

**SRC-II DEMONSTRATION PROJECT
PHASE ZERO
TASK NUMBER 3
DELIVERABLE NUMBER 8
VOL. 2 OF 5
CONCEPTUAL COMMERCIAL PLANT
PLANT DESCRIPTION**

JULY 31, 1979

THE PITTSBURG & MIDWAY COAL MINING CO.
DENVER, COLORADO

PREPARED FOR

MASTER

UNITED STATES DEPARTMENT OF ENERGY
UNDER CONTRACT
DE-AC05-78OR03055

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VOLUME 2

FOREWORD

This volume describes, in concept, an SRC-II coal conversion facility which could be constructed during the 1990's. It also defines the basic elements of configuration, product slate, thermal efficiency and costs.

Some aspects of processing and several design features affecting equipment development are work-in-progress within their respective industries and govern the conceptual treatment of this report. These items are discussed in the sections that follow. It should be noted that an evolutionary process of development characterizes this effort. It is possible that some new elements needed in process and equipment design may not be available in time. In each instance, however, alternate paths are available now. While such solutions might not be ideal in terms of capital cost and operating efficiency, they are expected to work

The premise of this conceptual approach is that the experience and knowledge gained from the design and operation of the first-generation SRC-II plants, with process and equipment development progressing within the same time frame, will resolve present questions bearing on the second-generation facility.

The Conceptual Commercial Plant defined here is based on processing 33,500 tons per stream day of high sulfur Powhatan coal to produce not only the low-sulfur fuel oils and pipeline gas produced by the initial SRC-II facilities but also an aromatic naphtha stream and light hydrocarbon gases. The aromatic naphtha can be upgraded to produce a high octane blending stock and the light hydrocarbon gases can be upgraded to ethylene, a basic raw material for the petrochemical industry.

This volume describes a grass-roots facility located on an unspecified site, since an exact location cannot be defined. This site is assumed to be

in close proximity to major highways, railroads, pipelines and a navigable river. The completed plant includes the processing units and all support facilities such as offices, maintenance shops, utility systems, roads and railyards. Electric power required for the plant is to be purchased from a local utility. Raw water will be provided from the nearby river. Coal supply to the plant is by rail. Transportation of final products is accomplished by a combination of rail, truck and pipeline.

The following sections will define the process details, physical configuration and cost of this plant. The basic plant configuration is broken down into the following functional units:

- Unit 10 - Primary Process Plant
- Unit 20 - Hydrogen Production Plants
- Unit 30 - Refining and Gas Plants
- Unit 40 - Secondary Recovery and Oxygen Plants
- Unit 50 - Utility Systems and General Facilities
- Unit 60 - Coal Supply System

Companion plants consisting of the High Octane Blending Stock Plant and the Ethylene Plant are also described in this section. These plants are considered to be totally outside the scope of the basic fuels plant and are excluded from all fuels plant utility and cost summaries.

This report is Volume 2, Plant Description, of Deliverable 8, Conceptual Commercial Plant for Phase Zero of the SRC-II Demonstration Project. Other Volumes in this deliverable are:

- Volume 1, Management Summary
- Volume 3, Supporting Reports
- Volume 4, Advanced Process Technology
- Volume 5, Economic Analysis

This volume presents detailed descriptive information on the engineering design of the Conceptual Commercial Plant. It includes process flow sheets, block diagrams and tabulated data on charge coal, products, operating conditions and equipment lists.

Licensors' and manufacturers' names are used in this volume for the purpose of identification of the type of process, an item of equipment or as a source of information or material. It is not meant to imply that these are the only acceptable sources that will be available.

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SECTION 1 PLANT DESCRIPTION

1.1 PHYSICAL DESCRIPTION

This plant is a grass-roots facility comprising all of the processing units and ancillaries, including storage for coal feed and liquid products, slag disposal, and all utilities. Some electric power must be purchased from the local utility and water will be supplied from the nearby river. The location of the plant has not been selected. Therefore, the plot plan and unit arrangement may need revision to conform to the topography of the site selected.

The plant plot plan is shown on Drawing 00-16-204 following this section.

The coal stockpile is located about 1700 feet from the main plant area as a fire precaution and for dust isolation. Storage for 900,000 tons of coal, approximately one month's supply, requires an area of about 1200 by 2000 feet (55 acres).

The main plant area is about 2500 by 4500 feet (250 acres). The key process sections are Units 10 (Primary Process Plants), 20 (Hydrogen Production Plants), and 30 (Refining and Gas Plants). These are centrally located in the main plant on an area about 1200 by 2000 feet (55 acres). The auxiliary equipment includes Units 40 (Secondary Recovery and Oxygen Plants), and 50 (Utility Systems and General Facilities). These are placed around the key Units 10, 20 and 30. The Product Storage Area is located at one end in an area about 1200 by 1200 feet (about 33 acres).

The plot plan was developed by sizing individual process areas in each unit then combining them in accordance with good engineering practice. Consideration was given to the logic of flow patterns between units to minimize piping and pumping power. Safety requirements for such items as flares, cooling towers, oxygen plant, sulfur plant, storage for flammable

liquids, and fired heaters were considered. The centrally located control building provides overall control of process operation using advanced instrumentation technology including computer based data acquisition and microprocessor controllers.

The control systems of the steam and power generation, water treatment, cooling water, and other utilities are coordinated separately at the powerhouse which is located adjacent to the key process units. Spacing between equipment areas provides for maintenance access roads and fire-fighting lanes. Security fences are provided around the coal stockpile and the entire main plant area except for the Administration Building.

The Area 11 Dissolver Plant is the heart of the SRC-II process. The plot area required is about 800 by 900 feet. Area 11 contains four parallel dissolver-high pressure letdown trains, each fed through two fired heaters and charge pumps. These four trains combine into two parallel trains as the flow enters the low pressure letdown section. The dissolvers and high pressure separators are the heaviest equipment in the plant, requiring massive foundations. These foundations, in addition to the requirements of piping expansion, maintenance, and pump-out dictate the physical arrangement of these vessels.

Unit 20 Hydrogen Production is near Area 11 and is close to the Area 34 Refining Plant. The arrangement is advantageous to the piping systems, particularly the mineral residue slurry system which must be kept hot and circulating. This equipment, together with the tanks for mineral residue slurry and diluent solvent (part of Area 34), are located next to Area 11.

The Unit 30 Refining and Gas Plants are placed in a logical grouping of areas, with Area 33 Sulfur Recovery. Based on an assumed prevailing wind, this area is somewhat isolated to prevent possible air contamination of other areas.

Unit 40 Secondary Recovery and Oxygen Plant is divided into separated areas. Area 41 Ammonia Recovery Plant and Area 42 Tar Acids Recovery are together and near storage tankage, while Area 43 Waste Water Reclamation is placed next to Area 52 Raw Water Treatment. Area 44 Oxygen Plant is located at the upwind corner of the plant for best air intake conditions.

Area 51 Steam Generation System has the most central location possible for economical distribution of utilities. The cooling towers for the Area 53 Plant Cooling Water System are located at the periphery of the main plant area.

The miscellaneous systems and ancillary facilities, such as the maintenance and warehouse area, the laboratory, change house, storage, surface drainage and disposal systems, etc., are located in accordance with usual plant design practice.

1.2 PROCESS CONFIGURATION

The facility described in this volume is a Conceptual Commercial Plant for liquefying coal using the SRC-II process. The Block Flow Diagram, Drawing OOC06-101, follows this section. The plant is designed to process 33,500 tons per stream day (tpsd) of Powhatan coal. Principal products from the plant are low-sulfur fuel oil, naphtha, C_2 - C_3 petrochemical feedstock, pipeline-quality gas, and butane, as well as sulfur, ammonia, and tar acid by-products. The heating value of the hydrocarbon products produced in the plant is approximately equal to that produced in a 100,000 barrel per day petroleum refinery.

The primary processing areas consist of coal-slurry preparation, dissolver, refinery, recycle gas treating and compression, and hydrogen recovery. Other areas include hydrogen production, gas plants and secondary recovery systems. Because the plant is designed as a grass-roots installation with utilities included, a minimal amount of the electric power required is purchased from a local utility.

The feed coal is pulverized and mixed with a recycle slurry stream from the process and then is pumped, together with hydrogen, through a preheater to a reactor or dissolver operated at high pressure and temperature. The coal is first dissolved in the liquid portion of the recycle slurry, then is largely hydrocracked to liquids and gases. Much of the sulfur, oxygen, and nitrogen in the original coal is hydrogenated to H_2S , H_2O , and NH_3 respectively. The rates of these reactions are increased by the catalytic activity of the undissolved mineral residues. This recycle of a portion of the product slurry contributes substantially to the process by increasing the concentration of catalytic mineral residue in the reactor.

The dissolver effluent is separated into gas, light hydrocarbon liquids, and slurry stream, using conventional flashing techniques. A portion of the mineral residue slurry and liquid hydrocarbon from the separation is recycled

to blend with the feed coal in the slurry preparation plant. The balance of the mineral residue slurry is vacuum flashed to recover additional fuel oil product.

The net dissolver gas stream consisting primarily of hydrogen, light hydrocarbons, and hydrogen sulfide is washed with fractionated solvent to remove liquid hydrocarbons and then is contacted with diethanolamine (DEA) in an absorption system to remove acid gases. After acid gas removal the major portion of this gas is treated cryogenically to remove nitrogen, methane and heavier hydrocarbon gases. The purified hydrogen stream is then recycled to the dissolver.

Mineral residue slurry feed is pumped to high-pressure gasifiers where it is partially oxidized to produce synthesis gas. The synthesis gas, primarily H_2 and CO , is then sent through shift conversion to produce more hydrogen. The significant advantages of the high-pressure gasifiers and shift converters are that the gasifier size is reduced and the power required for recompressing the makeup hydrogen is reduced. To ensure continuity of operation, a spare gasifier is included in the design.

Liquid products from the main process area are refined in the fractionation section. The fractionation section separates the coal liquids into naphtha, a lower-boiling fuel oil mix and a higher-boiling fuel oil mix.

Various liquid and gas streams are treated further in the gas plant to produce a petrochemical plant feedstock of C_2 - C_3 (ethane and propane), butane, and pipeline gas. Secondary recovery plants are provided to recover ammonia, tar acids and sulfur.

The process trains used in the Conceptual Commercial Plant are shown on the Plant Train Diagrams OOC06-103 and 104 following this section.

The Area 11 Dissolver Plant has two separate trains in parallel which can be run independently. Each of these has an equipment sequence as follows:

- 1 Coal feed slurry mixing system with three mixer-extruders; two 50% units operating and one 50% unit spare;
- 4 Disc mills, high pressure charge pumps, and dissolver charge heaters;
- 2 Dissolvers and first and second-stage high pressure cooling and separating systems;
- 1 Third and fourth-stage high pressure cooling and separating system;
- 2 Dissolver effluent slurry letdown systems;
- 2 Low-pressure first-stage cooling and separating systems;
- 1 Low-pressure second-stage cooling and separating system.

The equipment sequence in Area 12 Hydrogen Treating and Recovery Plant is as follows:

- 2 High-pressure gas-oil wash absorber systems;
- 2 High-pressure acid gas removal systems;
- 2 High-pressure recycle hydrogen compressor systems;
- 4 High-pressure cold boxes;
- 1 Off-gas compressor system.

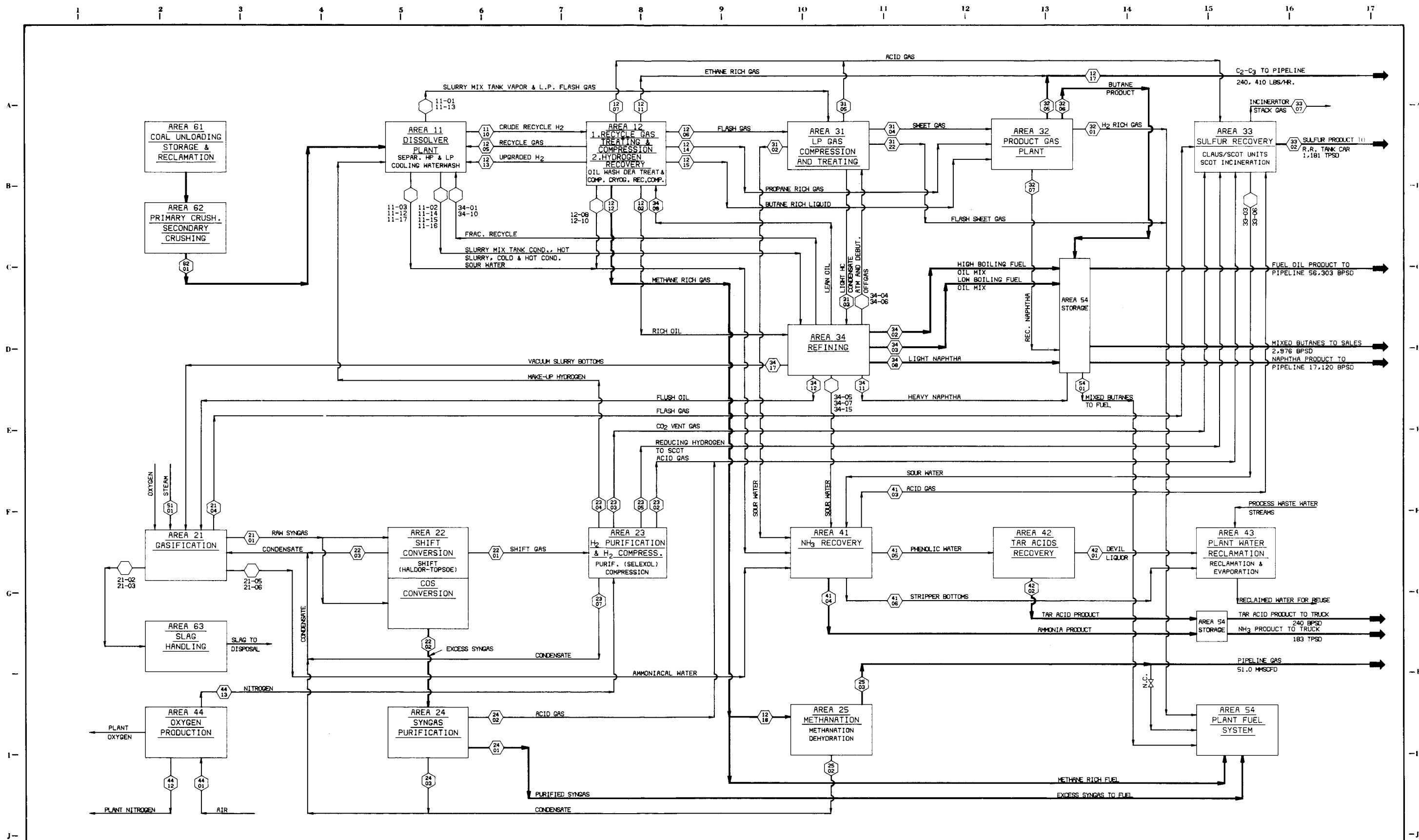
Area 34 Refining consists of a single main product fractionator and debutanizer and two vacuum flash separators. The Refining Plant solvent and mineral residue slurry storage-and-circulating system is included in Area 34.

A single train of equipment is used to meet the processing requirements in the Low-Pressure Gas Compression and Treating Plant and the Product Gas Plant.

As shown in the plant train diagrams, four gasification units, including one spare, are used for syngas production. The shift conversion area consists of two parallel trains each capable of handling 50%

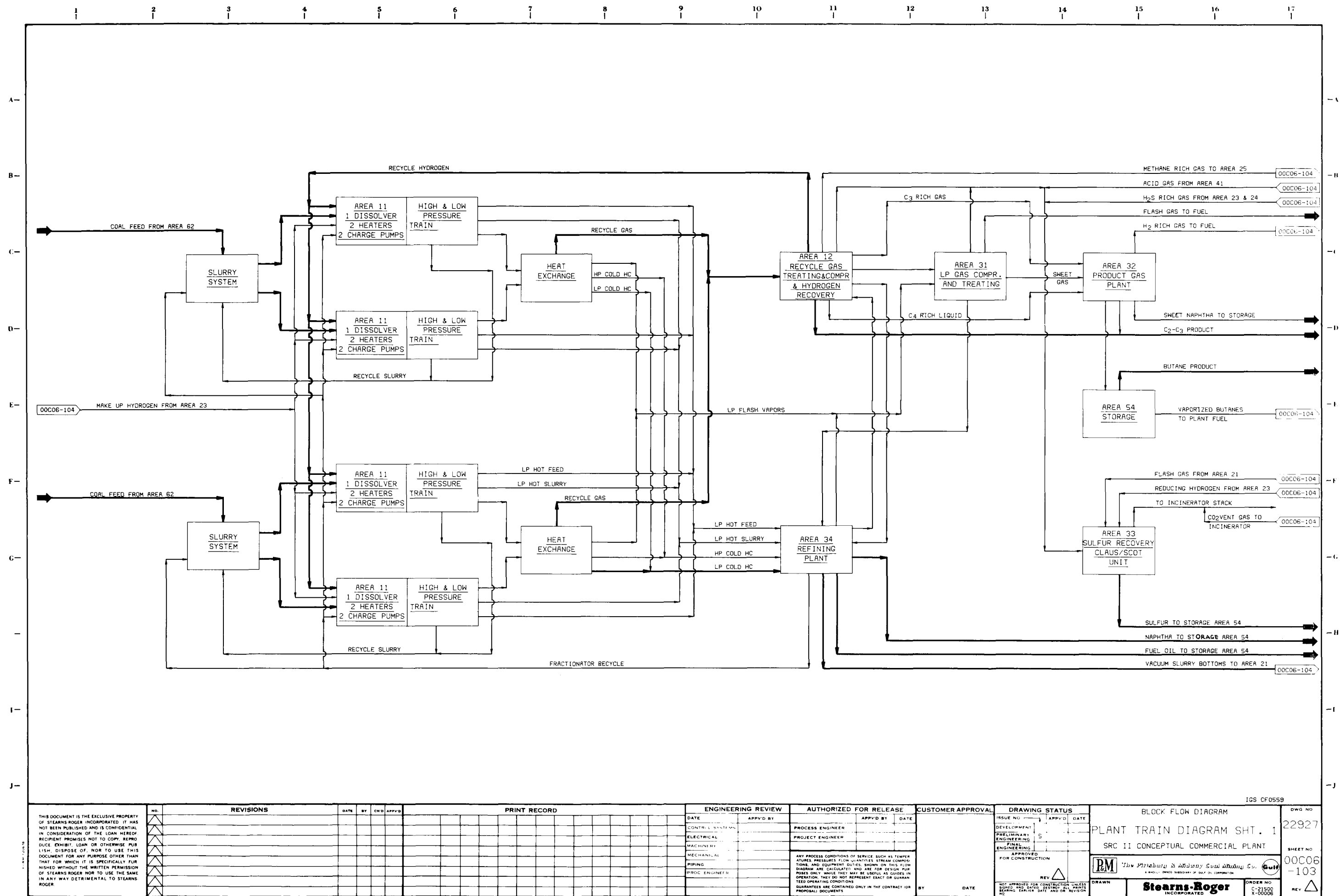
of the normal capacity. The Hydrogen Purification and Compression Plant also includes two parallel trains of 50% capacity. The Syngas Purification Plant, which purifies approximately 18% of the syngas produced by the gasifier, uses one train of equipment. The Methanation and Dehydration Plant, which converts approximately 50% of methane-rich gas to pipeline gas, also uses one train of equipment.

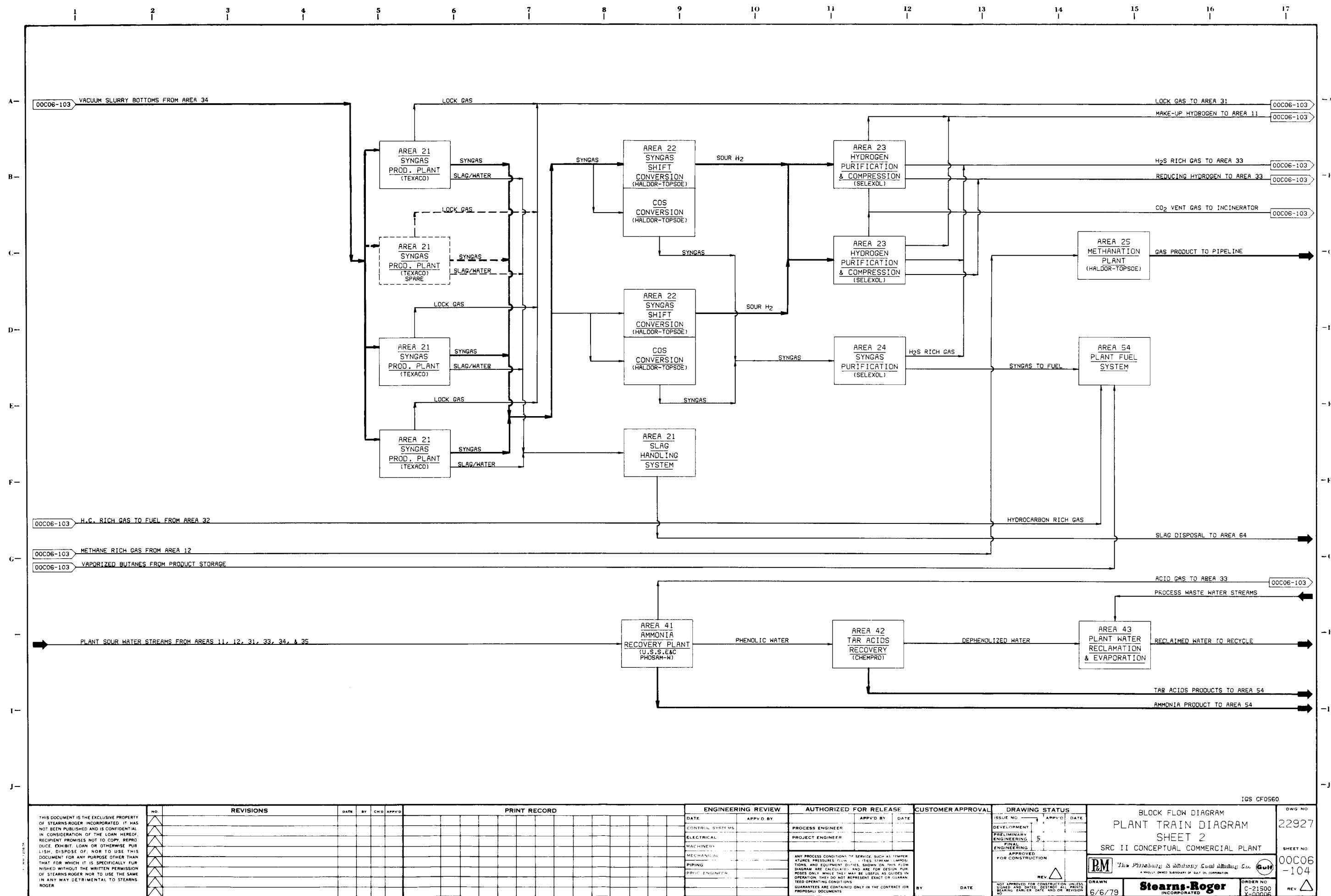
The Secondary Recovery Plants are single-train, but in some cases parallel items of specific equipment are utilized.



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SECTION 2

PROCESS DESIGN CRITERIA

2.1 FEEDSTOCK

Process design criteria for the Conceptual Commercial Plant are based on a considerable amount of data obtained with West Virginia Panhandle coals at Gulf Science and Technology Company, Harmarville, Pennsylvania, SRC-II pilot plant. Also, the Fort Lewis, Washington, pilot plant has furnished additional data on the same type of coal. Powhatan coal properties are listed on Table 2-1 and shown graphically on Figure 2-1. The analysis shown represents the expected blended properties for Powhatan coals. Coal blending facilities are provided in the Conceptual Commercial Plant design to maintain as closely as possible the properties of the design coal. The dissolver yields, thermal efficiency calculations, etc., are based on this analysis. Discussion of variable coal feedstocks, as related to this commercial plant design, is included in Section 5.3.1

The coal analysis shown is on a moisture-free basis. The plant is designed for a maximum of 9% coal moisture. Material balance and thermal calculations are based on an average coal moisture of 7.0%. Conventional coal analysis is used, but certain procedures for handling this basis of analysis are required. For material balance calculations which are consistent with laboratory expressed results, ash in equals ash out. In the coal charge composition, the sulfur and chlorine components are arithmetically removed from the ash value and are included in the elemental breakdown of the ultimate coal analysis.

TABLE 2-1
FEEDSTOCK COMPOSITION
POWHATAN COAL CASE

COAL COMPOSITION, WT% (MOISTURE-FREE BASIS)

Carbon		70.49
Hydrogen		4.88
Nitrogen		1.12
Oxygen		7.87
Sulfur		3.59
Pyrite	2.00	
Organic	1.54	
Sulfate	0.05	
Chlorine		0.05
Ash		12.00
Contained Iron	1.75	
TOTAL		100.00

2.2 PRODUCTS

The SRC-II Conceptual Commercial Plant is designed to process 33,500 tons per stream day of Powhatan coal. The only raw materials required for the plant are coal and water.

The products from the CCP are low-sulfur fuel oil, untreated naphtha, ethane-propane, liquid butanes, and pipeline quality gas. Ammonia, sulfur and tar acids are recovered as by-products. The product slate is given in Table 2-2 and a product slate pie chart is shown on Figure 2-1 following this section.

TABLE 2-2

NET PRODUCT SLATE
(Stream Day Basis)

<u>NET PRODUCTS (1)</u>	<u>UNITS</u>	<u>BASE CASE POWHATAN COAL</u>
Fuel Oil	barrels	56,303
Pipeline Gas	MM Std cu ft	51
Naphtha	barrels	17,120
Light Hydrocarbons	pounds	5,769,840
Butanes	pounds	603,912
Sulfur	short tons	1,181
Ammonia	short tons	183.5
Tar Acids	barrels	240

(1) Product Property Basis

Fuel Oil	350 ⁰ F to 900 ⁰ F nominal boiling range
Pipeline Gas	940 Btu/cu ft higher heating value
Naphtha	Pentanes to 350 ⁰ F nominal boiling range
Light Hydrocarbons	93% of 50-50 wt.% ethane and propane, 7 wt.% miscellaneous gases.
Butanes	96 wt.% of C ₄ hydrocarbons, 4 wt.% C ₃ and C ₅ hydrocarbons

2.3 MATERIAL BALANCE

The overall material balance is a closed balance representing the average stream day flow through the 33,500 tpsd Conceptual Commercial Plant. The major streams detailed on the overall material balance are consistent with the individual area process flow sheets. The Overall Plant Material Balance diagram is shown on drawing 00C06-102 following this section.

The plant material balance is based on 33,500 tpsd coal feed rate (dry basis). The dissolver yields were specified by Gulf Mineral Resources Co. (GMRC) based on pilot plant material balance studies and the coal analysis given in Table 2-1.

A material balance around the Area 11 Dissolver Plant was completed using the Powhatan coal feed rate and dissolver yield data. Preliminary block material balances were made for each of the major process units. Internal material balances for each area were then completed and provided the basis for heat balances and equipment design. Inconsistencies between the final overall material balances used for individual area design were relatively minor. Therefore, the equipment size and design, and the utilities described in this document, are representative of an SRC-II Conceptual Commercial Plant.

The yield data for the SRC-II process described in this Volume 2 were supplied by Gulf Mineral Resources Company. The yields are based on data obtained by Gulf Science and Technology Co. at the Harmarville SRC-II Pilot Plant utilizing Powhatan coal. The material balance is based on the yield distribution given in Table 2-3.

TABLE 2-3

YIELD DATA

<u>COAL DESCRIPTION</u>	<u>POWHATAN COAL CASE</u>
Hydrogen Consumption.	4.4
<u>COMPONENT</u>	<u>YIELD, (1)</u>
C ₁	5.8
C ₂	4.4
C ₃	4.1
C ₄	2.2
C ₅ to 350°F	7.9
350°F to 600°F	20.1
600°F to 900°F	8.0
900°F +	24.0
Undissolved Coal (IOM) (2)	4.62
H ₂ O	6.2
H ₂ S	2.45
NH ₃	0.45
CO	0.08
CO ₂	1.0
HCL	0.02
Ash	12.0
Residual S + Cl	<u>1.08</u>
TOTAL	104.40

(1) Wt.% of coal (moisture-free basis)

(2) Insoluble organic matter (IOM)

2.4 ENERGY BALANCE

The overall energy balance for the SRC-II Conceptual Commercial Plant is listed in Table 2-4, the energy input/output distribution is shown on Figure 2-3 and the energy output distribution (main and by products) is shown on Figure 2-4 following this section.

The total heat input was computed from the heat of combustion of the coal charged to the plant and the equivalent Btu's required to generate the purchased electric power per average stream day. The output realized from the products was computed in a similar fashion by summing the total Btu's available in the main product and by-product streams. The difference between total energy input and total energy available in the (a) main products only, and (b) the aggregate of main and by-products represents the overall plant energy consumption and losses. The overall plant thermal efficiency for the SRC-II Conceptual Commercial Plant is 71.4% based on main products only, or, if by-products are included, 73.0%.

TABLE 2-4

ENERGY BALANCE

<u>INPUT ENERGY</u>	<u>POUNDS PER HOUR</u>	<u>MILLION BTU'S PER HOUR (HHV)</u>
Coal	2,791,000	35,775
Electricity	10,430 kW (1)	<u>99</u>
INPUT TOTAL		35,874
 <u>OUTPUT ENERGY</u>		
<u>Main Products</u>		
Fuel Oil	811,820	13,806
Pipeline Gas	86,580	2,002
Naphtha	217,400	3,974
Light Hydrocarbons	240,410	5,291
Butanes	25,163	<u>526</u>
TOTAL MAIN PRODUCTS ONLY		25,599
 <u>By-Products</u>		
Sulfur	98,417	391
Ammonia	15,292	150
Tar Acids	3,100	<u>65</u>
TOTAL BY-PRODUCTS ONLY		606
 <u>OUTPUT TOTAL</u>		 26,205
 <u>Thermal Efficiency</u>		
Main Products Only		71.4%
Including By-Products		73.0%

(1) Based on a heat rate of 9500 Btu/kwh for purchased power.

2.5 FUEL BALANCE

The plant is self-sufficient in fuel, the bulk of the requirement coming from Area 12 Hydrogen Treating and Recovery Plant and Area 24 Syngas Purification Plant. Other fuel contributors are Area 31 Low-Pressure Gas Compression and Treating Plant, and Area 32 Product Gas Plant. The swing fuel will be butanes, from Area 54 Product Storage, which will be vaporized into the plant system as needed.

Natural gas will be required for emergencies and plant startup.

The major fuel users are Area 11 dissolver charge heaters, and Area 44 gas turbines driving the air compressors. The fuel balance is listed on Table 2-5. All data is given at the lower heating value (LHV).

TABLE 2-5
FUEL BALANCE

<u>AREA</u>	<u>FUEL</u>	<u>MMBTU/HR (LHV)</u>
<u>SOURCES</u>		
12	Methane-Rich Gas	1,918.0
24	Synthesis Gas	1,750.0
31	Flash Gas	5.3
32	Hydrogen-Rich Gas	847.1
54	Butanes	<u>521.5</u>
	TOTAL	5,041.9
<u>USERS</u>		
11	Charge Heaters	N/A
33	Sulfur Recovery	N/A
34	Refining	499.3
43	Water Reclamation	60.5
44	Gas Turbines (Air Compressors)	1,314.7
51	Steam Generation	684.5
54	Synthesis Gas Heater	<u>152.0</u>
	TOTAL	5,041.9

2.6 STEAM BALANCE

The CCP design is based on five pressure levels of steam generation. The bulk of the steam is generated in waste-heat recovery boilers and the convection sections of fired heaters.

Two power boilers are provided to balance the total requirement. They are sized to generate steam for startup.

Approximately half of the steam is used in condensing turbines. The other large consumers are process reboilers, heaters and direct injection into the process. More than 700,000 lbs/hr pass through one or more extraction or topping turbines.

The plant steam balance is shown on Table 2-6 at the end of this section. The generation and consumption totals for individual pressure levels do not balance because of re-use of steam through extraction or topping turbines.

TABLE 2-6
STEAM BALANCE
(Mlb/hr)

<u>PRESSURE LEVELS</u>	1500 <u>PSIG</u>	600 <u>PSIG</u>	250 <u>PSIG</u>	100 <u>PSIG</u>	50 <u>PSIG</u>	TOTAL
<u>GENERATION</u>						
Power Boilers	135					135
Process Waste Heat Boilers	957	669	1034	25	1200	3885
Gas Turbine						
Waste Heat Boilers		600				600
Dissolver Charge						
Heater Convection						
Sections	405					405
Flash Steam	—	<u>20</u>	<u>62</u>	—	<u>9</u>	<u>91</u>
TOTAL	1497	1289	1096	25	1209	5116
<u>CONSUMERS</u>						
Process	620	32	33	38	21	744
Reboilers/Heaters	94	202	19		1066	1381
Condensing Turbines	470	652	1553			2675
Deaerator					205	205
Loss to Atmosphere	—	—	<u>99</u>	<u>2</u>	<u>10</u>	<u>111</u>
TOTAL	1184	886	1704	40	1302	5116

2.7 WATER BALANCE

The plant water balance accounts for all water entering, leaving, or consumed on the site. The system is based on recovery and recycling of waste water streams so that no contaminated effluent is discharged to the natural drainage system.

As a result of recovering and recycling liquid streams in the Area 43 Waste Water Water Reclamation Unit, makeup water required from the river source is reduced by 6000 gallons per minute, or 36%.

The plant water balance is listed on Table 2-7 following this section.

