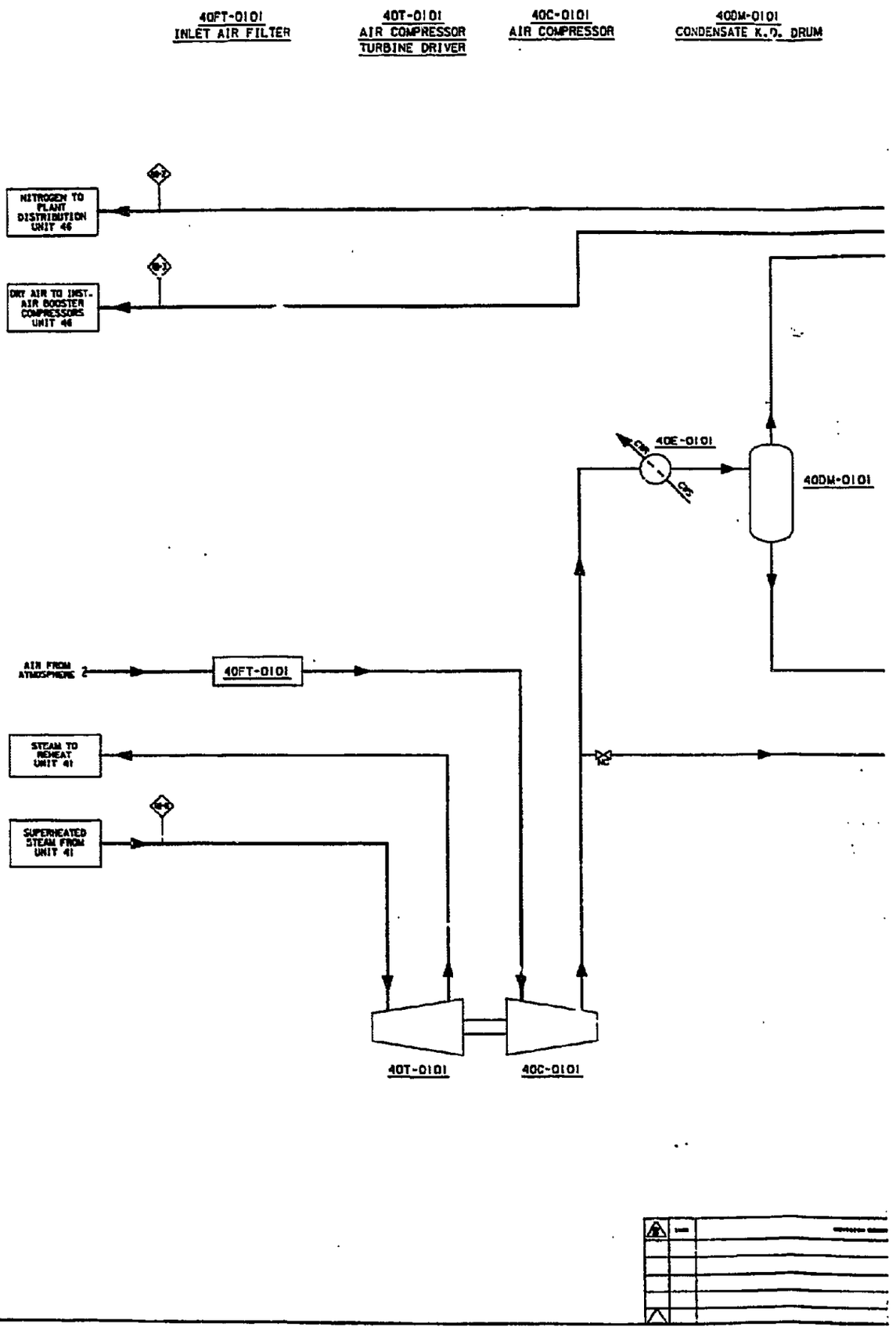
Air Filters - Upstream of the main air compressor to eliminate dust and particulate matter.

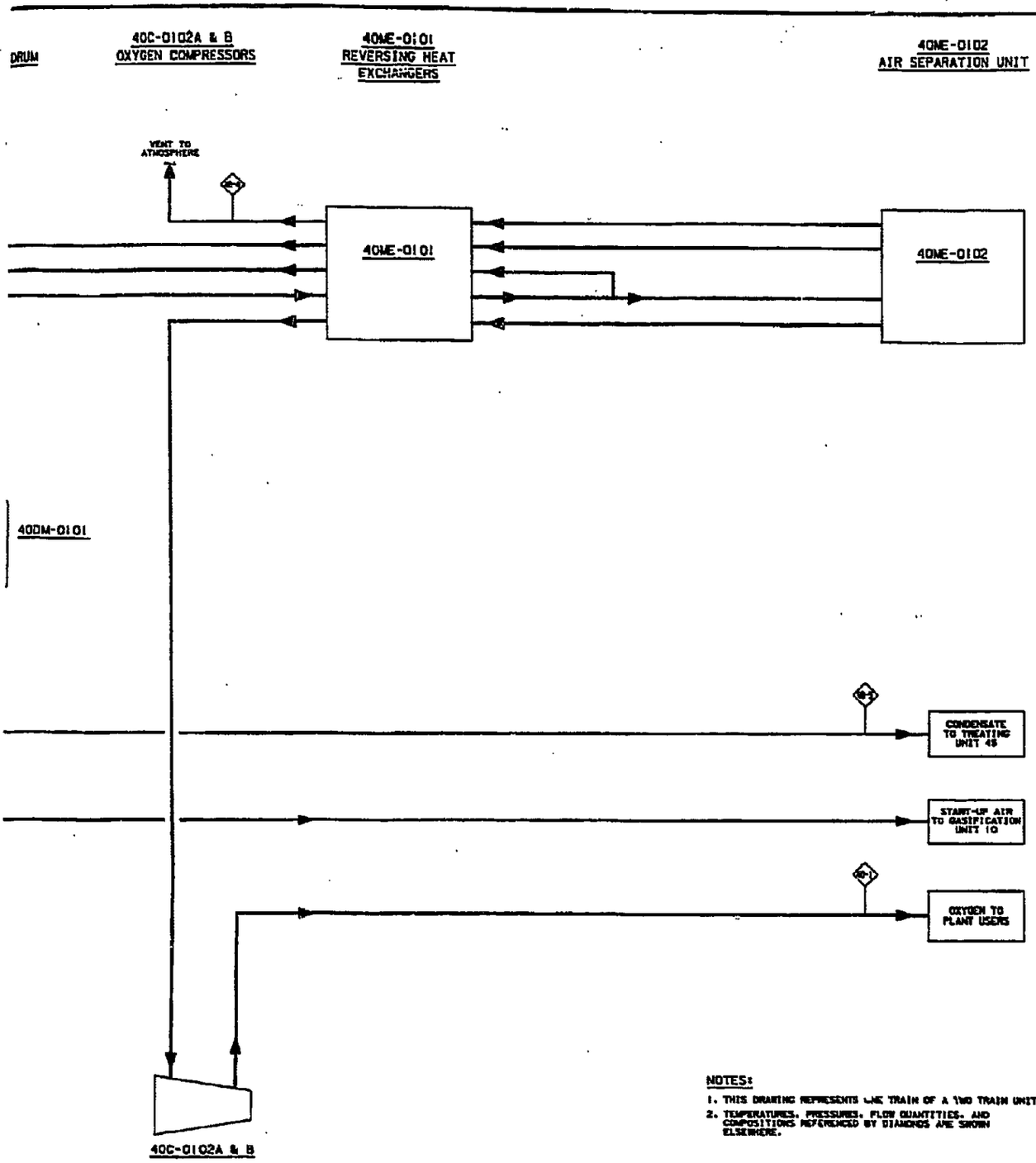
Reversing Exchangers - Reversing passages are used for the eliminating of carbon dioxide and water as well as for heat exchange. The passages also freeze out other condensible impurities which are then safely eliminated into the waste nitrogen stream.

Hydrocarbon Filters - Absorbers located within the Air Separation Unit are provided for the removal of hydrocarbon contaminants.

Unit Plot Area Requirements

Area required for two 1462 STPD trains is 200 x 200 feet.


40FT-0101
INLET AIR FILTER
40T-0101
AIR COMPRESSOR
TURBINE DRIVER
40C-0101
AIR COMPRESSOR
40DM-0101
CONDENSATE K.O. DRUM
NITROGEN TO PLANT DISTRIBUTION UNIT 46
DRY AIR TO INST. AIR BOOSTER COMPRESSORS UNIT 46
40E-0101
40DM-0101
AIR FROM ATMOSPHERE
40FT-0101
STEAM TO REHEAT UNIT 41
SUPERHEATED STEAM FROM UNIT 41
40T-0101
40C-0101



NOTES:

1. THIS DRAWING REPRESENTS ONE TRAIN OF A TWO TRAIN UNIT.
2. TEMPERATURES, PRESSURES, FLOW QUANTITIES, AND COMPOSITIONS REFERENCED BY DIAMONDS ARE SHOWN ELSEWHERE.

FLUOR

R. WHITE	
G.C. ABATAY	
R.D'ORAZIO	
R. McCARTHY	
R. LANG	

PROCESS FLOW DIAGRAM
OXYGEN PRODUCTION
UNIT 40

CROW TRIBE OF INDIANS — SYNFUELS FEASIBILITY STUDY

NONE	835704-40-4-101	1

003 3574010I

TABLE 6.3.1-1

MATERIAL BALANCE

OXYGEN PRODUCTION - UNIT 40

Stream Number	40-1		40-2		40-3		40-4	
Stream Name	Oxygen Product		Nitrogen Product		Dry Instrument Air		Vent To Atmosphere	
Component	lb-mol/hr	Mol%	lb-mol/hr	Mol%	lb-mol/hr	Mol%	lb-mol/hr	Mol%
N_2	114.4	1.5	1,592.1	100.0	374.9	78.0	27,651.8	97.4
Ar					4.5	0.9	252.7	1.2
O_2	7,516.8	98.5			101.1	21.1	395.5	1.4
Total Dry Gas	7,631.2	100.0	1,592.1	100.0	480.5	100.0	28,401.0	100.0
H_2O								
Total Wet Gas	7,631.2		1,592.1		480.5		28,401.0	
Dry Gas lb/hr	243,743		44,604		13,920		28,401	
H_2O lb/hr								
Steam								
Total lb/hr	243,743		44,604		13,920		28,401	
Pressure, psia	508		63		63			
Temperature, °F	230 (Max)		75		75			

NOTE: Flow quantities, temperatures, and pressures shown are for the total unit on a stream-da design purposes, and are not necessarily the conditions which will be attained during actu