TABLE 2-7
WATER BALANCE
 GPM

<u>WATER IN</u>	<u>GPM</u>
Coal Moisture	331
Air to Oxygen Plant	119
Rain	1,110
River Water	<u>10,920</u>
TOTAL	12,480

<u>WATER OUT</u>	
Cooling Tower Evaporation and Drift	10,066
Process Consumption	1,574
Slag	129
Sludge	35
Gas Turbine NO _x Control	188
Water Reclamation Incinerator	174
Steam Losses	101
Nitrogen and CO ₂ Vents	62
Miscellaneous	<u>151</u>
TOTAL	12,480

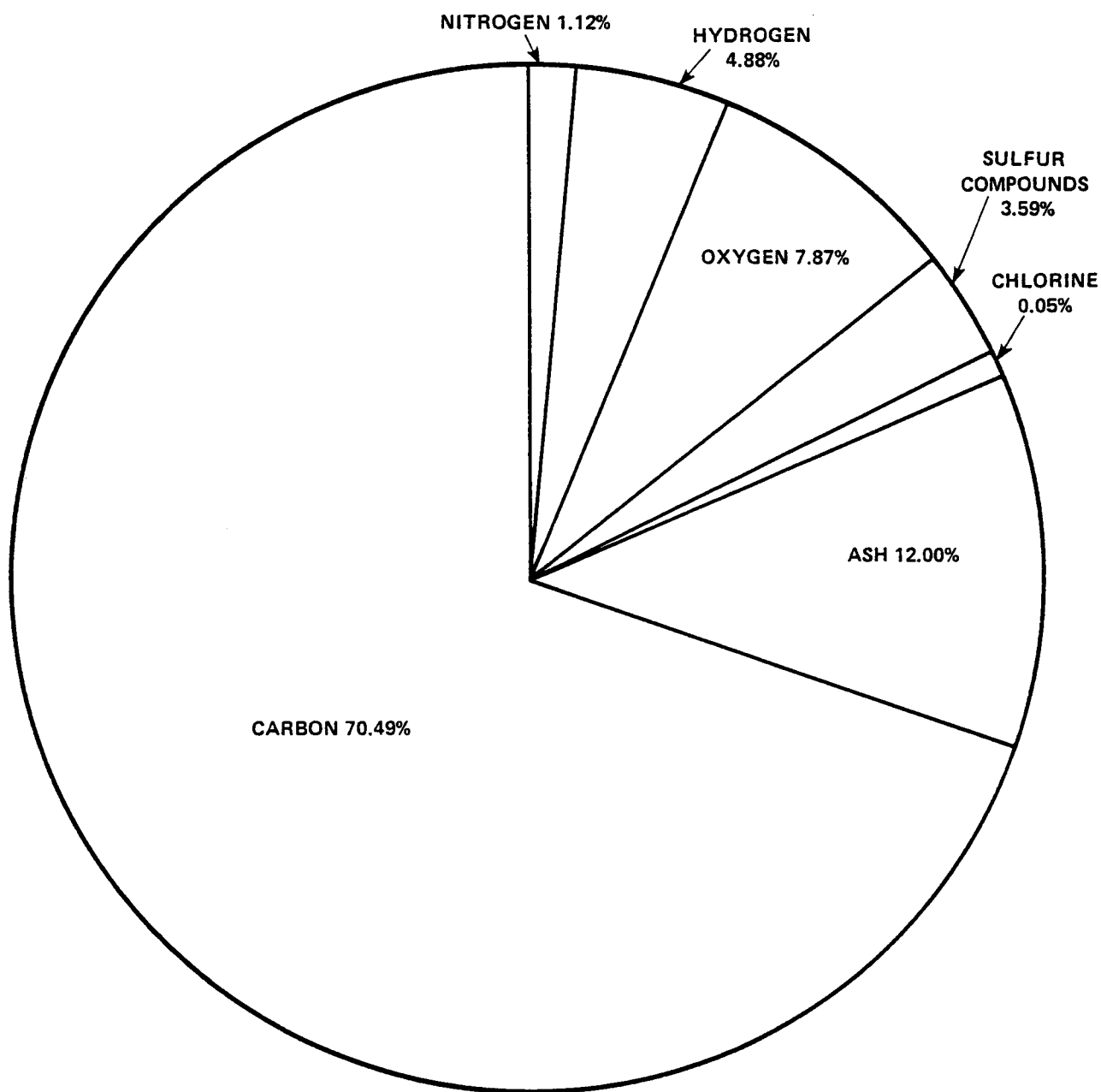


**FIGURE 2-1
FEEDSTOCK COMPOSITION
(POWHATAN COAL CASE)**

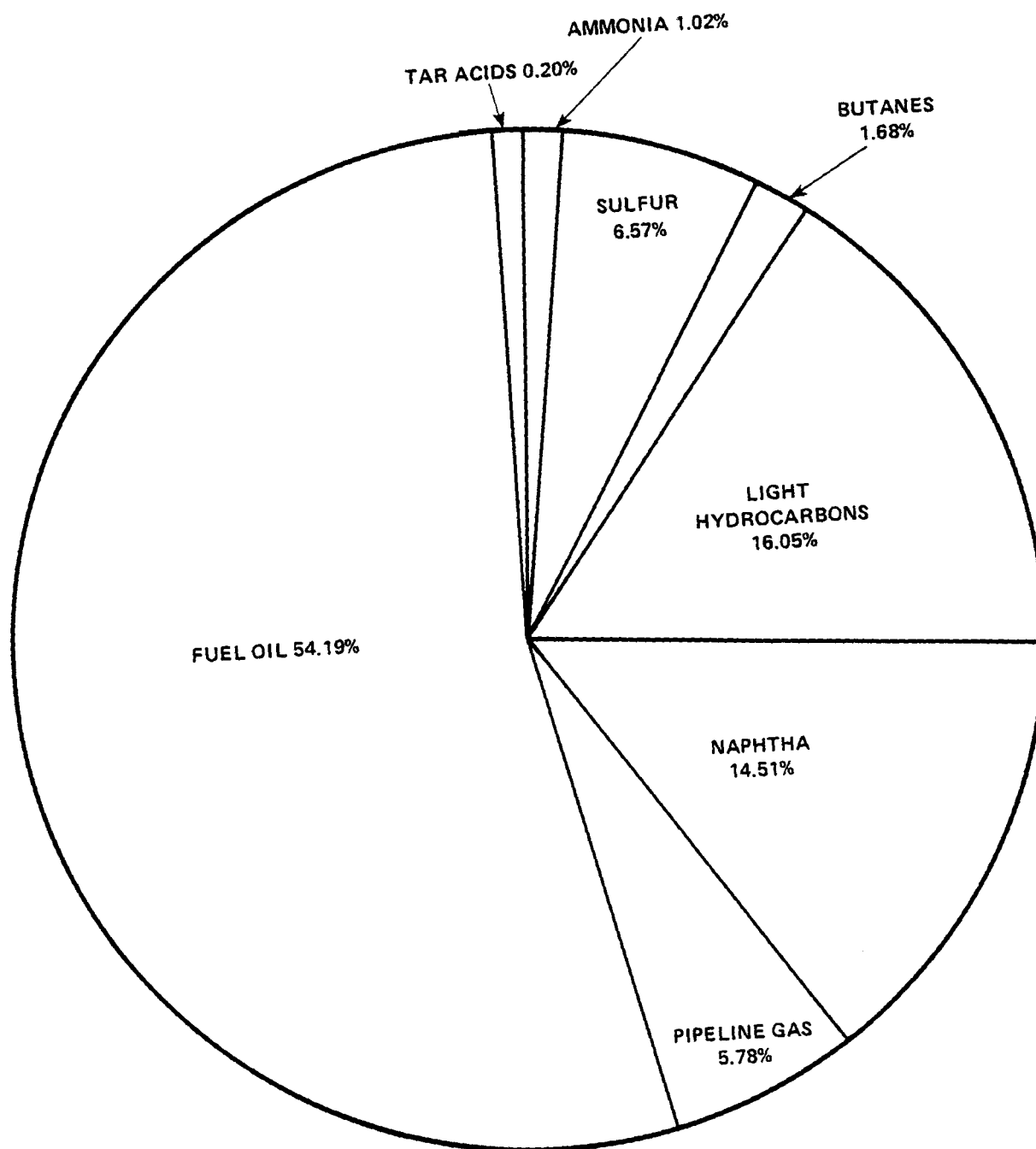


FIGURE 2-2
PRODUCTS (MASS BASIS)

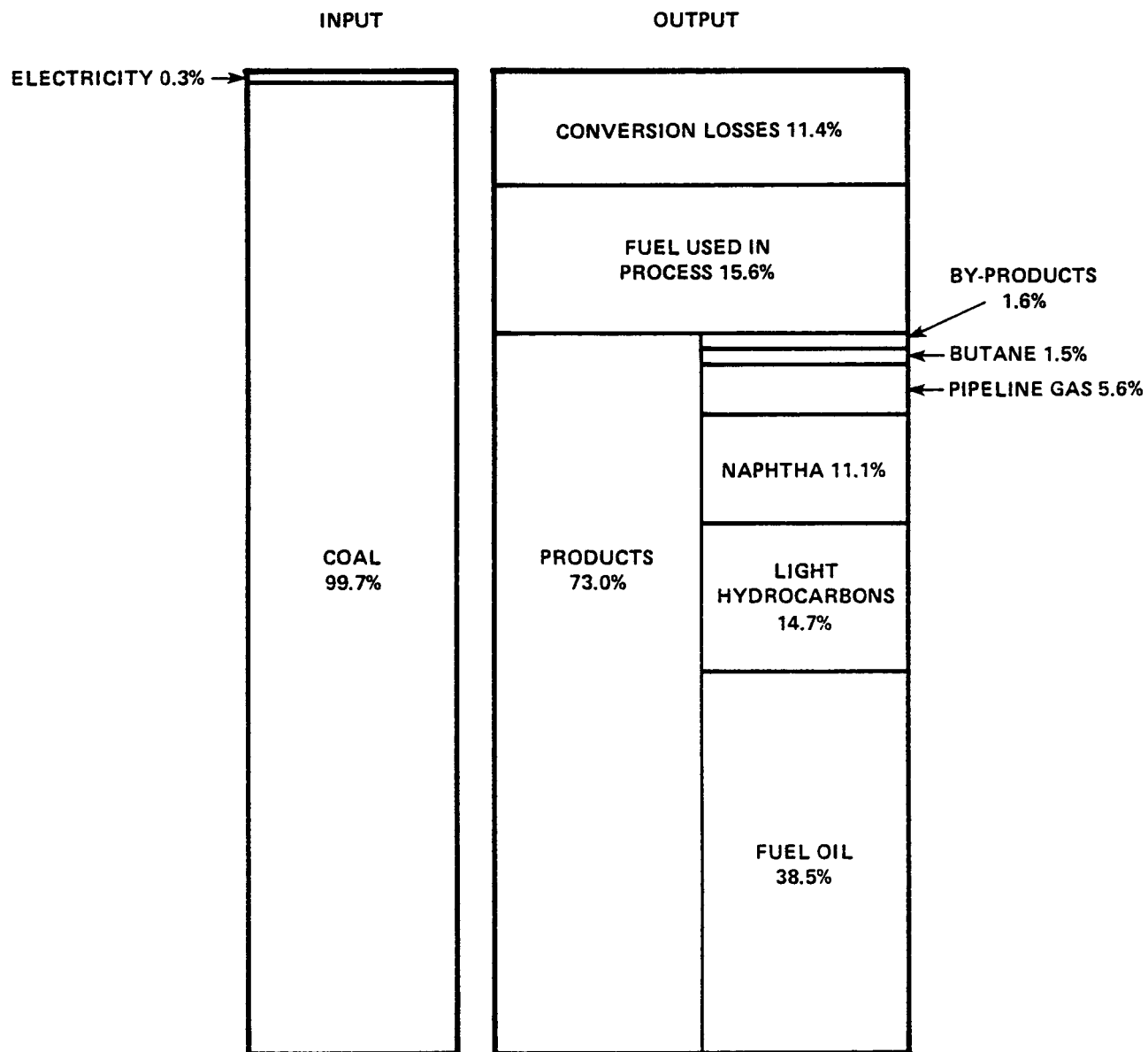


FIGURE 2-3
ENERGY INPUT/OUTPUT DISTRIBUTION

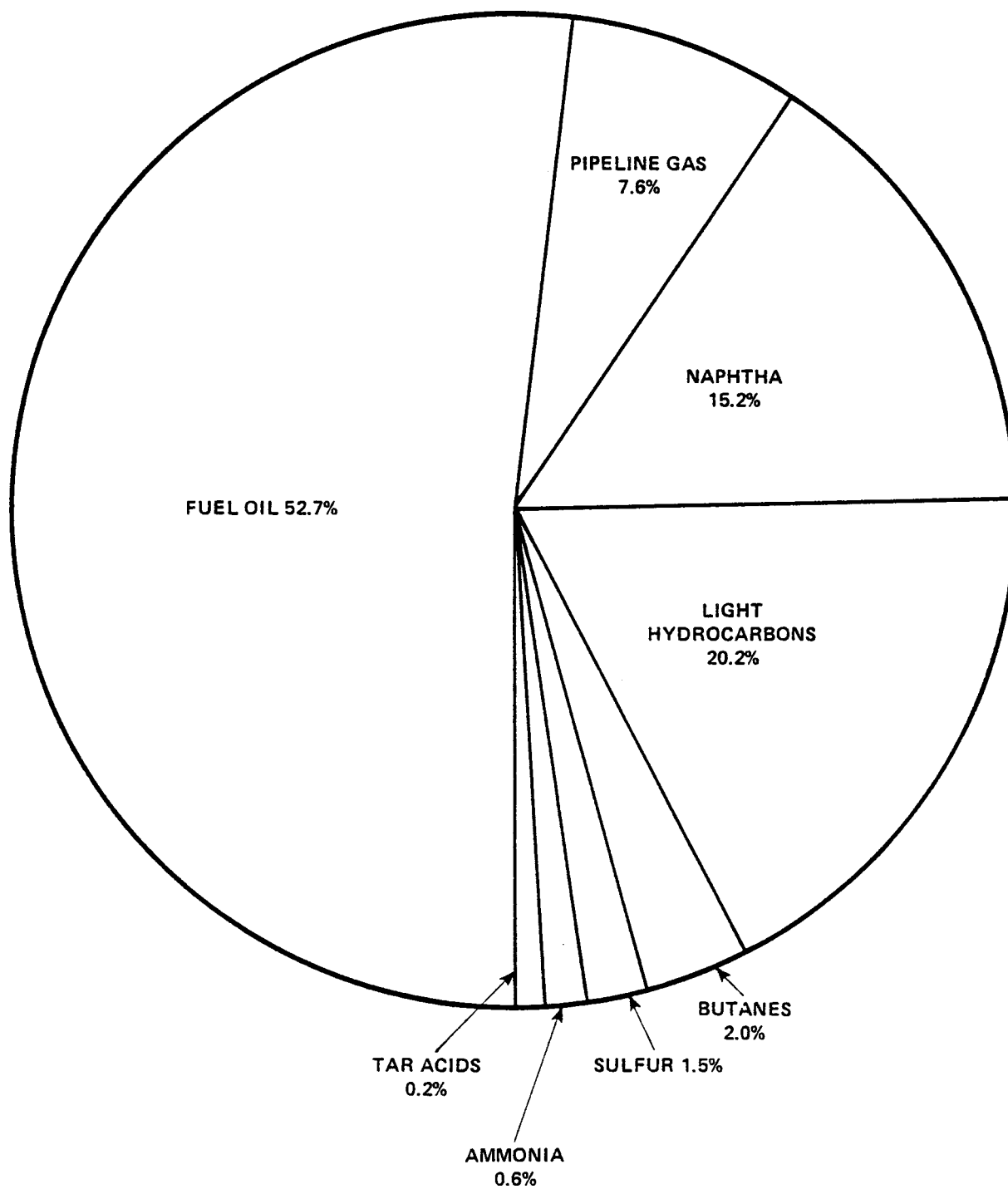


FIGURE 2-4
ENERGY OUTPUT DISTRIBUTION
(MAIN & BY-PRODUCTS)

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BY	DATE	ISSUE NO.	APPR'D	DATE	
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		ENGINEERING			
		FINAL			
APPROVED FOR CONSTRUCTION					
REV. 					
NET APPROVED AND CHECKED BY _____ DATE _____					

PROCESS FLOW DIAGRAM OVERALL PLANT MATERIAL BALANCE AREA 00 SRC □ CONCEPTUAL COMMERCIAL PLANT		DWG NO. 22927
The Pinedale & Midway Coal Mining Co. A WHOLLY OWNED SUBSIDIARY OF B&E IN CORPORATION		SHEET NO. 00C06
PM	Stearns-Rover	-102
DRAWN BY: JRS.	ORDER NO. C-71950	NOT

SECTION 3 PROCESSING UNITS

3.1 GENERAL DESCRIPTION

The SRC II Conceptual Commercial Plant is divided into units according to function and each unit is subdivided into areas by process sections. The conceptual engineering and cost estimates have been developed on an area basis.

An overall material balance has been prepared to resolve small discrepancies between area balances, and to achieve continuity between the predicted dissolver reactor yields and the plant product yields.

Unit 60 includes all coal receiving, processing, and handling. This unit also includes the slag handling and slag disposal systems. Units 10, 20, 30 and 40 are processing plants which upgrade the coal to produce liquid and gaseous products. Their supporting utility systems are included in Unit 50.

The writeup for each of the areas within the units outlined above includes area definition, design basis, process description, design discussion, utility summary and equipment list. The process flow diagrams are located at the end of each unit section.

Process designs for these units are not intended as detailed or optimized designs. The design definitions are limited to process equipment and conditions of service. Designs are complete only for overall heat and material balances, process flow diagrams, conditions of service for equipment, and estimates of utility requirements.

Equipment and vessel specifications have not been finalized. Piping design has not been undertaken beyond hydraulic estimates. Plant units and areas are listed on the following pages.

Unit 60 - Coal and Slag Systems

- Area 61 - Coal Supply System - Including railroad dump hopper, car dumper, dust suppression, dust collection, belt conveyors, primary crushing, sampling and stacking.
- Area 62 - Coal Crushing System - Including reclaim system, reclaim hoppers, front-end loaders, conveyors, secondary crushers, dust suppression, dust collection and coal conveyors.
- Area 63 - Slag Handling System - Including drum filter system, emergency slag holding system, slag belt conveyors and slag reclaim conveyors.
- Area 64 - Slag Disposal System.

Unit 10 Primary Process Plants

- Area 11 - Dissolver Plant - Including slurry mixing, slurry charge heaters, dissolvers, water wash, raw products separation and cooling.
- Area 12 - Hydrogen Treating and Recovery Plant - Including oil wash, acid gas removal, recycle compression and high-pressure cryogenic recovery plant.

Unit 20 Hydrogen Production Plants

- Area 21 - Syngas Production Plant - Including synthesis gas production via gasification and slag handling to the area battery limit.
- Area 22 - Syngas Shift Conversion Plant - Including high-pressure shift conversion based on Haldor Topsoe A/S data.

Area 23 - Hydrogen Purification and Compression Plant - Including H_2S and CO_2 removal via a Selexol Unit, plus compression of makeup hydrogen to dissolver pressure.

Area 24 - Syngas Purification Plant - Including H_2S removal via a Selexol Unit.

Area 25 - Methanation and Dehydration Plant - A methanator unit based on Haldor Topsoe A/S designs and glycol dehydration.

Unit 30 Refining and Gas Plants

Area 31 - Low Pressure Gas Compression and Treating Plant - Including vapor recovery, gas compression, DEA absorber and DEA regeneration.

Area 32 - Product Gas Plant - Including cryogenic separation unit, depropanizer, debutanizer and refrigeration unit.

Area 33 - Sulfur Recovery Plant - Including Claus and SUPERSCOT units.

Area 34 - Refining Plant - Including fractionator, debutanizer, vacuum flash towers and slurry transfer pumps.

Unit 40 Secondary Recovery and Oxygen Plants

Area 41 - Ammonia Recovery Plant - U.S. Steel Phosam-W Process.

Area 42 - Tar Acid Recovery Plant - ChemPro Equipment Corporation phenol recovery process.

Area 43 - Waste Water Reclamation Plant - Including plant waste water collection facilities and water treating and reclamation equipment.

Area 44 - Oxygen Plant - Including air compression, oxygen production unit and oxygen compressors.

Unit 50 Utility Systems and General Facilities

- Area 51 - Steam Generation System - Including boilers, boiler feedwater systems and condensate return system.
- Area 52 - Raw Water System - Including boiler feedwater and potable water treating.
- Area 53 - Cooling Water System - Including cooling towers, pumps and distribution system.
- Area 54 - Miscellaneous Systems - Including fuel system, flare and drain systems, fire water systems, sanitary sewage systems, storage and shipping facilities and electrical distribution.
- Area 55 - General Plant Facilities - Including site improvements and general plant buildings.

3.2 UNIT 60-COAL AND SLAG HANDLING

Unit Definition. Unit 60 provides for coal unloading and preparation of sized coal for pug mills in the Area 11 Dissolver Plant and disposes of slag and residue from Area 21 Syngas Production. Filtrate from the slag and residue is sent to Area 43 Plant Waste Reclamation.

The unit has been divided into four process areas:

- Area 61 - Coal Supply System
- Area 62 - Coal Crushing System
- Area 63 - Slag Handling System
- Area 64 - Slag Disposal System

3.2.1 Area 61 - Coal Supply System

Area Definition. This area includes the delivery of coal by unit trains to the plant site, unloading, primary crushing, sampling and stockpiling.

Process Description. The process configuration is shown on Process Flow Diagram 61C06-101.

Coal is received as 8" x 0 run-of-mine (ROM) coal by 100-car unit trains. Each car is automatically positioned and the coal unloaded by a rotary car dumper into a hopper provided with a grizzly and a hammermill crusher to reduce oversize coal and frozen lumps to a minus 8" size. Coal is withdrawn from the hopper by belt feeders and is conveyed to the primary crushing and sampling plant. The minus-8" x 0 coal is reduced to 2" x 0 by the primary crushers, sampled and conveyed to one of six long piles in the coal storage area.

Provision has been made for thawing frozen coal cars during extreme weather conditions at a rate of 30 cars per hour, reduced from the maximum dumping rate of 70 cars per hour.

Water spray dust suppression systems are provided at the dump hoppers and chutes. At the transfer points, bag-type dust collection systems are provided. Dust collected at these points is returned to the conveyor belts.

Design Discussion. Two separate unloading circuits have been provided. Each circuit has a maximum design rate of 3529 tph based on one 100 ton rail car dumped every 1.7 minutes, and will provide a normal estimated turnaround time for the 100-car unit train of four hours. Each unloading circuit, complete with a rotary car dumper, conveyors, feeders, primary crusher, samplers and stackers, has been sized for the maximum car unloading rate of 3529 tph.

Cross conveyors are installed at selected points throughout the system so that individual components may be shut down for maintenance. External conveyors are covered and dust suppression and/or collection systems are provided at hoppers and transfer points to control dust to an acceptable level.

The coal stockpile will provide storage for approximately thirty days of plant operation.

3.2.2 Area 62 - Coal Crushing System

Area Definition. This area includes reclaiming coal from the stockpile, conveying and secondary crushing.

Process Description. The process configuration is shown on Process Flow Diagram 62C06-101.

Coal is reclaimed from the long piles in Area 61 by a bucket wheel reclaimer and is conveyed to the secondary crushing plant. The secondary crushing plant reduces the 2" x 0 coal to minus-1/8" provide feed for the pug mills located in Area 11.

Design Discussion. The reclaim circuits have been designed for maximum reliability including front-end loader backup for the bucket-wheel reclaimer, spare conveyors, and spare secondary crushers.

All external conveyors are covered and dust collection has been provided at coal transfer points to control dust to an acceptable level.

3.2.3 Area 63 - Slag Handling System

Area Definition. This area includes the dewatering, storage and transportation of slag to the disposal area.

Process Description. The process configuration is shown on Process Flow Diagram 63C06-101.

The slag from Area 21 Syngas Production Plant is filtered in Area 63. The filter cake is conveyed to the slag bin and trucked to Area 64 Slag Disposal. The filtrate is pumped to Area 43 Waste Water Reclamation for treatment.

Design Discussion. The slag handling system is designed to handle 4020 tpsd (170 tph), which is 12% of the dry coal feed to the plant. The filtration equipment in this area has been spared for reliability.

3.2.4 Area 64 - Slag Disposal System

Area Definition. This area covers the disposal of slag from Area 63.

Process Description. Slag is trucked from Area 63 and is deposited in the impoundment area constructed for the disposal of slag.

Design Discussion. Because the SRC-II Conceptual Commercial Plant has been designated for an unspecified site, the method of slag disposal will depend upon the topography of the site selected. It is not known that the slag can be returned to the mines for disposal. It is assumed that the slag will be

disposed of onsite and an area of 300 acres, (33 million cubic yards to contain the slag produced in 25 years' operation) has been provided.

The impoundment area will be diked to provide a 5-foot freeboard. The area will be lined with impervious clay to prevent migration of any contained water into the surface streams and subsurface strata. The area will be encircled by a drainage ditch with a pumping system to collect seepage and return it to Area 43 Water Reclamation. Rain that falls within the diked area will also be returned to Area 43. Storm water will be diverted around and away from the impoundment area.

TABLE 3-1
AREA 61 - COAL SUPPLY SYSTEM
EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Compressors</u>				
C61C101/201	Air Compressor	500 cfm, 115 psig, 125 hp	Ambient	Atmos.
C61C102	Air Compressor	500 cfm, 115 psig, 125 hp	Ambient	Atmos.
<u>Separation Equipment</u>				
S61C101/201	Dust Collector	Bag Type, 2200 ACFM, 60 hp	Ambient	Atmos.
S61C01/201	Screw Conveyor	Dust Return, 5 hp	Ambient	Atmos.
S61C102/202	Dust Collector	Bag Type, 22,000 ACFM, 60 hp	Ambient	Atmos.
<u>Storage Bins</u>				
T61C101/201	Railroad Dump Hopper	500 Ton Capacity, Carbon Steel	Ambient	Atmos.
T61C101/201(S1)	Grizzly	8" opening, Carbon Steel	Ambient	Atmos.
T61C102/202	Crusher Feed Bin	100 Ton Capacity, Carbon Steel	Ambient	Atmos.
<u>Vessels</u>				
V61C101/201	Air Receivers	42" ID x 10' TT, Carbon Steel	Ambient	115
V61C102	Air Receiver	42" ID x 10' TT, Carbon Steel	Ambient	115
<u>Miscellaneous Equipment</u>				
X61C101/201	Rotary Car Dumper	3529 TPH, Carbon Steel	Ambient	Atmos.
X61C102/202	Dust Suppression System	Package System With Wetting Agents, 5 hp	Ambient	Atmos.

TABLE 3-1
AREA 61 - COAL SUPPLY SYSTEM

EQUIPMENT LIST

3-10

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Miscellaneous Equipment - Continued</u>				
X61C103/203	Service Elevator	Carbon Steel, 25 hp	Ambient	Atmos.
X61C104/204 A/B	Primary Crusher	1760 TPH, Roll Type, 200 hp	Ambient	Atmos.
X61C104/204	Discharge Chutes	Carbon Steel	Ambient	Atmos.
X61C105/205	Sampling Systems	Package System, 20 hp	Ambient	Atmos.
X61C106 A,B,C	Dust Suppression System	Package System With Wetting Agents, 5 hp	Ambient	Atmos.
X61C107	Shuttle Carriage	Rail Mounted Car For Moving Stackers and Reclaimer, 20 hp	Ambient	Atmos.
<u>Weighing and Feeding Equipment</u>				
Y61C101/201 A-D	Belt Feeders	882 TPH, 66" x 22" long Carbon Steel, 1328 TPH Design, 50 hp	Ambient	Atmos.
Y61C101/201 (X1) A-D	Discharge Chutes	Carbon Steel	Ambient	Atmos.
Y61C102/202	Shuttle Belt Conveyors	3529 TPH, 72" x 176" long Carbon Steel, 20 hp	Ambient	Atmos.
Y61C102/202(X)	Discharge Chutes	Carbon Steel	Ambient	Atmos.
Y61C103/203 A,B	Vibrating Grizzly Feeders	1765 TPH, 84" wide, Carbon Steel, 2" Opening, 15 hp	Ambient	Atmos.
Y61C103/203 (X) A,B	Discharge Chutes	Carbon Steel	Ambient	Atmos.

TABLE 3-1
AREA 61 - COAL SUPPLY SYSTEM
EQUIPMENT LIST

	EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
				TEMPERATURE (F)	PRESSURE (PSIG)
3-11	<u>Solids Transfer Equipment</u>				
	Z61C101/201	Collecting Belt Conveyor	3529 TPH, 72" x 76' long, 20 hp	Ambient	Atmos.
	Z61C101/201(X1)	Discharge Chute	Carbon Steel	Ambient	Atmos.
	Z61C101/201(S1)	Tramp Iron Magnets	3 kW	Ambient	Atmos.
	Z61C101/201(X2)	Tramp Iron Tote Bar	Carbon Steel	Ambient	Atmos.
	Z61C102/202	Speedup Belt Conveyor	3529 TPH, 60" x 29' long, 25 hp	Ambient	Atmos.
	Z61C102/202(X1)	Discharge Chute	Carbon Steel	Ambient	Atmos.
	Z61C102/202(Y1)	Belt Scales			
	Z61C103/203	Primary Crusher Feed Belt Conveyor	3529 TPH, 60" x 2105' long, 600 hp	Ambient	Atmos.
	Z61C103/203(X1)	Discharge Chute	Carbon Steel	Ambient	Atmos.
	Z61C104/204	Crushed Coal Belt Conveyor #1	3529 TPH, 60" x 60' long, 15 hp	Ambient	Atmos.
	Z61C104/204(X1)	Discharge Chute	Carbon Steel	Ambient	Atmos.
	Z61C105/205	Crushed Coal Belt Conveyor #2	3529 TPH, 60" x 60' long, 15 hp	Ambient	Atmos.
Z61C105/205(X1)	Discharge Chute	Carbon Steel	Ambient	Atmos.	

TABLE 3-1
AREA 61 - COAL SUPPLY SYSTEM

EQUIPMENT LIST

3-12

<u>EQUIPMENT NUMBER</u>	<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
			<u>TEMPERATURE (F)</u>	<u>PRESSURE (PSIG)</u>
<u>Solids Transfer Equipment - Continued</u>				
Z61C106 A,B	Distribution Belt Conveyors	3529 TPH, 60" x 390' long, 125 hp	Ambient	Atmos.
Z61C106(X1) A,B	Discharge Chutes	Carbon Steel	Ambient	Atmos.
Z61C107 A,B	Distribution Belt Conveyors	3529 TPH, 60" x 390' long, 125 hp	Ambient	Atmos.
Z61C107(X1) A,B	Discharge Chutes	Carbon Steel	Ambient	Atmos.
Z61C108 A-C	Stacker/Reclaimer Belt Conveyors	3529 TPH, 60" x 3900' long, 1000 hp	Ambient	Atmos.
Z61C108(Y1) A-C	Discharge Chutes	Carbon Steel	Ambient	Atmos.
Z61C109 A,B	Stacker	Twin Boom, Rail Mounted, 700 hp	Ambient	Atmos.
Z61C109(X1) A-C	Stacker Tripper Trailers	Carbon Steel	Ambient	Atmos.

TABLE 3-2
AREA 62 - COAL CRUSHING SYSTEM
EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Compressors</u>				
C62C101	Air Compressors	500 cfm, 115 psig, 125 hp	Ambient	115
<u>Separation Equipment</u>				
S62C101	Dust Collector	Bag Type, 7500 ACFM, 30 hp	Ambient	Atmos.
S62C101(Z1)	Screw Conveyor	Dust Return, 5hp	Ambient	Atmos.
S62C102	Dust Collector	Bag Type, 7500 ACFM, 30 hp	Ambient	Atmos.
S62C102(Z1)	Screw Conveyor	Dust Return, 5hp	Ambient	Atmos.
<u>Storage Bins</u>				
T62C101	Crusher Feed Bin	Carbon Steel	Ambient	Atmos.
<u>Vessels</u>				
V62C101	Air Receiver	42" ID x 10' TT, Carbon Steel	Ambient	Atmos.
<u>Miscellaneous Equipment</u>				
X62C101 A-C	Reclaim Hoppers	Carbon Steel, Emergency Service	Ambient	Atmos.
X62C101 A-F	Secondary Crushers	500 TPH, Crush 2" x 0 to 1/8" x 0, 1200 hp	Ambient	Atmos.
X62C101(X1) A-F	Crusher Chutes	Carbon Steel	Ambient	Atmos.

TABLE 3-2
AREA 62 - COAL CRUSHING SYSTEM

EQUIPMENT LIST

<u>EQUIPMENT NUMBER</u>	<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
			<u>TEMPERATURE (F)</u>	<u>PRESSURE (PSIG)</u>
<u>Weighing and Feeding Equipment</u>				
Y62C101 A,B	Front End Loader	12 Cu Yd Capacity, Emergency Service	Ambient	Atmos.
Y62C101 A-F	Vibrating Feeder	500 TPH, Carbon Steel, 15 hp	Ambient	Atmos.
<u>Solids Transfer Equipment</u>				
Z62C101	Reclaimer	1600 TPH, Bucket Wheel, Bridge Type, 350 hp	Ambient	Atmos.
Z62C102 A,B	Reclaim Collecting Belt Conveyor	1600 TPH, 48" x 980' long, 60 hp	Ambient	Atmos.
Z62C102(X1) A,B	Discharge Chute	Carbon Steel	Ambient	Atmos.
Z62C102(S1) A,B	Tramp Iron Magnet	3 kW	Ambient	Atmos.
Z62C102(Y2) A,B	Tramp Iron Tote Bar	Carbon Steel	Ambient	Atmos.
Z62C102(Y1) A,B	Belt Scale			
Z62C103 A,B	Secondary Crusher Feed Belt Conveyor	1600 TPH, 48" x 1820' long, 125 hp	Ambient	Atmos.
Z62C103(X1) A,B	Discharge Chutes	Carbon Steel	Ambient	Atmos.
Z62C104 A,B	Cross Belt Conveyor	1600 TPH, 48" x 20' long, 10 hp	Ambient	Atmos.
Z62C104(X1)	Discharge Chute	Carbon Steel	Ambient	Atmos.

TABLE 3-2
 AREA 62 - COAL CRUSHING SYSTEM
 EQUIPMENT LIST

<u>EQUIPMENT NUMBER</u>	<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
			<u>TEMPERATURE (F)</u>	<u>PRESSURE (PSIG)</u>
<u>Solids Transfer Equipment - Continued</u>				
Z62C105 A,B	Bin Feed Belt Conveyor	1600 TPH, 48" x 100" long, 40 hp	Ambient	Atmos.
Z62C105(X1) A,B	Trippers	Carbon Steel	Ambient	Atmos.
Z62C105(X2) A,B	Dribble Chute	Carbon Steel	Ambient	Atmos.

TABLE 3-3
AREA 63 - SLAG HANDLING SYSTEM
EQUIPMENT LIST

<u>EQUIPMENT NUMBER</u>	<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
			<u>TEMPERATURE (F)</u>	<u>PRESSURE (PSIG)</u>
<u>Pumps</u>				
P63C101 A,B	Sump Pumps	300 gpm, 70' TDH, 30 hp	Ambient	Atmos.
P63C102 A,B	Sump Pumps	300 gpm, 70' TDH, 30 hp	Ambient	Atmos.
<u>Separation Equipment</u>				
S63C101 A-C	Drum Filter System	10' Dia. x 16' Face w/Vacuum Pumps, Receivers, & Traps	Ambient	70" Hg
S63C102 A-C	Seal Tanks	Carbon Steel	Ambient	70" Hg
<u>Storage Bins</u>				
T63C101	Slag Bin	200 Ton Capacity Carbon Steel	Ambient	Atmos.
<u>Miscellaneous Equipment</u>				
X63C102	Dust Suppression System	Package System	Ambient	Atmos.
<u>Weighing and Feeding Equipment</u>				
X63C101	Front End Loader	12 Cu Yd Capacity	Ambient	Atmos.
<u>Solids Transfer Equipment</u>				
Z63C101 A,B	Slag Collecting Conveyor	200 TPH, 24" x 700' long, 25 hp	Ambient	Atmos.
Z63C101(X1) A,B	Discharge Chute	Carbon Steel	Ambient	Atmos.

TABLE 3-3
AREA 63 - SLAG HANDLING SYSTEM

EQUIPMENT LIST

<u>EQUIPMENT NUMBER</u>	<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
			<u>TEMPERATURE (F)</u>	<u>PRESSURE (PSIG)</u>
<u>Solids Transfer Equipment - Continued</u>				
Z63C102 A,B	Filter Cake Belt Conveyor	200 TPH, 24" x 100' long, 5 hp	Ambient	Atmos.
Z63C102(X1) A,B	Diverter Chute	Carbon Steel	Ambient	Atmos.
Z63C103	Emergency Slag Belt	200 TPH, 24" x 100 ' long, 15 hp	Ambient	Atmos.
Z63C103(X1)	Discharge Chute	Carbon Steel	Ambient	Atmos.
Z63C104	Slag Reclaim Belt Conveyor	400 TPH, 24" x 260' long, 20 hp	Ambient	Atmos.
Z63C105	Slag Trucks	40 Ton Capacity	Ambient	Atmos.
<u>Pumps</u>				
Z64C101	Slag Pond Sump Pumps	-----	Ambient	Atmos.

TABLE 3-4
UNIT 60

COMPOSITE UTILITY SUMMARY
AREAS 61, 62, 63 & 64

	AREA			
	61 16 hours per day	62 24 hours per day	63 24 hours per day	64 24 hours per day
<u>Electric Power</u>	<u>KW</u>	<u>KW</u>	<u>KW</u>	<u>KW</u>
Connected	6,670	6,195	350	22
Operating	5,000	3,210	150	-
Intermittent	-	-	90	22
Magnets	6kW	-	-	-
<u>Fuel</u>	<u>MM BTU/HR</u>			
Car Thawing Shed, Intermittent	66	-	-	-
<u>Cooling Water</u>				
None				
<u>Steam</u>				
None				

3.3 UNIT 10-PRIMARY PROCESS PLANT

Unit Definition. The Primary Process Plant is divided into two process areas:

Area 11 - Dissolver Plant

Area 12 - Hydrogen Treating and Recovery Plant

In Area 11, the feed coal from Area 62 Coal Crushing System is mixed with hot solvent and slurry recycle to remove moisture from the coal and to prepare a coal slurry feed. The slurry feed is combined at high pressure with hydrogen and passes through a preheater to the dissolvers. Additional hydrogen is added to the dissolver where the coal is converted to liquids and gases, leaving a small amount of unreacted coal and mineral residue. Following the dissolver, the three-phase stream is separated into a high-pressure recycle gas stream, liquid streams and a slurry stream. Part of the slurry stream is recycled back to slurry preparation and the net slurry is sent to Area 34 Refining. The hydrogen partial pressure needed for optimum dissolver conditions is provided by a high purity recycle hydrogen stream and fresh makeup hydrogen from the Hydrogen Production Plants.

The heavier hydrocarbon components in the high-pressure recycle stream are condensed in stages with heat recovery by steam generation in and heating hydrogen and boiler feedwater streams. Water wash with direct-contact quench cooling removes inorganic salts to prevent equipment fouling. Ammonia injection is used to control pH and remove chlorides for minimizing corrosion. Hydrocarbon liquids are separated and go on to Area 34 Refining for further treating. Sour water is sent to Unit 40 Secondary Recovery where water is reclaimed and returned for wash water use.

In Area 12 the raw recycle hydrogen gas stream is washed with recycle oil from Area 34 to remove additional hydrocarbon impurities including coal chemicals. The recycle stream then goes to an acid gas removal system where H_2S and CO_2 are removed with circulating DEA solution and sent to Area 33 Sulfur Recovery.

Recycle hydrogen is then compressed and about 10% is returned to Area 11 Dissolver Plant. The remainder, about 90%, is processed in a cryogenic hydrogen recovery system to increase purity and is then returned to Area 11. Separated gases, including some inerts, are sent in several streams to Unit 30 Refining and Gas Plants for further treatment.