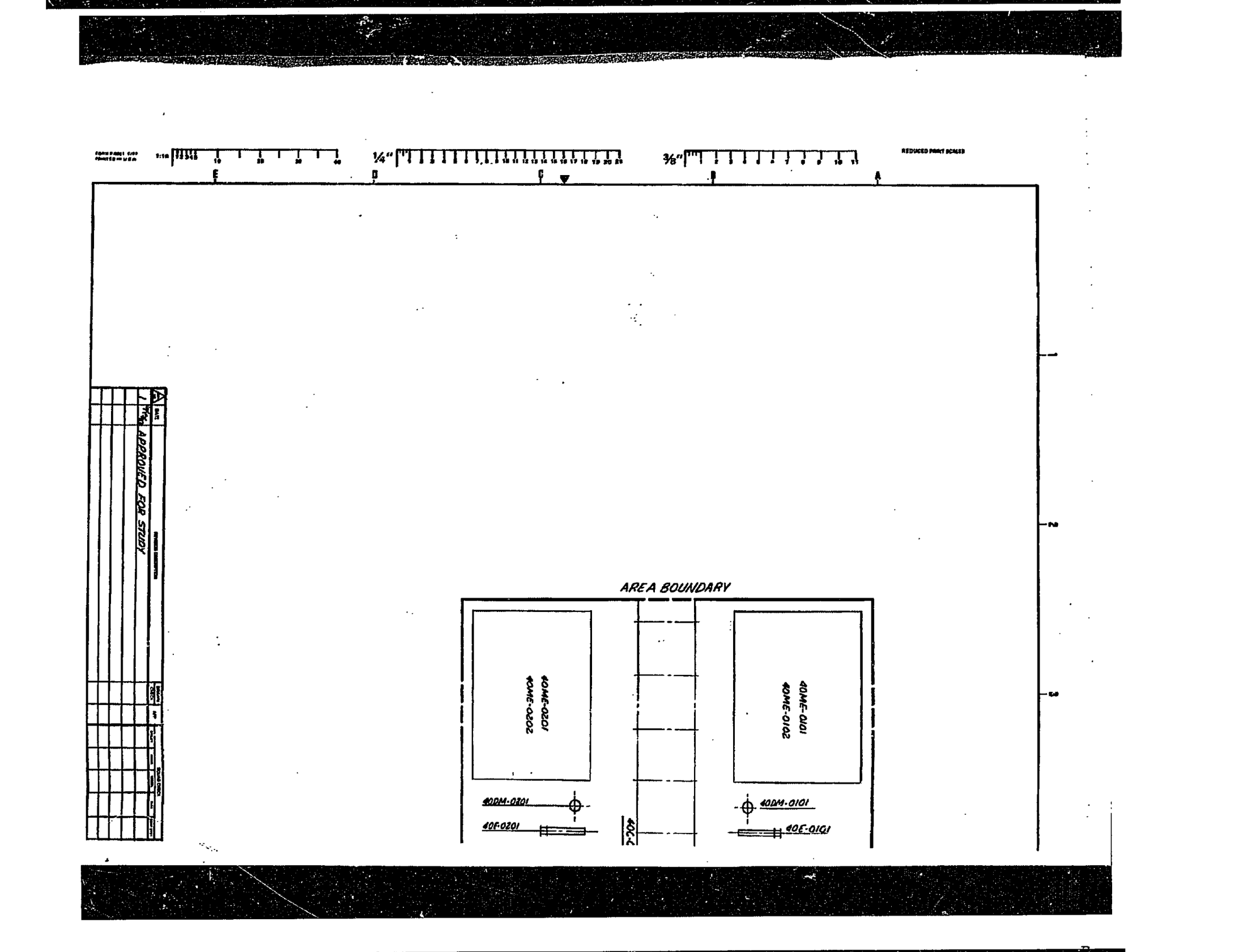
TABLE 6.3.1-1

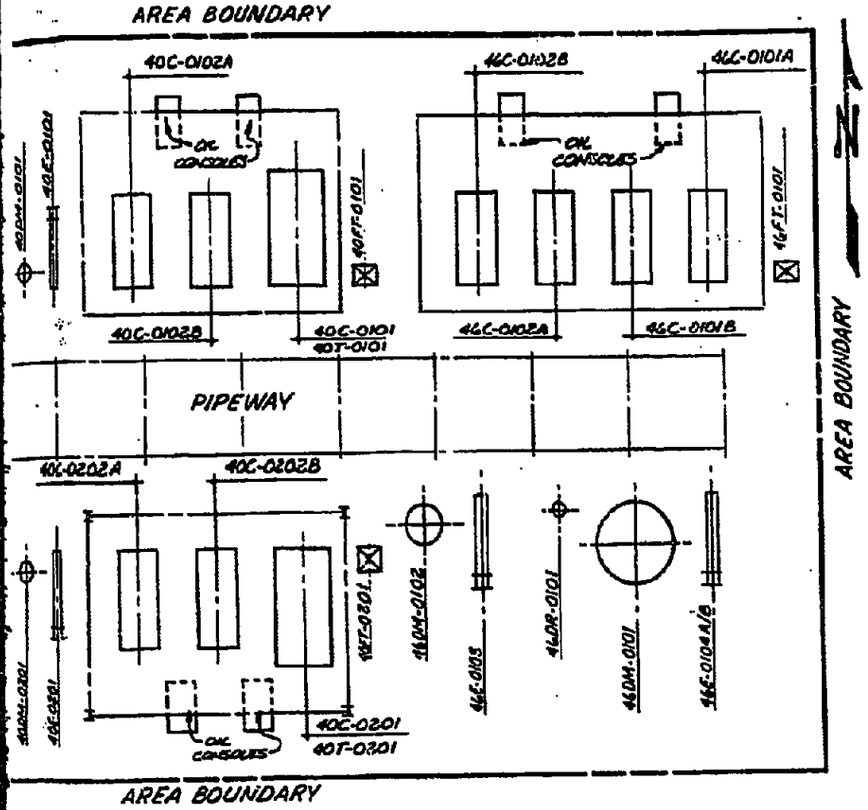
MATERIAL BALANCE

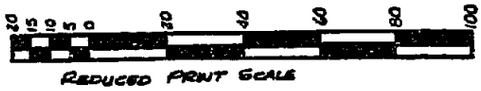
OXYGEN PRODUCTION - UNIT 40

0-2		40-3		40-4		40-5		40-6	
rogen oduct		Dry Instrument Air		Vent To Atmosphere		Process Condensate		HHP Stream	
r	Mol%	lb-mol/hr	Mol%	lb-mol/hr	Mol%	lb-mol/hr	Mol%	lb-mol/hr	Mol%
1	100.0	374.9	78.0	27,651.8	97.4				
		4.5	0.9	252.7	1.2				
		101.1	21.1	395.5	1.4				
1	100.0	480.5	100.0	28,401.0	100.0				
1		480.5		28,401.0					
	44,604		13,920		28,401				
							11,009		
									1,222,200
	44,604		13,920		28,401		11,009		1,222,200
	63		63						1,463
	75		75						925

sures shown are for the total unit on a stream-day basis, are to be used solely for process
y the conditions which will be attained during actual operations.


APPROVED FOR STUDY
AREA BOUNDARY
40ME-0201
40ME-0202
40DM-0201
40F-0201
40C-2
40ME-0101
40ME-0102
40DM-0101
40E-0101





ALL EQUIPMENT SIZES AND LOCATIONS ARE APPROXIMATE

00-S-050	SITE "J" PLOT PLAN	FLUOR	J.PARODI; HUTTEN; P.UNITS; J.SHEETS; R.LANG
			PLOT PLAN - UNITS 40 & 46 OXYGEN PRODUCTION AND AIR & NITROGEN CROW TRIBE OF INDIANS MONTANA
			1"=20'-0" 835704-40-4-050 1

TABLE 6.3.1-2

EQUIPMENT LIST

OXYGEN PRODUCTION

Item No.	Equipment Name	Number Required Oper.	Spare
40C-0101	Air Compressor	2	0
40C-0102 A/B	Oxygen Compressors	2	2
40E-0101	Air Compressor After Cooler	2	0
40DM-0101	Condensate K.O. Drum	2	0
40ME-0101	Reversing Heat Exchangers	2	0
40ME-0102	Air Separation Unit	2	0
40FT-0101	Inlet Air Filters	2	0
40T-0101	Air Compressor Turbine Driver	2	0

NOTE: Train #2 equipment numbers which are not shown are the same as indicated above except the train designation is 02 instead of 01.

Example:	Train #1	Train #2
	40C-0101	40C-0201

6.3.2 STEAM GENERATION - UNIT 41

6.3.2.1 DESIGN BASIS

Purpose of Unit

The Steam Generation unit produces steam using coal-fired boilers, distributes the steam throughout the plant and uses the cold condensate returning from the power plant for recycle to the boilers. The maximum use of returning condensate reduces the overall plant water makeup.

Scope of Unit

The Steam Generation unit consists of the production, collection, control and distribution of steam at five pressure levels to the process, offsite and utility consumers. Boiler feedwater deaeration is also included in this unit.

General Design Criteria

The Steam Generation unit consists of three 50 percent boilers plus ancillary equipment. Each boiler has a rated capacity of 2.1×10^6 lb/hr of 1500 psig/925°F steam with a normal operating rate of 1.4×10^6 lb/hr. Each boiler has two feed water pumps plus one spare with each pump rated at 2000 gpm. Normal operating flow rate for each pump is 1,400 gpm.

The Steam Generation Unit has the following equipment sparing philosophy:

Boilers - three 50 percent units

Boiler Feedwater Deaerators - 3 deaerators servicing three boilers.

Boiler Feedwater Pumps - 2 operating pumps and one spare per boiler.

6.3.2.1 (Continued)

Boilers are designed for continuous operation of steam supply to the plant. Scheduled shutdown of one boiler train does not affect the plant steam supply.

Drivers above 10,000 HP within the process, utility and offsite units are turbines using 600 psig/760°F steam to condensing.

Boiler Operating Range - 40 to 100% of design

Boiler Control Load - 50 to 100% of design

All steam pressure levels except LP steam have headers designed based on a line loss of 0.5 to 1.0 psi/100 ft. LP steam header is designed based on a line loss ranging from 0.25 to 0.5 psi/100 ft. Condensate return headers are designed for two phase flow.

Process Performance Objectives

The Steam Generation unit supplies and distributes the following levels of steam as required throughout the plant:

1500 psig/925°F superheated steam

600 psig/760°F superheated steam

650 psig/saturated steam

100 psig/saturated steam

60 psig/saturated steam

6.3.2.1 (Continued)

The steam generation unit also provides boiler feed water (BFW) at 1930 psig/ 230°F. The steam generation unit uses returning cold condensate from the power turbine surface condensers. The cold condensate is treated and then stored prior to use as boiler feed water. Demineralized water is used as BFW makeup.

Based on the analysis of Westmoreland coal, a boiler thermal efficiency of 85 percent is expected for the conversion of coal to raise steam.

Feedstock

The Steam Generation coal rate to the boilers is based on 40 percent fines or 7200 T/D (as received) of Westmoreland coal.

Coal Westmoreland (Lurgi Analysis)

Proximate (As received)		Ultimate (Dry Ash Free)	
Moisture	26.0%	Carbon	75.98%
Ash	7.4%	Hydrogen	4.59%
Fixed Carbon	40.1%	Nitrogen	1.09%
Volatiles	26.5%	Sulfur	1.23%
	100.0	Chlorine	.03%
Btu/lb (HHV)	8612.3	Oxygen	17.08%
			100.0
		Btu/lb (HHV)	12931.4

Treated Water

Makeup to boilers 392 gpm

6.3.2.1 (Continued)

Products

Steam

1500 psig/925°F	4,121,400 lb/hr
600 psig/760°F	4,121,300 lb/hr

Boiler Feed Water

HHP BFW	8,284 gpm

Blowdown

Boiler Blowdown	41 gpm

Ash

Fly Ash	35,377 lb/hr
Bottom Ash	8,880 lb/hr

Flue Gas

Temperature, 300°F

Component	Moles/hr	lb/hr	Mole %
CO	11	308	58 ppm
CO_2	25,280	1,112,585	13.4
H_2O	20,060	361,401	10.6
SO_2	153	9,821	809 ppm
HCl	3	124	16 ppm
O_2	8,073	258,339	4.3
N_2	135,473	3,795,115	71.6
NO_2	56	2,584	296 ppm
TOTAL	189,109	5,540,277	

6.3.2.1 (Continued)

Utilities

Power	32,500 kW Consumed

6.3.2.2 PROCESS DESCRIPTION

The utility flow stetch for the Steam Generation Unit is shown on Drawing No. 835704-41-R-101. The steam distribution system is shown on Drawing No. 835704-41-R-102. The material balance is shown on Table 6.3.2-1. The plot plan is shown on Drawing No. 835704-41-5-050. The equipment list is given in Table 6.3.2-2.

Steam Plant

The boilers are fired with coal fines recovered in the screening process required for obtaining sized coal for gasification. The boilers generate superheated 1500 psig steam to drive turbogenerators in the Power Generation Unit 42 and air compressors in the Oxygen Production Unit 40.

Boiler feed water consists of polished cold condensate from the surface condensers in the Power Generation unit. Makeup water is demineralized water from the BFW and Condensate Treating Unit 45. The BFW is pre-heated to 180°F with turbine extraction steam from the LP section of the turbogenerators. The preheated BFW is then deaerated.

The deaerator is normally operated at 7 psig and reduces the dissolved oxygen content in the BFW to less than 4 ppb. The temperature of the BFW flow from the deaerators is 230°F.

6.3.2.2 (Continued)

The deaerated BFW is pumped to the boilers by pumps driven by electrical motors. The pump discharge pressure is 1930 psig. The BFW is preheated to 430°F using turbine extraction steam from the LP section of the turbogenerators prior to flowing into the steam drum.

Boiler blowdown is flashed to recover 40 psig steam for BFW deaeration. The remaining blowdown is routed to the Utility Cooling Tower.

Steam Distribution

The process steam distribution system is comprised of distribution piping and controls for five levels of steam. The pressure levels are designated as:

1500 psig, 925°F superheated steam - this level is referred to as high-high pressure steam (HHP).

650 psig, saturated steam - this level is referred to as high pressure saturated steam (HPSAT).

600 psig, 760°F superheated steam - this level is referred to as high pressure superheated steam (HP).

100 psig, saturated steam - This level is referred to as medium pressure steam (MP).

60 psig saturated steam - this level is referred to as low pressure steam (LP).

6.3.2.2 (Continued)

High-High Pressure Steam

The HHP steam is generated in the coal fired boilers. The HHP steam is used to drive turbogenerators in the Power Generation Unit 42 and to drive the air compressors in the Oxygen Production Unit 40.

High Pressure Saturated Steam

The HPSAT steam is generated in process waste heat boilers in the Methanation Unit 22 and the Partial Oxidation Unit 24.

The HPSAT steam is consumed in the following process units:

Tar Distillation
Naphtha Hydrotreating
Phenosolvan
Ammonia Recovery
Partial Oxidation

Excess HPSAT steam is superheated in the Process Steam Superheating Unit 20 to produce high pressure superheated steam.

High Pressure Superheated Steam

The HP steam is exhausted from the backpressure section of the turbogenerators in the Power Generation Unit 42 and is passed through a reheater coil in the boiler before flowing into the HP steam header. Additional HP steam is generated in the Process Steam Superheating Unit 20.

6.3.2.2 (Continued)

The major consumers of HP steam are:

Coal Gasification
SNG Compressor Turbine Drivers
LP Section of the Turbogenerators

The HP steam is also consumed in small amounts by:

HPSAT steam startup
MP steam startup
LP steam startup

Medium Pressure Steam

The MP steam is produced in Gasification Unit 10 waste heat boilers, in Sulfur Recovery Unit 19 and in Partial Oxidation Unit 24. Letdown from the HP steam header is used to maintain pressure in the MP steam header as necessary.

MP steam is consumed in the following process units:

Rectisol
Phenosolvan
Ammonia Recovery
Tank Farm

MP steam is also used for steam tracing and motive steam for surface condenser ejectors. Any excess is let down to the LP steam header.