3.3.1 Area 11 - Dissolver Plant

Area Definition. In this area, crushed coal from Area 62 is first contacted and mixed with recycle solvent slurry. The hot mixture is then heated further in contact with hydrogen in fired heaters. The hot three-phase mixture is then fed to the dissolver vessels, where reaction proceeds with additional recycle hydrogen to yield raw product gases, liquids, solids containing the mineral residue, and some unreacted coal. The raw vapor product is cooled and water washed at high pressure and goes to Area 12. Purified high pressure hydrogen is recycled. The net heavy-hydrocarbon liquid slurry is processed in Area 34 and a portion is recycled to the coal feed slurry mixing system.

The lighter liquid hydrocarbon product which is condensed out of the dissolver vapors is also sent to Area 34 Refining after separating out the sour water. Low-pressure flash gas is treated in Area 31. The separated sour water is returned to Unit 40 Secondary Recovery where water is reclaimed and returned for use as wash water.

Design Basis. The Conceptual Commercial Plant is scaled up from the design basis for the 6700 tpsd Demonstration Project but with Powhatan coal feed. The final process design should have the benefit of operating data from the Demonstration Plant.

Two parallel slurry charge tanks are provided. The flow from each tank is further split into four streams via separate charge pumps and fired heaters. The number of parallel trains is dictated by equipment size limitations as well as by the requirement for continuous production capability.

Each slurry charge tank is fed with three 50% capacity coal premix systems, and two 100%-capacity slurry circulation pumps.

Consideration of slurry feed measurement and control, as well as coil design limitations for the fired heaters, resulted in four parallel disc mill feed-pump heater trains from each slurry feed tank, a total of eight trains. When one of the eight parallel trains is down for maintenance, the production rate is still over 90%, because the equipment design factor is 5% above the maximum expected operating rate.

The present limitations of fabrication and materials for the dissolver vessels should not be a factor by the time this plant is built. Using the largest diameter and wall thickness expected to be available results in four dissolvers in parallel; therefore, two slurry feed streams from their respective heaters are combined and fed to each dissolver. The four parallel processing trains are continued through the slurry letdown system, through the first and second high-pressure flash drums, and through the first and second low-pressure flash drums. Two trains are then combined for two parallel systems in both the high and low pressure separation lines. All dissolver plant equipment downstream of this point is combined into two systems. The two parallel trains of third and fourth high-pressure flash cooling and separation are provided with 100% sparing on pumping equipment.

Drawings 00C06-103 and 104 are included in Section 1.2. These show the plant train arrangement.

Process Description. The process configuration is shown on Process Flow Diagrams 11C06-101 through 105.

Coal feed (minus-1/8" nominal maximum particle size) from the Area 62 Coal Crushing System is first sent to pug mills and extruders in two parallel trains for blending and pressurizing, then contacted with hot recycle solvent slurry. It then flows into the slurry charge tanks, where moisture and light hydrocarbon vapors are flashed out. Flash gases go through a vapor recovery

system; hydrocarbon gas is sent to Area 31 Low-Pressure Gas Compression and Treating; hydrocarbon liquid condensate is sent to Area 34 Refining; and sour water is sent to Unit 40 Secondary Recovery.

Recirculating pumps are provided to maintain a homogeneous mixture in the charge tanks which have minimum liquid holding time to prevent gel formation. The slurry from each charge tank is divided into four streams and pressured through disc mills for size reduction ahead of the charge pumps.

Dissolver charge pumps feed the dissolver charge heaters at high pressure and controlled flow rates through four parallel coils in the fired heaters. Heated makeup hydrogen is also introduced at controlled flow rates into each coil. The three-phase fluid streams (gas, liquid, solids) are heated in the coils of the direct-fired preheaters and enter the dissolvers. Additional cold feed hydrogen is introduced into the dissolvers for temperature control of the exothermic reactions. A sufficient residence time in the dissolvers is required for reacting the solid particles with the liquid and gases to produce the desired yield of liquid and gas products. The liquid and vapor products from the dissolvers are quenched with cold recycle hydrocarbons to stop the reaction before entering the high-pressure effluent separators.

The separated liquid, together with remaining solids (mineral residue and some unreacted coal), is depressured in three stages. The pressure is controlled in each drum by throttling the overhead outlet flash gas.

The vapor product and unreacted hydrogen overhead from the dissolver effluent separators is cooled first in a steam generator to produce high-pressure steam, then is further cooled by interchange with make-up and recycle hydrogen. Condensed liquid is separated in the first high-pressure flash drum and removed under level control. The raw gas is further cooled by injection of recycle water in the second high-pressure flash drum. Ammonia is added to adjust pH for corrosion protection.

After the second high-pressure flash drum the four trains are combined into two trains. Relief valve protection and emergency gas disposal blowdown control valves are provided upstream of the isolation valving on the four trains.

Gas overhead from the second high-pressure flash drum is further cooled by interchange with boiler feedwater (three levels of pressure-temperature) and by low-pressure steam generation, for maximum heat recovery before going into the third high-pressure flash drum. The overhead vapor is further cooled in aerial coolers, then in cooling water trim coolers before entering the fourth high-pressure flash drum.

In both the third and fourth high-pressure flash drums, the gas is water-washed to remove chlorides and other water-soluble impurities. The gas then goes to Area 12 for cleanup and recovery of hydrogen, which is returned to Area 11 as recycle hydrogen to the dissolvers. The recycle hydrogen rate is set to maintain a high partial pressure of hydrogen in the dissolver.

Liquid condensate from the flash drums is cooled with water and put through separator drums. The net production is sent to Area 34 Refining for further treatment. The separated sour water is sent to Unit 40 Secondary Recovery, where the ammonia, tar acids, and other soluble impurities are removed. The reclaimed water is returned to Area 11 for use as wash water.

The depressured slurry from the dissolvers goes to the first low-pressure flash drum; from here the slurry is divided and the major portion is recycled to the coal feed slurry mixing system, and the net production is sent to Area 34 Refining for vacuum flash treatment.

Overhead gas from the first low-pressure flash drum is cooled by steam generation and by heating boiler feedwater before entering the second low-pressure flash drum. The four trains are then combined into two for subsequent processing. Relief protection and isolating valves are provided for each train. The condensed sour water is separated and sent to Unit 40

Secondary Recovery. The net liquid hydrocarbon condensate produced is sent to Area 34 Refining and some is returned as recycle solvent to the coal feed slurry-mixing system.

Overhead gas from the second low-pressure flash drum is further cooled in aerial coolers. Again, condensed sour water is sent to Unit 40 and condensed liquid hydrocarbons are sent to Area 34 Refining. Overhead gas is sent to Area 31 Low-Pressure Gas Compression and Treating. An emergency dump system is included in Area 11.

Design Discussion. The coal feed slurry-mixing system will be based on Ft. Lewis Pilot Plant testing and development work and Demonstration Project experience.

The individual slurry feed streams to the eight dissolver charge heaters will avoid stagnant spots in piping (which are prone to clogging with solids), will allow convenient isolation valving for equipment maintenance of individual trains, and will provide flow control essential to good slurry feed through each charge heater.

The charge pumps are centrifugals being developed by the Rocketdyne Division of Rockwell International.

Prototype equipment provided for the coal-mixing and the slurry-feed systems to the dissolver charge heaters differs somewhat from that in the Demonstration Project. It is assumed that by the time design begins on the CCP, sufficient pilot plant and Demonstration Project experience will confirm feasibility for scale-up and application to the CCP. This is further discussed in Section 5.

The dissolver charge heaters will be similar to those for the Demonstration Project, which has two for 6700 tpsd coal feed capacity. The eight heaters for 33,500 tpsd represent a scale-up factor of 1.25.

The four dissolver vessels are similar in configuration and operating conditions to those in the Demonstration Project. The scale-up factor per reactor is 2.5. It is expected that improved technology will permit that extrapolation.

The effluent slurry letdown separation system will be designed for minimum valving in the two-phase or three-phase flow lines, and for downward flow in these lines. Three stages of letdown are provided for longer operating life of the control valves which are subject to slurry erosion. Parallel letdown control valves have been provided to permit continuous operation for a minimum of one year without shutdown for maintenance repairs.

The high-pressure cooling and separation system is designed for optimum heat recovery, using steam generation, boiler feedwater heating, and process stream interchange. Aerial cooling is used where applicable to reduce the circulating cooling water requirement. In the water wash recirculation system, hydraulic turbine recirculation pump drivers are included for power recovery at pressure letdown.

The low-pressure cooling and separation system will include optimum heat recovery with steam generation and boiler feedwater heating. Provision for intermittent water wash of the aerial coolers has been made to prevent salt-deposit buildup.

3.3.2 Area 12 - Hydrogen Treating and Recovery Plant

Area Definition. A large quantity of recycle hydrogen is required to maintain a suitable partial pressure of hydrogen in the dissolvers. Hydrocarbon, acid gases, and inert components build up in the recycle gas and must be removed to maintain hydrogen purity. The purpose of Area 12 is to remove these contaminants and increase the hydrogen concentration of the incoming recycle gas.

In addition to the upgraded hydrogen, the following streams are also produced:

(1) Methane-rich gas. A portion is sent to Area 54 for plant fuel and the rest is sent to Area 25 Methanation and Dehydration for pipeline gas.

(2) The ethane-rich stream containing 5 vol% methane maximum is combined with a by product stream from Area 32 Product Gas Plant and pipelined to customers.

(3) The propane-rich gas side stream is sent to Area 32 for further processing.

(4) The hydrocarbon condensate, consisting largely of C_4 's, is sent to Area 32 for further processing.

(5) Sour water removed in the dryers is sent to Area 40 Secondary Recovery for treating.

Design Basis. The design is based on a recycle gas throughput rate corresponding to 33,500 tpsd of Powhatan coal processed in the Dissolver Plant.

Because of equipment size limitations, the unit operations within this area are split into parallel trains as follows:

	<u>Number of Parallel Trains</u>
Oil Wash	2
DEA Scrubbing and Regeneration	2
Hydrogen Compression	2
High-Pressure Cold Box	4
By-Product Recovery	1

The design for the high-pressure cold box and the by-product recovery is based on technology supplied by Air Liquide.

The raw recycle gas stream from Area 11 contains impurities (20 mol%), such as methane and heavier hydrocarbons, acid gases, and inerts, which are formed in the dissolvers. The Oil Absorber, Acid Gas Removal, and Cryogenic Separation Units are designed to remove these contaminants so that they do not build up in the recycle hydrogen.

Process Description. The process configuration is shown on Process Flow Diagram 12C06-101 through 104.

Raw recycle gas from Area 11 is washed in two absorber columns in parallel. The lean oil is received from Area 34 Refining. Substantially all of the C_5+ components are extracted and returned to Area 34 with the rich oil. The oil circulating pumps are driven by power-recovery turbines.

The scrubbed gas then goes to two parallel DEA absorption and stripping units to remove CO_2 and H_2S . The DEA is stripped of acid gas at low pressure. The solution pumps are driven with power recovery turbines.

The H_2S and CO_2 stream from the stripper overhead is sent to Area 33 Sulfur Recovery. A small amount of flash gas from the recirculating DEA solution is sent to Area 31 Low Pressure Gas Compression and Treating.

High-pressure recycle gas from the DEA absorber is then compressed for further cleanup in the cryogenic unit before returning to the dissolvers. The two parallel recycle hydrogen compressors are steam-turbine driven centrifugals.

Most of the recycle gas is sent to the cryogenic unit but a small amount (8% to 10%) is sent directly to Area 11. The condensed sour water is separated and sent to Area 40 Secondary Recovery Unit.

Each recycle gas stream is then split into two portions and sent through separate cold boxes. Thus, there are four high-pressure cold boxes in parallel. The gas is precooled with freon and dried prior to entering the cryogenic section. Three molecular sieve adsorber vessels are provided for each train, for a total of 12, to permit regeneration cycling. The molecular-sieve beds are regenerated with heated product hydrogen, which is cooled to condense the water and then mixed with the upgraded hydrogen. Regeneration is done at full pressure.

About half of the methane-rich gas is compressed in a single 3-stage centrifugal machine and is sent to Area 25 Methanation and Dehydration to make pipeline gas product. Condensate is separated and sent to Unit 40 Secondary Recovery for reclamation. The remainder of the methane-rich gas is sent to Area 54 Plant Fuel System.

Upgraded hydrogen is returned to Area 11 as a separate recycle stream.

Liquid nitrogen from the Area 44 Oxygen Plant is used for initial chilling of the cold box for startup.

Design Discussion. The oil wash system is designed to remove C_5+ components from the raw recycle gas. This processing technique is well known and is in wide use in the refining and petrochemical industries.

The cryogenic section is required to remove inert gases (nitrogen and argon), as well as hydrocarbons, to prevent buildup in the hydrogen recycle stream returned to Area 11.

The four parallel cold box sections permit one offline for maintenance, retaining 75-percent online capacity while still maintaining separated-products purity.

TABLE 3-6
AREA 11 - DISSOLVER PLANT

EQUIPMENT LIST

3-30

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Air-Cooled Equipment</u>				
A11C101 A11C201	Recycle Oil Air Cooler	46.33 MMBtu/hr, Carbon Steel	N/A	165
A11C102 A11C202	First Mix Tank Vapor Cooler	13.53 MMBtu/hr, Carbon Steel	N/A	65
A11C103 A11C203	Second Mix Tank Vapor Cooler	123.58 MMBtu/hr, Carbon Steel	N/A	55
A11C104 A11C204	Third HP Flash Drum Vapor Cooler	153.6 MMBtu/hr, Carbon Steel	N/A	2200
A11C105 A11C205	LP Vapor Cooler	69.1 MMBtu/hr, Carbon Steel	N/A	150
<u>Boilers</u>			<u>SS/TS</u>	<u>SS/TS</u>
B11C101 B11C201 B11C301 B11C401	High Pressure 1550 Psig Steam Generator	71.25 MMBtu/hr, Shell 2 1/4 Cr -1Mo Forged Tubes 9Cr-1Mo	N/A	1700/2200
B11C102 B11C202 B11C302 B11C402	650 Psig Steam Generator	32.95 MMBtu/hr, Shell Carbon Steel, Tubes 321 S.S.	N/A	750/150
B11C103 B11C203	50 Psig Steam Generator	32.3 MMBtu/hr, Shell Carbon Steel, Tubes 321 S.S.	N/A	150/2200

TABLE 3-6
AREA 11 - DISSOLVER PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Disc Mills</u>				
DM11C101 A & B DM11C201 A & B DM11C301 A & B DM11C401 A & B	Slurry Disc Mill	2200 GPM Disc Mill, 100 hp	N/A	N/A
<u>Heat Exchangers</u>			<u>SS/TS</u>	<u>SS/TS</u>
E11C101 E11C201 E11C301 E11C401	Make-Up Hydrogen Preheater	71.25 MMBtu/hr, Shell 2 1/4 Cr-1 Mo, Forged Tubes 9 Cr-1 Mo	N/A	2640/2200
E11C102 E11C202 E11C302 E11C402	First Recycle Hydrogen Preheater	55.0 MMBtu/hr, Shell 2 1/4 Cr-1 Mo, Forged Tubes 9 Cr-1 Mo	N/A	2640/2200
E11C103 E11C203 E11C303 E11C403	Second Recycle Hydrogen Preheater	29.16 MMBtu/hr, Shell and Tubes Carbon Steel	N/A	2300/2200
E11C104 E11C204 E11C304 E11C404	Second High Pressure Flash Liquid Trim Cooler	35.71 MMBtu/hr, Shell and Tubes Carbon Steel	N/A	100/2200
E11C105 E11C205	H.P. 750 psig Boiler Feed Water Preheater	39.5 MMBtu/hr, Shell and Tubes Carbon Steel	460/475	850/2200

TABLE 3-6
AREA 11 - DISSOLVER PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Heat Exchangers - Continued</u>			<u>SS/TS</u>	<u>SS/TS</u>
E11C106 E11C206	370 psig Boiler Feed Water Preheater	73.0 MMBtu/hr, Shell and Tubes Carbon Steel	N/A	2420/2200
E11C107 E11C207	2200 Psig Boiler Feed Water Preheater (H.P.)	87.7 MMBtu/hr, Shell and Tubes Carbon Steel	N/A	2200/2200
E11C108 E11C208	Recycle Gas Water Cooler	31.38 MMBtu/hr, Shell and Tubes Carbon Steel	170/200	100/2200
E11C109 E11C209 E11C309 E11C409	2200 Psig Boiler Feed Water Preheater (L.P.)	33.65 MMBtu/hr, Shell and Tubes Carbon Steel	N/A	2420/150
E11C110 E11C210	1st L.P. Boiler Feed Water Preheater	23.60 MMBtu/hr, Shell and Tubes Carbon Steel	N/A	830/150
E11C111 E11C211	Low Pressure Flash Trim Cooler	6.15 MMBtu/hr, Shell and Tubes Carbon Steel	N/A	100/150

TABLE 3-6
AREA 11 - DISSOLVER PLANT
EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Heat Exchangers - Continued</u>			<u>SS/TS</u>	<u>SS/TS</u>
E11C112 A,B,C,D E11C212 A,B,C,D	Dissolver Charge Pump Turbine Surface Condenser	32.2 MMBtu/hr, Shell and Tubes Carbon Steel	200/200	4" Hg/100
<u>Extruders</u>				
EX11C101 A,B,C EX11C201 A,B,C	Coal/oil Mix Extruder	Screw type extruder	N/A	N/A
<u>Fired Heaters</u>				
H11C101 A,B H11C201 A,B H11C301 A,B H11C401 A,B	Dissolver Charge Heater	Regenerative type air preheater, Incoloy 800 radiant tube material	N/A	N/A
<u>Pumps</u>				
P11C101 A,B P11C201 A,B	Slurry Circulation Pump	25,000 gpm, 25 psi ΔP, 600 hp, "A" Motor Driven, "B" Motor Driven Spare	N/A	50

TABLE 3-6
AREA 11 - DISSOLVER PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Pumps - Cont'd</u>				
P11C102 A,B,C,D P11C202 A,B,C,D	Dissolver Charge Pump	2220 gpm, 2300 psi ΔP, 4450 hp, All pumps steam turbine driven	N/A	2400
P11C103 A,B, P11C203 A,B,	Second H.P. Flash Quench Water Pump	600 gpm, 1930 psi ΔP, 1000 hp, "A" Turbine Driven, "B" Motor Driven Spare	200	2200
PC11C104 A,B PC11C204 A,B	Wash Tower Bottoms Pump	44 gpm, 25 psi ΔP, 1 hp, "B" Spare	N/A	50
P11C105 A,B P11C205 A,B	First Slurry Overhead Hydrocarbon Pump	79 gpm, 27 psi ΔP, 2 hp, "B" Spare	N/A	50
P11C106 A,B P11C206 A,B	Second Slurry Overhead Hydrocarbon Pump	117 gpm, 56 psi ΔP, 6.5 hp, "B" Spare	200	100
P11C107 A,B P11C207 A,B	Second Slurry Overhead Sour Water Pump	205 gpm, 22 psi ΔP, 4.5 hp "B" Spare	200	50

TABLE 3-6
AREA 11 - DISSOLVER PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Pumps - Cont'd</u>				
P11C108 A,B,C P11C208 A,B,C	Quench Oil Pump	470 gpm, 2000 psi Δ P, 785 hp, "C" Spare	N/A	2200
P11C109 A,B P11C209 A,B	Wash Water Booster Pump	278 gpm, 1941 psi Δ P, 525 hp, "A" Turbine Drive, "B" Motor Driven Spare	165	2200
P11C110 A,B P11C210 A,B	Ammonia Metering Pump	10 gpm, 2000 psi Δ P, 25 hp, 321 SS	N/A	2200
P11C111 A,B P11C211 A,B P11C311 A,B P11C411 A,B	Dump Tank Circulation Pump	625 gpm, 2000 psi Δ P, 60 hp,	N/A	2200
<u>Mixers-Pug Mills</u>				
PM11C101 A,B,C PM11C201 A,B,C	Coal/Oil Mixer	6' wide x 20' long x 5' deep Double Shaft, Removable Liner, Carbon Steel - 100 hp	N/A	Atm.

TABLE 3-6
AREA 11 - DISSOLVER PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Vessels</u>				
V11C101 V11C201	Slurry Charge Tank	Vert., Carbon Steel	N/A	100
V11C102 V11C202 V11C302 V11C402	Dissolver	Vert. 2 1/4 Cr - 1 Mo, 2 pass overlay, 1st pass 1/8" 304 SS, 2nd pass 1/8" 347 SS	N/A	2200
V11C103 V11C203 V11C203 V11C203	Dissolver Effluent Separator	186" I.D. x 24'-0" TT 600 Cone bottom, vert., 2 1/4 Cr - 1 Mo, 2 pass overlay, 1st pass 1/8" 304 SS, 2nd pass 1/8" 347 SS	N/A	2200
V11C104 V11C204 V11C304 V11C404	First High Pressure Flash Drum	120" I.D. x 31'-8" TT, 600 Cone Bottom, Vert., 2 1/4 Cr - 1 Mo w/1/8" 321 SS overlay	N/A	2200
V11C105 V11C205 V11C305 V11C405	Second High Pressure Flash Drum	116" I.D. x 33'-0" TT, Vert., 2 1/4 Cr - 1 Mo w 1/8" 321 SS overlay	N/A	2200
V11C106 V11C206	Third High Pressure Flash Drum	126" I.D. x 31'-6" TT Vert. 2 1/4" Cr - 1 Mo w/ 1/8" 321 SS overlay	N/A	200
V11C107 V11C207	Fourth High Pressure Flash Drum	150" I.D. x 16'-0" TT Vert. 2 1/4 Cr - 1 Mo w 1/8" 321 SS overlay	N/A	2200

TABLE 3-6
AREA 11 - DISSOLVER PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
Vessels - Contd				
V11C108 V11C208	First High Pressure Chlorides Separator Drum	138" I.D. x 34'-6" TT w/36" I.D. x 6'-0" Boot., Horiz., Carbon Steel	N/A	200
V11C109 V11C209	Second High Pressure Chlorides Separator Drum	90" I.D. x 22'-6" TT w/ 36" I.D. x 6'-0" Boot., Horiz., Carbon Steel	N/A	200
V11C110 V11C210	Vapor Wash Tower	180" I.D. x 30'-0" TT, Vert., Carbon Steel	N/A	100
V11C111 V11C211	First Overhead Condensate Separator	96" I.D. x 24'-0" TT w/ 36" I.D. x 6'0" Boot., Horiz., Carbon Steel	N/A	100
V11C112 V11C212	Second Overhead Condensate Separator	78" I.D. x 19'-6" TT w/ 48" I.D. Boot Horiz., Carbon Steel	N/A	100
V11C113 V11C213 V11C313 V11C413	High Pressure 1550 psig Saturated Steam Drum	72" I.D. x 18'-0" TT, Horiz., Carbon Steel	N/A	1700
V11C114 V11C214 V11C314 V11C414	650 psig Saturated Steam Drum	48" I.D. x 12'-0" TT, Horiz. Carbon Steel	N/A	715

TABLE 3-6
AREA 11 - DISSOLVER PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
Vessels - Contd				
V11C115 V11C215 V11C315 V11C415	First Effluent Separator Letdown Vessel	186" I.D. x 15'-0" TT, 600 Cone Bottom, 2 1/4 Cr - 1 Mo w/2 pass overlay, 1st Pass 1/8" 304 SS, 2nd Pass 1/8" 347 SS	N/A	2200
V11C116 V11C216 V11C316 V11C416	Second Effluent Separator Letdown Vessel	186" I.D. x 15'-0" TT, 600 Cone Bottom, 2 1/4 Cr - 1 Mo w/2 pass overlay, 1st Pass 1/8" 304 SS, 2nd Pass 1/8" 347 SS	N/A	810
V11C117 V11C217 V11C317 V11C417	Third Effluent Separator Letdown Vessel	186" I.D. x 15'-0" TT, 600 Cone Bottom, Vert., 1 1/4 Cr - 1/2 Mo w/2 pass overlay, 1st pass 1/8" 304 SS, 2nd pass 1/8" 347 SS	N/A	200
V11C118 V11C218 V11C318 V11C418	First Low Pressure Flash Drum	186" I.D. x 24'0" TT, 600 Cone Bottom, Vert., 1 1/4 Cr - 1/2 Mo w/2 pass overlay, 1st pass 1/8" 304 SS, 2nd pass 1/8" 347 SS	N/A	200
V11C119 V11C219	Second Low Pressure Flash Drum	180" I.D. x 45'-0" TT, w/48" I.D. x 8'-0" TT Boot, Horiz., Carbon Steel	N/A	200
V11C120 V11C220	Third Low Pressure Flash Drum	120" I.D. x 30'-0" TT, w/36" I.D. x 6'-0" Boot, Horiz., Carbon Steel	N/A	200
V11C121 V11C221	Quench Oil Surge Drum	126" I.D. x 31'-6" TT, Horiz., Carbon Steel	N/A	100

TABLE 3-6
AREA 11 - DISSOLVER PLANT

EQUIPMENT LIST

<u>EQUIPMENT NUMBER</u>	<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>DESIGN</u>	
			<u>TEMPERATURE (F)</u>	<u>PRESSURE (PSIG)</u>
<u>Vessels - Contd</u>				
V11C122 V11C222 V11C322 V11C422	Dissolver Dump Tank	204" I.D. x 34'-0" TT, 60° Cone Bottom, Vert., Carbon Steel	N/A	40
V11C123	Steam/Air Decoking Drum	72" I.D. x 15'-0" TT, Vert., Carbon Steel	650	15
V11C124	Hotwell	72" I.D. x 12'-0" TT, Vert., Carbon Steel	170	Full Vacuum
V11C125 V11C225	50 psig Saturated Steam Drum	54" I.D. x 13'-6" TT, Horiz., Carbon Steel	350	100

TABLE 3-8
AREA 12 - HYDROGEN TREATING AND RECOVERY PLANT
EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Aerial Coolers</u>				
A12C101 A12C201	DEA Stripper Overhead Air Cooler	61.2 MMBtu/hr	300	100
A12C102	First Stage Air Intercooler	7.37 MMBtu/hr	325	200
A12C103	Second Stage Air Intercooler	12.11 MMBtu/hr	400	420
<u>Compressors</u>				
C12C101 C12C201	Hydrogen Recycle Compressor	222 psi ΔP, Turbine Driven	200	2400
C12C102	Methane Rich Gas Compressor	42,230 scfm, 856 psi P, Turbine Driven, 13,740 hp	400	1100
C12C103	Ethane Recovery Unit #1 Recompressor	23,000 hp	N/A	N/A
C12C105	Ethane Recovery Unit #2 Recompressor	10,000 hp	N/A	N/A
<u>Heat Exchangers</u>			<u>SS/TS</u>	<u>SS/TS</u>
E12C101 E12C201	Lean/Rich DEA Exchanger	125.1 MMBtu/hr, Carbon Steel	305/305	50/100

TABLE 3-8
AREA 12 - HYDROGEN TREATING AND RECOVERY PLANT
EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
Heat Exchangers - Contd			SS/TS	SS/TS
E12C102 E12C202	Lean DEA Cooler	62.5 MMBtu/hr, Carbon Steel	200/220	100/1220
E12C103 E12C203	DEA Stripper Overhead Trim Cooler	3.0 MMBtu/hr, Carbon Steel	200/300	100/70
E12C104 E12C204	DEA Stripper Reboiler	137.2 MMBtu/hr, Carbon Steel	350/350	70/105
E12C105 E12C205	Recycle Compressor Discharge Trim Cooler	15.0 MMBtu/hr, Carbon Steel	200/200	100/2455
E12C111 E12C211 E12C311 E12C411	Molecular Sieve Bed Regenerator Cooler	N/A	N/A	
E12C112 E12C212 E12C312 E12C412	Molecular Sieve Bed Regenerator Cooler	N/A	N/A	
E12C113 E12C213	Hydrogen Recycle Compressor Turbine Surface Condensor	36.15 MMBtu/hr, Carbon Steel	200/200	4" Hg/100
E12C214	Ethane Recovery Unit #1 Turbine Surface Condensor	237.9 MMBtu/hr,	200/200	4" Hg/100
E12C215	Ethane Recovery Unit #2 Turbine	118.0 MMBtu/hr, Carbon Steel	200/200	4" Hg/100

TABLE 3-8
AREA 12 - HYDROGEN TREATING AND RECOVERY PLANT
EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Pumps</u>				
P12C101 A,B P12C201 A,B	High Pressure Lean Oil Pump	410 gpm, 1835 psi ΔP, 675 bhp, "A" Motor Driven Spare, "B" Hydraulic Turbins and Motor Driven.	200	2200
P12C102 A,B P12C202 A,B	Lean DEA Pump	2960 gpm, 1120 psi ΔP, 3550 bhp, "A" Steam Turbine Driven, "B" Motor Driven Spare.	250	1250
P12C103 A,B P12C203 A,B	DEA Booster Pump	2960 gpm, 860 psi ΔP, 2475 bhp, "A" Hydraulic Turbine Driven, "B" Motor Driven Spare.	200	2200
P12C104 A,B P12C204 A,B	DEA Stripper Reflux Pump	120 gpm, 47 psi ΔP, 7.5 hp, Motor Driven, "B" Spare.	200	100
P12C105 A,B	Sump Pump	225 gpm, 18 psiΔP, 15 hp, "B" Spare,	200	100
P12C106 A,B	Steam Condensate Pump	76 gpm, 34 psiΔP, 1.5 hp, "B" Spare,	350	100
P12C107 A,B	Hotwell Condensate Pump	275 gpm, 57 psiΔP, 10 hp, "B" Spare,	350	150

TABLE 3-8
AREA 12 - HYDROGEN TREATING AND RECOVERY PLANT
EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Filter Equipment</u>				
S12C101 S12C201	DEA Filter	300 gpm, 5 micron, Carbon Steel	250	250
S12C102 S12C202 S12C302 S12C402	Molecular Sieve Dust Filter	N/A	N/A	N/A
<u>Storage Tanks</u>				
T12C101	DEA Surge Tank	276" I.D. x 32'-0" high	250	Atm.
<u>Vessels</u>				
V12C102 V12C202	Oil Wash Absorber	108" I.D. x 45'-0" TT, Carbon Steel, 12 SS Trays	170	2000
V12C103 V12C203	Lean Oil Surge Drum	72" I.D. x 18'-0" TT, Carbon Steel	170	200
V12C105 V12C205	DEA Contactor	186" I.D. x 60'-0" TT, Carbon Steel, 24 SS Trays	170	2200
V12C106 V12C206	DEA Stripper	192" I.D. x 60'-0" TT, Carbon Steel, 24 SS Trays	200	100
V12C107 V12C207	DEA Stripper Overhead Accumulator	96" I.D. x 24'-0" TT, Carbon Steel	250	100

TABLE 3-8
AREA 12 - HYDROGEN TREATING AND RECOVERY PLANT
EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
Vessels - Contd				
V12C108 V12C208	DEA Flash Drum	132" I.D. x 33'-0" TT, Carbon Steel	200	150
V12C109 V12C209	Hydrogen Recycle Compressor Suction Knockout Drum	96" I.D. x 24'-0" TT, Carbon Steel	170	2200
V12C110 V12C210	Hydrogen Recycle Compressor Discharge Knockout Drum	72" I.D. x 18'-0" TT,	150	2350
V12C111	Sump (Concrete)	13'-0" x 13'-0" x 13'-0" Deep	Ambient	Atmos.
V12C115 V12C215 V12C315 V12C415	Water Knockout Drum	N/A	N/A	N/A
V12C116 A,B,C V12C216 A,B,C V12C316 A,B,C V12C416 A,B,C	Molecular Sieve Bed	N/A	N/A	N/A
V12C117	Off Gas Surge Drum	190" I.D. x 22'-6" TT, Carbon Steel	150	100
V12C118	First Stage Knockout Drum	72" I.D. x 18'-0" TT, Carbon Steel	200	200

TABLE 3-8
AREA 12 - HYDROGEN TREATING AND RECOVERY PLANT
EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Vessels - Contd</u>				
V12C119	Second Stage Knockout Drum	60" I.D. x 15'-0" TT, Carbon Steel	200	420
V12C121	Hotwell	60" I.D. x 9'0" TT, Carbon Steel	180	Full Vacuum
V12C104 V12C204	Recycle Gas Knockout Drum	96" I.D. x 24'-0" TT, Carbon Steel	170	2200
<u>Packaged Process Units</u>				
U12C101 U12C201 U12C301 U12C401	High Pressure Cold Box	N/A	N/A	N/A
U12C102 U12C202 U12C302 U12C402	Low Level Refrigeration Unit #1	N/A	N/A	N/A
U12C103	Ethane Recovery Unit #1	N/A	N/A	N/A
U12C104	Ethylene Cycle Unit #1	N/A	N/A	N/A
U12C105	Ethane Recovery Unit #2	N/A	N/A	N/A
U12C106	Ethylene Cycle Unit #2	N/A	N/A	N/A
U12C107	Low Level Refrigeration Unit #2	N/A	N/A	N/A

TABLE 3-5
AREA 11 - DISSOLVER PLANT

UTILITY SUMMARY

<u>Electric Power</u>		<u>KW</u>	
Connected		12,673	
Operating		5,765	
<u>Steam</u>		<u>LB/HR</u>	<u>PSIG</u>
Consumption:			
P11C102 A/B/C/D	Dissolver Charge Pump	270,560	600 to 4"Hg
P11C202 A/B/C/D			
Generation:			
V11C113 V11C213 V11C313 V11C413	High Pressure 1500 psig Saturated Steam Drum	244,824	1500 Saturated
V11C114 V11C214 V11C314 V11C414	650 psig Saturated Steam Drum	109,650	600 Saturated
V11C125 V11C225	50 psig Saturated Steam Drum	54,788	50 Saturated

TABLE 3-5
AREA 11 - DISSOLVER PLANT

UTILITY SUMMARY - Cont.

		<u>LB/HR</u>	<u>PSIG</u>
H11C101 A/B	Dissolver Charge Heater	405,380	1500 at 950°F
H11C201 A/B			
H11C301 A/B			
H11C401 A/B			

Superheat:

H11C101 A/B	Dissolver Charge Heater	337,090	1500 at 950°F
H11C201 A/B			
H11C301 A/B			
H11C401 A/B			

<u>Boiler Feedwater Preheat</u>		<u>LB/HR</u>	<u>PSIG</u>
E11C105	HP 750 psig BFW Preheater	502,000	700 at 410°F
E11C205			
E11C106	370 psig BFW Preheater	1,010,000	350 at 398°F
E11C206			
E11C107	HP 2200 psig BFW Preheater	1,571,400	2200 at 367°F
E11C207			
E11C109	2200 psig BFW Preheater	1,028,100	700 at 485°F
E11C209			
E11C309			
E11C409			
E11C110	LP 750 psig BFW Preheater	183,700	700 at 497°F
E11C210			

TABLE 3-5
AREA 11 - DISSOLVER PLANT

UTILITY SUMMARY - Cont.

<u>Fuel</u>		<u>MM BTU/HR</u>
H11C101 A/B	Dissolver Charge Heaters	N/A
H11C201 A/B		
H11C301 A/B		
H11C401 A/B		
V11C121	Quench Oil Surge Drum	Fuel Gas Blanket-Negligible
V11C221		
<u>Cooling Water (300F Rise)</u>		<u>GPM</u>
E11C104	2nd HP Flash Liquid	9,523
E11C204	Trim Cooler	
E11C304		
E11C404		
E11C108	Recycle Gas Water Cooler	4,184
E11C208		
E11C111	LP Flash Trim Cooler	820
E11C211		
E11C112	Dissolver Charge	17,160
A/B/C/D	Pump Turbine Surface	
E11C212	Condenser	
A/B/C/D		
<u>Chemicals</u>		
None		

TABLE 3-7
AREA 12 - HYDROGEN TREATING AND RECOVERY PLANT

UTILITY SUMMARY

<u>Electric Power</u>		<u>KW</u>	
Connected		12,722	
Operating		793	
<u>Steam</u>		<u>LB/HR</u>	<u>PSIG</u>
Consumption:			
C12C101	Hydrogen Recycle	N/A	1500 to 4" Hg
C12C201	Compressor		
C12C102	Methane-Rich Gas	119,810	250 to 4"Hg
	Compressor		
E12C104	DEA Stripper Reboiler	301,000	50 to Condensate
E12C204			
P12C102A	Lean DEA Pump	310,000	600 to 300
P12C202A			
E12C112	Molecular Sieve Bed	90,000	1500 to Condensate
	Regenerator Heater		
U12C201	Methane-Rich Gas Compressor	241,540	250 to 4" Hg
U12C202	Ethane-Rich Gas Compressor	159,700	250 to 4" Hg
U12C106	Ethylene Cycle Unit No.2	700	100 (for ejector)
<u>Fuel</u>			
None			

TABLE 3-7
AREA 12 - HYDROGEN TREATING AND RECOVERY PLANT

UTILITY SUMMARY - Cont.

<u>Cooling Water (30°F Rise)</u>		<u>GPM</u>
E12C102 E12C202	Lean DEA Cooler	8,337
E12C103 E12C203	DEA Stripper Overhead Trim Cooler	400
E12C105 E12C205	Recycle Compressor Discharge Trim Cooler	2,000
E12C111	Molecular Sieve Bed	14,400
U12C101	HP Cold Box	15,865 10,490
E12C116	Methane Rich Gas Compressor Turbine Surface Condenser	7,870
E12C113 E12C213	H ₂ Recycle Compressor Turbine Surface Condenser	4,821

TABLE 3-7
AREA 12 - HYDROGEN TREATING AND RECOVERY PLANT
UTILITY SUMMARY - Cont.

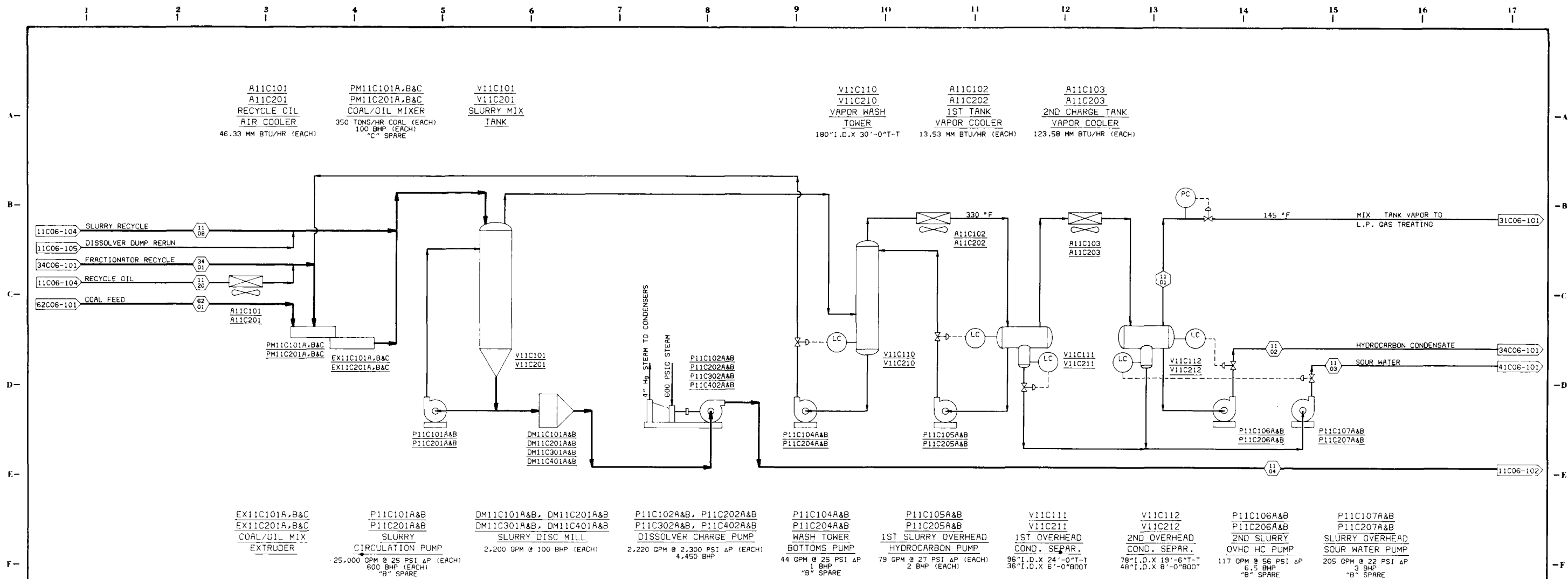
Catalysts & Chemicals

V12C116 A/B/C	Molecular Sieve Beds	Activated Carbon
V12C216 A/B/C	Molecular Sieve Beds	Activated Carbon
V12C316 A/B/C	Molecular Sieve Beds	Activated Carbon
V12C416 A/B/C	Molecular Sieve Beds	Activated Carbon
U12C101	HP Cold Box	Freon Gas
U12C201	HP Cold Box	Freon Gas
U12C301	HP Cold Box	Freon Gas
U12C401	HP Cold Box	Freon Gas
U12C105	Ethane Recovery Unit #2	Freon Gas
U12C202	Ethylene Cycle	Ethylene
U12C106	Systems	
	Diethanolamine	98.5 wt% min 250 lb/sd
	Antifoamer	100% 7 lb/sd

Miscellaneous

Nitrogen

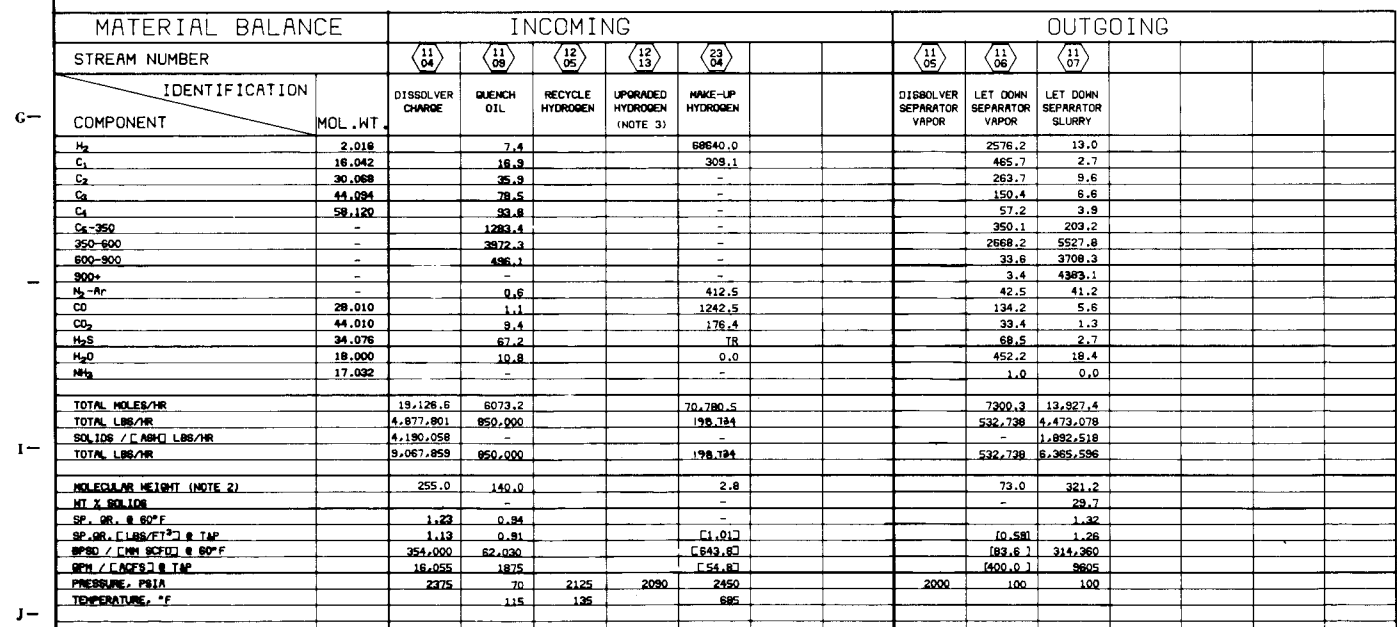
T12C101	DEA Surge Tank	Blanket Gas



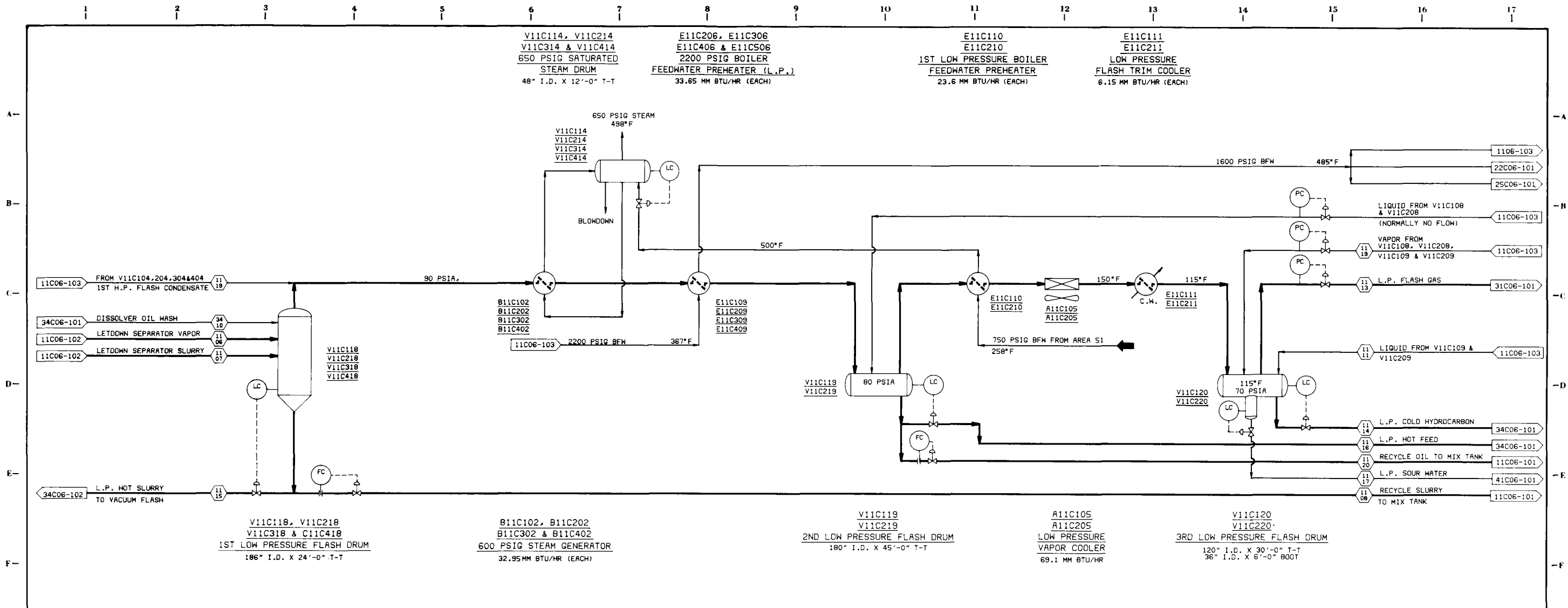
MATERIAL BALANCE		INCOMING				OUTGOING			
STREAM NUMBER		11 08	11 20	34 01	62 01	11 01	11 02	11 03	11 04
IDENTIFICATION		SLURRY RECYCLE TO MIX TANK	RECYCLE OIL	FRACTIONATOR RECYCLE	COAL	SLURRY MIX TANK VAPOR	SLURRY MIX TANK CONDENSATE	SOUR WATER	DISSOLVER CHARGE
COMPONENT	MOL. WT.								
H ₂	2.016					45.8	-	-	
C ₁	16.042					10.4	-	-	
C ₂	30.068					12.8	-	-	
C ₃	44.094					8.5	-	-	
C ₄	58.120					3.4	-	-	
C ₅₋₃₅₀						1.9	-	-	
350-600						0.2	185.0	-	
600-900						-	426.9	-	
900+						-	5.0	-	
H ₂ -Ar						19.9	-	-	
CO	28.010					4.5	-	-	
CO ₂	44.010					1.7	-	TR	
H ₂ S	34.076					4.0	-	TR	
H ₂ O	18.000				10.857.013	11.4	10.5	10.800	
NH ₃	17.032					-	-	TR	
TOTAL MOLES/HR		9006.0	7820.9	2993.5	10.857.0	123.4	627.4	10.800	19.126.6
TOTAL LBS/HR		3,078,500	1,402,275	500,000	195,430	2501	101,503	194,400	4,877,801
SOLIDS (ASH) LBS/HR		1,398,388	-	-	2,791,670	-	-	-	4,190,058
TOTAL LBS/HR		4,476,888	1,402,275	500,000	2,987,100	2501	101,503	194,400	9,067,859
MOLECULAR WEIGHT (NOTE 2)		341.9	179.3	167.0	-	20.3	161.8	18.0	255.0
WT % SOLIDS		-	-	-	93.0	-	-	-	-
SP. GR. @ 60°F		1.27	1.01	0.88	-	-	0.94	1.0	1.23
SP. GR. @ T & P		1.12	0.77	0.88	-	0.114	0.89	0.98	1.13
BPSD/(MM SCFD) @ 60°F		169.270	95.240	35.089	-	1.1	7401	-	354,000
GPM/(ACFS) @ T & P		8000	3640	1138	-	6.17	228	387	16,055
PRESSURE, PSIA		90	70	35	ATMOS	28	70	18	2375
TEMPERATURE, °F					60	145	145	145	

NOTES:
 1. MATERIAL BALANCE IS FOR TOTAL PLANT FLOW.
 2. SOLIDS NOT INCLUDED.
 3. INCLUDES COAL INHERENT MOISTURE.

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	ORDER NO. C-21500 X-00006																															
	Stearns-Roger INCORPORATED																															
	NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. REPEAT ALL PRINTS BEARING EARLIER DATE AND OR REVISION NO.																															



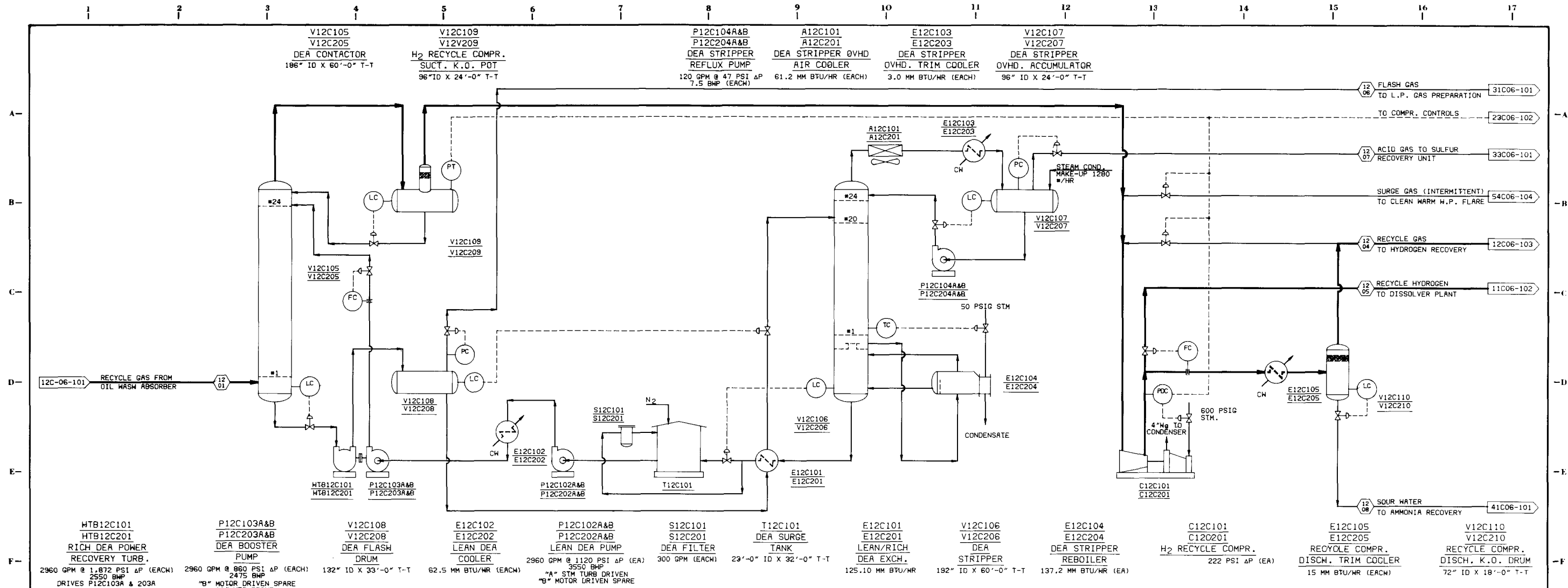
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										DATE	APPV'D BY	PROCESS ENGINEER	APPV'D BY	DATE	ISSUE NO.	APPV'D	DATE	DEVELOPMENT	5	22927	
											ELECTRICAL	PROJECT ENGINEER			PRELIMINARY ENGINEERING				AREA II		SHEET NO.
											MACHINERY				ENGINEERING				SRC II CONCEPTUAL COMMERCIAL PLANT		11C06
											MECHANICAL				APPROVED FOR CONSTRUCTION				 The Primary & Heavy Coal Mining Co. 		-102
											PIPING				REV 						ORDER NO.
											PROC. ENGINEER				NOT APPROVED FOR CONSTRUCTION UNLESS DATED AND SIGNED BY THE ENGINEER						C-21500
															BEARING EARLIER DATE AND/OR REVISION NO.						X-00006
																					REV 
																					
																					
																					
																					
																					
																					
																					



MATERIAL BALANCE		INCOMING							OUTGOING						
STREAM NUMBER		11 06	11 07	11 11	11 18	11 19	34 10		11 08	11 13	11 14	11 15	11 16	11 17	11 20
IDENTIFICATION	MOL. WEIGHT	LETDOWN SEPARATOR VAPOR	LETDOWN SEPARATOR SLURRY	H.P. COLD TO L.P. TRAIN	FIRST HP FLASH CONDENSATE	H.P. VAPOR TO L.P. TRAIN	DISSOLVER OIL WASH		SLURRY RECYCLE TO MIX TANK	DISSOLVER L.P. FLASH GAS	L.P. COLD FEED	HOT SLURRY TO VACUUM FLASH	L.P. HOT FEED	L.P. SOUR WATER	RECYCLE OIL
COMPONENT															
H ₂	2.018	2,576.2	13.0	1.1	899.9	598.7	-			4,023.8	4.7		5.7	-	20.6
C ₁	18.042	465.7	2.7	6.0	219.3	232.8	-			901.4	11.4		1.6	-	5.6
C ₂	30.068	269.7	9.6	19.4	132.6	153.7	-			529.0	31.3		2.2	-	7.7
C ₃	44.094	150.4	6.6	65.3	103.6	136.7	-			362.6	86.9		2.1	-	7.3
C ₄	58.120	57.2	3.9	105.8	58.1	60.2	-			141.9	131.8		1.4	-	5.9
C ₅₋₃₅₀	-	350.1	203.2	999.7	585.8	7.7	TR			29.7	1,698.4		69.2	6.0(3)	242.2
350-600	-	2,688.2	5,527.8	782.8	4,659.6	0.4	355.2			2.5	3,408.0		1,543.6	-	5,402.6
600-900	-	33.6	3,708.3	10.7	2,776.8	-	288.2			-	155.6		594.0	-	2,079.0
900+	-	42.5	4,389.1	-	15.8	-	17.8			-	-		3.7	-	19.0
H ₂ -Ar	-	41.2	0.1	38.7	28.3	-	-			126.6	0.3		2.2	-	7.8
CO	28.010	134.2	5.6	0.2	88.5	48.5	-			250.5	0.6		0.4	-	1.6
CO ₂	44.010	33.4	1.3	5.4	27.2	33.5	-			86.3	7.6		0.3	2.5	1.0
H ₂ S	34.078	68.5	2.7	57.5	75.2	109.1	-			233.8	71.6		1.0	0.5	3.5
H ₂ O	18.000	452.2	18.4	3.5	458.0	23.9	4.8			135.9	9.4		6.6	770.3	23.1
NH ₃	17.032	1.0	0.0	-	0.0	-	-			-	-		-	1.0	-
TOTAL MOLES/HR		7,300.2	13,927.4	2,037.5	10,121.0	1,435.5	645.8		9,006.0	6,826.0	5,618.5	3,181.8	2,234.0	780.3	7,820.8
TOTAL LBS/HR		532,738	4,473,078	228,353	1,411,209	27,730	135,000		3,078,500	90,790	734,470	1,087,810	400,650	14,610	1,402,275
SOLIDS/ (ASH) (LBS/HR)		-	1,882,518	-	-	-	-		1,398,388	-	-	494,130	-	-	-
TOTAL (LBS/HR)		532,738	6,365,596	228,353	1,411,209	27,730	135,000		4,476,888	90,790	734,470	1,581,940	400,650	14,610	1,402,275
MOLECULAR WEIGHT (NOTE 2)		73.0	321.2	112.8	139.4	19.3	209		341.9	13.3	130.7	341.9	179.3	18.7	179.3
MT.% SOLIDS		-	29.7	-	-	-	-		31.2	-	-	31.2	-	-	-
SP GR. @ 60°F		-	1.32	0.89	0.964	-	1.01		1.27	-	0.93	1.27	1.01	1.00	1.01
SP GR. (LBS/FT ³) @ TAP		0.59	1.26	0.89	0.96	[D.16]	0.91		1.12	[D.148]	0.90	1.12	0.77	0.98	0.77
BP@/ (MM SCFD) @ 60°F		[89.8]	314,360	17,680	100,420	[19.1]	9,182		169,270	[62.7]	54,190	85,450	272,210	-	95,240
QPH/ (ACF) @ TAP		[200.0]	9,605	520	4,410	[49.1]	297		8,000	[170]	1,630	2830	1,040	30	3,640
PRESSURE (PSIA)		100	100	70	1,390	80	100		90	70	70	90	70	70	70
TEMPERATURE (°F)		-	-	115	-	115	-		-	115	115	-	-	115	-

NOTES:
1. MATERIAL BALANCE IS FOR TOTAL PLANT FLOW.
2. SOLIDS NOT INCLUDED.
3. C₅₋₃₅₀ FRACTION IN SOUR WATER STREAM CONSISTS PRIMARILY OF PHENOLIC CRESYLIC & HIGHER BOILING RANGE AROMATIC.

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MATERIAL BALANCE		INCOMING			OUTGOING				
STREAM NUMBER		12 01			12 04	12 05	12 06	12 07	12 08
IDENTIFICATION		RECYCLE GAS TO DEA TREATING			RECYCLE GAS TO HYDROGEN RECOVERY	RECYCLE HYDROGEN TO DISSOLVER	FLASH GAS	ACID GAS	SOUR WATER
COMPONENT	MOL. WT.								
H ₂	2.016						69.5	-	-
C ₁	16.042						12.0	2.5	-
C ₂	30.068						3.5	-	-
C ₃	44.094						-	-	-
C ₄	58.120						-	-	-
C ₅₋₃₅₀	-						-	-	-
350-600	-						-	-	-
600-900	-						-	-	-
N ₂	-						-	-	-
CO	28.010						3.0	-	-
CO ₂	44.010						2.5	477.0	TR
H ₂ S	34.076						2.0	1422.0	TR
H ₂ O	18.000						1.0	87.0	47.7
TOTAL MOLES/HR							87.5	1968.5	47.7
TOTAL LBS/HR							706	70694	860
MOLECULAR WEIGHT							8.1	35.9	18.0
SP. GR. @ 60°F							-	-	1.00
SP. GR. @ 60°F @ TAP							[0.109]	[0.168]	1.00
BP@ 60°F @ 60°F							[0.80]	[7.9]	-
GPM/ACFS							[1.80]	[18.9]	1.7
PRESSURE, PSIA		1960			2120	2125	30	28	50
TEMPERATURE, °F		117			100	135	140	100	100

NOTES:

1. A LINED SUMP (V12C111 13'-0" X 13'-0" X 13'-0") AND A SUMP PUMP (P12C105A&B, 15 BHP) ARE INCLUDED IN THIS AREA BUT ARE NOT SHOWN ON THE DRAWING.
2. MATERIAL BALANCE IS FOR TOTAL PLANT FLOW.
3. STREAM 12 05 CONTAINS 0.8 MOLES/HR OF C₅-350 FRACTION WHICH IS SHOWN HERE BUT NOT ACCOUNTED FOR IN THE OVERALL MATERIAL BALANCE.

105 CF0546

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Stearns-Roger INCORPORATED

ORDER NO. C-21500 X-00006

3.4 UNIT 20 - HYDROGEN PRODUCTION PLANTS

Unit Definition. Unit 20 Hydrogen Production Plants utilizes vacuum tower bottoms slurry from Area 34 to produce purified high-pressure hydrogen and essentially sulfur-free fuel gas. All of the makeup hydrogen required by the Dissolver Plant is produced in this unit. Also included in Unit 20 is a Methanation and Dehydration Plant which converts excess methane-rich gas from Area 12 to a pipeline gas product.

Processing Areas included in Unit 20 are:

Area 21 - Syngas Production Plant;

Area 22 - Syngas Shift Conversion Plant;

Area 23 - Hydrogen Purification and Compression Plant;.

Area 24 - Syngas Purification Plant;

Area 25 - Methanation and Dehydration Plant.

3.4.1 Area 21 - Syngas Production Plant

Area Definition. All of the vacuum-bottoms slurry produced in the plant is fed to gasifiers which, in the presence of steam, partially oxidize the hydrocarbon and coal content to CO and hydrogen. Oxygen and 1500 psig steam are utilized in the gasification unit. The mineral matter present in the feed slurry is converted to slag in the gasifier and is transferred to Area 63 Slag Handling System.

Design Basis. The Syngas Production Plant is designed to gasify vacuum-bottoms slurry. Syngas, consisting primarily of H_2 , CO, and CO_2 , with some H_2S , and water of saturation, is produced. There will be four

parallel gasification trains. Slag separation is handled in two parallel units. The water for recycle is reclaimed in one unit.

Process Description. The process configuration is shown on Process Flow Diagram 21C06-101.

In the gasifier, some of the organic matter is combusted with O_2 in the first part of the reaction zone to supply the heat of reaction and maintain the operating temperature. The remaining hydrocarbon then reacts with the water to form CO and H_2 . Substantially all of the liquid hydrocarbon and solid organic matter is converted to CO and H_2 in an equilibrium mixture, with some CO_2 and H_2S . Clean syngas saturated with water exits the scrubber and is sent to Area 22 Shift Conversion Plant. Slag is removed through a lockhopper, dewatered in Area 63 Slag Handling Area and trucked to Area 64 Slag Disposal System.

In order to maintain recycle water quality, a quantity of water is purged from the system. This water is reclaimed in Area 43.

Design Discussion. Partial oxidation or gasification serves a three-fold purpose. First, all of the hydrogen requirements for the dissolver can be met by utilizing the heavy liquid/solid slurry product from the process itself without the need for extraneous feed stock. Secondly, it provides an environmentally-acceptable method for disposing of the mineral residue. Third, the sulfur in the residue is converted to a form (H_2S) which is easily removed from the syngas and recovered as elemental sulfur in Area 33 Sulfur Recovery Plant.

The gasification technology used in this area is based on the Texaco Coal Gasification Process. It is a high-pressure method producing clean, heavy hydrocarbon-free syngas for hydrogen production. The high operating pressure results in economies of heat recovery, compression, and CO_2 removal.

Turndown should be excellent for the gasification area, since each gasification unit can be turned down to 50% of design capacity.

3.4.2 Area 22 - Syngas Shift Conversion Plant

Area Definition. The basic purpose of this area is to convert CO in the syngas to an equivalent volume of H_2 by the shift conversion reaction with H_2O . The CO_2 formed is scrubbed out to produce high-purity H_2 . A major amount (82%) of syngas produced through gasification in Area 21 is passed through two shift converters in series to produce the hydrogen required for makeup to the dissolvers, as well as to supply reducing hydrogen to the SCOT Units in Area 33. The remainder of the syngas is routed through a hydrolysis reactor where COS is converted to H_2S . Conversion of COS to H_2S facilitates its removal in the downstream Selexol system in Area 24. The purified excess syngas is ultimately used as plant fuel.

Design Basis. The shift conversion area consists of two parallel trains. Each train is sized to handle 50% of the design flow.

The composition, or purity, of the product hydrogen stream is based on the makeup hydrogen purity required for the dissolver area. Two stages of shift conversion are used in this design in order to reduce the CO concentration of the product gas to about 1% CO (dry basis). The COS hydrolysis reactors treat the excess syngas stream.

The reaction is exothermic and waste heat is recovered most economically at three stream pressure levels; 1550 psig, 650 psig and 300 psig. A large quantity of 300 psig steam is produced in waste-heat boilers by condensation of excess steam in the product gas. The design also incorporates preheat of boiler feed water prior to steam production at the 1550 psig and 650 psig levels.

Process Description. The process configuration is shown on Process Flow Diagram 22C06-101.

The shift conversion and COS hydrolysis systems utilize proven technology. The Haldor Topsoe type SSK shift catalyst used in this design is capable of performing over a wider range of temperatures than those permissible with conventional catalysts. It displays high and stable activity in the presence of hydrogen sulfide and other sulfur compounds in the gas stream. This catalyst also effects conversion of COS to H_2S while catalyzing the shift reaction.

The excess syngas is treated over Haldor Topsoe's type CKA catalyst. This catalyst also displays high and stable activity in the required temperature range and enables conversion of nearly all of the COS to H_2S , thus facilitating removal of sulfur as H_2S in the downstream syngas purification unit.

Syngas from the gasification area is first split into two streams. The major portion of the syngas (82%), together with excess steam, is heated above its dewpoint in a feed/effluent exchanger. The heated feed gas is then passed through the first shift converter where most of the CO is converted to CO_2 . The high-temperature effluent from the first reactor is cooled in three heat exchangers to recover heat by generating steam and preheating the feed gas. The gas then passes through the second-stage shift converter where the residual CO is shifted to hydrogen. After further heat recovery, the product gas is sent to Area 23 Hydrogen Purification and Compression Plant. The steam-to-dry-gas ratio in the syngas entering the shift units directly affects the concentration of CO in the product gas. Operation at the design ratio will result in a conversion of 97% of the incoming CO to CO_2 , which results in a product CO concentration of about 1%.

Design Discussion. Process design for the shift conversion area was provided by Haldor Topsoe and is based on their proprietary catalyst technology. The sulfur-tolerant type SSK shift catalyst was originally developed by Exxon Research and Engineering Company. Haldor Topsoe obtained exclusive rights to this catalyst and over the years have further refined it and have made it

commercially available. The capability of the SSK catalyst has been commercially demonstrated in the following plants:

1. SUPRA, AB, Kvarntorp, Sweden. This plant produces ammonia using partial oxidation of oil. Startup date was March, 1974.
2. SUPRA, AB, Koping, Sweden. This plant also produces ammonia from the partial oxidation of oil. Start up date was April, 1978.
3. Dansk-Norsk Kvaelstoffabrik I/S, Grenaa, Denmark. This plant utilizes partial oxidation of oil to produce ammonia. Startup date was May, 1979.

Another plant where the SSK catalyst will be used is:

1. Tennessee Valley Authority, Muscle Shoals, Alabama. Slated for start up in 1980, this plant will utilize partial oxidation of coal to make synthesis gas for producing ammonia.

Scale-up of this shift-conversion process is not expected to pose any problems in the SRC-II process. The use of two 50% trains in the Conceptual Commercial Plant will provide flexibility and excellent turndown capability.

3.4.3 Area 23 - Hydrogen Purification And Compression Plant

Area Definition. The Hydrogen Purification Unit is designed to selectively remove hydrogen sulfide, carbon dioxide, and other trace impurities from the hydrogen-rich shift gas produced in Area 22 Syngas Shift Conversion. The sweet hydrogen is compressed and is sent to Area 11 Dissolver Plant, where it is consumed in the coal dissolver reactions. A side stream has been provided to send sweet hydrogen to Area 33 Sulfur Recovery, to be used for makeup hydrogen in the SCOT Unit. Hydrogen sulfide-rich acid gas is sent directly to Area 33 (Claus Unit). The CO₂ vent gas is incinerated in Area 33.

Design Basis. Allied Chemical's Selexol process is employed to remove acid gases from the hydrogen-rich shift gas. The unit is designed to produce a hydrogen product stream with 1 ppm H_2S and 2500 ppm CO_2 . Two parallel units are employed, each capable of handling 50% of the total feed.

The shift gas entering Area 23 is composed of approximately 40% hydrogen, 27% carbon dioxide, 32% water, and 4600 ppm hydrogen sulfide. The purified hydrogen stream consists of 97% hydrogen, 2% carbon monoxide, 0.25% carbon dioxide, 1 ppm H_2S , and less than 2% nitrogen, methane, and argon. The H_2S acid gas stream produced is rich enough (22% H_2S) to be delivered to the Claus Unit feed at 120°F and 28 psia. The CO_2 vent gas contains only a few ppm of H_2S and is sent directly to incineration.

Process Description. The process configuration is shown on Process Flow Diagram 23C06-101 through 103.

The crude makeup hydrogen feed gas is cooled to 120°F in a series of exchangers. Recycle flash gas is injected into the feed and the mixture is further cooled by exchange with the product gas. The cold gas mixture is then contacted with Selexol solution in two absorbers in series, the first for selective H_2S removal, and the second for CO_2 removal. Each absorber has its own solution stripper which allows recovery of an H_2S -rich stream for feed to the Claus Unit and rejection of a nearly sulfur-free CO_2 stream directly to incineration. A portion of the rich Selexol solution from the bottom of the CO_2 absorber is used as the lean solution feed to the H_2S absorber. The solution selectively absorbs H_2S down to about 2 ppm in the hydrogen leaving the absorber.

A slipstream of rich Selexol solution is mixed with the gas leaving the first tower prior to refrigeration to prevent the formation of hydrates. Subsequent exchange with flashed rich Selexol solution, and then with refrigerant, removes some heat of absorption and reduces the mixed stream temperature feeding the CO_2 absorber. Sweet hydrogen leaving the absorber

is warmed by cross-exchange with the H_2S absorber feed gas, as mentioned, before entering the Compression Area.

The bottom portion of the CO_2 absorber serves as a gas/liquid separator for the mixed phase feed. Rich Selexol solution also collects on the bottom chimney tray and is pumped back to mix with the gas from the H_2S absorber for the hydrate-prevention step described above.

The rich Selexol solution in the bottom of the H_2S absorber is reduced in pressure through two flash stages, the first incorporating a hydraulic power-recovery turbine. Flash vapor from both stages is collected, compressed, and recycled to the H_2S absorber inlet. The final flash liquid is introduced to the top of the H_2S stripper. The heat for regeneration of the solvent is provided by a steam-heated reboiler. Lean solution from the bottom of the stripper is mixed with lean solution from the CO_2 stripper and is recirculated to the top of the CO_2 absorber. Acid gas from the H_2S stripper is fed directly to the Claus Unit.

A small portion of the rich Selexol solution in the bottom of the CO_2 absorber is sent to the H_2S absorber as lean solvent. The remainder is reduced in pressure through two flash stages. In this instance, both flashes involve sufficient energy to justify hydraulic power-recovery turbines. The first-stage flash vapors are compressed and recycled to the CO_2 absorber inlet as described above. The second stage, which contains very small amounts of H_2S and less than 0.5% combustion gases, is sent directly to incineration.

The final flash liquid, after exchanging heat with the CO_2 absorber feed stream, is recycled to the top of the CO_2 stripper. The CO_2 is stripped out with high-purity nitrogen from the Oxygen Plant. The lean solution is pumped back to the top of the CO_2 absorber. The nitrogen/carbon dioxide mixture leaving the top of the stripper contains less than 4 ppm H_2S and is sent directly to incineration.

The purified hydrogen leaving the CO₂ absorber is compressed to 2450 psia and delivered to the Area 11 Dissolver Plant. Two three-stage centrifugal machines are provided to compress the hydrogen. They are driven by 18,650 bhp condensing turbines.

Design Discussion. The Selexol process was developed by Allied Chemical Corporation. The process utilizes a glycol-ether type solvent to remove H₂S, CO₂, and other acidic and non-acidic components from industrial gases by physical absorption. Since the process involves physical absorption it is well suited for gases at high pressures with high acid gas concentrations. The process is highly selective to sulfur compounds and yields a high sulfur feed for the Claus Unit. The solvent is physically and chemically stable, and plants can run for an extended period with little makeup solvent.

Two trains are employed in Area 23 with each train capable of handling 50% of the total feed. The two train philosophy has been selected to keep the CO₂ absorber vessel within a reasonable size by commercial standards.

Feed conditions can be varied over a wide range. The absorption capacity of the solvent is proportional to the partial pressure of the acid gas. Therefore, as the concentration of acid gas increases, the absorption capacity of the solvent increases enough to absorb the increased quantity of acid gas.

Turndown should be excellent for Area 23. Two trains are available and each train can be turned down 50%, resulting in an overall turndown ratio of 25%.

Only standard, proven construction materials are required. No unusual startup, shutdown or maintenance problems are anticipated.

3.4.4. Area 24 - Syngas Purification Plant

Area Definition. Area 24 Syngas Purification is designed to selectively remove hydrogen sulfide from the syngas following COS conversion in Area 22 Syngas Shift Conversion. The purified syngas is then used as plant fuel. Hydrogen sulfide-rich acid gas is delivered directly to the Claus Unit.

Design Basis. Allied Chemical Corporation's Selexol Process is used to remove the hydrogen sulfide from the syngas. The unit is designed to reduce the H_2S to 1 ppm. The acid gas stream containing 29.4% hydrogen sulfide is sent to the Claus Unit in Area 33.

Process Description. The process configuration is shown on Process Flow Diagram 24C06-101.

Syngas enters Area 24 and is cooled in a series of exchangers prior to entering the H_2S absorber. Refrigerated lean Selexol solution enters the top of the absorber for counter-current scrubbing of the syngas which is then sent directly to the fuel system.

The rich Selexol solution is depressured and flashed in one stage through a valve. The flash vapor combines with the stripper overhead gas and is sent to the Claus Unit. The flashed liquid is sent to the top of the H_2S stripper tower where the H_2S is stripped-out with a steam-heated reboiler.