6.3.2.2 (Continued)

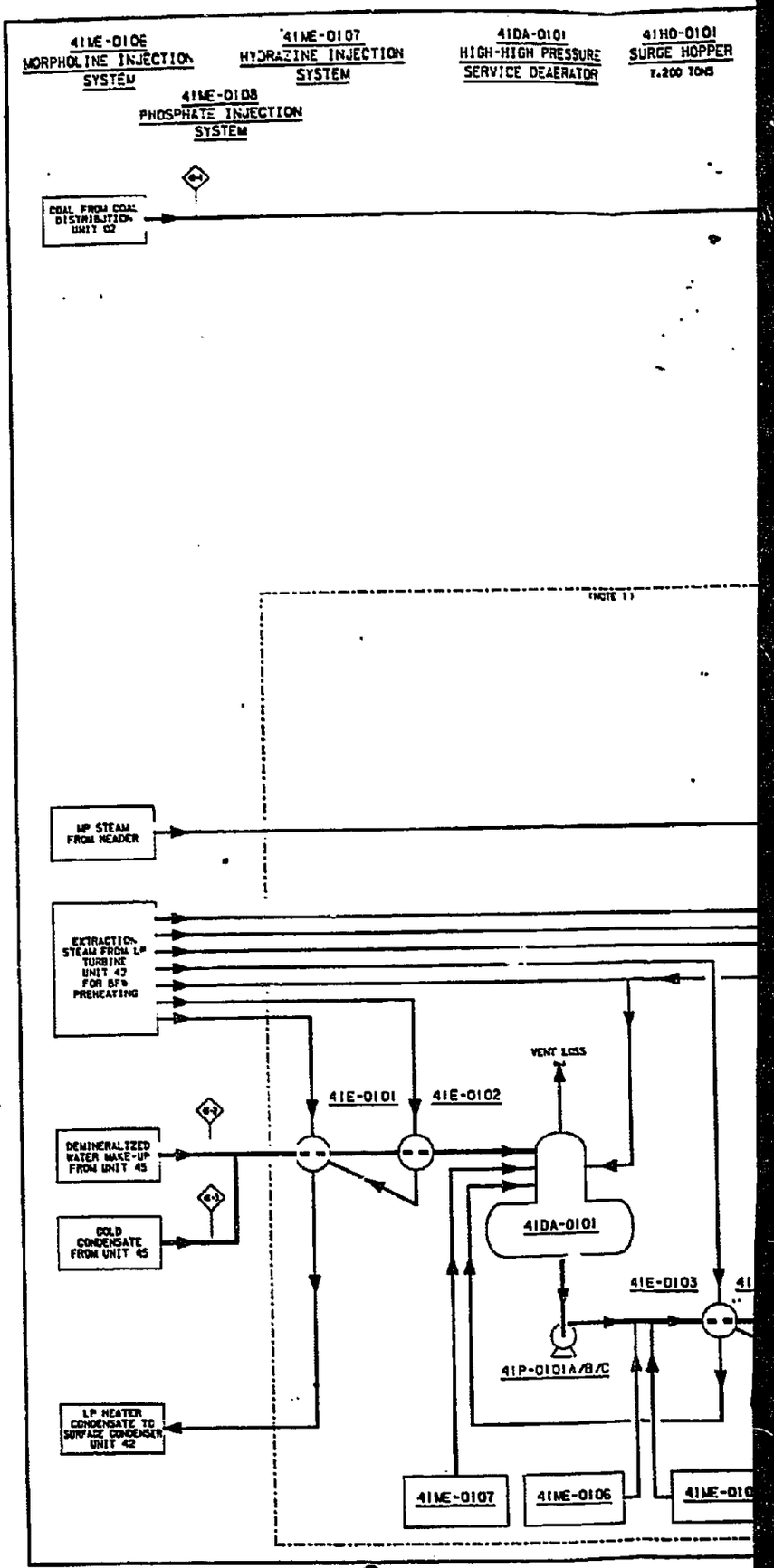
Low Pressure Steam

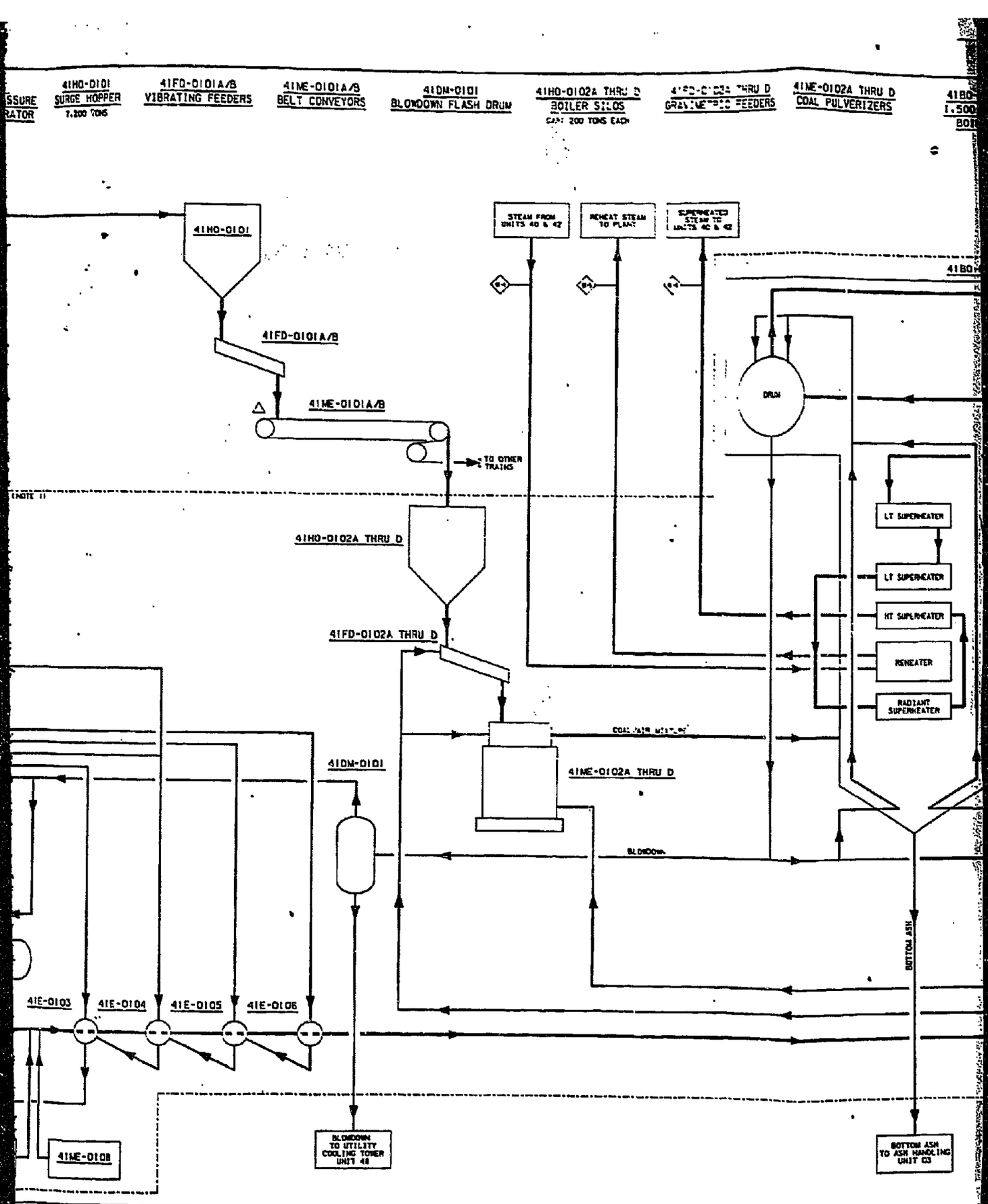
LP steam is produced in Gas Cooling Unit 12 and Sulfur Recovery Unit 19. Relatively small amounts are produced by blowdown flash drums from process waste heat boilers and by steam condensate flash drums. The LP steam header pressure is maintained, as necessary, by letdown from the MP steam header.

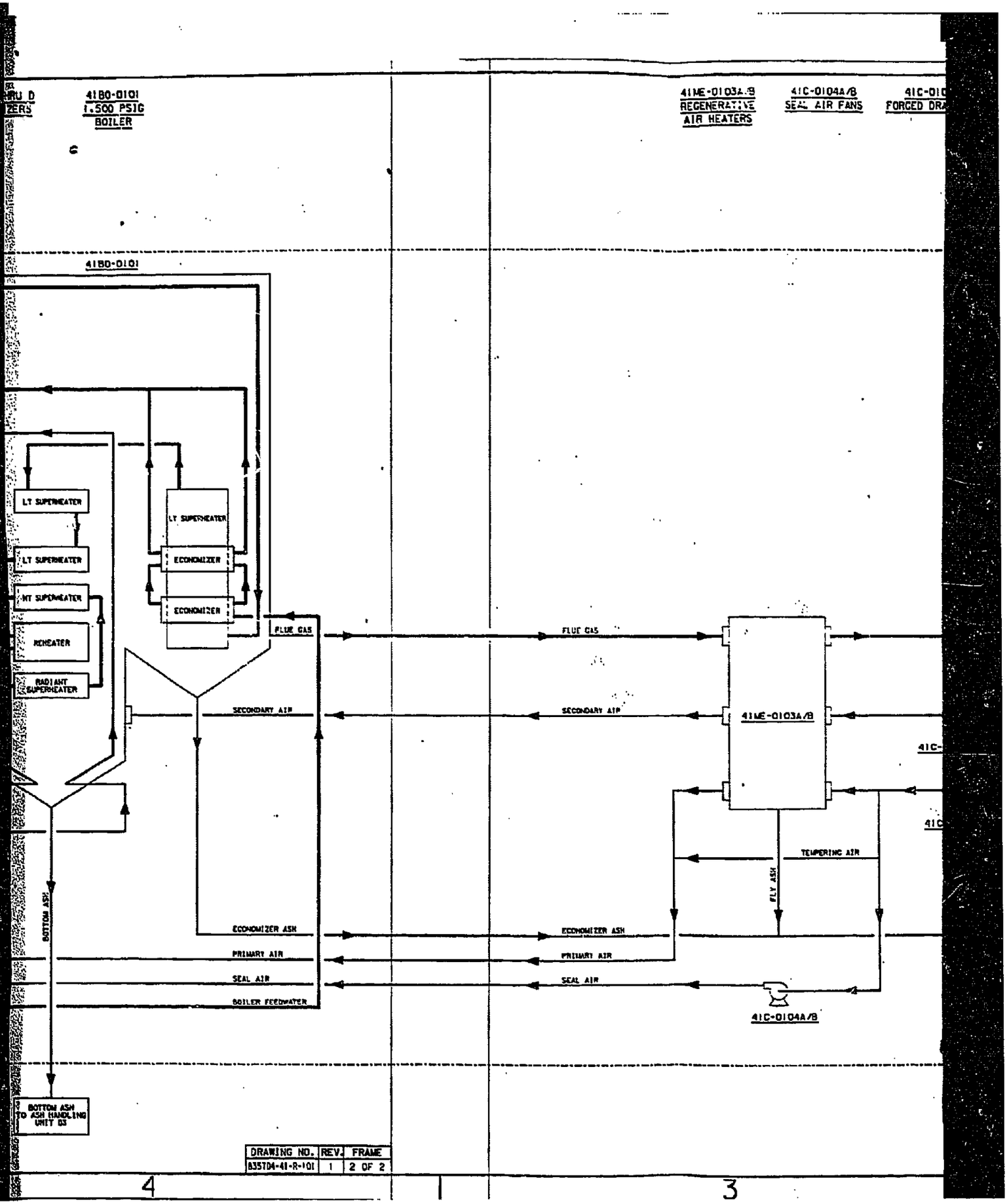
LP steam is consumed in the following units:

Rectisol
Tar Distillation
Naphtha Hydrotreating
Phenosolvan
Sulfur Recovery
Tank Farm
Wastewater Treating

LP steam is also used in process BFW deaerators. During system upsets excess LP steam is vented to the atmosphere to control header pressure.


41ME-0106
MORPHOLINE INJECTION SYSTEM
41ME-0107
HYDRAZINE INJECTION SYSTEM
41DA-0101
HIGH-HIGH PRESSURE SERVICE DEAERATOR
41HO-0101
SURGE HOPPER
41ME-0108
PHOSPHATE INJECTION SYSTEM
COAL FROM COAL DISTRIBUTION UNIT 52
(NOTE 1)
MP STEAM FROM HEADER
EXTRACTION STEAM FROM LP TURBINE UNIT 42 FOR BFW PREHEATING
VENT LESS
41E-0101
41E-0102
DEMINERALIZED WATER MAKE-UP FROM UNIT 45
COLD CONDENSATE FROM UNIT 45
41DA-0101
41E-0103
41P-0101A/B/C
LP HEATER CONDENSATE TO SURFACE CONDENSER UNIT 42
41ME-0107
41ME-0106


41HO-0101
SURGE HOPPER
7,200 TONS
41FD-0101A/B
VIBRATING FEEDERS
41ME-0101A/B
BELT CONVEYORS
41DM-0101
BLOWDOWN FLASH DRUM
41HO-0102A THRU D
BOILER SILOS
CAP: 200 TONS EACH
41ME-0102A THRU D
COAL PULVERIZERS
STEAM FROM UNITS 40 & 42
REHEAT STEAM TO PLANT
41HO-0101
41FD-0101A/B
41ME-0101A/B
TO OTHER TRAINS
DRUM
LT SUPERHEATER
LT SUPERHEATER
HT SUPERHEATER
REHEATER
RADIANT SUPERHEATER
41HO-0102A THRU D
41FD-0102A THRU D
41DM-0101
41ME-0102A THRU D
BLOWDOWN
BOTTOM ASH
41E-0103
41E-0104
41E-0105
41E-0106
41ME-0108
BLOWDOWN TO UTILITY COOLING TOWER UNIT 48
BOTTOM ASH TO ASH HANDLING UNIT 03