Design Discussion. The Selexol process was developed by the Allied Chemical Corporation in the early 1960's. The process utilizes a glycol-ether type solvent to remove H_2S , CO_2 , and other acidic and nonacidic components from industrial gases by physical absorption. Since the process involves physical absorption, it is well suited for gases at high pressures with high acid gas concentrations. The process is highly selective to sulfur compounds and yields a high sulfur feed for the Claus Unit. The solvent is physically and chemically stable, and plants can run for an extended period with little makeup solvent.

Turndown in Area 24 will be approximately 50% of design feed capacity.

Only standard, proven construction materials are required. No unusual startup, shutdown, or maintenance problems are anticipated.

3.4.5 Area 25 - Methanation and Dehydration Plant

Area Definition. The methanation area converts methane-rich gas from the hydrogen recovery unit in Area 12 into pipeline gas. Carbon monoxide and ethane in the feed gas streams are reacted with hydrogen in the presence of a catalyst to form methane. The product gas from the methanation area is dried in a glycol dehydration unit prior to transmission to a natural gas pipeline system.

Design Basis. The methanation and glycol dehydration area consists of a single train. The design capacity is 55 MM scfd of dry pipeline gas.

The composition of the feed gas is set by the operating conditions of the cryogenic unit in Area 12. Since the hydrogen content of the feed gas is higher than the stoichiometric hydrogen requirement needed for the methanation reaction, no hydrogen addition is required. The methanation reaction takes place in two stages with the final product stream containing virtually no carbon monoxide. Steam diluent is added to the reactor to control the outlet temperature and to prevent sudden temperature excursions. Steam addition also serves to prevent carbon formation in the methanator. The high temperature at the reactor outlet enables high-level waste heat recovery as well as feed gas preheat.

Process Description. The process configuration is shown on Process Flow Diagrams 25C06-101 and 102.

The process design for the methanation unit was prepared by Haldor Topsoe. Haldor Topsoe catalysts are used in the first and second stage methanator reactors respectively. Sulfur guard beds are used for removing

sulfur in the feed stream to a concentration below 1 ppm. The exothermic nature of the methanation reaction permits generation of 1550 psig and 650 psig steam through waste heat recovery. The heat in the methanator effluent is also used to preheat feed gas. Lower-level steam (100 psig) is produced in the process of cooling the product stream from the second-stage methanator.

The feed gas enters the area at 100⁰F and is preheated in two feed/effluent exchangers, and is then passed through a fired heater before entering the sulfur guard beds. High-pressure (1550 psig) steam is added to the sulfur-free gas prior to the first-stage methanator. The effluent gas from the first stage methanator is cooled in 1550 psig and 650 psig steam generators before entering the second-stage methanator.

Ethane, heavier hydrocarbons and most of the CO in the feed gas are converted to methane in the first stage methanator. Residual amounts of CO are converted to methane in the second reactor. The product gas from this reactor (which contains methane, hydrogen, nitrogen, and water) is cooled and routed to the glycol dehydration unit.

The glycol dehydration unit dries the gas to a specification of less than four pounds water per million standard cubic feet. The dried product gas at 830 psig is sent through a metering station to a natural gas pipeline.

Design Discussion. The basic concepts used in Haldor Topsoe's methanation technology have been developed and demonstrated since 1972. The reactor design incorporates fixed-bed reactors that can be operated over a wide temperature range from low-inlet to high-outlet temperatures. The catalyst used in the first-stage methanator combines a low tendency for carbon formation with high temperature tolerance and high activity at low temperature.

Haldor Topsoe has successfully demonstrated the process on a pilot-plant scale. A three-stage process designed to operate under more severe conditions has been installed in a West German project to develop a long distance energy transmission system in West Germany.

The methanation area design for the Conceptual Commercial Plant utilizes conventional proven equipment. No unusual problem with respect to materials, maintenance, startup or shutdown are anticipated.

TABLE 3-10
AREA 21 - SYNGAS PRODUCTION PLANT
EQUIPMENT LIST

<u>EQUIPMENT NUMBER</u>	<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
			<u>TEMPERATURE</u> (F)	<u>PRESSURE</u> (PSIG)

Equipment items, names and descriptions are omitted because they contain
licensed Texaco Development Corporation synthesis gas production information.

TABLE 3-12
AREA 22 - SYNGAS SHIFT CONVERSION PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Heat Exchangers</u>				
E22C101 E22C201	1500 psig Steam Generator	N/A		N/A
E22C102 E22C202	1st Stage Shift Feed Effluent Exchanger	N/A		N/A
E22C103 E22C203	2nd Stage Inlet 600 psig Steam Generator	N/A		N/A
E22C104 E22C204	2nd Stage Outlet 600 psig Steam Generator	N/A		N/A
E22C105 E22C205	700 psig Boiler Feed Water Heater	N/A		N/A
E22C106 E22C206	250 psig Steam Generator	N/A		N/A
E22C107 E22C207	Shift Gas/Condensate	N/A		N/A
<u>Pumps</u>				
P22C101 A/B P22C201 A/B	Shift Condensate Return Pump	N/A		N/A

TABLE 3-12
AREA 22 - SYNGAS SHIFT CONVERSION PLANT
EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Vessels</u>				
V22C101 V22C201	1st Stage Shift Converter	N/A		N/A
V22C102 V22C202	2nd Stage Shift Converter	N/A		N/A
V22C103 V22C203	COS Hydrolysis Converter	N/A		N/A
V22C104 V22C204	1500 psig Steam Drum	N/A		N/A
V22C105 V22C205	600 psig Steam Drum No. 1	N/A		N/A
V22C106 V22C206	250 psig Steam Drum	N/A		N/A
V22C107 V22C207	Shift Condensate Separator	N/A		N/A
V22C108 V22C208	Shift Condensate Surge Drum	N/A		N/A
V22C109 V22C209	600 psig Steam Drum No. 2	N/A		N/A

TABLE 3-14
AREA 23 - HYDROGEN PURIFICATION & COMPRESSION PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Air Cooled Equipment</u>				
A23C101	H ₂ S Stripper Overhead Condenser	N/A		N/A
A23C201				
A23C102	Feed Gas Air Cooler	N/A		N/A
A23C202				
<u>Compressors</u>				
C23C101	H ₂ S Recycle Compressor (Includes Steam Trubine Driver)	N/A		N/A
C23C201				
C23C102	CO ₂ Absorber Recycle Compressor	N/A		N/A
C23C202				
C23C103	Make-Up Hydrogen Compressor	18,650 bhp each, 1320 psiΔP, Steam Turbine Drive	200	2435
C23C203				
<u>Heat Exchangers</u>				
E23C103	50 psig Steam Generator	N/A		N/A
E23C203				
E23C105	Absorber Precooler	N/A		N/A
E23C205				
E23C106	Feed Gas Cooler I	N/A		N/A
E23C206				
E23C107	Feed Gas Cooler II	N/A		N/A
E23C207				
E23C108	Recycle Compressor Exchanger	N/A		N/A
E23C208				
E23C109	Recycle Compressor Aftercooler	N/A		N/A
E23C209				

TABLE 3-14
AREA 23 - HYDROGEN PURIFICATION & COMPRESSION PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
Heat Exchangers - Contd			SS/TS	SS/TS
E23C110	Solvent/Solvent Exchanger	N/A	N/A	
E23C210				
E23C111	H ₂ S Stripper Reboiler	N/A	N/A	
E23C211				
E23C112	Solution Exchanger	N/A	N/A	
E23C212				
E23C113	Absorber Chiller	N/A	N/A	
E23C213				
E23C114	Recycle Compressor Aftercooler	N/A	N/A	
E23C214				
E23C115	Hydrogen Compressor Recirc. Cooler	20 MMBtu/hr, Carbon Steel Tubes	125/200	150/1305
E23C215				
E23C116	Hydrogen Compressor Surface Condenser	160.2 MMBtu/hr, Carbon Steel Tubes	125/125	150/115
E23C216				
E23C117	Refrigeration Unit Surface Condenser (Includes Steam Ejector)	N/A	N/A	
E23C217				
E23C118	CO ₂ Main Solvent Pump Surface Condenser (Includes Steam Ejector)	N/A	N/A	
C23C218				
E23C119	H ₂ S Recycle Compressor Surface Condenser (Includes Steam Ejector)	N/A	N/A	
E23C219				

TABLE 3-14
AREA 23 - HYDROGEN PURIFICATION & COMPRESSION PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Hydraulic Power Recovery Units</u>				
HTB23C102 HTB23C202	H ₂ S Solution Hydraulic Power Recov. Unit	N/A	N/A	
HTB23C106 HTB23C206	CO ₂ L.P. Solution Hydraulic Power Recov. Unit	N/A	N/A	
HTB23C105 HTB23C205	CO ₂ L.P. Solution Hydraulic Power Recov. Unit	N/A		N/A
<u>Packaged Units</u>				
J23C101	Hydrogen Compressor Steam Ejector Unit	3" Hg abs. With Jets & Condensers	125	3 " Hg
<u>Pumps</u>				
P23C101 A/B	Stripper Feed Pump	N/A		N/A
P23C201 C/D				
P23C102 A/B/C	Lean Solution Charge Pump	N/A		N/A
P23C202 D/E/F				
P23C103 A/B	CO ₂ Absorber Exchanger Pump	N/A		N/A
P23C203 C/D				
P23C104 A/B/C	CO ₂ Stripper Feed Pump	N/A		N/A
P23C204 D/E/F				

TABLE 3-14
AREA 23 - HYDROGEN PURIFICATION & COMPRESSION PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Pumps - Contd</u>				
P23C105 A/B/C	CO ₂ Main Solvent Pump (Incl. Steam Turbine Driver)	N/A		N/A
P23C205 C/D/E				
P23C106 A/B	Solvent Transfer Pump	N/A		N/A
P23C206 C/D				
P23C107 A/B	Solvent Sump Pump	N/A		N/A
P23C207 C/D				
P23C108 A/B	H ₂ S Absorber Solution Pump	N/A		N/A
P23C208 C/D				
P23C209 A/B	H ₂ S Striper Overhead Condenser Pump	N/A		N/A
P23C209 C/D				
P23C110 A/B	H ₂ S Recycle Compressor Turbine Condensate Pump	N/A		N/A
P23C210 C/D				
P23C111 A/B	H ₂ S Recycle Comp. Hotwell Condensate Pump	N/A		N/A
P23C211 C/D				

TABLE 3-14
AREA 23 - HYDROGEN PURIFICATION & COMPRESSION PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
Pumps - Contd				
P23C112 A/B P23C212 C/D	Steam Condensate Pump	360gpm, 57 psi ΔP, 22.8 hp Carbon Steel	125	50
P23C113 A/B P23C213 C/D				
	Hotwell Condensate Pump	1.0 gpm, 1 hp	125	35
Vessels				
V23C101 V23C201	H ₂ S Absorber	N/A		N/A
V23C102 V23C202	H.P. Flash Drum	N/A		N/A
V23C103 V23C203	L.P. Flash Drum	N/A		N/A
V23C103 V23C204	H ₂ S Stripper	N/A		N/A

TABLE 3-14
AREA 23 - HYDROGEN PURIFICATION & COMPRESSION PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Vessels - contd</u>				
V23C105 V23C205	Precooler K.O. Drum	N/A		N/A
V23C106 V23C206	50 psig Steam Generator K.O. Drum	N/A		N/A
V23C108 V23C208	Air Cooler K.O. Drum	N/A		N/A
V23C109 V23C209	CO ₂ Absorber	N/A		N/A
V23C110 V23C210	Recycle Flash Drum	N/A		N/A
V23C111 V23C211	CO ₂ Stripper	N/A		N/A
V23C212 V23C212	Solvent Sump	N/A		N/A
V23C113 C23C213	H ₂ S Stripper Overhead Condenser Drum	N/A		N/A
V23C114 V23C214	CO ₂ Stripper Overhead K.O. Drum	N/A		N/A

TABLE 3-14
AREA 23 - HYDROGEN PURIFICATION & COMPRESSION PLANT

EQUIPMENT LIST

<u>EQUIPMENT NUMBER</u>	<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
			<u>TEMPERATURE (F)</u>	<u>PRESSURE (PSIG)</u>
<u>Vessels - contd</u>				
V23C115	Hydrogen Compressor	28" ID x 7' -0" T.T.,	150	995
V23C215	Suction K.O. Drum	Carbon Steel		
V23C117	Compressor Hotwell	18" ID x 3' -0" T.T.,	165	
V23C217		Carbon Steel		
<u>Tanks</u>				
T23C101	Solvent Storage Tank	N/A		N/A
T23C201				
<u>Package Units</u>				
U23C101	Refrigeration Unit			
U23C201	(Incl. Turbine Driver)	N/A		N/A

TABLE 3-16
AREA 24 - SYNGAS PURIFICATION PLANT
EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Heat Exchangers</u>				
E24C101	50 psig Steam Generator	N/A		N/A
E24C102	250 psig Steam Generator	N/A		N/A
E24C103	Absorber Precooler	N/A		N/A
E24C104	Absorber Feed/Product Exchanger	N/A		N/A
E24C105	Rich/Lean Solvent Exchanger	N/A		N/A
E24C106	H ₂ S Absorber Chiller	N/A		N/A
E24C107	H ₂ S Stripper Reboiler	N/A		N/A
E24C108	H ₂ S Stripper Overhead Condenser	N/A		N/A
<u>Pumps</u>				
P24C101 A/B	H ₂ S Lean Solvent Charge Pump	N/A		N/A
P24C102	H ₂ S Lean Solvent Booster Pump	N/A		N/A
P24C103 A/B	H ₂ S Solvent Sump Pump	N/A		N/A
P24C104 A/B	H ₂ S Stripper Overhead Condenser Pump	N/A		N/A

TABLE 3-16
AREA 24 - SYNGAS PURIFICATION PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Vessels</u>				
V24C101	250 psig Steam Generator Gas K.O. Drum	N/A		N/A
V24C102	Precooler K.O. Drum	N/A		N/A
V24C103	Steam Generator Outlet Gas K.O. Drum	N/A		N/A
V24C104	H ₂ S Absorber	N/A		N/A
V24C105	H ₂ S Stripper	N/A		N/A
V24C106	Cooler K.O. Drum	N/A		N/A
V24C108	H ₂ S Flash Drum	N/A		N/A
V24C110	H ₂ S Stripper Overhead Condenser Drum	N/A		N/A
<u>Package Equipment</u>				
U24C101	Refrigeration Package	N/A		N/A

TABLE 3-18
AREA 25 - METHANATION AND DEHYDRATION PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Heat Exchangers</u>				
E25C101	1500 psig Steam Generator	N/A	N/A	
E25C102	600 psig Steam Generator	N/A	N/A	
E25C103	Methanator Feed Gas Secondary Heater	N/A	N/A	
E25C104	100 psig Steam Generator	N/A	N/A	
E25C105	Methanator Feed Gas Primary Heater	N/A	N/A	
E25C106	Methane Gas Cooler	N/A	N/A	
E25C107	Lean Glycol Cooler	0.20 MMBtu/hr., Carbon Steel	230/165	35/70
E25C108	Rich/Lean Glycol Exchanger	0.56 MMBtu/hr., Carbon Steel	430/400	40/885
E25C109	Glycol Reboiler	0.47 MMBtu/hr., Carbon Steel	430/460	40/275
E25C110	Regenerator Overhead Partial Condenser	0.22 MMBtu/hr., Carbon Steel	300/160	40/70
<u>Heaters</u>				
H25C101	Methanator Feed Gas Fired Heater	N/A	N/A	
<u>Pumps</u>				
P25C101 A/B	Condensate Pump	N/A	N/A	

TABLE 3-18
AREA 25 - METHANATION AND DEHYDRATION PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Pumps - Contd</u>				
P25C102 A/B	High Pressure Lean Glycol Pump	9.4 gpm, 860 psiΔP. 10 hp	100	860
P25C103	Glycol Regenerator Reflux Pump	0.4 gpm, 10 psi ΔP. 0.2 hp	150	15
P25C105 A/B	TEG Sump Pump	0.4 gpm, 51 psiΔP. 1/2 hp	100	51
<u>Filters</u>				
S25C101	High Pressure Glycol Filter	30" ID x 4' -0" TT. 9.6 gpm	150	910
<u>Storage Tanks</u>				
T25C101	TEG Sump Tank	36" ID x 60" TT. Carbon Steel	130	0
T25C102	TEG Storage Tank	5' -0" ID x 12' -6" TT Carbon Steel	130	0
<u>Vessels</u>				
V25C101 A/B	Sulfur Guard Bed	N/A	N/A	
V25C102	1st Stage Methanator	N/A	N/A	
V25C103	2st Stage Methanator	N/A	N/A	
V25C104	100 psig Steam Generator K.O. Drum	N/A	N/A	
V25C105	Methanator Feed Gas Primary Heater K.O. Drum	N/A	N/A	

TABLE 3-18
AREA 25 - METHANATION AND DEHYDRATION PLANT
EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Vessels</u> - Contd				
V25C106	Methane Gas Cooler K.O. Drum	N/A		N/A
V25C107	Condensate Drum	N/A		N/A
V25C108	1500 psig Steam Drum	N/A		N/A
V25C109	High Pressure Glycol Dehydrator	45" ID x 18'-0" TT, 6 sieve trays Carbon Steel	150	920
V25C110	High Pressure Dehydrator K.O. Drum	39" x 6'-0" TT, Carbon Steel	150	920
V25C111	Lean Glycol Surge Drum	27" ID x 4'-0" TT, Carbon Steel	150	20
V25C112	Glycol Regenerator	27" ID x 26'0" TT, 10 sieve trays	450	50
V25C113	Glycol Regenerator Reflux Accumulator	12" ID x 5'-0" TT, Carbon Steel	--	--

TABLE 3-9
AREA 21 - SYNGAS PRODUCTION PLANT

UTILITY SUMMARY

NOT AVAILABLE

TABLE 3-11
AREA 22 - SHIFT CONVERSION PLANT

UTILITY SUMMARY

<u>Electric Power</u>		<u>KW</u>	
Connected		821	
Operating		621	
<u>Steam</u>		<u>LB/HR</u>	<u>PSIG</u>
Generation:		552,000	1550 Saturated
		194,400	650 Saturated
		694,000	300 Saturated
<u>Catalysts and Chemicals</u>			
V22C101 & 201	1st-Stage Shift Converter	Haldor Topsoe Shift Catalyst	
V22C102 & 202	2nd-Stage Shift Converter	Haldor Topsoe Shift Catalyst	
V22C103 & 203	COS Hydrolysis Converter	Haldor Topsoe COS Hydrolysis Catalyst	

TABLE 3-13
AREA 23 - HYDROGEN PURIFICATION & COMPRESSION PLANT

UTILITY SUMMARY

<u>Electric Power</u>	<u>KW</u>	
Connected	16,413	
Operating	6,435	
<u>Steam</u>	<u>LB/HR</u>	<u>PSIG</u>
Generation:	859,600	50 Saturated
Consumption:	108,820	50 to Condensate
	3,785	100 to Condensate
	576,531	250 to Condensate
	63,130	600 to Condensate
<u>Cooling Water (30°F Rise)</u>	<u>GPM</u>	
	82,635	
<u>Fuel</u>		
None		
<u>Chemicals</u>		
Selexol Solvent		Not Available.

TABLE 3-15
AREA 24 - SYNGAS PURIFICATION PLANT

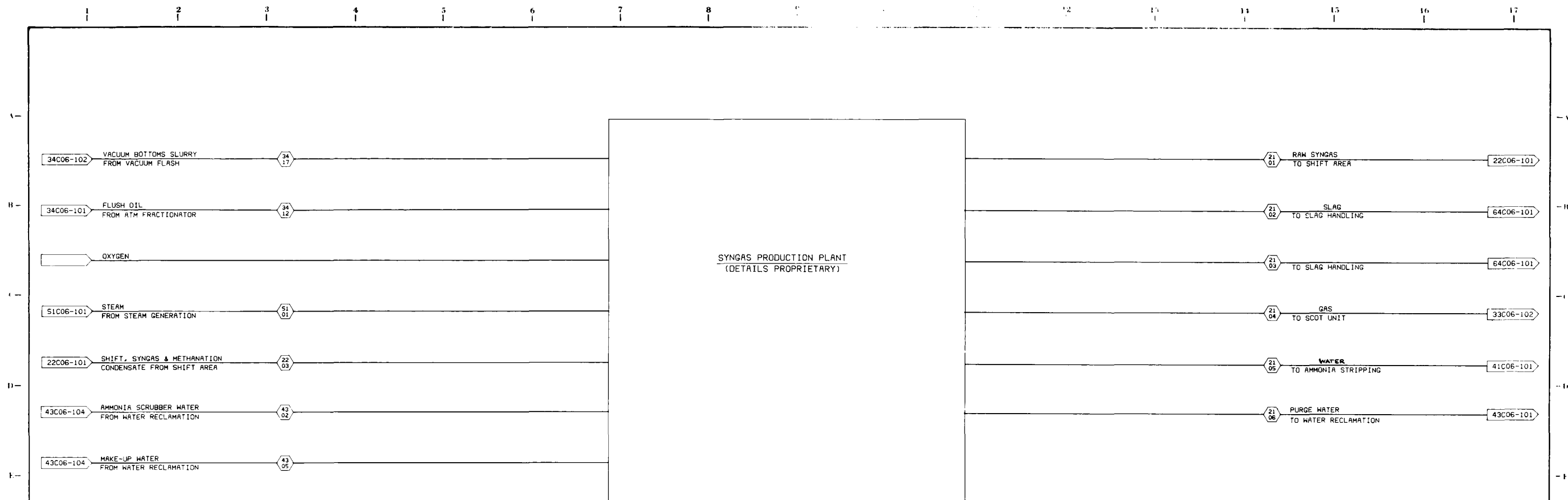
UTILITY SUMMARY

<u>Electric Power</u>	<u>KW</u>	
Connected	2450	
Operating	1515	
<u>Steam</u>	<u>LB/HR</u>	<u>PSIG</u>
Consumption:	18,700	50 to Condensate
Generation:	336,530	300 Saturated
	130,730	50 Saturated
<u>Cooling Water (30°F Rise)</u>	<u>GPM</u>	
	6420	
<u>Fuel</u>		
None		
<u>Chemicals</u>		
Selexol Solvent		Not Available.

TABLE 3-17
AREA 25 - METHANATION & DEHYDRATION PLANT

UTILITY SUMMARY

<u>Electric Power</u>		<u>KW</u>	
Connected		89	
Operating		39	
<u>Steam</u>		<u>LB/HR</u>	<u>PSIG</u>
Consumption:		N/A	N/A
Generation:		47,600	1550 Saturated
		6,500	650 Saturated
		24,500	100 Saturated
<u>Cooling Water (30°F Rise)</u>		<u>GPM</u>	
TOTAL		1337	
<u>Fuel</u>		<u>MM BTU/HR</u>	
TOTAL		12	
<u>Catalysts and Chemicals</u>			
V25C101	Sulfur Guard Bed	Haldor Topsoe Catalyst	
V25C102	1st-Stage Methanator	Haldor Topsoe Methanation Catalyst	
V25C103	2nd-Stage Methanator	Haldor Topsoe Methanation Catalyst	
	Triethelyne Glycol	80 lb/sd	

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3.5 UNIT 30 - REFINING AND GAS PLANTS

Unit Definition. The Refining and Gas Plant unit is designed to process the sour hydrocarbon gases and liquids produced throughout the entire SRC-II plant to produce an ethane-propane gas mixture, commercial butane, debutanized naphtha, liquid sulfur, fuel oil, and fuel gas for plant use.

The unit is divided into four process areas:

Area 31	-	Low-Pressure Gas Compression and Treating Plant
Area 32	-	Product Gas Plant
Area 33	-	Sulfur Recovery Plant
Area 34	-	Refining Plant

Low-pressure sour hydrocarbon gas streams are compressed and treated in Area 31 Low-Pressure Gas Compression and Treating Plant to remove acid gases (H_2S and CO_2). The sweet gas from Area 31 is sent along with a propane-rich gas and a butane-rich liquid from the Area 12 Hydrogen Treating and Recovery Plant to the Area 32 Product Gas Plant, where hydrogen-rich gas for plant fuel, an ethane-propane gas mixture, butane, and sweet naphtha are produced.

Acid gases from acid gas removal units throughout the Conceptual Commercial Plant are collected at the Area 33 Sulfur Recovery Plant, where H_2S is converted to elemental sulfur product. The Sulfur Recovery Plant off-gases are treated in a SUPERSHOT unit and are then incinerated to oxidize residual H_2S and CO to SO_2 and CO_2 .

Hydrocarbon fractions from the Area 11 Dissolver Plant are separated in the Area 34 Refining Plant. The high-boiling slurry product is routed to the gasifier in the Area 21 Syngas Production Plant for hydrogen production. The light hydrocarbon fractions (C_4 and lighter) are sent to the Area 31 Low-Pressure Gas Compression and Treating Plant. The debutanized naphtha product and a mixture of the light and heavy fuel oil products are sent to Area 54 Product Storage.

3.5.1 Area 31 - Low-Pressure Gas Compression and Treating Plant

Area Definition. This section of the plant includes two centrifugal compressors, a DEA contactor and a DEA regenerator. Low-pressure sour hydrocarbon gas streams produced in Areas 11, 12, and 34 are collected and compressed to 520 psia to facilitate the removal of the heavier hydrocarbons and to provide the pressure necessary for satisfactory acid gas removal. Acid gases are removed from the compressed sour hydrocarbon gases by counter-current gas/liquid absorption in the DEA contactor. The sweet hydrocarbon gases from the DEA contactor are sent to the Area 32 Product Gas Plant. The rich DEA from the DEA contactor is sent to the DEA regenerator for removal of the acid gases absorbed in the rich DEA. The acid gases produced from the DEA regenerator are sent to the Area 33 Sulfur Recovery Plant for conversion to liquid sulfur.

Design Basis. The low-pressure gas treating facilities normally process 77.7 MM scfd of sour hydrocarbon gases containing 1.6 mole percent CO_2 , 5.7 mole percent H_2S and 2.6 mole percent C_5 and heavier hydrocarbons. A sweet gas containing a maximum of 10 ppm of H_2S is produced by a 25 tray DEA contactor. The lean DEA feed to the DEA contactor is a 20 weight-percent solution. Acid gas pickup in the DEA contactor has been limited to 0.4 moles/mole of DEA. This low acid gas loading in the rich DEA solution is used to better cope with possible variations in the acid gas content of the feed streams, depending on sulfur content of the coal. A relatively high circulation rate of 1750 gpm is required. Before going to the DEA regenerator to remove dissolved hydrocarbons, the rich DEA from the DEA contactor is flashed in a DEA flash drum operating at 70 psia. This is necessary to ensure that the acid gases from the DEA regenerator will contain less than 0.5 mole-percent of hydrocarbons and will not cause production of black sulfur. The DEA regenerator is designed to operate at 36 psia minimum. This is the minimum pressure required for supply of acid gas feed to the Area 33 Sulfur Recovery Plant. The DEA regenerator reboiler has been designed for a heating duty of 1500 Btu/gal of DEA solution circulated. Area 31 is sized to accommodate 110% of the stated design low-pressure gas feed rate.

Process Description The process configuration is shown on Process Flow Diagrams 31C06-101 and 31C06-102.

Sour hydrocarbon gas streams produced from the Area 11 Dissolver Plant, and from the Area 34 Refining Plant, at about 20 psia, are combined and compressed to 70 psia with the L.P. gas booster compressor. The compressed gas is then combined with additional sour gas streams produced from the Area 11 Dissolver Plant, Area 12 Hydrogen Treating and Recovery Plant, and the Area 34 Refining Plant. The combined L.P. gas stream is cooled in the L.P. gas cooler, to 100°F with cooling water and then is further cooled with a recycle hydrocarbon stream. This cooled feed stream flows into the L.P. gas compressor suction drum where liquid hydrocarbons and sour water are separated from the vapors. The hydrocarbon liquid collected in the L.P. gas compressor interstage suction drum is pumped to the debutanizer in Area 34 Refining Plant.

These vapors from the L.P. gas compressor suction drum are compressed in the first case of the L.P. gas compressor from 65 psia to 180 psia. They are cooled with cooling water then further cooled with a recycle hydrocarbon stream. Liquid hydrocarbons and sour water are separated from the vapors in the L.P. gas compressor interstage suction drum.

The vapors from the L.P. gas compressor interstage suction drum are then further compressed from 180 psia to 520 psia in the second case of the L.P. gas compressor and are cooled to 100°F with cooling water. After cooling, liquid hydrocarbons and sour water are separated from the vapors in the L.P. gas compressor discharge drum. Sour water is pressured to the Area 41 Ammonia Recovery Plant. The sour gas from the L.P. gas compression discharge drum flows to the L.P. gas DEA contactor.

The acid gases (H_2S and CO_2) present in the sour gas are removed by counter-current contacting with lean DEA solution in the L.P. gas DEA contactor. The sweet gas leaves the top of the contactor and enters the L.P. gas DEA contactor afterscrubber where it is washed with water to remove any

amine solution carried over from the contactor. The sweet gas then flows to the sweet gas cold box in Area 32.

Rich DEA solution, containing the H_2S and CO_2 and some entrained hydrocarbons removed from the sour gas, flow from the bottom of the L.P. gas DEA contactor to the DEA flash drum. Amine solution removed from the sweet gas in the afterscrubber flows to the DEA flash drum. The wash water from the L.P. gas DEA contactor afterscrubber also flows to the DEA flash drum. The DEA flash drum is operated at a low pressure to remove entrained hydrocarbon gases from the rich DEA solution. The hydrocarbon vapors from the DEA flash drum contain small quantities of acid gas which are removed by contacting the hydrocarbon vapors with a slipstream of lean DEA in a packed column. The sweetened gas from the DEA flash drum is sent to Area 54 Fuel System.

The flashed, rich DEA solution is heated by exchange with lean DEA solution in the rich/lean DEA solution exchanger and then flows to the DEA regenerator where the absorbed acid gases are removed by heating and steam stripping. The heat necessary to regenerate the DEA is supplied by a 50-psig steam reboiler. The acid gases and steam which come overhead from the DEA regenerator are cooled with cooling water and flow to the DEA reflux accumulator where a vapor-liquid separation is made. Steam condensate saturated with acid gases is returned to the DEA regenerator as reflux. The non-condensed acid gases containing some water vapor are sent to Area 33 Sulfury Recovery Plant.

The lean solution from the DEA surge tank is further cooled with cooling water and then is recirculated to the L.P. gas DEA contactor and the packed column. A ten percent slipstream of the circulating DEA solution is bypassed through a DEA solution filter to remove solid particles from the solution. Ten percent of this slipstream is also sent through a DEA solution activated-carbon filter to remove impurities and degradation products from the DEA solution.

Design Discussion. Because the low pressure gases are produced from the processing of coal, there is a possibility that a number of contaminants such as COS, CS₂ and HCN may be present in the various streams feeding this area. Therefore, the use of DEA instead of MEA or other amines is considered prudent because these possible contaminants will form non-regenerable degradation products with MEA but will not form them with DEA.

The DEA storage tank and DEA solution surge tank are nitrogen-blanketed to prevent degradation of the DEA by oxidation. A lined sump tank is also provided to collect any DEA solution which may be spilled or drained from the equipment during operation or maintenance.

3.5.2 Area 32 - Product Gas Plant

Area Definition. This area uses a sweet gas cold box, a refrigerated depropanizer, and a debutanizer to produce hydrogen-rich gas, ethane-propane gas mixture, commercial butane, and debutanized naphtha.

Design Basis. The sweet gas cold box is designed to minimize loss of ethane to the hydrogen-rich gas product and to produce an ethane/propane gas stream suitable for ethylene plant feedstock which contains a maximum of 5 mole percent methane. The desired separation is accomplished in the sweet gas cold box using a series of adiabatic flash separation and fractionation steps at low temperature.

The depropanizer is designed to operate at 220 psia and to limit a maximum of 2 mole percent propane in the bottom product and 99 mole percent recovery of the butane in the depropanizer feed. The debutanizer is designed to produce a butane product containing a maximum of 2 mole percent pentane and heavier hydrocarbon.

Process Description. The process configuration is shown on Process Flow Diagrams 32C06-101 and 32C06-102.

The sweet gas from Area 31 is fed to a fixed bed adsorber containing molecular sieves to remove trace quantities of water, carbon dioxide, and hydrogen sulfide. The sweet gas then enters the sweet gas cold box (cryogenic unit) where the stream is expanded by the feed gas expansion turbine, lowering its temperature to about -200°F . The methane and ethane components are partially liquified and the propane and heavier hydrocarbons are completely liquified in a series of feed-product exchange and adiabatic flash steps, thus producing a hydrogen-rich gas for use as the plant fuel. The condensed hydrocarbons are fed to a fractionation column where an ethane-propane gas mixture is taken overhead and a butane and heavier-liquid bottoms product is obtained. The ethane/propane gas product is used for ethylene plant feedstock and the butane and heavier liquid product is sent to the depropanizer for further fractionation.

A portion of the hydrogen-rich gas is heated and used to regenerate the molecular sieve adsorber. The gases from regeneration are cooled and returned to the hydrogen-rich gas headers. Parallel adsorbers are provided so that one may be regenerated while the other is on line.

The mixed butane from the sweet gas cold box is combined with propane-rich gas and butane-rich liquid streams produced from Area 12 Hydrogen Treating and Recovery Plant. The combined stream is heated by exchange with 50 psig steam and is charged to the depropanizer which is operated at 220 psia. The overhead vapors from the depropanizer are partially condensed in the depropanizer overhead cooler at 67°F using freon refrigeration. The liquid and vapor are separated in the depropanizer overhead accumulator and the liquid is used as reflux for the depropanizer. The non-condensed vapors from the depropanizer overhead accumulator combine with the ethane/propane gas stream from the sweet gas cold box. These propane and light ends mixtures are sent to the Area 12 Hydrogen Treating and Recovery Plant to combine with an ethane-rich gas stream in that plant. The depropanizer is reboiled with 50 psig steam.

The liquid from the bottom of the depropanizer is fed to the debutanizer. The overhead vapors from the debutanizer are totally condensed with cooling water. A portion of the condensed butane product is used for reflux and the remainder is pumped to the commercial-grade liquid butane Area 54 product storage tanks. Any non-condensable vapor present in the debutanizer overhead accumulator is vented to the ethane-propane gas stream header. The debutanizer is reboiled with 300 psig steam. The liquid leaving the bottom of the debutanizer is cooled and sent to the naphtha product storage tanks in Area 54.

Design Discussion. Feed composition to the sweet gas cold box is based on the components of product produced from Area 31 L.P. Gas Treating Plant. The sweet gas cold box maximizes recovery of ethane and propane suitable for ethylene plant feedstock, while limiting the methane content of this stream to 5 mole percent.

The sweet gas cold box is a package unit designed by Air Liquide to process 110 percent of the normal 68 MM scfd sweet-gas feed rate.

The process design for the light ends recovery in this area is based on well-proven technology. The design conditions for the depropanizer and the debutanizer maximize ethane-propane recovery and facilitate production of commercial-grade liquid butane.

3.5.3 Area 33 - Sulfur Recovery Plant

Area Definition. The Sulfur Recovery Plant includes a conventional Claus Unit with two sulfur converters in series, a Shell SUPERSHOT unit and an incineration unit. The Claus Unit is used to convert the H_2S in the acid gas feed to sulfur. The SUPERSHOT unit is used to convert sulfur compounds remaining in the tail gas from the Claus Unit to H_2S and to recover the H_2S produced for recycle back to the Claus Unit. The tail gas from the SUPERSHOT unit contains some CO and small quantities of H_2S and COS. The

incinerator is used to convert these compounds to CO_2 , H_2O , and SO_2 before the tail gas is released to the atmosphere.

The Sulfur Recovery Plant receives acid gas streams produced throughout the entire Conceptual Commercial Plant. H_2S and CO_2 are the primary components of these streams. Essentially all of the sulfur in the sulfur plant feed is converted to elemental sulfur in the liquid state and is pumped to the sulfur storage tank.

Design Basis. The Area 33 Sulfur Recovery Plant is designed to process all of the acid gas streams which contain H_2S and CO_2 produced by the entire Conceptual Commercial Plant. The raw coal used as a basis for design of the SRC-II Conceptual Commercial Plant contains 3.59 wt.% sulfur. Essentially all of the sulfur in the coal is recovered in Area 33 Sulfur Recovery Plant as elemental sulfur. The sulfur plant recovers 99.9% of the sulfur in the Area 33 feed and produces 1811 tpsd of liquid sulfur.

The concentration of H_2S in the feed gas to the Claus Unit is 38.7 mole percent. For flexibility, a split flow arrangement is specified in which one-third of the feed gas is burned in the Claus Reaction Furnace, and two-thirds of the feed gas bypasses the reaction furnace. Two sulfur converters in series are provided downstream of the reaction furnace. This design is capable of recovering approximately 95% of the sulfur in the feed gas. In addition, all equipment within the Claus Unit has been sized to handle 110% of the design feed rate in order to provide the flexibility to handle possible variations in the sulfur content of the coal feed to the plant.

The SUPERSHOT Unit recovers the sulfur compounds from the Claus Unit tail gas, converts them to H_2S , and returns them to Claus Unit feed. In order for the Shell SUPERSHOT Unit to handle upsets that might occur in the Claus Unit, the SUPERSHOT Unit is designed to handle tail gas resulting from as low as 92.5% recovery of sulfur in the Claus Unit. The material balance on the Area 33 flow sheets reflects this low Claus recovery and therefore represents

the highest sulfur emissions expected rather than normal operation. In addition, the SUPERSHOT equipment has been sized to handle 110% of the design feed rate.

The gasifier flash gas from Area 21 is fed to the SUPERSHOT H_2S absorber so that the H_2S , along with the sulfur in the tail gas from the Claus Unit, can be recovered and the CO , H_2 , and CH_4 can be burned in the incinerator to minimize outside fuel gas requirements.

The incinerator is designed to burn any impurities and contaminants remaining in the SUPERSHOT Vent Gas and in the CO_2 -rich gas produced from the Selexol Area 23 Hydrogen Purification and Compression Plant, thereby converting them to CO_2 , SO_2 , and H_2O . Again, all equipment in this area is designed for 110% of the design feed rate. The incinerator stack is designed for an inlet temperature of $500^{\circ}F$, which should result in an exit temperature above $400^{\circ}F$ from the 150-ft. stack.

Process Description. The process configuration is shown on Process Flow Diagrams 33C06-101 through 33C06-103.

Acid gas streams from Area 12 Recycle Gas Treating, Area 23 Hydrogen Purification and Compression Plant, Area 24 Syngas Purification Plant, Area 31 Low-Pressure Gas Compression and Treating Plant, and Area 41 Ammonia Recovery Plant, are combined and charged to the Claus Unit along with a recycle stream from the SUPERSHOT Unit. Some sour water and liquid hydrocarbons in the feed gas are separated in the acid gas K.O. drum, and sent to Area 41 Ammonia Recovery Plant. With the split flow design, approximately one-third of the acid gas feed is charged to the Claus reaction furnace and the remaining two-thirds of the acid gas feed is bypassed around the reaction furnace and waste heat boiler.

Combustion air is fed to the reaction furnace along with the acid gas feed. This results in conversion of the H_2S in the acid gas feed to SO_2 . The hot product vapors from the reaction furnace are cooled in the waste heat boiler by generation of 650 psig saturated steam from preheated

boiler feedwater. The cooled vapors from the waste heat boiler then combine with the acid gas feed that bypassed the furnace and waste heat boiler. This combined stream is heated to a temperature of 420⁰F by direct mixing with a 1200⁰F hot bypass vapor stream from the waste heat boiler. The hot vapor stream flows to the No. 1 sulfur converter where the H₂S and CO₂ in the vapor react to form elemental sulfur and water.

The vapor from the No. 1 sulfur converter is then cooled and the sulfur condensed by generation of 50 psig steam in the No. 1 sulfur condenser. The condensed sulfur flows to the sulfur storage pit. The non-condensed vapors from the No. 1 sulfur condenser are reheated to 420⁰F by direct mixing with a second 1200⁰F bypass vapor stream from the waste heat boiler. The hot vapor then enters the No. 2 sulfur converter where more elemental sulfur is produced.

The vapors from the No. 2 sulfur converter are then cooled by generation of 50 psig steam in the No. 2 sulfur condenser and heating of boiler feed water in the No. 3 sulfur condenser. The elemental sulfur which is condensed in the No. 2 and No. 3 sulfur condensers also flows to the sulfur storage pit. The non-condensed vapors from the No. 3 sulfur condenser flow through the tail gas separator where some entrained liquid sulfur is removed, and then flow on to the SUPERSHOT Unit.

The sulfur in the storage pit is kept in the liquid state by heating with 50 psig steam. The liquid sulfur is then pumped to the Area 54 liquid sulfur storage tank. No bulk storage for solid sulfur is provided.

The boiler feedwater which is preheated in the No. 3 sulfur condenser is used in the No. 1 and No. 2 sulfur condensers, and in the waste heat boiler on the SUPERSHOT Unit. All of these steam generators produce 50-psig saturated steam.

The Claus Unit tail gas is mixed with a reducing gas (primarily hydrogen), supplied from Area 23 Hydrogen Purification and Compression Plant, and then is

heated by direct mixing with the hot combustion products from the burning of a fuel gas stream with air in the SUPERSHOT inline burner/mixer. The heated vapors go to the hydrogenation reactor where elemental sulfur and sulfur compounds are converted to H_2S . The reactor effluent is cooled by generation of 50-psig steam in the SUPERSHOT waste heat boiler and by direct quenching with water in the quench tower. The cooled vapors are then combined with the flash gas from Area 21 Syngas Production Plant and flows to the H_2S absorber where they are contacted with the SUPERSHOT solvent. The solvent, which selectively absorbs H_2S in the presence of CO_2 , absorbs nearly all of the H_2S , along with some CO_2 . The vent gas from the absorber goes to the incineration unit. The rich solvent from the H_2S absorber is preheated by exchange with the lean solvent and is charged to the solution stripper.

The rich solvent solution is stripped of H_2S and CO_2 in the stripper reboiler with 50-psig steam. The stripper overhead vapors, which consist of H_2S , CO_2 , and H_2O , are first condensed with a fan-type air cooler and then are further condensed by exchange with cooling water. The resulting vapor/liquid mixture is separated in the stripper reflux drum. The H_2S and CO_2 rich vapors from the reflux drum are recycled back to the Claus Unit. Part of the liquid condensate is used as reflux to the stripper and the excess condensate not required for reflux is fed to the sour water stripper in Area 41 Ammonia Recovery Plant. The regenerated lean solvent from the bottom of the stripper is cooled by exchange with rich solvent feed, and by exchange with cooling water, and recirculated back to the H_2S absorber.

The vent gas from the H_2S absorber, and the CO_2 -rich gas from Area 23 Hydrogen Purification and Compression Plant are mixed and preheated by exchange with the hot combustion products from the incinerator in the waste heat recovery exchanger. Fuel gas and combustion air are then added to the incinerator feed. This mixture is burned in the incinerator to heat the gases to the stack gas temperature ($1200^{\circ}F$) required for complete oxidation of all contaminants. The combustion products are cooled to $500^{\circ}F$ in the waste heat recovery exchanger and are vented to the atmosphere through the incinerator stack.

Design Discussion. The process design and equipment sizes used in the Claus, SUPERSHOT, and incineration units of Area 33 are all of existing and proven technology. Therefore, startup, shutdown, operation, and maintenance of the units are of established reliability and no problems are expected. The design and nature of the processes allow for considerable variations in the feed composition. This will permit reasonable variations in the sulfur content of the raw coal feed to the plant. A turndown of approximately 50% is possible and, if need be, special considerations during detailed design could improve upon this figure. Some alloy metals are required in particularly corrosive sections of the SUPERSHOT solution stripper, but otherwise carbon steel is satisfactory.

3.5.4 Area 34 - Refining Plant

Area Definition. The Area 34 Refining Plant fractionates liquid hydrocarbon feeds and oil-solids slurry streams produced in the cooling and separation section of the Area 11 Dissolver Plant. Also, light ends absorbed in the rich oil from the recycle gas oil wash absorber located in Area 12 are removed and the resultant lean oil stream is returned to Area 12. Miscellaneous condensed hydrocarbon streams from Areas 11, 12, 31, and 32 are also collected and fractionated in the Refining Plant.

The Refining Plant includes an atmospheric fractionator, naphtha stabilizer (debutanizer) and two parallel vacuum flash units. The atmospheric fractionator produces the following five product streams:

1. Low-Pressure Offgas
2. Unstabilized Light Naphtha
3. Heavy Naphtha
4. Side Draw Low-Boiling Distillate Fuel Oil
5. High-Boiling Fuel Oil Bottoms

The net fuel oil products are sent to storage in Area 54. The overhead low-pressure offgas product is routed to Area 31.

The unstabilized light naphtha, and a recycle condensate feed produced in Area 31, are fed to the naphtha stabilizer (debutanizer). The naphtha stabilizer is operated to produce a debutanized naphtha bottoms product with a maximum Reid vapor pressure of 10 psia and an overhead gas product which is routed to the Area 31 Low-Pressure Gas Compression and Treating Plant. The debutanized light naphtha from the stabilizer, and the heavy naphtha from the fractionator, are sent to the untreated naphtha storage tank in Area 54.

The two vacuum flash units process the oil-solids slurry stream produced in the Area 11 Dissolver Plant. The vacuum flash ejector system is designed to obtain a vacuum of 20 mm Hg absolute at the vacuum flash drums in order to minimize the quantity of the heavy bottoms slurry produced which must be fed to the Area 21 Gasifier Unit. The overhead products from the two vacuum flash drums are recycled back to the atmospheric fractionator for additional fractionation.

Design Basis. The fractionation design is based on computer simulation using the following design basis:

1. The cut point between heavy naphtha and lower boiling fuel oil was set at 350°F. The 350°F cut point for the combined naphtha product was specified to maximize production of fuel oil.
2. The cut point between the low boiling side draw fuel oil and the higher boiling heavy fuel oil bottoms was set at 600°F
3. The vacuum flash drums are designed to operate at 20 mm Hg absolute at the overhead nozzle in order to minimize bottoms slurry production while limiting the operating temperature to a maximum of 650°F. The design limit on the solids content of the bottoms slurry stream is 50%.

4. The solids contents of all net products sent to storage are limited to a maximum of 0.015%.
5. The naphtha stabilizer (debutanizer) is designed to remove essentially all of the C_4 and lighter hydrocarbons present in the feed to produce a debutanized bottoms product.

Process Description. The process configuration is shown on Process Flow Diagrams 34C06-101 through 103.

Solids-free streams produced from the Area 11 Dissolver Plant are charged to the atmospheric fractionator. They are the low-pressure hot feed and the low pressure cold feed. The low-pressure cold feed is first charged to a surge drum where the pressure is reduced and a vapor/liquid separation made. The vapor feed from the surge drum flows directly to the top of the fractionator. The liquid feed is preheated by exchange with the fractionator bottoms and further heated in a fired heater before entering the fractionator. The low-pressure hot feed flows directly to the fractionator and enters the tower near the bottom of the rectification section. Other feed streams include a rich absorption oil from the recycle gas-oil wash absorber in Area 12 and a heavy oil which is obtained as the overhead product from the two vacuum flash towers. The rich absorption oil is first charged to a surge drum where the pressure is reduced and a vapor/liquid separation is made. The vapor from the surge drum is sent to the Area 31 Low-Pressure Gas Compression and Treating Plant. The liquid from the surge drum is heated by exchange with fractionator bottoms and is fed to the fractionator. Heat input to the fractionator is supplied by a fired heater. Superheated steam is injected into the bottom stripping section of the fractionator to assist in removal of light ends from the bottoms product. Sidestream strippers are used to remove light ends from the heavy naphtha and lower-boiling fuel oil products and to meet flash point specifications.

The vapors taken overhead from the fractionator are cooled to 120°F and sent to the overhead accumulator where a vapor/liquid separation is made. The vapors from the overhead accumulator are sent to the Area 31 Low Pressure Gas

Compression and Treating Plant. Sour water is separated from the liquid hydrocarbons collected in the overhead accumulator and is pumped to the sour water stripper located in the Area 41 Ammonia Recovery Plant. Some of the hydrocarbon liquid from the overhead accumulator is used as reflux to the top of the fractionator. The net hydrocarbon liquid product from the accumulator is combined with a light condensate stream from the Area 31 Low-Pressure Gas Compression and Treating Plant and is fed to the naphtha stabilizer (debutanizer).

The naphtha stabilizer (debutanizer) is operated to produce a debutanized naphtha bottoms product free of H_2S , H_2 , and dissolved light hydrocarbon gases. Heat required for fractionation is supplied by 600 psig steam via and debutanizer reboiler exchanger. The overhead vapors are cooled to $130^{\circ}F$ and are sent to the debutanizer overhead accumulator where a vapor/liquid separation is made. The vapors from the accumulator are sent to the Area 31 Low Pressure Gas Compression Treating Plant for further processing. Sour water is separated from the liquid hydrocarbons collected in the overhead accumulator and is sent to the sour water stripper located in the Area 41

Ammonia Recovery Plant. The hydrocarbon liquids recovered in the overhead accumulator are used to supply reflux to the top of the debutanizer. The bottoms product from the Debutanizer is cooled to 120°F and is sent to untreated naphtha storage in Area 54.

The hot oils-solids slurry stream from the Area 11 Dissolver Plant is fed directly into the two vacuum flash drums without heating. The vacuum flash drums operate at a vacuum of 20 mm Hg absolute at the overhead nozzles. This vacuum is produced by a four-stage condensing ejector system. The overhead vapors from the flash drums are condensed, cooled to 150°F, and are pumped to the atmospheric fractionator for additional fractionation. The hot slurry oil bottoms streams from the vacuum flash drums are pumped directly to the gasifiers in Area 21. Oil-water mixtures collected at the hotwell for the vacuum ejector system are separated. The recovered oil is combined with the overhead products from the vacuum flash drums and is sent to the atmospheric fractionator. The sour water is sent to the sour water stripper located in Area 41 Ammonia Recovery Plant.

Design Discussion. Only conventional equipment has been used in the Refining Plant and all pumps have been spared for added operational reliability. Minimum maintenance requirements are anticipated, except in the area of the vacuum flash bottoms. Some erosion and plugging problems can be expected due to the high temperatures and the high solids content.

Considerable flexibility has been provided in the design of the fractionation equipment to allow for variations in product yields obtained from various types of coal and for operation at reduced production rates. Although only one atmospheric fractionator is provided, two duplicate vacuum flash units have been provided so that the entire plant can be operated at 50% of capacity if one of the vacuum flash trains is down for maintenance.

TABLE 3-20
AREA 31 - LOW PRESSURE GAS COMPRESSION & TREATING PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN CONDITIONS	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Compressors</u>				
C31C102	L.P. Gas Compressor	1st case 59,500 scfm, 120 psi Δ P, 2nd case 58,500 scfm, 340 psi Δ P, 13,000 hp, carbon steel, Turbine Driven		
C31C103	L.P. Gas Booster Compressor	11,000 scfm 50 psig Δ P, 1,500 hp. Carbon Steel, Electrical Motor Driven		
<u>Heat Exchangers</u>			<u>SS/TS</u>	<u>SS/TS</u>
E31C104	L.P. Gas Compressor	18.5 MMBtu/hr., Carbon Steel.	300/150	560/75
E31C106	Rich/Lean DEA Solution Exchanger	103.1 MMBtu/hr., Carbon Steel.	350/300	50/100
E31C107	DEA Regenerator Reboiler	158.0 MMBtu/hr., Carbon Steel.	350/350	50/75
E31C108	DEA Regenerator Reflux Cooler	107.8 MMBtu/hr., Carbon Steel.	300/200	50/75
E31C111	L.P. Gas Cooler	7.8 MMBtu/hr., Carbon Steel.	200/150	100/75
E31C112	L.P. Gas Compressor Interstage Cooler	18.5 MMBtu/hr., Carbon Steel.	300/150	230/75
E31C114	DEA Solution Cooler	55.6 MMBtu/hr., Carbon Steel.	200/150	150/75
E31C115	L.P. Gas Compressor Turbine Surface Condenser	108.3 MMBtu/hr., Carbon Steel.	300/200	50/75

TABLE 3-20
AREA 31 - LOW PRESSURE GAS COMPRESSION & TREATING PLANT

EQUIPMENT LIST

3-101

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN CONDITIONS	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Pumps</u>				
P31C102 A,B	DEA Solution Circulation Pump	2,000 gpm, 480 psi Δ P, 800 hp., Carbon Steel.		
P31C103 A,B	DEA Regenerator Reflux Pump	200 gpm, 45 psi Δ P, 10 hp., Carbon Steel.		
P31C104 A,B	L.P. Gas Compressor Hydrocarbon Condensate Pump	45 gpm, 132 psi Δ P, 6 hp., Carbon Steel.		
P31C105 A,B	L.P. Gas Compressor Turbine Condensate Pump	230 gpm, 92 psi Δ P, 20 hp., Carbon Steel.		
P31C106 A,B	DEA Solution Booster Pump	2,200 gpm, 125 psi Δ P, 250 hp., Carbon Steel.		
P31C107 A,B	DEA Make-Up Pump	30 gpm, 30 psi Δ P, 2 hp., Carbon Steel.		
P31C108	Amine Sump Pump	60 gpm, 19 psi Δ P, 2 hp., Carbon Steel.		
<u>Filter Equipment</u>				
S31C102 A,B	Dea Solution Diatomaceous Filter	5 microns, 220 gpm, Carbon Steel.	200	150
S31C103 A,B	DEA Solution Activated	5 microns, 25 gpm, Carbon Steel.	200	150

TABLE 3-20
AREA 31 - LOW PRESSURE GAS COMPRESSION & TREATING PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN CONDITIONS	
			TEMPERATURE (F)	PRESSURE (PSIG)
Vessels				
V31C103	L.P. Gas Compressor Suction Drum	84" ID x 22'-0" TT, Carbon Steel.	150	100
V31C111	DEA Regenerator	102" ID & 162" ID x 58'-0" TT, Carbon Steel with 20 SS trays.	320	70
V31C113	DEA Regenerator Reflux Accumulator	56" ID x 14'-0" TT, Carbon Steel.	150	70
V31C114	L.P. Gas Booster Compressor Suction Drum	60" ID x 16'-0" TT, Carbon Steel.	170	50
V31C115	L.P. Gas Compressor Interstage Suction Drum	66" ID x 21'-0" TT, Carbon Steel.	150	210
V31C116	L.P. Gas Compressor Discharge Drum	54" ID x 19'-0" TT, Carbon Steel.	150	550
V31C120	L.P. Gas DEA Contactor	108" ID x 62'-0" TT, Carbon Steel, 25 SS trays	170	550
V31C121	L.P. Gas DEA Contactor After-Scrubber	48" ID x 13'-0" TT, Carbon Steel.	170	550
V31C122	DEA Flash Drum	18" ID x 10'-0" TT, with 7' packing & 96" ID x 32'-0" TT, Carbon Steel.	170	100
V31C123	L.P. Gas Compressor Turbine Steam Ejector Hotwell	18" ID x 3'-0" TT, Carbon Steel.	150	50
V31C124	Amine Sump	18' (L) x 14' (W) x 7' (H) Carbon Steel	200	10

TABLE 3-20
AREA 31 - LOW PRESSURE GAS COMPRESSION & TREATING PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN CONDITIONS	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Tanks</u>				
T31C101	DEA Solution Surge Tank	16'-0" ID x 17'-0" Vert. Carbon Steel. 25,000 gallons.	200	
T31C102	DEA Storage Tank	12'-0" ID x 10'-0" Vert. Carbon Steel. 8,000 gallons.	150	
<u>Packaged Equipment</u>				
U31C101	L.P. Gas Compressor Steam Ejector System	4" Hg absolute, include the following *		
U31C101 (E1)	1st stage Vacuum Condensor	Carbon Steel.		
U31C101 (E2)	2nd stage Vacuum Condensor	Carbon Steel.		
U31C101 (J1)	1st stage Ejector	Cast Iron.		
U31C101 (J2)	2nd stage Ejector	Cast Iron.		

TABLE 3-22
AREA 32 - PRODUCT GAS PLANT

EQUIPMENT LIST

<u>EQUIPMENT NUMBER</u>	<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>DESIGN</u>	
			<u>TEMPERATURE (F)</u>	<u>PRESSURE (PSIG)</u>
<u>Compressors</u>				
C32C101	Ethane Reflux Compressors	16,000 scfm, 490 psi ΔP, 3,000 hp. Electric Motor Driver. Carbon Steel		
C32C102	Ethane Column Feed Compressor	12,100 scfm, 90 psi ΔP, 2,250 hp. (1,000 hp power recovery from Feed Gas Expansion Turbine, combined with 1,250 hp. Electric Motor Driver), Carbon Steel		
<u>Heat Exchangers</u>			<u>SS/TS</u>	<u>SS/TS</u>
E32C101	Adsorber Regeneration Cooler	N/A	N/A	N/A
E32C102	Adsorber Regeneration Heater	N/A	N/A	N/A
E32C103	Depropanizer Feed Heater	12.7 MMBtu/hr, Carbon Steel.	350/250	75/300
E32C104	Depropanizer Reboiler	12.2 MMBtu/hr, Carbon Steel.	350/300	75/300
E32C105	Depropanizer Overhead Cooler	16.6 MMBtu/hr, Carbon Steel.	150/150	250/50
E32C106	Naphtha Product Cooler	0.5 MMBtu/hr, Carbon Steel.	400/200	200/70
E32C107	Debutanizer Reboiler	0.5 MMBtu/hr, Carbon Steel.	400/200	200/70
E32C108	Debutanizer Overhead Condenser	12.0 MMBtu/hr, Carbon Steel.	250/200	200/70
E32C109	Ethane Column Feed Compressor Cooler	6.0 MMBtu/hr, Carbon Steel.	300/150	150/75

TABLE 3-22
AREA 32 - PRODUCT GAS PLANT

EQUIPMENT LIST

<u>EQUIPMENT NUMBER</u>	<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>DESIGN</u>	
			<u>TEMPERATURE (F)</u>	<u>PRESSURE (PSIG)</u>
E32C110	Ethane Column Reboiler	N/A	N/A	N/A
E32C111	Ethane Reflux Compressor Cooler	20.1 MMBtu/hr, Carbon Steel.	350/150	600/75
<u>Pumps</u>				
P32C101 A,B	Depropanizer Feed Pump	150 gpm, 195 psi Δ P, 25 hp, Carbon Steel.		
P32C102 A,B	Depropanizer Reflux Pump	400 gpm, 60 psi Δ P, 25 hp, Carbon Steel.		
P32C103 A,B	Debutanizer Reflux Pump	240 gpm, 55 psi Δ P, 15 hp, Carbon Steel.		
P32C104	Brine Water Pump	1,200 gpm, 118 psi Δ P, 125 hp, Carbon Steel.		
<u>Filter Equipment</u>				
S32C101	Dust Filter	N/A	N/A	N/A
<u>Expander</u>				
ET32C101	Feed Gas Expansion Turbine	N/A	N/A	N/A
<u>Vessels</u>				
V32C101	Knockout Drum	72" ID x 18'-0" TT, Carbon Steel.	150	50
V32C102 A,B	Adsorber	N/A	N/A	N/A

TABLE 3-22
AREA 32 - PRODUCT GAS PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
V32C103	Brine Water Surge Drum	84" ID x 21'-0" TT, Carbon Steel.	100	20
V32C104	Depropanizer Feed Surge Drum	48" ID x 10'-0" TT, Carbon Steel.	150	100
V32C105	Depropanizer Overhead Accumulator	66" ID x 20'-0" TT, Carbon Steel.	150	250
V32C106	Depropanizer	66" ID x 75'-0" TT, Carbon Steel with 30 C.S. trays.	300	250
V32C107	Debutanizer	54" x 75'-0" TT, Carbon Steel with 30 C.S. trays.	400	200
V32C108	Debutanizer Overhead Accumulator	54" ID x 18'-0" TT, Carbon Steel	200	200
<u>Packaged Equipment</u>				
U32C101	Sweet Gas Cold Box	N/A	N/A	N/A
U32C102	Depropanizer Refrigeration Unit	N/A	N/A	N/A

TABLE 3-24
AREA 33 - SULFUR RECOVERY PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Air Cooled Equipment</u>				
A33C101	Stripper Overhead Air Cooler	N/A	N/A	N/A
<u>Boilers</u>			<u>SS/TS</u>	<u>SS/TS</u>
B33C101	Claus Waste Heat Boiler	239.6 MMBtu/hr, Carbon Steel.	550/3000	750/35
B33C102	SCOT Waste Heat Boiler	N/A	N/A	N/A
<u>Compressors</u>				
C33C101	Combustion Air Blower	68,000 scfm, 14.5 psiΔP, 4,800 hp. Carbon Steel, Turbine Driven.	250	35
C33C102	Incinerator Air Blower	55,000 scfm, 3.5 psiΔP, 1,250 hp. Carbon Steel, Motor Driven.	150	25
<u>Heat Exchangers</u>				
E33C101	No. 1 Sulfur Condenser	67.87 MMBtu/hr, Carbon Steel.	350/750	75/25
E33C102	No. 2 Sulfur Condenser	29.15 MMBtu/hr, Carbon Steel.	350/500	75/25
E33C103	No. 3 Sulfur Condenser	6.19 MMBtu/hr, Carbon Steel.	350/350	100/25
E33C105	SCOT Quench Cooler	N/A	N/A	N/A
E33C106	H ₂ S Absorber Feed Cooler	N/A	N/A	N/A
E33C108	Lean Solution Cooler	N/A	N/A	N/A

TABLE 3-24
AREA 33 - SULFUR RECOVERY PLANT

EQUIPMENT LIST

<u>EQUIPMENT NUMBER</u>	<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>DESIGN</u>	
			<u>TEMPERATURE (F)</u>	<u>PRESSURE (PSIG)</u>
E33C109	Lean/Rich Solution Exchanger	N/A	N/A	N/A
E33C110	Stripper Reflux Condenser	N/A	N/A	N/A
E33C111	Stripper Reboiler	N/A	N/A	N/A
E33C114	Waste Heat Recovery Exchanger	583.9 MMBtu/hr, 500,000 scfm, 304SS corrugated plate	1500	25
E33C115	Turbine Surface Condenser	27.31 MMBtu/hr, Carbon Steel.	175/160	FV + 150/75
<u>Furnaces and Stacks</u>				
H33C101	Claus Reaction Furnace	290.0 MMBtu/hr. heat release, 3,000 ft. ³ volume, Refractory Lined, Carbon Steel.	3100	40
H33C103	SCOT Inline Burner/Mixer	N/A	N/A	N/A
H33C105	Incinerator	18' ID x 52 TT, Refractory Lined, Carbon Steel.	1500	20
H33C106	Incinerator Stack	28'-0" ID base, 20'-0" ID x 150' high, Refractory Lined	700	10
<u>Pumps</u>				
P33C101 A,B	Sulfur Product Pump	132 gpm, 60 psi P, 10 hp. Cast Iron	290	60
P33C102 A,B	Quench Circulation Pump	N/A	N/A	N/A

TABLE 3-24
AREA 33 - SULFUR RECOVERY PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
P33C103 A,B	Rich Solution Pump	N/A	N/A	N/A
P33C104 A,B	Lean Solution Pump	N/A	N/A	N/A
P33C105 A,B	Stripper Reflux Pump	N/A	N/A	N/A
P33C107 A,B	Solvent Transfer Pump	N/A	N/A	N/A
P33C108 A,B	Solvent Sump Pump	N/A	N/A	N/A
P33C111 A,B	Turbine Condensate Pump	75 gpm, 57 psi Δ P, 5 hp, Carbon Steel.	150	50
<u>Filter Equipment</u>				
S33C101 A,B	Quench Water Filter	N/A	N/A	N/A
S33C102 A,B	Lean Solution Filter	N/A	N/A	N/A
<u>Storage Tanks</u>				
T33C101	Solvent Storage Tank	N/A	N/A	N/A
<u>Packaged Process Units</u>				
U33C103	Turbine Steam Ejector System	2 stage with intercooler & aftercooler, 3 Hg suction.		
<u>Vessels</u>				
V33C101	Acid Gas K.O Drum	138" ID x 14' TT, Carbon Steel.	175	40

3-109A

TABLE 3-24
AREA 33 - SULFUR RECOVERY PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
V33C102 A,B	No. 1 Sulfur Converter	240" ID x 86' TT, Carbon Steel w/Internal Refractory, 4,900 ft ³ Alumina Catalyst	725	30
V33C103 A,B	No. 2 Sulfur Converter	240" ID x 86' TT, Carbon Steel w/Internal Refractory, 4,900 ft ³ Alumina Catalyst	550	25
V33C104	Tail Gas Separator	144" ID x 24' TT, Carbon Steel.	325	25
V33C105	Hydrogenation Reactor	N/A	N/A	N/A
V33C106	Quench Tower	N/A	N/A	N/A
V33C107	Absorber Inlet Scrubber	N/A	N/A	N/A
V33C108	H ₂ S Absorber	N/A	N/A	N/A
V33C109	Solution Stripper	N/A	N/A	N/A
V33C110	Stripper Reflux Accumulator	N/A	N/A	N/A
V33C113	L.P. Steam Separator	108" ID x 18'-6" TT, Carbon Steel.	350	100
V33C114	Solvent Sump	N/A	N/A	N/A
V33C115	Hotwell	N/A	N/A	N/A

3-109B

TABLE 3-26
AREA 34 - REFINING PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Air Cooled Equipment</u>				
A34C101	Fractionator Overhead Condenser	396.7 MM Btu/hr, Fans 812 hp.		
A34C102	Higher Boiling Fuel Oil Product Cooler	15 MM Btu/hr, Fans 50 hp.		
A34C103	Debutanizer Bottoms Air Cooler	16 MM Btu/hr, Fans 54 hp.		
A34C104	Lower Boiling Fuel Oil Cooler	80 MM Btu/hr		
A34C106	Vacuum Flash Overhead Condenser	88.1 MM Btu/hr, Fans 589 hp.		
A34C107	Heavy Naphtha Product Air Cooler	14.37 MM Btu/hr, Fans 48 hp.		
<u>Compressors</u>				
C34C131	Vapor Recovery Compressor	1500 scfm, 5 psi Δ P, 150 hp, Carbon Steel		
<u>Heat Exchangers</u>			<u>SS/TS</u>	<u>SS/TS</u>
E34C101	Fractionator Overhead Trim Cooler	28.0 MM Btu/hr, Carbon Steel Tubes	200/170	50/100
E34C105	Lower Boiling Fuel Oil Trim Cooler	11.9 MM Btu/hr, Carbon Steel Tubes	200/170	185/100

TABLE 3-26
AREA 34 - REFINING PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
E34C109	Fractionator Pumparound Cooler	150 MM Btu/hr, Carbon Steel Tubes	420/200	125/100
E34C111	Debutanizer Overhead Condenser	9.5 MM Btu/hr, Carbon Steel Tubes	235/170	125/100
E34C112	Debutanizer Feed Heater	5.5 MM Btu/hr, Carbon Steel Tubes	415/325	130/130
E34C113	Debutanizer Reboiler	20 MM Btu/hr, Carbon Steel Tubes	415/550	130/660
E34C114	Debutanizer Bottoms Trim Cooler	0.889 MM Btu/hr, Carbon Steel Tubes	200/170	130/100
E34C120	Higher Boiling Fuel Oil Trim Cooler	2.5 MM Btu/hr, Carbon Steel Tubes	200/170	135/100
E34C125	Vacuum Overhead Condenser	43.8 MM Btu/hr, Carbon Steel Tubes	700/625	30+FV/100
E34C133	Heavy Naphtha Product Trim Cooler	3 MM Btu/hr, Carbon Steel Tubes	200/70	90/100
E34C134	L.P. Cold Feed Preheater	77.5 MM Btu/hr, Carbon Steel Tubes	450/515	135/135
E34C135	Rich Oil/Higher Boiling Fuel Oil Exchanger	77.5 MM Btu/hr, Carbon Steel Tubes	475/660	95/135
E34C136 A,B	Vacuum Flash Overhead/Lower Boiling Fuel Oil Exchanger	30 MM Btu/hr, Carbon Steel Tubes	510/373	185/100
<u>Fired Heaters</u>				
H34C131	Mineral Residue Slurry Heater	11.8 MM Btu/hr	550	25

TABLE 3-26
AREA 34 - REFINING PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
H34C132	Fractionator Reboiler	309.5 MM Btu/hr, Radiant 30.0 MM Btu/hr, Convective	800	178
H34C133	Fractionator Feed Heater	56.8 MM Btu/hr.	550	60
<u>Mixers</u>				
M34C131 A,B	Mineral Residue Slurry Tank Mixer	Type 304 SS, 14 hp.		
M34C132 A,B	MRS Dilution Tank Mixer	Type 304 SS, 75 hp.		
<u>Pumps</u>				
P34C101 A,B	Fractionator Reflux Pump	159 gpm, 115 psi Δ P, 25 hp, Carbon Steel		
P34C102 A,B	Side Stream Stripper Bottoms Pump	2446 gpm, 135 psi Δ P, 250 hp, Carbon Steel		
P34C103 A,B	Fractionator Bottoms Pump	2266 gpm, 135 psi Δ P, 250 hp, Carbon Steel		
P34C105 A,B	Fractionator Accumulator Sour Water Pump	66 gpm 135 psi Δ P, 5 hp, Carbon Steel		
P34C109 A,B	Fractionator Pumparound Cooler Pump	3510 gpm, 36 psi Δ P, 100 hp, Carbon Steel		
P34C111 A,B	Debutanizer Reflux Pump	125 gpm, 30 psi Δ P, 5 hp, Carbon Steel		
P34C112 A,B	Low Pressure Feed Pump	1278 gpm, 70 psi Δ P, 75 hp, Carbon Steel		

TABLE 3-26
AREA 34 - REFINING PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
P34C121 A,B,C,D	Vacuums Flash Accumulator Bottoms Pump	1234 gpm, 49 psi Δ P, 50 hp, Carbon Steel		
P34C122 A,B,C,D	Vacuum Bottoms Pump	1821 gpm, 65 psi Δ P, 200 hp, Carbon Steel		
P34C123 A,B	Vacuum Hotwell Oil Pump	20 gpm, 35 psi Δ P, 2 hp, Carbon Steel		
P34C124 A,B	Vacuum Hotwell Water Pump	25 gpm, 45 psi Δ P, 2 hp, Carbon Steel		
P34C133 A,B	Solvent Make-Up Pump	250 gpm, 150 psi Δ P, 50 hp, Carbon Steel		
P34C134 A,B	Solvent Dilution Pump	6250 gpm, 50 psi Δ P, 250 hp, Carbon Steel		
P34C135	Slops/Heavy Oil Pump	313 gpm, 150 psi Δ P, 50 hp, Carbon Steel		
P34C136 A,B,C,D	Mineral Residue Slurry Pump	876 gpm, 150 psi Δ P, 125 hp, Carbon Steel		
P34C139 A,B	Fractionator Reboiler Pump	3076 gpm, 60 psi Δ P, 150 hp, Carbon Steel		
P34C143 A,B	Heavy Naphtha Product Pump	436 gpm, 40 psi Δ P, 150 hp, Carbon Steel		
P34C144 A,B,C	MRS Circ./Transfer Pump	220 gpm, 50 psi Δ P, 15 hp, Carbon Steel		
<u>Storage Tanks</u>				
T34C133	Solvent Tanks	80' Dia. x 40'-0" high 35,000 bbl, Carbon Steel		
T34C134	Mineral Residue Storage Tank	240" Dia. x 20'-0" high 2,000 bbl, Carbon Steel		

TABLE 3-26
AREA 34 - REFINING PLANT

EQUIPMENT LIST

<u>EQUIPMENT NUMBER</u>	<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>DESIGN</u>	
			<u>TEMPERATURE (F)</u>	<u>PRESSURE (PSIG)</u>
T34C135	Slops Tank	67' Dia. x 40'-0" high 25,000 bbl, Carbon Steel		
T34C136 A/B	Dilute MRS Hold Tank	80' Dia. x 40'-0" high 35,000 bbl, Carbon Steel		
<u>Packaged Process Equipment</u>				
U34C122 A,B	Vacuum Ejector System	N/A		
<u>Vessels</u>				
V34C102	Atmospheric Fractionator	360" ID x 65'-0" TT, CS clad w/316L, SS, 28 sieve trays, Hastalloy	620	50
V34C103	Fractionator Overhead Accumulator	168" ID x 42'-0" TT, with water boot 48" ID x 12" TT, Carbon Steel	170	50
V34C104	Fractionator Side Stream Stripper	72" ID x 18'-0" TT, Carbon Steel clad w/316L, SS, 6 sieve trays, Hastalloy	520	50
V34C111	Debutanizer	102" ID x 58'-0" TT, Carbon Steel, 26 sieve trays, 304 TT	415	125
V34C112	Debutanizer Overhead Accumulator	84" ID x 21'-0" TT with water boot, 24" ID x 6'-0" TT, Carbon Steel	170	125
V34C114	Rich Oil Surge Drum	264" ID x 66'-0" TT, Carbon Steel	170	80
V34C115	Low Pressure Feed Surge Drum	324" ID x 81'-0" TT, Carbon Steel	170	130

TABLE 3-26
AREA 34 - REFINING PLANT

EQUIPMENT LIST

<u>EQUIPMENT NUMBER</u>	<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>DESIGN</u>	
			<u>TEMPERATURE (F)</u>	<u>PRESSURE (PSIG)</u>
V34C121 A,B	Vacuum Flash Drum	480" ID x 24'-0" TT and 84" ID x 20'-0" TT, 72'-6" overall TT, Carbon Steel	690	30
V34C122 A,B	Vacuum Flash Overhead Accumulator	60" ID x 20'-6" TT, Carbon Steel	170	30
V34C123	Vacuum Hotwell	60" ID x 15'-0" TT, Carbon Steel with internal weir	170	30