41B0-0101
1,500 PSIG
BOILER
41ME-0103A/B
REGENERATIVE
AIR HEATERS
41C-0104A/B
SEAL AIR FANS
41B0-0101
LT SUPERHEATER
LT SUPERHEATER
LT SUPERHEATER
ECONOMIZER
HT SUPERHEATER
ECONOMIZER
REHEATER
RADIANT
SUPERHEATER
FLUE GAS
FLUE GAS
SECONDARY AIR
SECONDARY AIR
41ME-0103A/B
TEMPERING AIR
FLY ASH
BOTTOM ASH
ECONOMIZER ASH
ECONOMIZER ASH
PRIMARY AIR
PRIMARY AIR
SEAL AIR
SEAL AIR
BOILER FEEDWATER
41C-0104A/B
BOTTOM ASH
TO ASH HANDLING
UNIT 03
DRAWING NO.
REV.
FRAME
835704-41-R-101
1
2 OF 2
4
1
3

41ME-0103A/B
REGENERATIVE AIR HEATERS

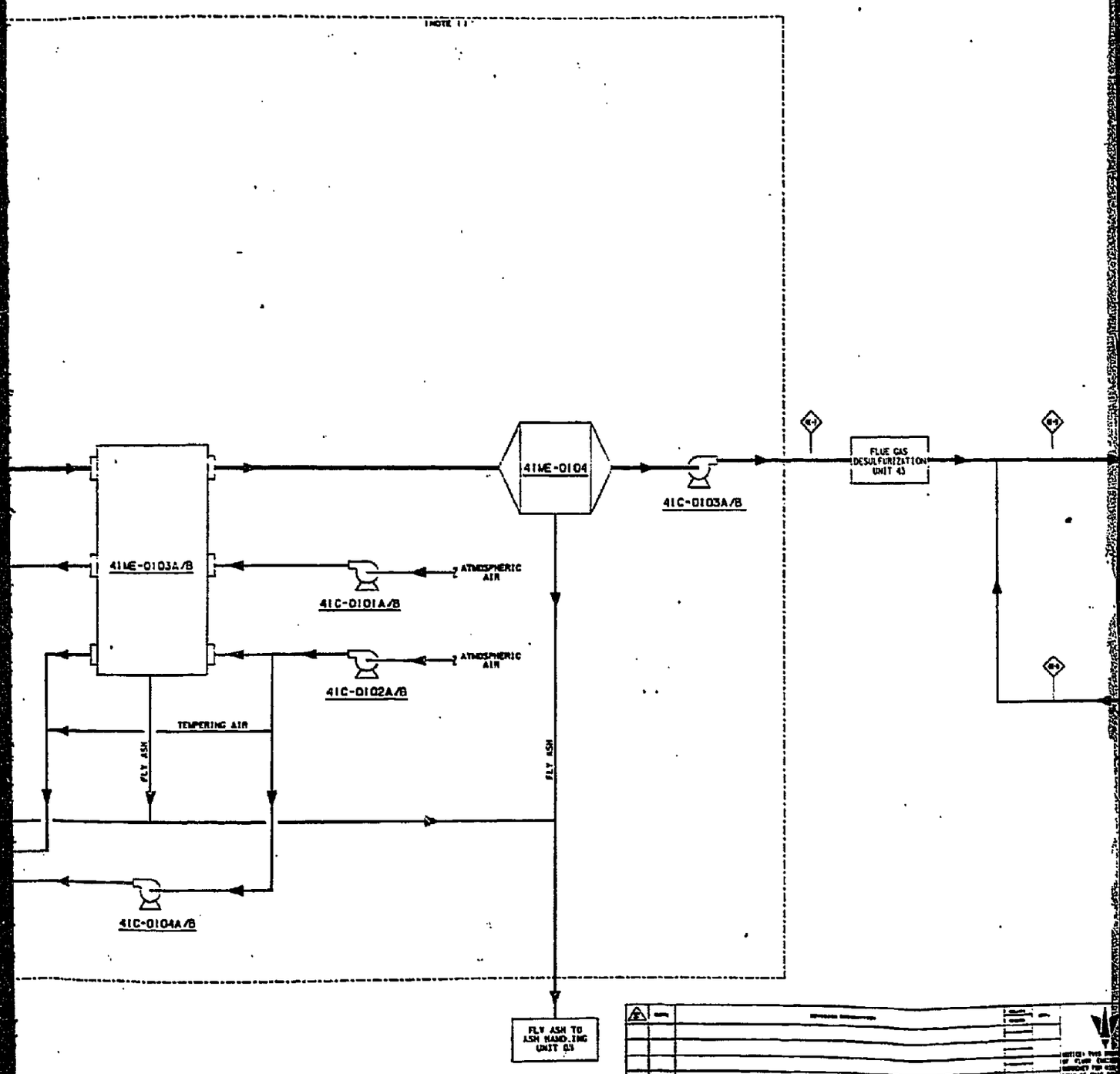
41C-0104A/B
SEAL AIR FANS

41C-0101A/B
FORCED DRAFT FANS

41C-0102A/B
PRIMARY AIR FANS

41ME-0104
ELECTROSTATIC PRECIPITATOR

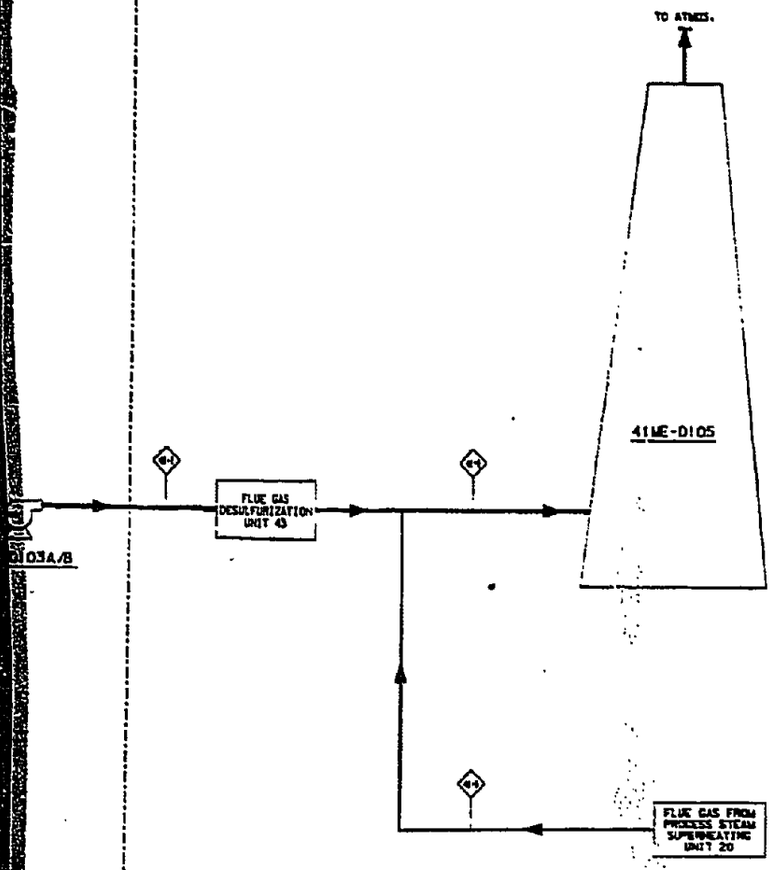
41C-0103A/B
INDUCED DRAFT FANS



3 2

41C-0103A/B
INDUCED DRAFT FANS

41ME-0105
BOILER STACK



NOTES:

1. EQUIPMENT WITHIN DOT-DASHED LINES REPRESENT ONE TRAIN OF A THREE TRAIN UNIT.
2. TEMPERATURES, PRESSURES, FLOW QUANTITIES AND COMPOSITIONS REFERENCED BY DIAMONDS ARE SHOWN SEPARATELY.

USE OR DISCLOSURE OF REPORT DATA IS SUBJECT TO THE RESTRICTION ON THE NOTICE PAGE AT THE FRONT OF THIS REPORT

FLUOR

R. WHITE
C.C. ABATAY
W.D. BELMITO
R. McCARTHY
R. LANG

PROCESS FLOW DIAGRAM
STEAM GENERATION
UNIT 41

CROW TRIBE OF INDIANS — SYNFUELS FEASIBILITY STUDY

NONE

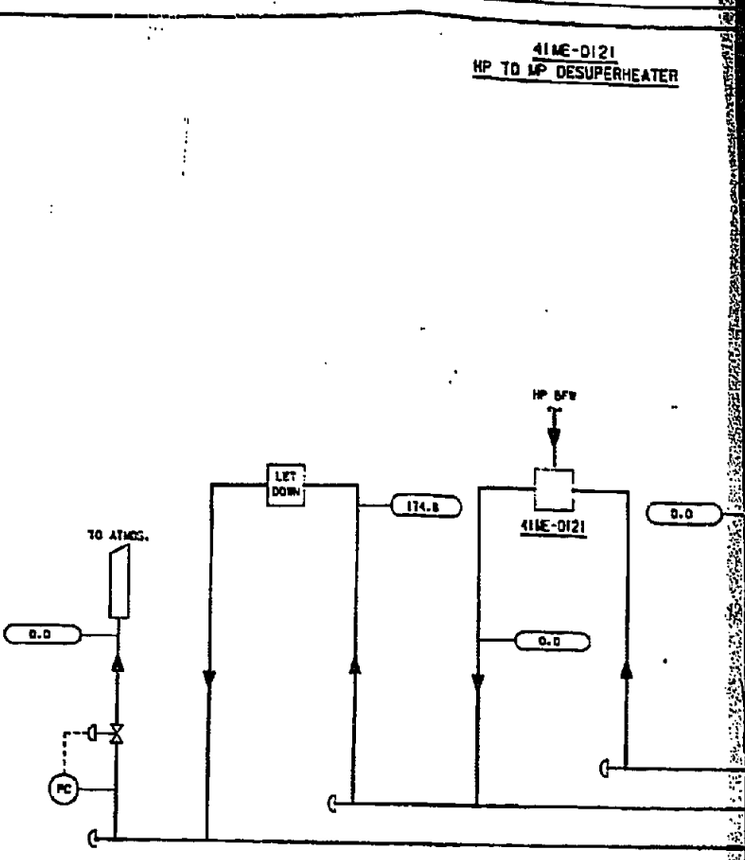
835704-41-R-101

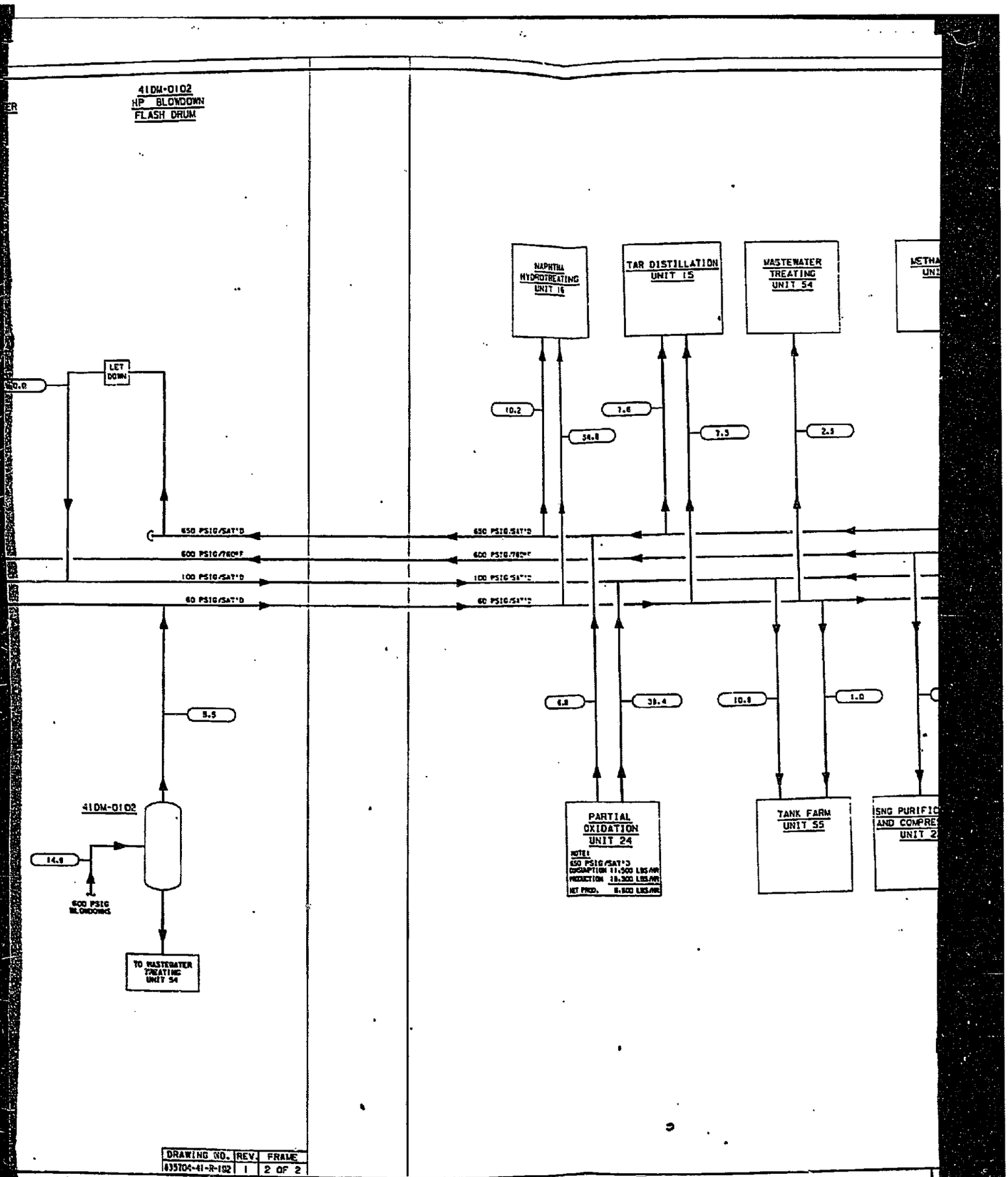
MICROFILM FRAME NO. 1 OF 2

1

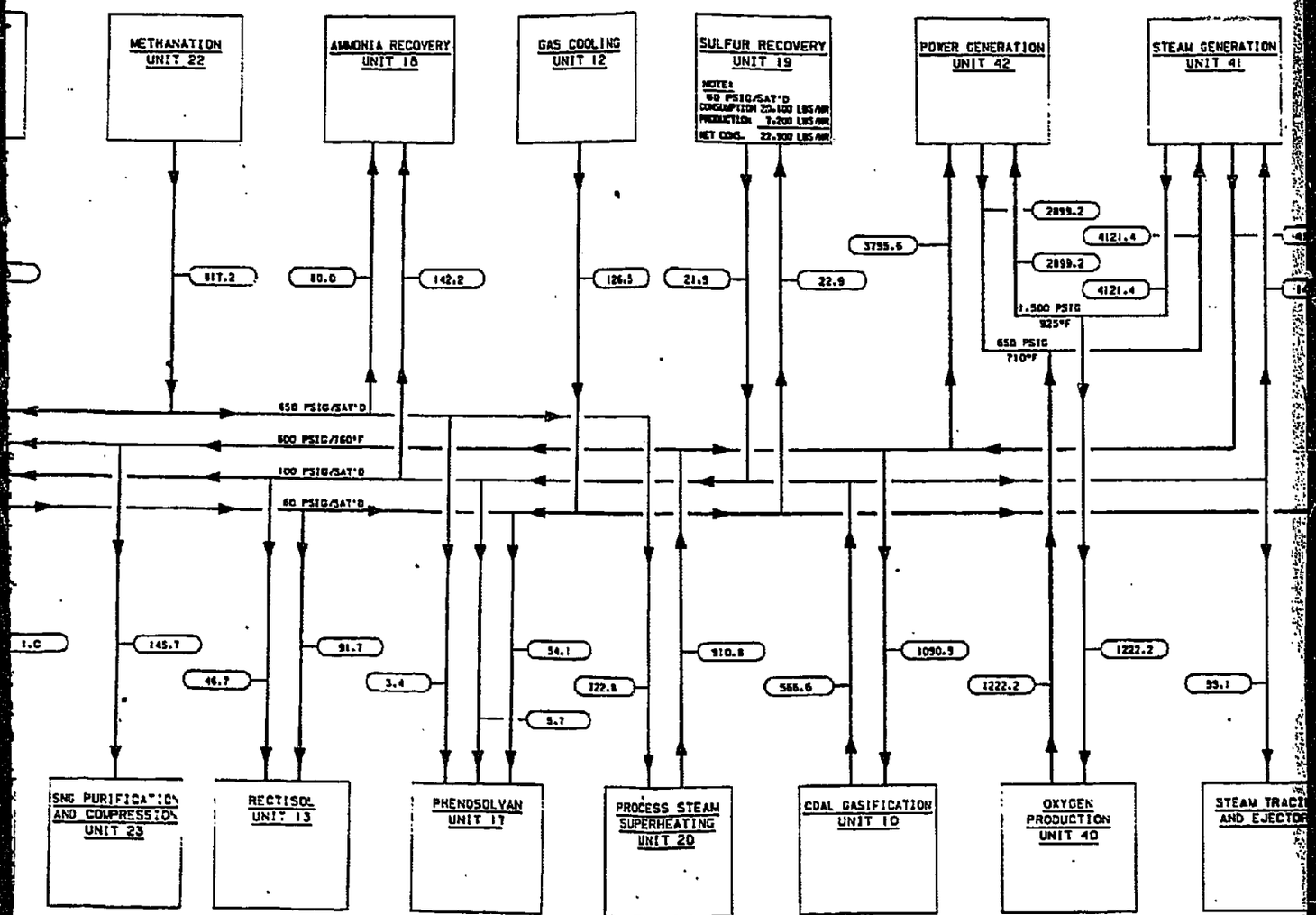
003 35741101

2

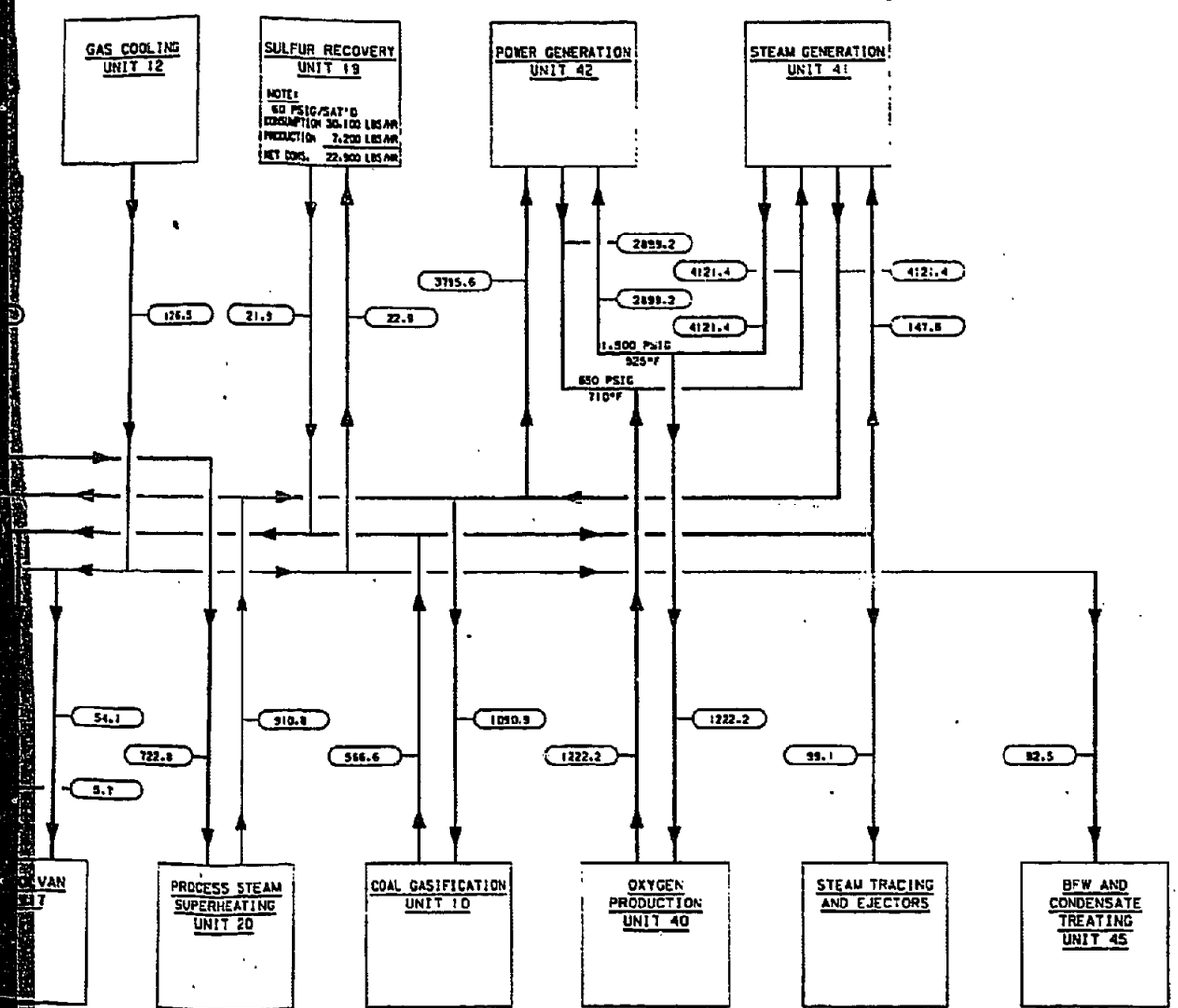

41ME-0121
HP TO MP DESUPERHEATER
HP BFW
LET DOWN
174.8
41ME-0121
0.0
TO ATMOS.
0.0
0.0
PC



DRAWING NO.	REV.	FRAME
835704-41-R-102	1	2 OF 2


METHANATION
UNIT 22
AMMONIA RECOVERY
UNIT 18
GAS COOLING
UNIT 12
SULFUR RECOVERY
UNIT 19
NOTE:
60 PSIG/SAT'D
CONSUMPTION 23,100 LBS/HR
PRODUCTION 7,200 LBS/HR
NET CONS. 22,900 LBS/HR
POWER GENERATION
UNIT 42
STEAM GENERATION
UNIT 41
2899.2
4121.4
3795.6
2899.2
4121.4
1,500 PSIG
925°F
650 PSIG
710°F
817.2
80.0
142.2
126.5
21.9
22.9
650 PSIG/SAT'D
600 PSIG/750°F
100 PSIG/SAT'D
60 PSIG/SAT'D
1.0
145.7
91.7
54.1
910.8
1090.9
1222.2
46.7
3.4
722.8
566.6
1222.2
93.1
9.7
SNG PURIFICATION
AND COMPRESSION
UNIT 23
RECTISOL
UNIT 13
PHENOSOLVAN
UNIT 17
PROCESS STEAM
SUPERHEATING
UNIT 20
COAL GASIFICATION
UNIT 10
OXYGEN
PRODUCTION
UNIT 40
STEAM TRACI
AND EJECTOR
LEGEND:
FLOW 1000 LBS/HR
NOTES:
1. THE TEMPERA
TO BE USED

FLUOR



LEGEND:

FLOW 1000 LBS/HR

NOTES:

1. THE TEMPERATURES, PRESSURES AND FLOW QUANTITIES SHOWN ARE TO BE USED SOLELY FOR PROCESS DESIGN PURPOSES.

FLUOR

D. P. HALVERSON

PROCESS FLOW DIAGRAM
STEAM GENERATION - STEAM DISTRIBUTION SYSTEM
UNIT 41

CROW TRIBE OF INDIANS — SYNFUELS FEASIBILITY STUDY

NONE

835704-41-R-102

MICROFILM FRAME NO. 1 OF 2

003 3574102

1

TA

MATE

STEAM GE

Stream Number	41-1	41-2	41-3	4
Stream Name	Coal Fines	Demineralized Water	Cold Condensate	HP E St
Component	Lb-mol/hr Mol%	Lb-mol/hr Mol%	Lb-mol/hr Mol%	Lb-m
N_2				
O_2				
CO				
CO_2				
SO_2				
HCl				
NO_2				
Total Dry Gas				
H_2O				
Total Wet Gas				
Dry Gas, lb/hr				
H_2O, lb/hr		196,100	2,912,800	
Steam, lb/hr				4,1
Coal, lb/hr	600,000			
Particulates, lb/hr				
Total, lb/hr	600,000	196,100	2,912,800	4,121
Pressure, psia		88	88	
Temperature, °F		80	80	

NOTE: The flow quantities, temperatures, and pressures shown a
purposes, and are not necessarily the conditions which wil