TABLE 3-19
AREA 31 - L.P. GAS COMPRESSION AND TREATING PLANT

UTILITY SUMMARY

<u>Electric Power</u>		<u>KW</u>	
Connected		2,750	
Operating		1,700	
<u>Steam</u>		<u>LB/HR</u>	<u>PSIG</u>
Consumption:			
E31C102	LP Gas Compressor	100,280	250 to 4"Hg
E31C107	DEA Regenerator Reboiler	157,500	50 to Condensate
U31C101 (J1&J2)	LP Gas Compressor Steam Ejector System	700	100 to Condensate
<u>Cooling Water (30°F Rise)</u>			<u>GPM</u>
E31C104	LP Gas Compressor Aftercooler		1,120
E31C108	DEA Regenerator Reflux Cooler		6,540
E31C111	LP Gas Cooler		480
E31C112	LP Gas Compressor Interstage Cooler		1,120
E31C114	DEA Solution Cooler		3,370
E31C115	LP Gas Compressor Surface Condenser		6,590
U31C101 (E1 & E2)	LP Gas Compressor Steam Ejector System		50
<u>Chemicals</u>			
	Diethanolamine		400 lb/sd
	Antifoam Agent		10 gal/mo

TABLE 3-21
AREA 32 - PRODUCT GAS PLANT

UTILITY SUMMARY

<u>Electric Power</u>		<u>KW</u>	
Operating		4100	
Connected		5500	
<u>Steam</u>		<u>LB/HR</u>	<u>PSIG</u>
Consumption:			
E32C102	Adsorber Regeneration Heater	4,200	1500 to Condensate
E32C103	Depropanizer Feed Heater	12,700	50 to Condensate
E32C104	Depropanizer Reboiler	12,500	50 to Condensate
E32C107	Debutanizer Reboiler	9,500	300 to Condensate
E32C110	Ethane Column Reboiler	N/A	300 to Condensate
<u>Cooling Water (300F Rise)</u>			<u>GPM</u>
E32C101	Adsorber Regeneration Cooler		N/A
E32C106	Naphtha Product Cooler		30
E32C108	Debutanizer Overhead		730
E32C109	Ethane Column Feed Compressor Cooler		360
E32C111	Ethane Reflux Compressor Cooler		1220
ET32C101	Feed Gas Expansion Turbine		N/A
U32C103	Depropanizer Refrigeration Unit		1500

TABLE 3-23
AREA 33 - SULFUR RECOVERY PLANT

UTILITY SUMMARY

<u>Electric Power</u>		<u>KW</u>	
Connected		2371	
Operating		1467	
<u>Steam</u>		<u>LB/HR</u>	<u>PSIG</u>
Consumption:			
C33C101	Combustion Air Blower Turbine	34,200	600 to 4" Hg
E33C111	Stripper Reboiler	N/A	50 to Condensate
U33C103	Turbine Steam Ejector	N/A	75 to Condensate
	Sulfur Storage Pit	Pit Heating	50 to Condensate
Generation:			
B33C101	Claus Waste Heat Boiler	271,178	650
B33C102	SCOT Waste Heat Boiler	N/A	50
V33C113	L.P. Steam Separator	96,753	50
<u>Fuel</u>		<u>MM BTU/HR</u>	
H33C101	Claus Reaction furnace	85 (Start-up)	
H33C103	SCOT Inline Burner Mixer	N/A	
H33C105	Incinerator	N/A	
<u>Cooling Water (30°F Rise)</u>		<u>GPM</u>	
E33C105	Quench Cooler	N/A	
E33C108	Lean Solution Cooler	N/A	
E33C110	Stripper Reflux Condenser	N/A	
E33C115	Turbine Surface Condenser	N/A	
U33C103	Ejector System	N/A	

TABLE 3-23
AREA 33 - SULFUR RECOVERY PLANT

UTILITY SUMMARY - Contd

Chemicals & Catalysts

V33C102	No. 1 Sulfur Converter	4900 cu.ft. alumina catalyst
V33C103	No. 2 Sulfur Converter	4900 cu.ft. alumina catalyst
V33C105	Hydrogenation Reactor	Hydrogenation catalyst, amount N/A
V33C108	Solvent	N/A

TABLE 3-25
AREA 34 - REFINING PLANT

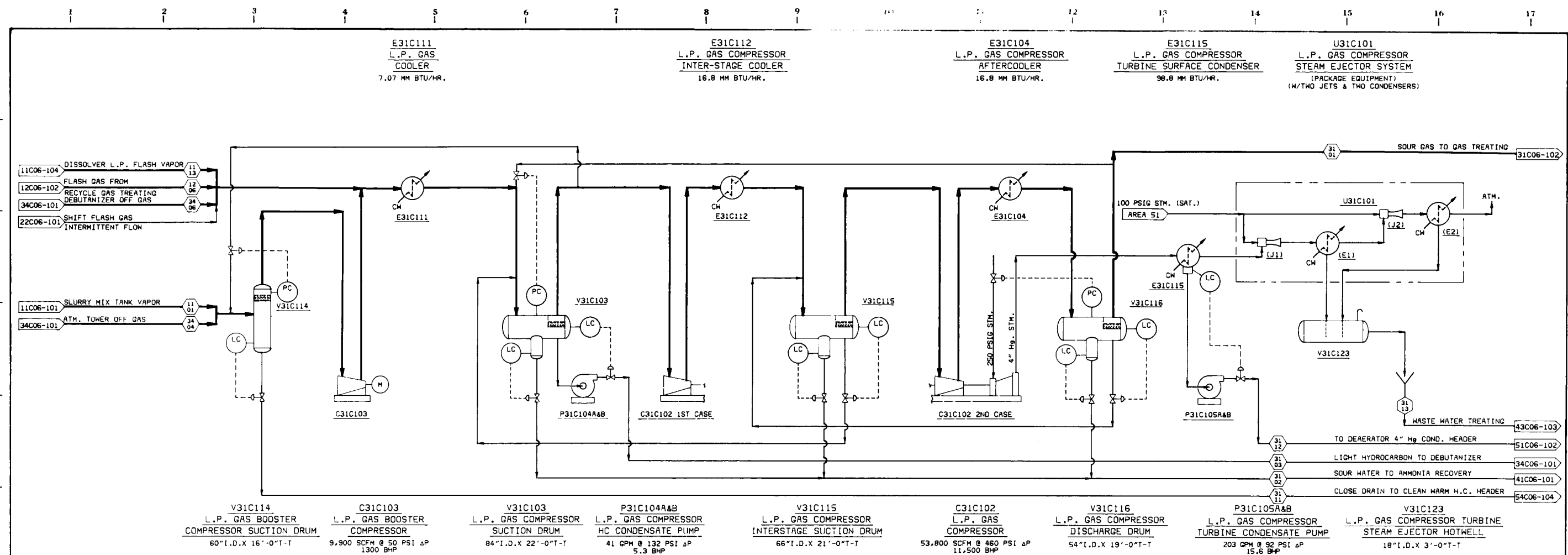
UTILITY SUMMARY

<u>Electric Power</u>		<u>KW</u>	
Connected		4,232	
Operating		2,715	
<u>Steam</u>		<u>LB/HR</u>	<u>PSIG</u>
Consumption:			
V34C102	Atmospheric Fractionator	27,000	600 to Condensate
V34C104	Fractionator Sidestream Stripper	4,500	600 to Condensate
E34C113	Debutanizer Reboiler	34,000	600 to Condensate
U34C122 A/B	Vacuum Flash Ejector System	14,000	100 to Condensate
<u>Fuel</u>		<u>MM BTU/HR</u>	
H34C131	Mineral-Residue Slurry Heater	11.8	
H34C132	Fractionator Reboiler	309.5 Radiant 30.0 Convection.	
H34C133	Fractionator Feed Heater	56.8	
<u>Nitrogen</u>			
T34C134	Mineral-Residue Storage Tank	Blanket Gas	
T34C136 A/B	Dilute MRS Hold Tank	Blanket Gas	
<u>Make-up Boiler Feed Water (For Heat Exchange Only)</u>			<u>GPM</u>
E34C109	Fractionator Pumparound Cooler		2144

TABLE 3-25
AREA 34 - REFINING PLANT

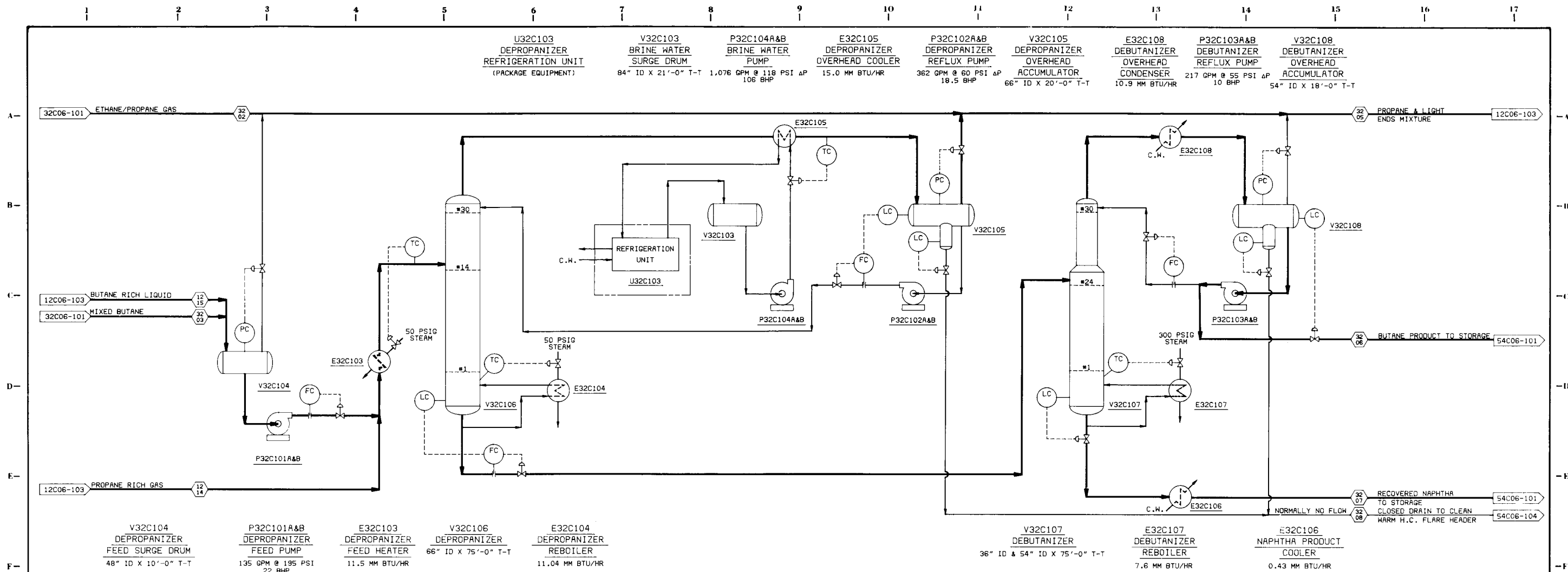
UTILITY SUMMARY - Cont.

<u>Cooling Water (30°F Rise)</u>		<u>GPM</u>
E34C101	Fractionator Overhead Trim Cooler	1866
E34C105	Lower-Boiling Fuel Oil Trim Cooler	793
E34C111	Debutanizer Overhead Condenser	633
E34C114	Debutanizer Bottoms Trim Cooler	67
E34C120	Higher-Boiling Fuel Oil	167
E34C133	Heavy Naphtha Product Trim Cooler	20
E34C122 A/B	Vacuum Flash Ejector System	900



MATERIAL BALANCE		INCOMING						OUTGOING					
STREAM NUMBER		11 01	11 13	12 06	34 04	34 06		31 01	31 02	31 03	31 11	31 12	31 13
IDENTIFICATION		SLURRY MIX TANK VAPOR	DIS. L.P. FLASH GAS	FLASH GAS FR. REC. GAS TREAT.	ATM. TWR. OFF GAS	DEBUTANIZER OFF-GAS		SOUR GAS	SOUR WATER	LIGHT HYDROCARBON	CLOSE DRAIN	CONDENSATE	WASTE WATER
COMPONENT	MOL. WT.												
H2	2.016	45.9	4023.8	63.5	190.9	0.3		4314.1	-	0.2	-	-	-
C1	16.042	10.4	901.4	12.0	103.5	0.7		1027.6	-	0.4	-	-	-
C2	30.068	12.8	529.0	3.5	124.5	2.7		671.3	-	1.2	-	-	-
C3	44.094	8.5	362.6	-	228.4	11.9		607.9	-	3.6	-	-	-
C4	58.120	3.4	141.9	-	224.9	35.7		396.7	-	9.2	-	-	-
C5-350	-	1.9	29.7	-	181.7	3.4		49.3	-	187.4	-	-	-
350-600	-	0.2	2.5	-	-	-		-	-	2.7	-	-	-
N2	28.016	19.8	126.6	-	8.8	-		154.2	-	-	-	-	-
CO	28.010	4.5	250.5	3.0	12.4	0.1		270.4	-	0.1	-	-	-
CO2	44.010	1.7	88.3	2.5	39.8	0.7		132.8	TR	0.2	-	-	-
H2S	34.076	4.0	233.8	2.0	235.8	9.2		482.9	TR	2.0	-	-	-
H2O	18.000	11.4	135.9	1.0	97.4	1.5		14.7	232.2	0.2	0.1	5571.1	38.9
TOTAL (M3/HR)		123.4	6826.0	87.5	1439.1	66.2		8121.7	232.2	187.2	0.1	5571.1	38.9
TOTAL (LBS/HR)		2.501	90.790	706	57.050	3.319		133.659	4.180	16.524	2	100.280	700
MOLECULAR WEIGHT		20.3	13.3	8.1	39.7	50.1		16.46	18.0	88.2	18.0	18.0	18.0
WT. % SOLIDS		-	-	-	-	-		-	-	-	-	-	-
SP. GR. @ 50°F		-	-	-	-	-		-	1.0	0.83	1.0	1.0	1.0
SP. GR. @ 150°F @ TAP		0.114	0.140	0.105	0.152	0.061		0.1454	-	-	-	-	-
BP50 (MM SCFD)		0.1	0.2	0.4	0.1	0.6		0.73.8	286.5	1.365.2	0.14	6.874	48
GPM (ACF3) @ TAP		0.1	0.70	0.4	0.04.6	0.1		0.25.52	8.4	41	0.004	203	1.4
PRESSURE (PSIA)		28	70	90	25	100		515	85	110	20	96	14.7
TEMPERATURE (°F)		145	115	140	120	130		100	90	94	120	125	100

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MATERIAL BALANCE		INCOMING				OUTGOING		
STREAM NUMBER		12 14	12 15	32 02	32 03	32 05	32 06	32 07
IDENTIFICATION		PROPANE RICH GAS	BUTANE RICH LIQUID	ETHANE/PROPANE GAS	MIXED BUTANE	PROPANE & LIGHT ENDS MIXTURE	BUTANE PRODUCT	RECOVERED NAPHTHA
COMPONENT	MOL. WT.							
H ₂	2.018	99.3	-	-	-	99.3	-	-
C ₁	16.042	132.1	-	63.0	-	195.1	-	-
C ₂	30.068	215.8	-	617.9	-	833.7	-	-
C ₃	44.094	433.0	32.8	547.9	57.8	1,052.7	18.9	-
C ₄	58.120	341.4	169.2	37.0	358.3	45.7	958.5	1.7
C ₅ -350	-	8.1	2.0	-	49.1	-	13.4	45.8
N ₂	28.016	5.1	-	-	-	5.1	-	-
CO	28.010	11.2	-	-	-	11.2	-	-
CO ₂	44.010	-	-	-	-	-	-	-
H ₂ S	34.076	-	-	-	-	-	-	-
H ₂ O	18.000	-	-	-	-	-	-	-
TOTAL (M/HR)		1,245.0	204.0	1,265.8	465.2	2,241.8	890.7	47.5
TOTAL (LBS/HR)		48,805	11,430	45,899	27,337	77,827	51,727	3,817
MOLECULAR WEIGHT		39.2	56.03	38.26	58.76	34.76	58.07	80.3
SP GR @ 60°F		-	0.57	-	0.6	-	0.58	0.81
SP GR (LBS/FT ³) @ TAP		[4.7]	0.55 [0.52]	0.58		[0.48]	0.56	0.78
BPMO (CHG/FO) []		[11.4]	1,375 [11.52]	3,123		[20.4]	6,112.8	322.3
BPMO (CHG/FO) @ TAP		[2.67]	41.7 [24.66]	92.8		[45.0]	185.1	9.7
PRESSURE (PSIA)		230	85	80	85	75	180	170
TEMPERATURE (°F)		52	100	90	100	72	100	115

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ENGINEERING REVIEW

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PROCESS ENGINEER

PROJECT ENGINEER

AUTHORIZED FOR RELEASE

APPVD BY

DATE

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DATE

DRAWING STATUS

ISSUE NO.

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DATE

PROCESS FLOW DIAGRAM

PRODUCT GAS PLANT LIGHT ENDS RECOVERY AREA 32 SRC II CONCEPTUAL COMMERCIAL PLANT

DM

The Phillips & Midway Coal Mining Co.

Gulf

Stearns-Roger INCORPORATED

DRAWN

DAN

ORDER NO.

C-21500

NO.

X00008

DWG NO.

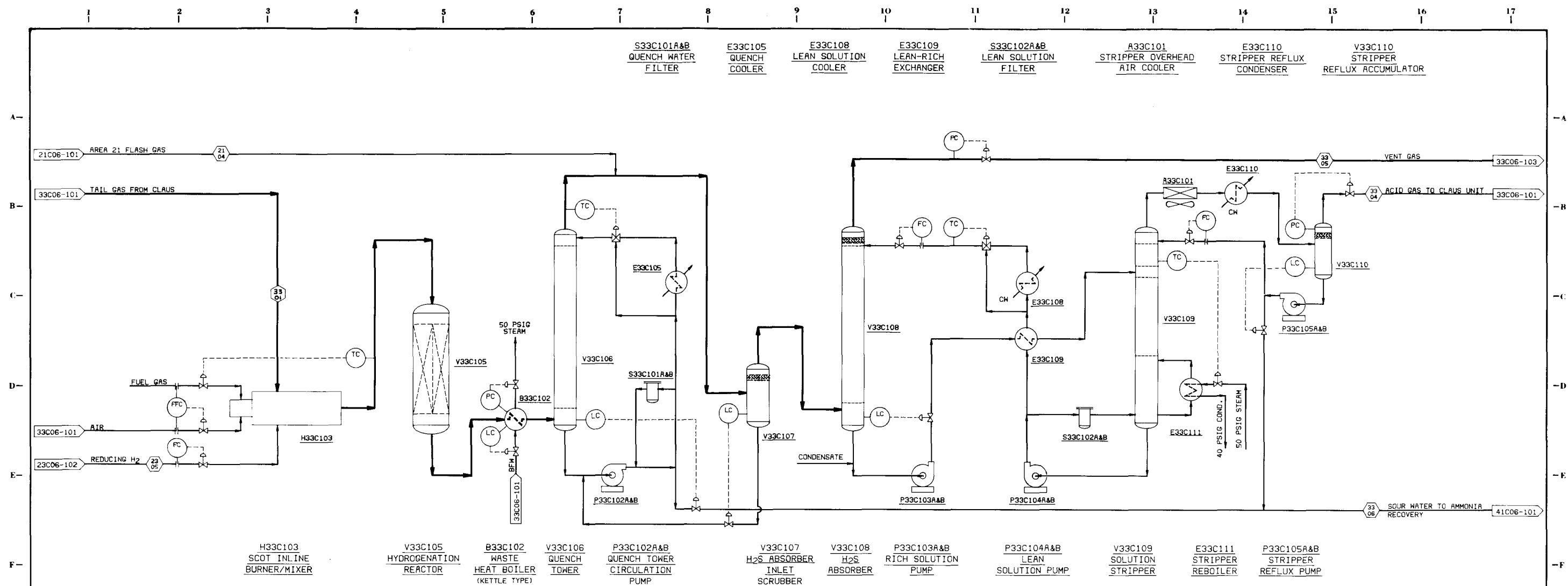
22927

SHEET NO.

32C06-102

REV.

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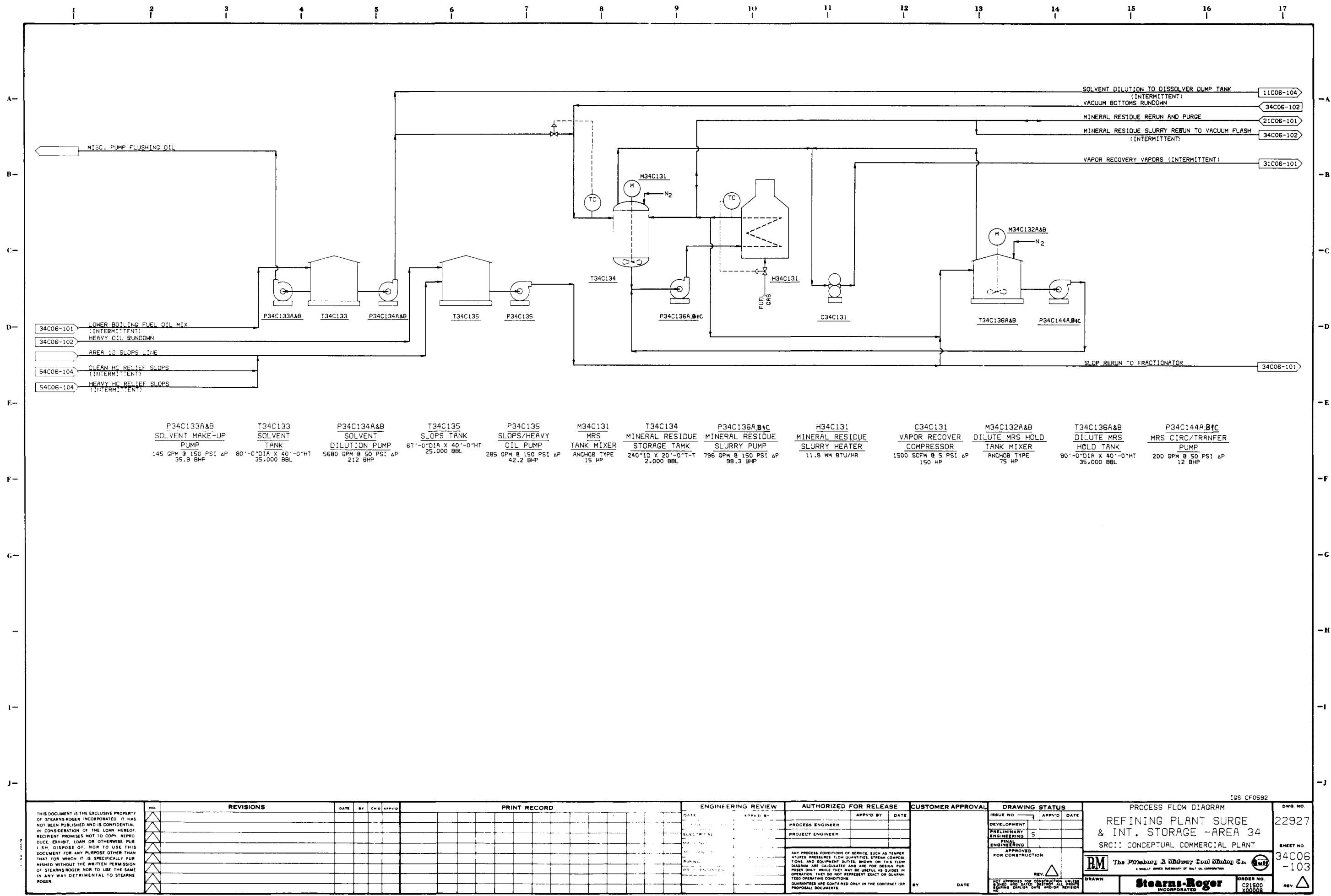
MATERIAL BALANCE			INCOMING			OUTGOING		
STREAM NUMBER			(24)	(25)	(31)	(33 04)	(33 05)	(33 06)
COMPONENT	MOL. WT.	IDENTIFICATION	FLASH GAS	REDUCING HYDROGEN	TAIL GAS FROM CLAUS	ACID GAS TO CLAUS	VENT GAS	SCOT SOUR WATER
H ₂	2.016			489.1	17.7	-	806.5	-
C ₁	16.042			2.3	2.5	-	4.8	-
C ₂	30.068			-	0.5	-	0.5	-
C ₃	44.084			-	0.5	-	0.5	-
C ₄	58.120			-	0.3	-	0.3	-
H ₂ +Ar	28.016			3.0	6325.9	-	7185.9	-
NH ₃	17.032			-	-	0.5	-	-
CO	28.010			8.5	46.7	-	572.4	-
CO ₂	44.010			1.3	4778.5	990.2	4255.2	TR
H ₂ S	34.078			TR	133.6	318.3	1.4	TR
S	32.060			-	47.3	-	-	-
CS ₂	60.07			-	0.8	-	3.5	-
SO ₂	64.059			-	86.7	-	-	-
H ₂ O	18.000			-	3625.9	55.6	869.1	3258.9
TOTAL (M/HR)			1575.3	504.2	15047.6	1362.8	13,680.1	3,258.9
TOTAL (LBS/HR)			-	1,412	464,677	55,366	421,722	58,660
SOLIDS/CASO (LBS/HR)			-	-	-	-	-	-
TOTAL (LBS/HR)			-	1,412	464,677	55,366	421,722	58,660
TOTAL (TPD)			-	-	-	-	-	-
MOLECULAR WEIGHT			-	2.81	30.88	40.63	30.82	18.00
MT X SOLIDS			-	-	-	-	-	-
SP GR 60°F			-	-	-	-	-	-
SP GR/(LBS/FT ³) @T+P			-	-	-	-	-	.39
BPSO/(MM SCFD)			-	[4.8]	[137.1]	[12.4]	[124.6]	-
BPM/(ACS) @T+P			-	-	-	-	-	118.4
PRESSURE (PSIA)			24	1010	22.5	27	18.1	32
TEMPERATURE (°F)			120	25	280	105	107	105

NOTES:

1. THE SUPERCOST UNIT IS DESIGNED FOR A CLAUS RECOVERY 2.5% LOWER THEN THE CLAUS UNIT DESIGN IN ORDER TO HANDLE UPSSETS IN THE CLAUS UNIT.
2. THIS MATERIAL BALANCE REFLECTS A LOWER CLAUS RECOVERY, USED TO DESIGN THE SUPERCOST UNIT AND THEREFORE REPRESENTS THE HIGHEST SULFUR EMISSIONS THAT CAN BE EXPECTED.
3. SOLVENT SUMP V33C114
SOLVENT GUMP PUMP P33C108AAB
SOLVENT STORAGE TANK T33C101
SOLVENT TRANSFER PUMP P33C107AAB
ARE INCLUDED IN THIS AREA BUT NOT SHOWN ON DRAWING.

IGS NO. CF0561

[illegible]



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																																																		SHEET NO. 34C06-103														

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BY: _____ DATE: _____

REVISIONS:

REV.	DESCRIPTION	DATE
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ORDER NO. C21500 X00006

INCORPORATED

3.6 UNIT 40 - SECONDARY RECOVERY AND OXYGEN PLANTS

Unit Definition. The Secondary Recovery Plants recover ammonia and tar acids and treat waste water for reuse within the plant. The Unit is designed to assure that no contaminated liquid effluent will leave the plant property. The oxygen plant supplies all of the oxygen required in the plant complex.

Unit 40 is divided into four process areas:

- Area 41 - Ammonia Recovery Plant
- Area 42 - Tar Acid Recovery Plant
- Area 43 - Waste Water Reclamation Plant
- Area 44 - Oxygen Plant

3.6.1 Area 41 - Ammonia Recovery Plant

Area Definition. The purpose of this Process Area is to recover ammonia from sour water streams as a salable by-product. The process suppresses the volatilization of tar acids, which leave Area 41 in the water stream fed to Area 42 Tar Acid Recovery Plant. Acid gases are stripped from the water and are routed to Area 33 Sulfur Recovery Plant. Area 41 consists of feed tanks, feed pumps, and a U.S.S. Engineers and Consultants, Inc. licensed Phosam-W Ammonia Recovery Plant.

Design Basis. The ammonia recovery process used in Area 41 was developed by U.S.S. Engineers and Consultants, Inc., and is a licensed process. The unit produces:

- (1) Water with less than 250 ppm ammonia;
- (2) An offgas composed of H_2S , CO_2 , and light hydrocarbons;
- (3) High purity ammonia product (99.9% anhydrous ammonia).

Process Description. The process configuration is shown on Process Flow Diagram 41C06-101 and 41C06-102.

All of the plant sour water streams, excluding gasifier purge water and gasifier ammonia absorber water, are collected in the NH_3 recovery feed tank and are fed to the Superstill at a continuous rate. The feed enters the bottom section of the Superstill from which acid gases and ammonia are released to the top section. In the top section the ammonia is selectively absorbed by a recirculating solution. The acid gases are drawn from the top of the still and are routed to Area 33 Sulfur Recovery. The water, which contains tar acids, leaves the bottom of the still and is pumped to Area 42 Tar Acid Recovery Plant.

The recirculating solution is regenerated in the stripper. The regenerated solution is returned to the top section of the Superstill and the ammonia-water mixture stripped from the solution is fed to the fractionator. The fractionator bottoms are recycled to the bottom section of the Superstill. The fractionator overhead is condensed and the product anhydrous ammonia is sent to storage Area 54.

The gasifier purge water and gasifier ammonia absorber water are collected in the stripper feed tank. From here the stream is pumped to the NH_3 Stripper. The stripped ammonia gas comes off the top and is routed to the absorber section of the Superstill. Stripped water leaves the bottom of the NH_3 Stripper and is sent to Area 43 Waste Water Reclamation.

Design Discussion. The present design is based on a process design furnished by U.S.S. Engineers and Consultants, Inc. (UEC).

The most important assumption affecting the design of this area is the sequence of Area 41 Ammonia Recovery and Area 42 Tar Acid Recovery. Discussions with UEC and Jones & Laughlin (process licensor for Area 42) concluded that ammonia recovery would precede tar acid recovery. This results in a special design which suppresses the amount of tar acids that go overhead from the Superstill into the ammonia system or to sulfur recovery. Optimization of the ammonia recovery system requires a detailed review of the heat recovery system, steam balance, and ammonia content of the feed.

According to UEC, the process is sensitive to changes in ammonia content. The Phosam-W process is successfully utilized in treating coke oven gases in several installations around the world.

Only standard proven construction materials are required. No unusual startup, shutdown, and maintenance problems are anticipated. Storage for incoming sour water is provided enabling the Unit to be shut down for short periods of time for maintenance. The Unit is oversized to deplete the stored sour water gradually while processing the normal flow of sour water.

3.6.2 Area 42 - Tar Acid Recovery Plant

Area Definition. The area consists of a solvent extraction system developed by Jones & Laughlin Steel Company and licensed by ChemPro Equipment Corporation.

The purpose of this area is to remove tar acids (water soluble polar aromatics) from water leaving Area 41 Ammonia Recovery Plant. The recovered tar acids may be blended with the fuel oil product or stored as a separate product in Area 54 Product Storage. All of the dephenolized water is routed to Area 43 Waste Water Reclamation Plant for additional treatment.

Design Basis. The design of Area 42 Tar Acid Recovery is based on a process design package supplied by ChemPro Equipment Corporation. The tar acid product is 99% pure, and the treated water contains only trace amounts of tar acid and solvent.

Process Description. The process configuration is shown on Process Flow Diagram 42C06-101.

The feed from Area 41 Ammonia Recovery Plant is stored in the tar acid feed surge tank before being pumped to the extraction columns. The water flows counter-current to a flow of solvent which absorbs tar acids from the water. The tar acid containing solvent then flows to the solvent recovery column.

The overhead from the solvent recovery column is returned to the solvent drum from which the solvent is recycled to the extraction columns. Solvent recovery column bottoms are fed to a tar acid still where the remaining solvent is drawn off the top of the still and returned to the solvent recovery column. The tar acid still bottoms are then pumped to product storage for storage as a separate product or to be mixed with the fuel oil product.

The bottoms water from the extraction column is fed to the solvent stripping column where residual solvent is recovered. The stripping column bottoms water is then pumped to Area 43 Waste Water Reclamation Plant.

Design Discussion. This process is utilized and has been proven in phenolic resin plants and in treating coke oven gases in the steel industry. Only standard proven construction materials are required. No unusual startup, shutdown, or maintenance problems are anticipated. Protection of employees from exposure to tar acids and solvent must incorporate design procedures similar to plants processing phenols, cresols, and xylenols.

3.6.3 Area 43 - Waste Water Reclamation Plant

Area Definition. Process configuration is shown on Process Flow Diagrams 43C06-101 through 43C06-105.

The operation of the Conceptual Commercial Plant produces various waste streams that are processed and reclaimed to the extent practicable in Area 43 Waste Water Reclamation Plant. The plant treats waste water so that no contaminated liquid effluent is discharged into surface streams or subsurface strata. Solid wastes removed from the waste streams are detoxified and disposal is by land burial in an ecologically-sound manner.

Design Basis. The Waste Water Reclamation Area is designed to provide maximum flexibility in the treatment selected because of changing characteristics of many of the waste streams. In order to design the waste reclamation treatment processes, the expected waste streams at the plant have been quantified and

characterized on a preliminary basis. A short description of each waste stream and its treatment is presented in the following subsections.

Demineralizer Regenerant Wastes. The ion exchange demineralizers remove dissolved solids from the makeup water. When the ion exchange resin becomes exhausted, regeneration is accomplished by passing sulfuric acid through the cation resin and sodium hydroxide through the anion resin. The waste streams from the system are segregated into high- and low-quality streams. The high-quality stream consists of all of the backwash water and the major portion of the final rinse. The low-quality waste stream contains the acid and caustic regenerant waste flows, the slow rinse, and a small portion of the final rinse.

The high quality demineralizer waste stream requires no treatment for reclamation. The low-quality demineralizer waste stream is expected to be low in pH and is blended with the cooling tower blowdown water prior to being concentrated in the brine concentrator.

Boiler Blowdown. The boilers are supplied with demineralized water. The small quantity of solids present in the feedwater will concentrate in the boilers as the water is evaporated to steam; to control the concentration of solids in the boiler, a small amount of the boiler water is blown down and is considered to be sufficiently high in quality to be reused without requiring treatment. It is piped to the reclaimed water holding tank.

Cooling Tower Blowdown. Cooling tower blowdown serves the purpose of maintaining the recirculating water TDS concentration at a level which does not cause heat exchanger scaling or fouling. The chemical constituents of this stream include: calcium, magnesium and sodium carbonates, bicarbonates, sulfates, nitrates, chlorides and silica. Cooling tower blowdown is pumped to the brine concentrator feed tank. The brine concentrator concentrates the flow to about 5% of the inlet volume. The distillate is pumped to the reclaimed water holding tank and the brine is pumped to the incinerator.

Clarifier Sludge Blowdown. The coagulated solids in the raw water clarifier will settle and accumulate in the bottom of the clarifier. These solids are intermittently blown down, pumped to a thickener, and are further processed in a belt filter. The dewatered solids from the belt filter are transferred to Area 64 Slag Disposal. Filtrate and overflow from the thickener are pumped back to the raw water reservoir.

Rainwater Runoff. Rainwater runoff is divided into three categories: low quality, high quality, and coal pile. The plant drain system is designed to separately collect rainwater runoff from those areas which are expected to be polluted. A separate holding pond is provided for each category of runoff. The holding ponds and treating equipment are sized for total containment and treatment of the quantity of water associated with the largest rainfall anticipated to occur in 24 hours over a 10-year period.

The low quality rainwater runoff is collected in a lined pond. Oil is removed with a skimming device and is pumped to the incinerator. After skimming, the water is pumped to the oil removal system if it contains soluble oil. In either case, the oil-free water is mixed with the high-quality rainwater runoff and is processed through a clarifier for removal of suspended solids, then sand-filtered, carbon-filtered, and pumped to the reclaimed water holding tank. Sludge from the rainwater runoff clarifier is pumped to the raw water clarifier sludge thickener.

Rainwater runoff from the coal pile is expected to contain large amounts of dissolved solids, which would include high sulfate, iron, and aluminum levels; high suspended solids, which would include coal fines, etc., which would have a pH in the 2-3 range. An analysis of coal pile runoff from a high sulfur coal-fired power plant has been used as a guide for handling this coal pile runoff water. Treatment for this stream consists of raising the pH to approximately 9 in a special high volume sludge type clarifier-thickener. Effluent from the clarifier-thickener is sand-filtered, carbon-filtered and then is pumped to the low quality reclaimed water holding tank. This

reclaimed water is used for sand-filter backwash, dust control, and incinerator quench, with any excess being either incinerated or concentrated in the brine concentrator. The clarifier-thickener sludge is thickened and disposed of in the slag impoundment.