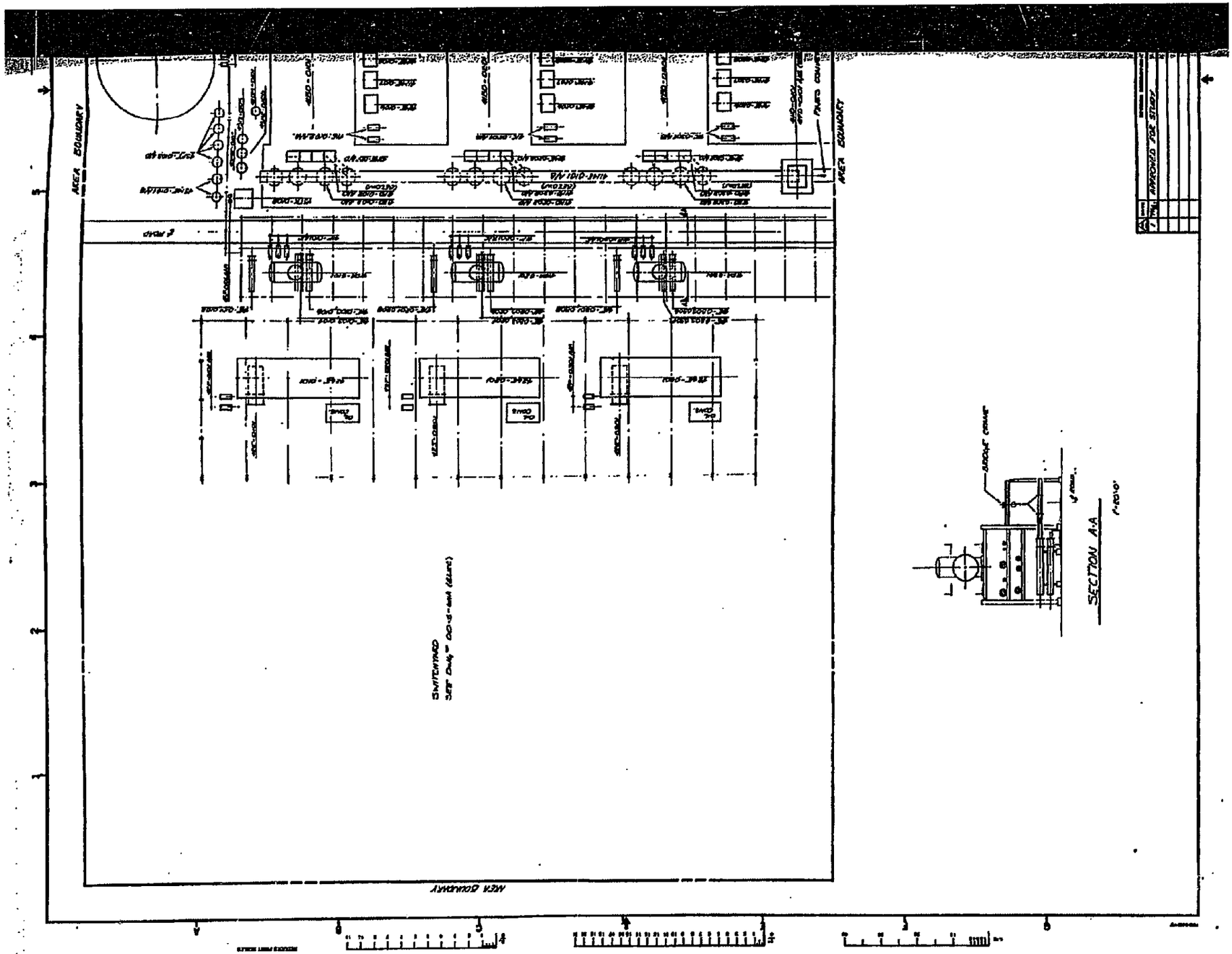
TABLE 6.3.2-1

MATERIAL BALANCE

STEAM GENERATION - UNIT 41

41-4		41-5		41-6		41-7		41-8		41-9	
	HP Exhaust Steam		Reheat Steam		HHP Steam		Boiler Flue Gas		Process Steam Superheating Flue Gas		Flue Gas To Stack
Mol%	Lb-mol/hr	Mol%	Lb-mol/hr	Mol%	Lb-mol/hr	Mol%	Lb-mol/hr	Mol%	Lb-mol/hr	Mol%	Lb-mol/hr	Mol%
							135,473	80.14	11,169	33.42	147,873	72.53
							8,073	4.78	642	1.92	9,043	4.44
							11	0.01	Trace	-	11	-
							25,280	14.95	21,602	64.64	46,882	23.00
							153	0.09	3	-	18	-
							3	-	-	-	-	-
							56	0.03	5	0.02	61	.03
							169,949	100.0	33,421	100.0	203,877	100.0
							20,060		3,327		36,296	
							189,109		36,748		240,173	
							5,178,876		1,284,596		6,497,327	
							361,401		59,934		653,376	
	4,121,400		4,121,400		4,121,400							
							143				143	
	4,121,400		4,121,400		4,121,400		5,540,420		1,344,530		7,150,846	
	663		613		1513		13.3		13.5		13.1	
	710		760		930		300		400		175	

shown are for the total unit on a stream-day basis, are to be used solely for process design which will be attained during actual operations.


AREA BOUNDARY
AREA BOUNDARY
AREA BOUNDARY
SECTION A-A
APPROVED FOR STUDY

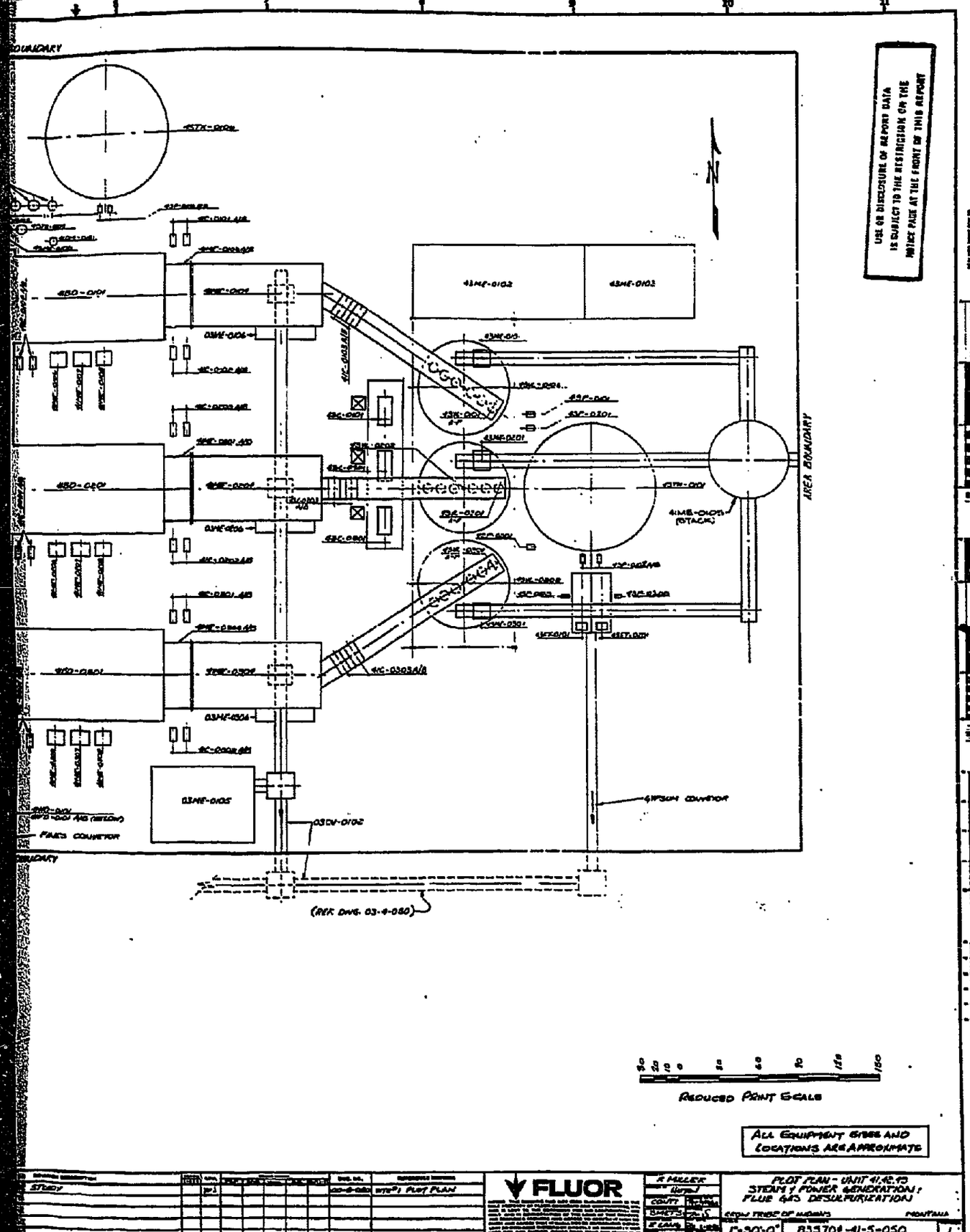

USE OR DISCLOSURE OF REPORT DATA IS SUBJECT TO THE RESTRICTION ON THE NOTICE PAGE AT THE FRONT OF THIS REPORT
AREA BOUNDARY
(4)ME-0101 (STACK)
(REF. DWG. 03-9-050)
REDUCED PRINT SCALE
ALL EQUIPMENT SIZES AND LOCATIONS ARE APPROXIMATE
FLUOR
PLOT PLAN - UNIT 41,42,43
STEAM & POWER GENERATION;
FLUE GAS DESULFURIZATION
1"=50'-0"
833701-41-5-050

TABLE 6.3.2-2

EQUIPMENT LIST

OXYGEN PRODUCTION

Item No.	Equipment Name	Number Required Oper.	Spare
41E-0101	1st BFW Preheater	3	0
41E-0102	2nd BFW Preheater	3	0
41E-0103	3rd BFW Preheater	3	0
41E-0104	4th BFW Preheater	3	0
41E-0105	5th BFW Preheater	3	0
41E-0106	6th BFW Preheater	3	0
41C-0101 A/B	Force Draft Fans	3	3
41C-0102 A/B	Primary Air Fans	3	3
41C-0103 A/B	Induced Draft Fans	3	3
41C-0104 A/B	Seal Air Fans	3	3
41DA-0101	High-High Pressure Service Deaerators	3	0
41BO-0101	1500 psig Boilers	3	0
41HO-0101	Surge Hopper	1	0
41HO-0102 A/B/C/D	Boiler Silos	12	
41P-0101 A/B/C	BFW Pumps	6	3
41DM-0101	Blowdown Flash Drum	3	0
41DM-0102	HP Blowdown Flash Drum		

TABLE 6.3.2-2 (Continued)

EQUIPMENT LIST

OXYGEN PRODUCTION

Item No.	Equipment Name	Number Required Oper.	Spare
41FD-0101 A/B	Vibrating Feeders	2	0
41FD-0102 A/B/C/D	Gravimetric Feeders	12	0
41ME-0101 A/B	Belt Conveyors	2	0
41ME-0102 A/B/C/D	Coal Pulverizers	12	0
41ME-0103 A/B	Regenerative Air Heaters	6	0
41ME-0104	Electrostatic Precipitators	3	0
41ME-0105	Boiler Stack	1	0
41ME-0106	Morpholine Injection System	3	0
41ME-0107	Hydrozine Injection System	3	0
41ME-0108	Phosphate Injection System	3	0
41ME-0121	HP to MP Desuperheater	1	0

6.3.3 POWER GENERATION - UNIT 42

6.3.3.1 DESIGN BASIS

Purpose of Unit

The Power Generation Unit provides electric power for process, offsites and utility consumers. The Power Generation unit produces electric power in excess of the power required for total plant self-sufficiency. Export of this electric power is considered in the design.

Scope of Unit

The Power Generation unit consists of a stand-alone, onsite power plant, power distribution system and an uninterruptible power system for critical users. The integration of the Power Generation unit into the overall plant is shown on Figure 6.3.3-1.

General Design Criteria

The Power Generation unit will consist of three multistage reheat turbogenerators. Each turbogenerator will produce 135.0 MW of electric power.

Due to the high reliability of the turbogenerators, a spare turbogenerator train will not be required. Also, in the event of an emergency, power can be taken from an electrical grid source external to the plant (see Section 6.3.20, Electrical Distribution, in this volume).

The turbogenerators are designed for continuous operation. The onstream factor is compatible with the overall plant onstream factor of 332 days/year.

6.3.3.1 (Continued)

Process Performance Objectives

Power plant generation will be at 24,000 volts.

Power is supplied as follows:

User	Voltage	Cycles	Phase
Motors above 151 BHP	4,000	60	3
Motors below 151 BHP	400	60	3
Lighting, Instrumentation, etc.	240/120	60	1

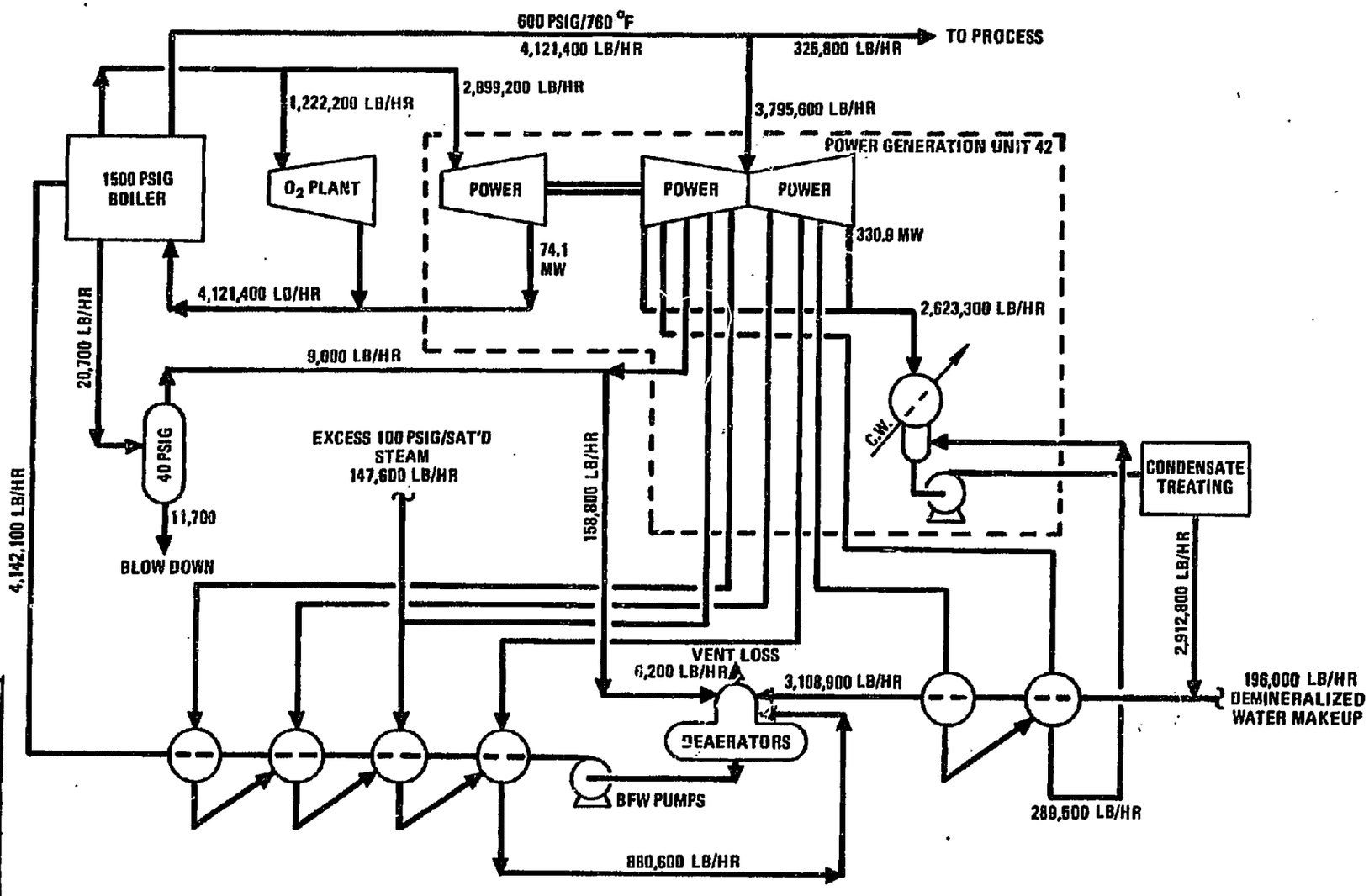
Utilities

	Steam	
Consumed (1)	1500 psig/925°F	2.9×10^6 lb/hr
	600 psig/760°F	3.8×10^6 lb/hr
	100 psig/sat'd (ejectors)	78,700 lb/hr
	Cooling Water	162,300 gpm
	Power	310 kW
Produced	Condensate	2.91×10^6 lb/hr
	Power	405 MW

(1) Steam exits the unit at 650 psig for reheat and inclusion in 600 psig 760°F flow.

FIGURE 6.3.3-1

POWER GENERATION INTERFACE WITH PROCESS PLANT



6.3.3.2 PROCESS DESCRIPTION

The utility flow sketch for the Power Generation Unit is shown on Drawing No. 835704-42-4-101. The material balance is shown on Table 6.3.3-1 and the equipment list (Table 6.3.3-2) follows.

Power Plant

The power plant is designed to supply total plant requirement and export power for sales. Power is generated onsite by three parallel units of 135 MW turbogenerators. The generators are hydrogen cooled and rated a 24 kV. Power Generation by parallel units of 135 MW turbogenerators provides reliable and flexible supply of power to the Process and Utility/ Offsite units in the plant. The total plant load for the Westmoreland 40 percent fines SNG case is 121.8 MW. Power in excess of plant requirements is approximately 283.2 MW.

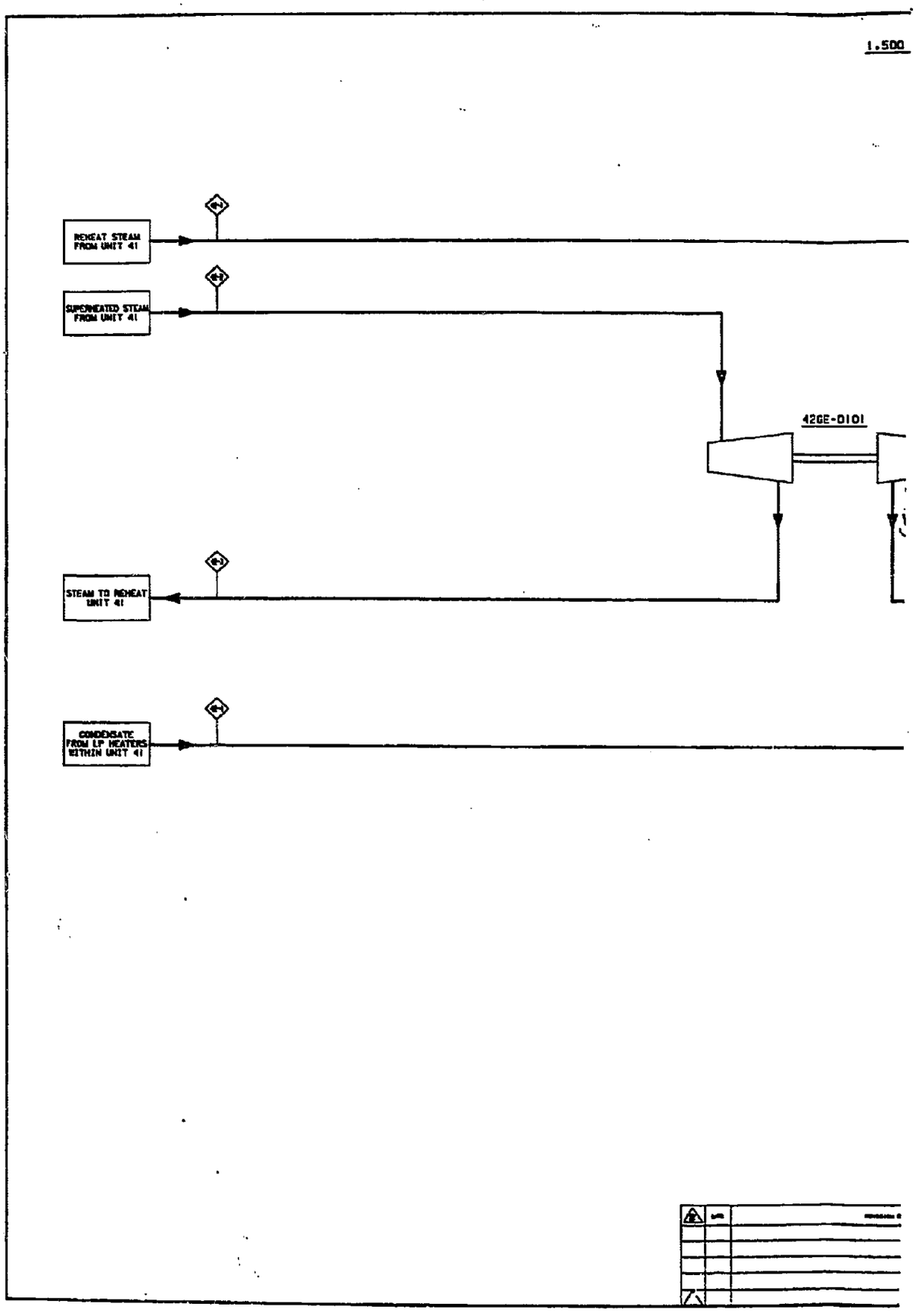
The power plant is fully integrated with the Steam Generation Unit 41 which supplies 1500 psig/925°F steam to the back pressure section of the turbogenerators. The exhaust steam exits the turbine at 650 psig/710°F. This exhaust steam is reheated in the boilers to provide 600 psig/760°F steam for plant use and to generate additional power. A major portion of the reheated steam is sent back to the Power Generation unit and is used in the condensing section of the turbogenerators to generate additional power. The condensing section of the turbogenerators have several extraction ports to supply steam used for BFW preheating and BFW deaeration.

Cooling water is used to condense the exhaust steam from the LP section of the turbogenerators. Design condensing pressure is four inches Hg absolute. The cold condensate is pumped to the BFW & Condensate Treating Unit 45 where it is treated in a mixed bed de-ionization unit and recycled for use as BFW.

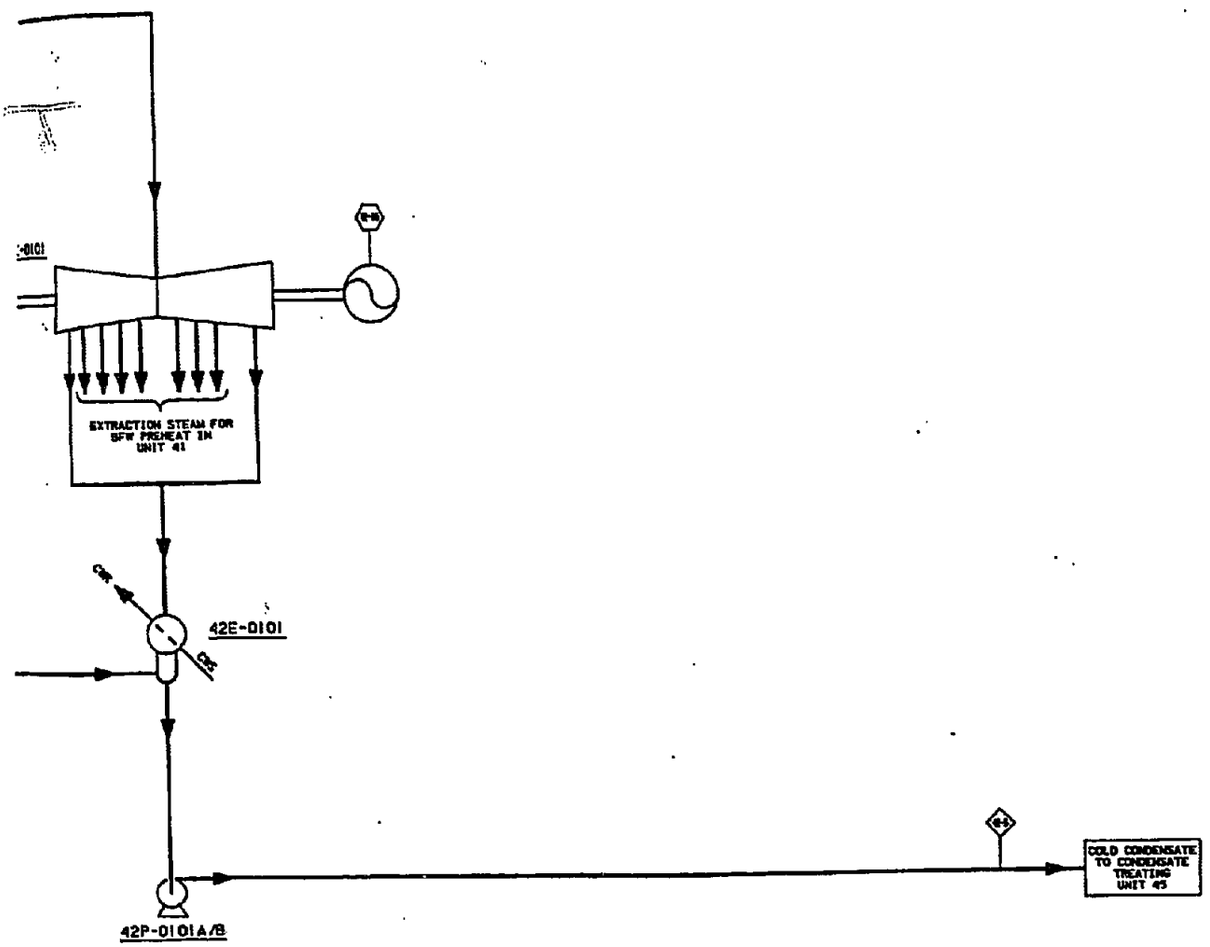
6.3.3.2 (Continued)

Power Distribution

The Power Distribution system is discussed in Section 6.3.20 of this report.


1.500
REHEAT STEAM FROM UNIT 41
SUPERHEATED STEAM FROM UNIT 41
42GE-0101
STEAM TO REHEAT UNIT 41
CONDENSATE FROM LP HEATERS WITHIN UNIT 41

42GE-0101
1500 PSIG/600 PSIG TURBINE
GENERATOR SET



NOTES:
1. THIS DRAWING REPRESENTS ONE TRAIN OF A THREE TRAIN UNIT.
2. TEMPERATURES, PRESSURES, FLOW QUANTITIES AND COMPOSITIONS REFERENCED BY DIAMOND SYMBOLS AND POWER GENERATION DATA REFERENCED BY HEXAGONS ARE SHOWN SEPARATELY.

[illegible] OF CONTROLLED DATA
[illegible] RESTRICTION IN THE
NOTICE PAGE AT THE FRONT OF THIS REPORT

FLUOR	D.P.HALVERSON	PROCESS FLOW DIAGRAM POWER GENERATION UNIT 42				003 3574210
	G.C.ABATAY					
	R.D'BELMITO					
	P.McCARTHY	CROW TRIBE OF INDIANS		SYNFUELS FEASIBILITY STUDY		
	H.LANG	NONE	835704-42-4-101		1	

TABLE 6.3.3-1

MATERIAL BALANCE

POWER GENERATION - UNIT 42

Stream Number	42-1	42-2	42-3	42-4	42-5	42-10
Stream Name	Reheat Steam	HHP Steam	Condensate HP Exhaust Steam	From LP Heaters	Cold Condensate	Power Output
H_2O lb/hr				289,500	2,912,800	
Steam lb/hr	3,795,600	2,899,200	2,899,200			
Total lb/hr	2,795,600	2,899,200	2,899,200	289,500	2,912,800	405.0
Pressure, psia	563	1463	663		3.5	110
Temperature, °F	756	925	710		90	125

NOTE: Flow quantities, temperatures, and pressures shown are for the total unit on a stream-day basis, are to be used solely for process design purposes, and are not necessarily the conditions which will be attained during actual operations.

TABLE 6.3.3-2

EQUIPMENT LIST

POWER GENERATION - UNIT 42

Item No.	Equipment Name	Number Required Oper.	Spare
42E-0101	HP Turbine Surface Condenser	3	0
42P-0101 A/B	HP Vacuum Condensate Pump	3	3
42GE-0101	1500 psig/600 psig Turbine Generator Set	3	0

NOTE: Train #2 and Train #3 equipment numbers which are not shown are the same as indicated above except the train designation is 02 or 03 instead of 01.

Example:	Train #1	Train #2	Train #3
	42E-0101	42E-0201	42E-0301

6.3.4 FLUE GAS DESULFURIZATION - UNIT 43

6.3.4.1 DESIGN BASIS

Purpose of Unit

The purpose of the Flue Gas Desulfurization unit is to reduce the SO_2 emissions from the coal-fired boiler plant.

Scope of Unit

The unit consists of facilities for SO_2 absorption, oxidation of SO_2 to SO_4^{-2}, precipitation of gypsum, chemical makeup, and waste solids concentration.

General Design Criteria

The unit has three 50 percent capacity trains of absorption and oxidation. The chemical makeup systems and solids thickener are single train systems. The gypsum filtering consists of two 50 percent trains. Sufficient spare capacity is provided such that continuous SO_2 removal is expected.

Process Performance Objectives

The sulfur removal efficiency is 90 percent based on 0.82 weight percent sulfur as received in the coal feed to the boilers.

6.3.4.1 (Continued)

Feedstock

Boiler Flue Gas

Component	moles/hr
O_2	8,073
N_2	135,473
CO	11
CO_2	25,280
H_2O	20,060
SO_3	153
NO_2	56
HCl	3
TOTAL	189,109
Temperature	300°F

Products

Flue Gas to Stack

Component	moles/hr
O_2	8,401
N_2	136,704
CO	11
CO_2	25,280
H_2O	32,969
SO_2	15
NO_2	56
TOTAL	203,436
Temperature	128°F

6.3.4.1 (Continued)

Gypsum

32,350 lb/hr

Utility and Chemical Requirements

Lime	8,792 lb/hr
Formic Acid	117 lb/hr
Water Makeup	244,000 lb/hr
Power	5,070 kW

6.3.4.2 PROCESS DESCRIPTION

The process flow sketch for Unit 43 is shown on Drawing No. 835704-43-4-101. The unit material balance (Table 6.3.4-1) and the equipment list (Table 6.3.4-2) follow the drawing.

The Davy McKee Saarberg-Hoelter FGD process is a wet scrubbing process using lime for SO_2 removal. The process has four main steps: SO_2 absorption, oxidation, lime addition, and solids separation.

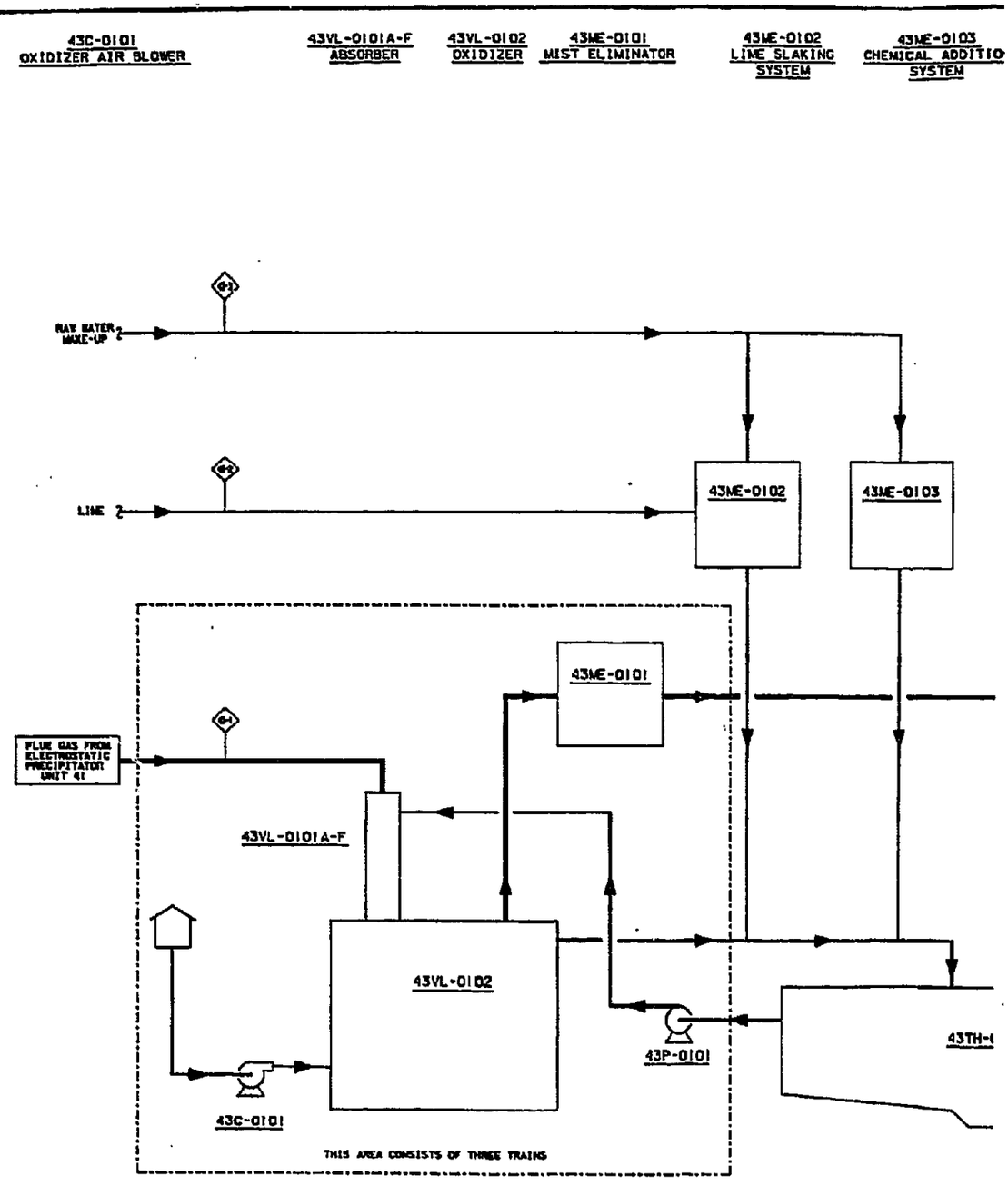
The boiler flue gas is contacted co-currently with the lime washing solution. Calcium ions in the form of calcium hydroxide, $Ca(OH)_2$, calcium formate, $Ca(COOH)_2$, and calcium chloride, $CaCl_2$, in the solution are used to absorb sulfur dioxide from the flue gas. The absorbed SO_2 reacts to form calcium bisulfite, $Ca(HSO_3)_2$, which is water soluble.

In the oxidizer, air contacts the solution and converts bisulfite ion, HSO_3^-, to sulfate ions which react with the calcium ions to form calcium sulfate dihydrate (gypsum) crystals. The oxidizer solution overflows into the mixing channel and to the thickener.

6.3.4.2 (Continued)

In the mixing channel, lime in the form of slurried lime, $Ca(OH)_2$, is added to the scrubbing fluid. Lime is added to replenish calcium ions (consumed by the formation of gypsum in the oxidizer) and to adjust the pH value to that required for SO_2 absorption. A small amount of formic acid is added to maintain calcium solubility in the clean solution.

The gypsum crystals formed in the oxidizer and mixing channel are separated from the washing fluid in the thickener. The crystals are pumped form the bottom of the thickener to a vacuum filter. The vacuum filter produces a gypsum cake containing approximately 77 percent solids (23 percent free H_2O). The filtrate is recirculated to the thickener. The clear overflow from the top of the thickener is returned to the absorber as washing fluid.

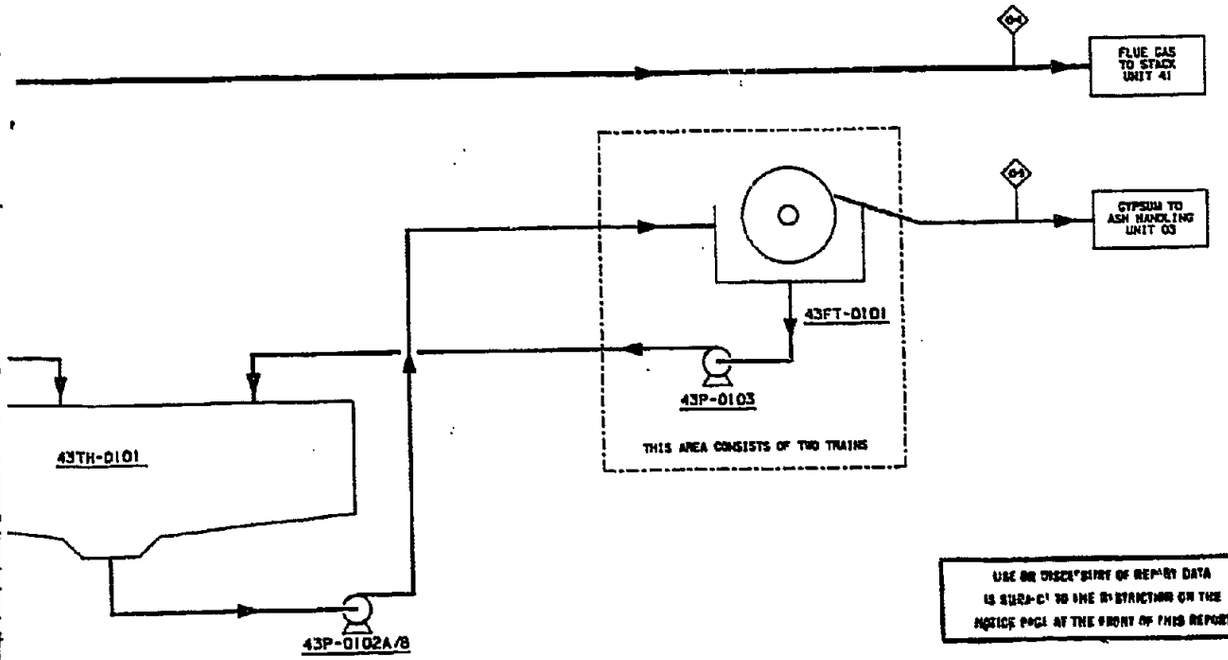

43C-0101
OXIDIZER AIR BLOWER
43VL-0101A-F
ABSORBER
43VL-0102
OXIDIZER
43ME-0101
MIST ELIMINATOR
43ME-0102
LIME SLAKING SYSTEM
43ME-0103
CHEMICAL ADDITIO SYSTEM
RAW WATER MAKE-UP
LIME
G-2
G-2
G-1
FLUE GAS FROM ELECTROSTATIC PRECIPITATOR UNIT 41
43ME-0102
43ME-0103
43ME-0101
43VL-0101A-F
43VL-0102
43P-0101
43C-0101
43TH-1
THIS AREA CONSISTS OF THREE TRAINS

SHE-0103
LIME ADDITION
SYSTEM

43TH-0101
THICKENER

43FT-0101
VACUUM FILTER

0103



USE OR DISCLOSURE OF REPORT DATA
IS SUBJECT TO THE RESTRICTION ON THE
NOTICE PAGE AT THE FRONT OF THIS REPORT

NOTES:

1. THE FLOW QUANTITIES, COMPOSITIONS AND CONDITIONS REFERENCED BY DIAMONDS ARE SHOWN ELSEWHERE.
2. THIS DRAWING IS A SIMPLIFIED FLOW DIAGRAM OF A PROPRIETARY UNIT. STREAM CONFIGURATIONS AND/OR EQUIPMENT ARE NOT COMPLETELY REPRESENTED.

FLUOR

DESIGNED BY	R. WHITE
DRAWN BY	C.C. ABATAY
CHECKED BY	R.O'BELMITO
APPROVED BY	R. McCARTHY
PROJECT MGR.	R. LANG

PROCESS FLOW DIAGRAM
FLUE GAS DESULFURIZATION
UNIT 43

CROW TRIBE OF INDIANS — SYNFUELS FEASIBILITY STUDY

NONE	835704-43-4-101	1

003 3574310I

TABLE 6.3.4-1

MATERIAL BALANCE

FLUE GAS DESULFURIZATION - UNIT 43

Stream Number		43-1		43-2	43-3
Stream Name		Flue Gas From Unit 41		Lime	Raw Water Makeup
Component		lb mol/hr	mol %		
N_2		135,473	80.14		
O_2		8,073	4.78		
CO_2		35,380	14.95		
CO		11	0.01		
NO_2		56	0.03		
HCl		3	0.002		
SO_2		153	0.09		
Total Dry Gas		169,049	100.00		
H_2O		20,060			
Total Wet Gas		189,109			
Dry Gas,	lb/hr	5,178,876			
H_2O	lb/hr	361,401			244,000
Lime	lb/hr			8,792	
Dry Gypsum	lb/hr				
Particulates	lb/hr	143			
Total	lb/hr	5,540,420		8,792	244,000
Pressure, psia		13.3			
Temperature °F		300			

NOTE: Flow quantities, pressures and temperatures shown are for the total unit on a stream-day design purposes, and are not necessarily the conditions which will be attained during actual

TABLE 6.3.4-1

MATERIAL BALANCE

FLUE GAS DESULFURIZATION - UNIT 43

	43-2	43-3	43-4		43-5
ıs	Lime	Raw Water Makeup	Flue Gas to Unit 41		Gypsum to Unit 03
1					
ol %			lb mol/hr	mol %	
.14			136,704	80.19	
.78			8,701	4.93	
.95			25,280	14.83	
.01			11	0.01	
.03			56	0.03	
.002					
.09			15	0.01	
.00			170,467	100.00	
			32,969		
			203,436		
			5,212,731		
		244,000	593,442		7,418
	8,792				
			143		24,832
	8,792	244,000	5,806,316		32,350
.3				13.1	
				128	

res shown are for the total unit on a stream-day basis, are to be used solely for process the conditions which will be attained during actual operations.

TABLE 6.3.4-2

EQUIPMENT LIST

FLUE GAS DESULFURIZATION - UNIT 43

Equipment Number	Equipment Name	No. Required	
		Operating	Spare
43 VL-0101 A-F (1)	Absorber	18	0
43 VL-0102 (1)	Oxidizer	3	0
43 TH-0101	Thickener	1	0
43 FT-0101(2)	Vacuum Filter	2	0
43 ME-0101(1)	Mist Eliminator	3	0
43 ME-0102	Lime Slaking System	1	0
43 ME-0103	Chemical Addition System	1	0
43 C-0101(1)	Oxidizer Air Blower	2	1
43 P-0101(1)	Washing Fluid Pump	2	1
43 P-0102 A/B	Filter Feed Pump	1	1
43 P-0102(2)	Filtrate Pump	2	0

NOTES: (1) Part of a three train area. Equipment numbers for Train #2 and Train #3 are the same as indicated above except the train designation is 02 or 03 instead of 01.

Example:	Train #1	Train #2	Train #3
	43VL-0102	43VL-0202	43VL-0302

(2) Part of a two train area.