Gasifier Blowdown and Vacuum Filter Filtrate. The blowdown portion of this waste stream is associated primarily with minimizing the corrosion taking place in the gasifier system. The current control component is the chloride level. The gasifier blowdown and the vacuum filter filtrate from the slag dewatering process contain similar contaminants including heavy metals, suspended solids, fluorine, thiocyanate, and ammonia. Treatment of this stream consists of lime addition followed by coagulation and clarification, then hydrogen peroxide treatment, sand filtration, and activated-carbon filtration.

Sludge from the clarifier is combined with heavy metal sludge from the coal pile runoff and is dewatered in the filter press, with the filtrate going to the gasifier blowdown/vacuum filter filtrate-equalization tank. The dewatered sludge is disposed as landfill in an ecologically acceptable manner.

Sand filter backwash is returned to the gasifier blowdown/vacuum filter tank. The sand filter backwash water source is filtered water from 3 of the 4 sand filters. It is anticipated that activated-carbon consumption is sufficient to utilize onsite activated carbon regeneration. Filtered water from the activated carbon column is pumped to the reclaimed water holding tank.

Devil Liquor. This stream is pretreated in Area 41 Ammonia Recovery and Area 42 Tar Acid Recovery prior to being pumped to Area 43 Waste Water Reclamation. A major portion of hydrogen sulfide, ammonia, phenolic-type hydrocarbons, and other high-boiling hydrocarbons, are removed in Areas 41 and 42. The waste stream entering Area 43 contains approximately 70 ppm hydrogen sulfide, 250 ppm ammonia and very low levels of hydrocarbons.

This stream is collected in an equalization tank. Ferrous sulfate and hydrogen peroxide are added prior to coagulation and clarification in order to

remove the remaining hydrogen sulfide and any suspended solids. Following clarification provisions, hydrogen peroxide is added to oxidize remaining hydrocarbons prior to sand and activated-carbon filtration. Approximately 10-15 minutes holding time precedes filtration to complete the hydrogen peroxide oxidation reaction.

Filtered water from the activated carbon columns is pumped to the reclaimed water holding tank. Sand-filter backwash (provided by 4 of the 5 filters) is piped to the devil liquor equalization tank for recycle treatment. Sludge from the clarifier is dewatered and incinerated and/or disposed of in a suitable burial site.

Miscellaneous Process Wastes. This stream is a catch all. It includes waste water from floor drains, area washdown water, system cleaning wastes, etc. It is also expected to contain oil, miscellaneous hydrocarbons, hydrogen sulfide, and phenol. The treatment scheme for this waste stream includes collection in an equalization tank, and oil removal through the oil removal system, with the oil-free stream being pumped to the devil liquor holding tank for further treatment.

Contaminated Condensate. Condensate which may contain low levels of hydrocarbon contamination will be piped to a holding tank fitted with provisions for feed of hydrogen peroxide to provide emergency oxidation in the event of higher-than-expected hydrocarbon contamination. Contaminated condensate is filtered through activated-carbon beds columns and is pumped to the reclaimed water holding tank.

3.6.4 Area 44 - Oxygen Plant

Area Definition. The primary purpose of Area 44 Oxygen Plant, is to provide a nominal 10,000 tpd of 99.5% pure oxygen for Area 21 Syngas Production Plant and other plant uses. Four air separation units are provided, each with a maximum capacity of 2750 tpd of oxygen. Each unit consists of air compression, cryogenic oxygen separation, and oxygen compression.

Process Description. The process configuration is shown on Process Flow Diagrams 44C06-101 through 103.

Area 44 contains four parallel trains of equipment for air compression, air separation, and oxygen compression. The air compressors provide the Air Separation Plant with air at 106 psia and 87°F. At the maximum oxygen production rate of 11,000 tpsd, the air compressors will supply 964,900 scfm of air to the Air Separation Plant. The four compressors are each driven by gas turbines which are fueled by excess syngas. Steam addition suppresses NO_x formation in the turbines. Waste heat boilers utilize the hot exhaust gases from the turbines to generate 650 psig steam.

The Air Separation Plant normally produces 9763 tpsd of pure oxygen (9824 tpsd of 99.5% oxygen) at 15.5 psia and 85°F. The maximum capability is 11,000 tpsd of pure oxygen, (11,069 tpsd of 99.5% oxygen). The plant also produces gaseous nitrogen containing 100 ppm of oxygen at 47 psia and 85°F. Nitrogen for process use and for the utilities system is provided as required, and excess nitrogen is vented to atmosphere.

Although the oxygen compressors normally receive gaseous oxygen directly from the Air Separation Plant, they can also receive feed from the liquid oxygen backup system. The two 2500 ton liquid oxygen tanks provide storage for maintenance downtime on equipment. The oxygen compressors are driven by extracting steam turbines.

An oxygen recycle loop is provided around each oxygen compressor for surge control. The recycle loops are sized to allow turn-down to 60% of compressor design.

Design Discussion. The Air Separation Plant normally produces 9763 tpsd pure oxygen, and has a maximum capacity of 11,000 tpsd. The air compression and oxygen compression sections are designed to match the 11,000 tpsd pure oxygen.

If one air compressor or the driver is down, the remaining three can supply 8250 tpsd of pure oxygen, or 84.5% of normal rate. The difference between oxygen requirements and production can be supplied by the oxygen backup system for 79 hours. If an oxygen compressor fails, the other three can supply 8250 tpsd of pure oxygen or 84.5% of normal rate. In this case, the backup oxygen system is of no use and the main process rates will have to be reduced about 15%. The loss of two oxygen compressors requires the main process rate to be reduced about 44%.

The Air Separation Plant can be turned down to 60% of maximum production to match main process requirements. Oxygen production at 60% turndown is 6600 tpsd.

Liquified oxygen and nitrogen are each produced at a maximum rate of 55 tpsd per unit. The oxygen is stored in two 2500 ton liquid oxygen tanks and the nitrogen in one 500 ton liquid nitrogen storage tank. The oxygen storage system uses two pumps, one operating and one spare, to feed liquid oxygen to one steam heated vaporizer which can supply up to 5000 tpsd of backup oxygen to the oxygen compression system. The liquid nitrogen system uses two pumps, one operating and one spare, to supply liquid nitrogen to the Area 12 Hydrogen Recovery Plant during the startup of that system. It is also the source of backup nitrogen for the utilities system and the Selexol Unit in Area 23.

The Air Separation Plant, air compressors, and the oxygen compressors are extensions of current technology due to both the flow and pressure requirements of Area 44. The largest air separation plant in current use produces 2200 tpsd of oxygen. A 2480 tpsd plant located in South Africa is due on stream in 1979. Air separation and compressor vendors agree that 3000 tpd oxygen plants are within the technology of the Eighties.

Compressor vendors indicate that there are no air compressors currently in operation that meet both the flow and pressure requirements of Area 44. However, there are designs and production capabilities for axial-radial compressors which will provide air for a 3000 tpsd oxygen plant. Axial

sections are now operating at these rates on air, and radial sections have been proven for these rates and pressure. The two sections have not yet been combined into a single machine. These compressors will be capable of turn-down to 60 to 65 percent without serious loss of efficiency.

Compressor vendors indicate that there are no oxygen compressors currently in operation that meet both the flow and pressure requirements of Area 44. However, there are designs and production capabilities for three-case centrifugal compressors which will compress 3000 tpd of oxygen to 1600 psig or more. The low-pressure and intermediate-pressure cases have been proven on oxygen at rates approaching the requirements of the CCP. The high pressure third case has been proven on other gases at pressures well above 1600 psig. However, the third case has not yet been proven in oxygen service. The centrifugal design offers the advantages of lower capital, of less floor space, and of 2% greater efficiency over the alternative hybrid centrifugal/reciprocating compressor.

In each section of Area 44, the designs for the units are available, the technology and, in some cases, the components have been demonstrated, and their manufacture awaits only an application.

TABLE 3-28
AREA 41 AMMONIA RECOVERY PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Heat Exchangers</u>				
E41C101	Stripper Cross Exchange	N/A		N/A
E41C102	Ammonia Stripper Reboiler	N/A		N/A
E41C103	Stripped Water Cooler	N/A		N/A
E41C104	Lean Solution Cooler	N/A		N/A
E41C105	Feed Preheater	N/A		N/A
E41C106	After Condenser Cooler	N/A		N/A
E41C107	Solution Exchanger	N/A		N/A
E41C108	Reflux Condenser	N/A		N/A
E41C109	Super Still Reboiler	N/A		N/A
E41C110	Stripper Reboiler	N/A		N/A
E41C111	Stripper Condenser	N/A		N/A
E41C112	Fractionator Condenser	N/A		N/A
E41C113	Fractionator Reboiler	N/A		N/A
<u>Pumps</u>				
P41C101A&B	NH ₃ Recovery Feed Pump	N/A		N/A
P41C102A&B	Stripper Feed Pump	N/A		N/A
P41C103A&B	Absorber Circulation Pump	N/A		N/A
P41C104A&B	Rich Solution Pump	N/A		N/A
P41C105A&B	Reflux Condenser Pump	N/A		N/A
P41C106A&B	Fractionator Feed Pump	N/A		N/A
P41C107A&B	Fractionator Reflux Pump	N/A		N/A
P41C108A&B	After Condenser Pump	N/A		N/A
P41C109	Phosphoric Acid Pump	N/A		N/A
P41C110A&B	Caustic Metering Pump	N/A		N/A

TABLE 3-28
AREA 41 AMMONIA RECOVERY PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Tanks</u>				
T41C101	NH ₃ Recovery Feed Tank	N/A		N/A
T41C102	Stripper Feed Tank	N/A		N/A
<u>Vessels</u>				
V41C101	Ammonia Stripper	N/A		N/A
V41C102	Super Still	N/A		N/A
V41C103	Stripper	N/A		N/A
V41C104	Fractionator	N/A		N/A
V41C105	Fractionator Feed Tank	N/A		N/A
V41C106	HP Steam Flash Drum	N/A		N/A
V41C107	LP Steam Flash Drum	N/A		N/A
V41C108	Phosphoric Acid Tank	N/A		N/A
V41C109	Caustic Tank	N/A		N/A

TABLE 3-30
AREA 42 TAR ACID RECOVERY PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Heat Exchangers</u>				
E42C101A&B	Stripping Column Ovhd Condenser	N/A	N/A	
E42C102A&B	Solvent Recovery Column Ovhd Condenser	N/A	N/A	
E42C103A&B	Solvent Recovery Column Reboiler	N/A	N/A	
E42C104A&B	Tar Acid Still Ovhd Condenser	N/A	N/A	
E42C105	Tar Acid Still Reboiler	N/A	N/A	
E42C106	Devil Liquor Cooler	N/A	N/A	
<u>Package Units</u>				
J42C101	Tar Acid Ejector	N/A	N/A	
<u>Pumps</u>				
P42C101A&B	Tar Acid Feed Pump	N/A	N/A	
P42C102A&B	Devil Liquor Pump	N/A	N/A	
P42C103A&B	Solvent Pump	N/A	N/A	
P42C104A&B	Stripping Column Reflux Pump	N/A	N/A	
P42C105A&B	Solvent Make-Up Pump	N/A	N/A	
P42C106A&B	Solvent Recovery Column Bottoms Pump	N/A	N/A	
P42C107A&B	Tar Acid Still Reflux Pump	N/A	N/A	
P42C108A&B	Tar Acid Still Btms Pump	N/A	N/A	
P42C109A&B	Tar Acid Product Pump	N/A	N/A	

TABLE 3-30
AREA 42 TAR ACID RECOVERY PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Tanks</u>				
T42C101	Solvent Make-Up Tank	N/A		N/A
<u>Vessels</u>				
V42C101A/B/C	Extraction Column	N/A		N/A
V42C102	Solvent Stripping Column	N/A		N/A
V42C103	Solvent Recovery Column	N/A		N/A
V42C104	Tar Acid Still	N/A		N/A
V42C105	Tar Acid Feed Surge Tank	N/A		N/A
V42C106	Solvent Drum	N/A		N/A
V42C107	Tar Acid Ovhd Accumulator	N/A		N/A
V42C108	Tar Acid Product Tank	N/A		N/A

TABLE 3-32
AREA 43 - WASTE WATER RECLAMATION PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN CONDITIONS	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Fired Heaters</u>				
H43C101	Incineration	Incinerators, 10 units, 1125 gph each.		
<u>Pumps</u>				
P43C102 A/B	Miscellaneous Process Waste Air Flotation Feed Pump	300 gpm, 20 psi Δ P, 7-1/2 hp, Carbon Steel.	120	20
P43C103 A/B	Miscellaneous Process Waste Oil Skimmer Oil Pump	20 gpm, 26 psi Δ P, 1/2 hp, Carbon Steel.	120	26
P43C105 A/B	Low Quality Rain Water Air Flotation Feed Pump	300 gpm, 20 psi Δ P, 7-1/2 hp, Carbon Steel.	120	20
P43C107 A/B	Air Flotation Combined Oil Pump	60 gpm, 16 psi Δ P, 1-1/2 hp, Carbon Steel.	120	16
P43C108 A/B	Rainwater Clarifier Overflow Pump	400 gpm, 36 psi Δ P, 1-1/2 hp, Carbon Steel.	120	36
P43C109 A/B	Rainwater Clarifier Sludge Pump	25 gpm, 7 psi Δ P, (air), Carbon Steel.	Ambient	7

TABLE 3-32
AREA 43 - WASTE WATER RECLAMATION PLANT
EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN CONDITIONS	
			TEMPERATURE (F)	PRESSURE (PSIG)
Pumps - Continued				
P43C110 A/B	Rainwater Thickener Overflow Pump	25 gpm, 43 psi Δ P, 1/2 hp, (Positive Displacement), Carbon Steel.	120	43
P43C111 A/B	Rainwater Thickener Sludge Pump	10 gpm, 5 psi Δ P, (air), Carbon Steel.	Ambient	5
P43C112 A/B	Rainwater Belt Filter Filtrate Pump	10 gpm, 43 psi Δ P, 1/2 hp, Carbon Steel.	120	43
P43C113 A/B/C	Air Floatation Caustic Pump	10 gpm, 43 psi Δ P, 1/2 hp, Stainless Steel.	120	43
P43C114 A/B	Devil Liquor Caustic Pump	50 gpm, 43 psi Δ P, 1 hp, Stainless Steel.	120	43
P43C115 A/B	Air Floatation Acid Pump	10 gpm, 43 psi Δ P, 1/2 hp, Alloy 20.	120	43
P43C116 A/B	Devil Liquor Clarifier Feed Pump	2400 gpm, 21 psi Δ P, 40 hp, Carbon Steel.	120	21
P43C117 A/B	Devil Liquor Clarifier Sludge Pump	150 gpm, 7 psi Δ P, (air), Carbon Steel.	Ambient	7

TABLE 3-32
AREA 43 - WASTE WATER RECLAMATION PLANT
EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN CONDITIONS	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Pumps - Continued</u>				
P43C118 A/B	Devil Liquor Filter Feed Pump	2500 gpm, 52 psi Δ P, 100 hp, Carbon Steel.	120	52
P43C119 A/B	Gasifier Clarifier Feed Pump	2000 gpm, 14 psi Δ P, 40 hp, Carbon Steel.	120	14
P43C120 A/B	Gasifier Clarifier Sludge Pump	100 gpm, 9 psi Δ P, (air), Carbon Steel.	120	9
P43C121 A/B	Gasifier Filter Feed Pump	2000 gpm, 57 psi Δ P, 100 hp, Carbon Steel.	120	57
P43C122 A/B	D&T Carbon Column Effluent Pump	4000 gpm, 15 psi Δ P, 50 hp, Carbon Steel.	120	15
P43C123 A/B	C.P. Runoff Filter Press Filtrate Pump	70 gpm, 13 psi Δ P, 1-1/2 hp, Carbon Steel.	120	13
P43C124 A/B	C.P. Clarifier Overflow Pump	300 gpm, 20 psi Δ P, 7-1/2 hp, Carbon Steel.	120	20
P43C125 A/B/C	Hydrogen Peroxide Pumps (D&T)	50 gpm, 44 psi Δ P, 1 hp, Stainless Steel.	120	44

TABLE 3-32
AREA 43 - WASTE WATER RECLAMATION PLANT
EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN CONDITIONS	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Pumps</u> - Continued				
P43C126 A/B/C	Hydrogen Peroxide Pumps (C.P. & C)	10 gpm, 43 psi Δ P, 1/2 hp, Stainless Steel.	120	44
P43C127 A/B	C.P. Active Carbon Column Effluent Pump	300 gpm, 20 psi Δ P, 7-1/2 hp, Carbon Steel.	120	20
P43C128 A/B	D&T Thickener Overflow Pump	150 gpm, 17 psi Δ P, 2 hp, Carbon Steel.	120	17
P43C129 A/B	D&T Belt Filter Filtrate Pump	100 gpm, 17 psi Δ P, 1-1/2 hp, Carbon Steel.	120	17
P43C130 A/B	D&T Belt Filter Feed Pump	150 gpm, 7 psi Δ P, (air). Carbon Steel.	120	7
P43C131 A/B	Incinerator Feed Pump	200 gpm, 26 psi Δ P, 3 hp, Carbon Steel.	120	26
P43C132 A/B	Incinerator Oil Pump	75 gpm, 13 psi Δ P, 1-1/2 hp, Carbon Steel.	120	13
P43C133 A/B/C	Reclaimed Water Transfer Pumps	3500 gpm, 39 psi Δ P, 100 hp, Carbon Steel.	120	39

TABLE 3-32
AREA 43 - WASTE WATER RECLAMATION PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN CONDITIONS	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Pumps - Continued</u>				
P43C134 A/B	Coal Pile & H.Q.R.W Runoff Sand Filter B.W. Pumps	425 gpm, 22 psi Δ P, 10 hp, Carbon Steel.	120	22
P43C137 A/B	Dust, Incineration & Quench Water Pump	160 gpm, 33 psi Δ P, 7-1/2 hp, Carbon Steel.	120	33
P43C138 A/B	Contaminated Condensate Carbon Column Feed Pump	400 gpm, 22 psi Δ P, 10 hp, Carbon Steel	120	22
<u>Separation & Filter Equipment</u>				
S43C101	Miscellaneous Process Wastes	265 gpm, AFL Ind. Model VTC 300C, Oil Skimmer	120	Atmos.
S43C102	Rainwater	60'-0" diameter clarifier.	Ambient	Atmos.
S43C103	Rainwater	Thickener 30'-0" diameter.	Ambient	Atmos.
S43C104	Rainwater	Belt Filter Press.	Ambient	Atmos.
S43C105 A/B	Rainwater	Sand filter system, two 6'-0" diameter filters.	Ambient	Atmos.
S43C106	Devil Liquor Waste Flow	140'-0" diameter clarifier.	120	Atmos.
S43C107 A - D	Devil Liquor	Sand filter system, 8'-6" diameter filters.	120	Atmos.

TABLE 3-32
AREA 43 - WASTE WATER RECLAMATION PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN CONDITIONS	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Separation & Filter Equipment - Continued</u>				
S43C108 A - E	Devil Liquor	Activated carbon system. Five absorber columns, 10'-0" diameter, 24'-0" height.	120	Atmos.
S43C109	Gasifier Waste Flow	90'-0" diameter clarifier.	120	Atmos.
S43C110	Gasifier	Sand filter system, Four 8'-0" diameter filters.	120	A - D
S43C111 A - D	Gasifier Waste Flow	Activated carbon system, Four absorber columns, 10'-0" diameter, 24'-0" height.	120	Atmos.
S43C112	Coal Pile Rainwater Runoff	Filter press.	Ambient	Atmos.
S43C113	Coal Pile Rainwater Runoff	17'-6" diameter clarifier.	Ambient	Atmos.
S43C114 A/B	Coal Pile Rainwater Runoff	Sand filter system, Two 6'-6" diameter filters.	Ambient	Atmos.
S43C115 A/B	Coal Pile Rainwater Runoff	Activated carbon system, Two absorber columns, 10'-0" diameter, 12'-0" height.	Ambient	Atmos.

TABLE 3-32
AREA 43 - WASTE WATER RECLAMATION PLANT
EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN CONDITIONS	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Separation & Filter Equipment - Continued</u>				
S43C116	Devil Liquor/Gasifier	Belt filter press.	120	Atmos.
S43C117 A/B	Contaminated Condensate	Activated carbon system, Two absorber columns, 10'-0" diameter, 12'-0" height.	120	Atmos.
S43C118	Devil Liquor/Gasifier	Thickener, 20'-0" diameter	Ambient	Atmos.
<u>Storage Tanks</u>				
T43C101	Brine Concentrator	Holding Tank 33'-6" diameter, 24'-0" height, Carbon Steel.	Ambient	Atmos.
T43C102	Low Quality Rainwater Runoff	Holding Tank 30'-0" diameter, 32'-0" height, Carbon Steel.	Ambient	Atmos.
T43C103	Devil Liquor	Holding Tank 42'-6" diameter, 48'-0" height, Carbon Steel.	120	Atmos.
T43C104	Gasifier	Holding Tank, 42'-6" diameter, 40'-0" height, Carbon Steel.	120	Atmos.
T43C105	Reclaimed Water "A"	Holding Tank, 48'-0" diameter, 48'-0" height, Carbon Steel.	Ambient	Atmos.

TABLE 3-32
AREA 43 - WASTE WATER RECLAMATION PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN CONDITIONS	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Storage Tanks - Continued</u>				
T43C106	Reclaimed Water	Holding Tank, 21'-3" diameter, 24'-0" height, Carbon Steel.	Ambient	Atmos.
T43C107	Contaminated Condensate	Holding Tank, 26'-0" diameter, 32'-0" height, Carbon Steel.	Ambient	Atmos.
T43C109	Incinerator Water	Holding Tank, 30'-0": diameter, 48'-0" height, Carbon Steel.	Ambient	Atmos.
T43C110	Incinerator Oil	Holding Tank, 21'-3" diameter, 24'-0" height, Carbon Steel.	Ambient	Atmos.
T43C111	Acid	Acid Storage Tank, 21'-3" diameter, 24'-0" height, Carbon Steel.	70	Atmos.
T43C112	Caustic	Caustic Storage Tank, 21'-3" diameter, 32'-0" height, Carbon Steel.	70	Atmos.
T34C113	Hydrogen Peroxide	Hydrogen peroxide storage tank, 35'-0" diameter , 32'-0" height, Aluminum.	70	Atmos.
<u>Packaged Process Units</u>				
U43C101	Cooling Tower Blowdown	Brine Concentrator.		

TABLE 3-32
AREA 43 - WASTE WATER RECLAMATION PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN CONDITIONS	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Packaged Process Units - Continued</u>				
U43C102	Miscellaneous Process Wastes	Air Flotation System.		
U43C103	Low Quality Rainwater Runoff	Air Flotation System.		
U43C104	Activated Carbon	Regeneration/Dewatering Storage System.		
U43C105	Bulk Lime	Bulk Lime Handling and Storage System.		
<u>Water Treating Equipment</u>				
W43C101	Air Flotation System	Alum solution feed system.	70	30
W43C102	Air Flotation System	Polymer solution feed system.	70	30
W43C103	Air Flotation System	Lime slaker solution feed system.	70	30
W43C104	Rainwater Runoff Thickener	Polymer solution feed system.	70	30
W43C105	Rainwater Runoff clarifier	Polymer solution feed system.	70	30
W43C106	Rainwater Runoff Clarifier	Alum solution feed system.	70	30

TABLE 3-32
AREA 43 - WASTE WATER RECLAMATION PLANT
EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN CONDITIONS	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Water Treating Equipment - Continued</u>				
W43C107	Devil Liquor/Gasifier Thickener	Polymer solution feed system.	70	30
W43C108	Devil Liquor Clarifier	Ferrous salt solution feed system.	70	30
W43C109	Devil Liquor Clarifier	Polymer solution feed system.	70	30
W43C110	Gasifier Clarifier	Polymer solution feed system.	70	30
W43C111	Gasifier Clarifier	Alum solution feed system.	70	30
W43C112	Gasifier Clarifier	Lime slaker solution feed system	70	30
W43C113	Coal Pile Runoff Clarifier	Polymer solution feed system	70	30
W43C114	Coal Pile Runoff Clarifier	Alum solution feed system	70	30
W43C115	Coal Pile Runoff Clarifier	Lime slaker solution feed system	70	30

TABLE 3-34
AREA 44 - OXYGEN PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
C44C101 A-D	Oxygen Plant Air Compressor	With interstage coolers, 218,050 scfm, 250 95 psi Δ P, 43,425 bhp, gas turbine drive.		95
C44C103 A-D	Oxygen Compressor	With interstage coolers; 40,430 scfm, 220 1460 psi Δ P, 21,560 bhp, extraction steam turbine drive.		1461
CT44C101 A-D	Air Compressor Gas Turbine	43,425 bhp, syngas fuel.		
CT44C102 A-D	Startup Steam Turbine	500 hp, atmospheric exhaust		
CT44C103 A-D	Oxygen Compressor Steam Turbine	Extraction turbine, 21,560 bhp		
<u>Heat Exchangers</u>			<u>SS/TS</u>	<u>SS/TS</u>
E44C101 A-D	Air Compressor Aftercooler	28.8 MMBtu/hr, Stainless Steel.	96/169	60/92
E44C102 A-D	Gas Turbine Waste Heat Boiler	146.1 MMBtu/hr, 650 psig steam generated	260/410	500/925
E44C105	Liquid Oxygen Vaporizer	65.1 MMBtu/hr, Stainless Steel.	-300/320	25/75

TABLE 3-34
AREA 44 - OXYGEN PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
E44C106 A-D	Oxygen By-Pass Cooler	2.0 MMBtu/hr, Stainless Steel.	96/185	60/100
E44C107 A-D	Oxygen Compressor Turbine Surface Condenser	112.6 MMBtu/hr, Carbon Steel.	126/96	4" Hg/60
<u>Jet Equipment</u>				
J44C103 A-D	Oxygen Compressor Steam Ejector	Two stage, Condensing Jets.	---	---
<u>Pumps</u>				
P44C103 A/B	Liquid Oxygen Pump	730 gpm, 25 psi Δ P, 16.4 hp.	-295	25
P44C104 A/B	Liquid Nitrogen Pump	65 gpm, 275 psi Δ P, 33.5 hp.	-300	305
P44C105 A1-D2	Oxygen Compressor Turbine Condensate Pump	235 gpm, 40 psi Δ P, 8.4 hp.	126	25

TABLE 3-34
AREA 44 - OXYGEN PLANT

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	OPERATING	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Separation and Filter Equipment</u>				
S44C101 A-D	Air Compressor Suction Filter and Silencer	By Air Compressor Vendor	Ambient	Atmos.
<u>Storage Tanks</u>				
T44C101 A/B	Liquid Oxygen Storage Tank	45'-0" diameter x 45'-0" high.	-295	Atmos.
T44C102	Liquid Nitrogen Storage Tank	22'-6" diameter x 50'-0" high.	-300	33
<u>Packaged Process Units</u>				
U44C101 A-D	Air Separation Unit	2750 tpd gaseous oxygen, 99.5% purity, --- 55 tpd liquid oxygen, 55 tpd liquid nitrogen, 550 kW net export.		---
<u>Vessels</u>				
V44C101 A-D	Air Compressor Knockout Drum	13'-0" ID x 17'-3" TT, Carbon Steel.	87	92
V44C105 A-D	Steam Ejector Hot Well	2'-0" ID x 4'-0" TT, Carbon Steel.	140	Atmos.

TABLE 3-27
AREA 41 - AMMONIA RECOVERY PLANT

UTILITY SUMMARY

Utility information incomplete since some
information is not available.

<u>Electric Power</u>	<u>KW</u>	
Connected	875	
Operating	370	
<u>Steam</u>		
Consumption:	<u>LB/HR</u>	<u>PSIG</u>
Total area 41	110,000	600 (77,000 lb/hr return to cond.)
	152,000	50 to Condensate
<u>Cooling Water (200F Rise)</u>	<u>GPM</u>	
Total area 41	11,400	
<u>Fuel</u>		
None		
<u>Chemicals</u>		
Phosphoric Acid (100% Equivalent)	575 lb/sd	
Sodium Hydroxide (100% Equivalent)	3800 lb/sd	

TABLE 3-29
AREA 42 - TAR ACID RECOVERY PLANT

UTILITY SUMMARY

<u>Electric Power</u>	<u>KW</u>	
Connected	318	
Operating	119	
<u>Steam</u>	<u>LB/HR</u>	<u>PSIG</u>
Consumption:		
All Users*	7,000	300 to Condensate
All Users*	3,500	100
All Users*	20,500	50
<u>Cooling Water (30°F Rise)</u>	<u>GPM</u>	
All Users*	675	
<u>Fuel</u>		
None		
<u>Chemicals</u>		
Solvent	N/A	

*Breakdown of Users Not Available

TABLE 3-31
AREA 43 - WASTE WATER RECLAMATION PLANT

UTILITY SUMMARY

<u>Electric Power</u>	<u>KW</u>	
Connected	3,160	
Operating	1,140	
<u>Steam</u>	<u>LB/HR</u>	<u>PSIG</u>
Consumption:		
U43C101 Brine Concentrator	136,800	600 to 4"Hg
<u>Fuel</u>	<u>MM BTU/HR</u>	
H43C101 Incinerator	60.6	
<u>Cooling Water (30°F Rise)</u>	<u>GPM</u>	
U43C101 Brine Concentrator	8,676	
<u>Chemicals</u>		
Lime	35,000 lb/SD	
Caustic (50% NaOH)		600 lb/sd
Ferric Salt		1,058 lb/sd
Ferrous Sulfate		1,058 lb/sd
Sulfuric Acid (66°F Be)		594 lb/sd
Activated Carbon		430 lb/sd
Polymer A		32 lb/sd
Polymer B		95 lb/sd
Polymer C		126 lb/sd
Polymer D		14 lb/sd
Polymer E		28 lb/sd
Polymer F		8 lb/sd
Hydrogen Peroxide		400 gal/sd

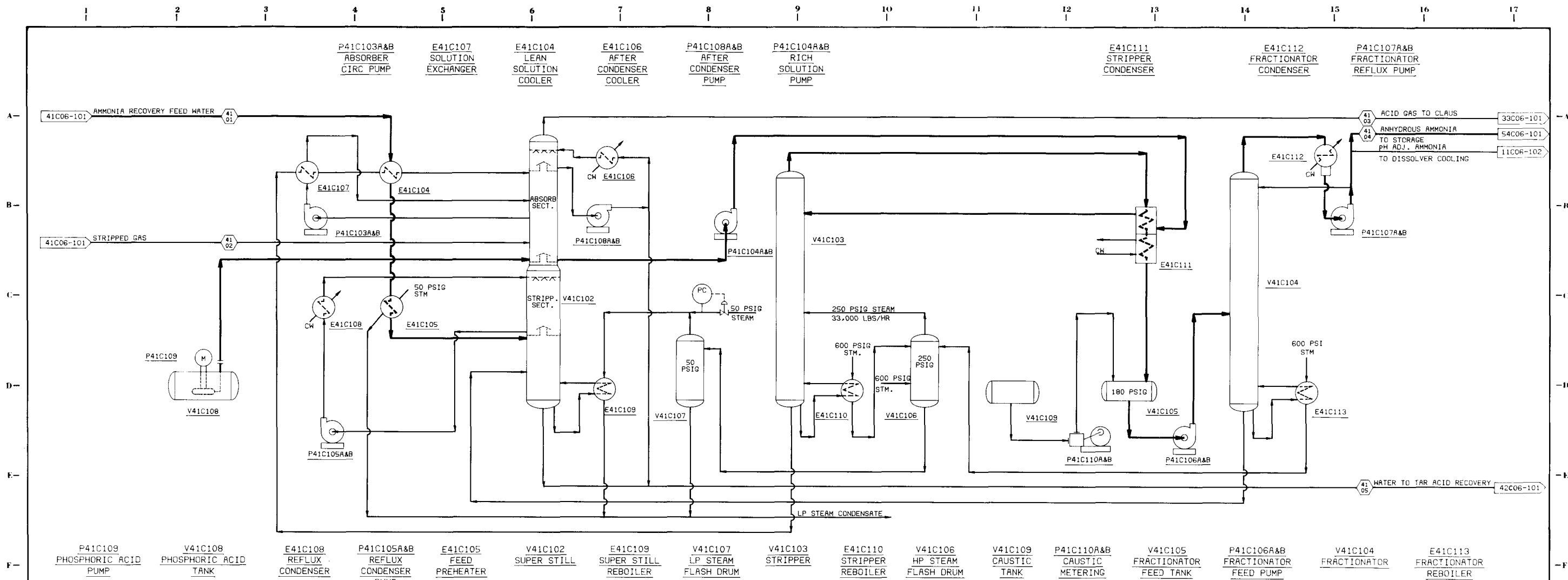
TABLE 3-33
AREA 44 - OXYGEN PLANT
UTILITY SUMMARY

<u>Electrical Power</u>		<u>KW</u>	
Connected		148	
Operating		121	
Generation:			
U44C101 A/B/C/D	Air Separation Plant	2200	
<u>Steam</u>		<u>LB/HR</u>	<u>PSIG</u>
Consumption:			
CT44C101 A/B/C/D	Air Compressor Gas Turbine (NO _x Control)	94,000	300
CT44C102 A/B/C/D	Start-up Steam Turbine	(18,000) (start-up only)	300 to atms.
CT44C103 A/B/C/D	Oxygen Compressor Steam Turbine Drive:		
	Extraction Section	313,380	1500 to 650
	Condensing Section	470,150	1500 to 4" Hg
E44C105	Liquid Oxygen Vaporizer	(52,990) Intermittent	75 to Condensate
J44C103 A/B/C/D	Oxygen Compressor Steam Ejector	2800	75 to Condensate

TABLE 3-33
AREA 44 - OXYGEN PLANT
UTILITY SUMMARY - Cont.

Generation:

E44C102 A/B/C/D	Gas Turbine Waste-Heat Boiler	600,000	650 saturated
<u>Cooling Water (150F Rise)</u>		<u>GPM</u>	
C44C101 A/B/C/D	Oxygen Plant Air Compressor Intercoolers	30,740	
C44C103 A/B/C/D	Oxygen Compressor Intercoolers	25,030 (10° Rise)	
E44C101 A/B/C/D	Air Compressor Aftercooler	15,340	
E44C106 A/B/C/D	Oxygen Bypass Cooler	1,060	
E44C107 A/B/C/D	Oxygen Compressor Turbine Surface Condenser	30,040 (300F Rise)	
J44C103 A/B/C/D	Oxygen Compressor Steam Ejector Condenser	200	
<u>Fuel Gas</u>		<u>MM BTU/HR</u>	
CT44C101 A/B/C/D	Air Compressor Gas Turbine	1,315	



MATERIAL BALANCE		INCOMING						OUTGOING					
STREAM NUMBER		41 01	41 02					41 03	41 04	41 05			
IDENTIFICATION		AMMONIA REC FEED WATER	STRIPPED GAS					ACID GAS TO CLAUD	ANHYD. AMMONIA PRODUCT	WATER TO TAR ACID RECOVERY			
COMPONENT	MOL. WT.												
CO ₂	44.01	220.0						220.0	-	TR			
H ₂ S	34.076	124.5						124.5	-	TR			
NH ₃	17.032	738.0						0.5	897.6	10.4			
HCN	27.03	-						-	-	-			
C ₅ +	100.0	33.0						2.0	-	31.0			
H ₂ O	18.0	41,607.9						90.3	-	43,876.1			
TOTAL (M/HR)		42,723.4						437.3	897.6	43,917.5			
TOTAL (LBS/HR)		778,762						15,790	15,290	792,992			
SOLIDS (LBS/HR)		-						-	-	-			
TOTAL (LBS/HR)		778,762						15,790	15,290	792,992			
TOTAL (TPD)		-						-	183	-			
MOLECULAR WEIGHT		18.2						36.1	17.0	18.1			
BPSD		-						-	-	-			
SP OR. 60°F		0.99						-	0.82	1.0			
SP OR./LBS/FT ³ @ TAP		0.99						-	0.58	0.94			
OPN @ 60°F		1.573						-	49	1.586			
OPN./ACFSD @ TAP		1.573						-	53	1.687			
PRESSURE (PSIA)		65						27.0	260	33			
TEMPERATURE (°F)		118						150	100	255			

- NOTES:
- THIS IS A LICENSED PROCESS AND CERTAIN EQUIPMENT DATA AND OPERATING CONDITIONS ARE NOT AVAILABLE.
 - C₅+ FRACTION CONSISTS PRIMARILY OF PHENOLIC, CRESYLIC, AND HIGHER BOILING RANGE POLAR AROMATICS.
 - ASSUMES ALL ACID GASES ARE TIED UP WITH AMMONIA.
 - AREA CONSISTS OF ONE TRAIN OF EQUIPMENT.
 - MATERIAL BALANCE IS FOR 100% PLANT CAPACITY.

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		NO.	DATE	BY	CHKD	APPVD				DATE	APPVD BY	DATE	DATE	DATE	DATE	DATE	DATE	The Phoenix & Midway South Building Co. A WHOLLY OWNED SUBSIDIARY OF GULF OIL CORPORATION		SHEET NO. 41C06 102	

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DRAWN 155 7/16/79

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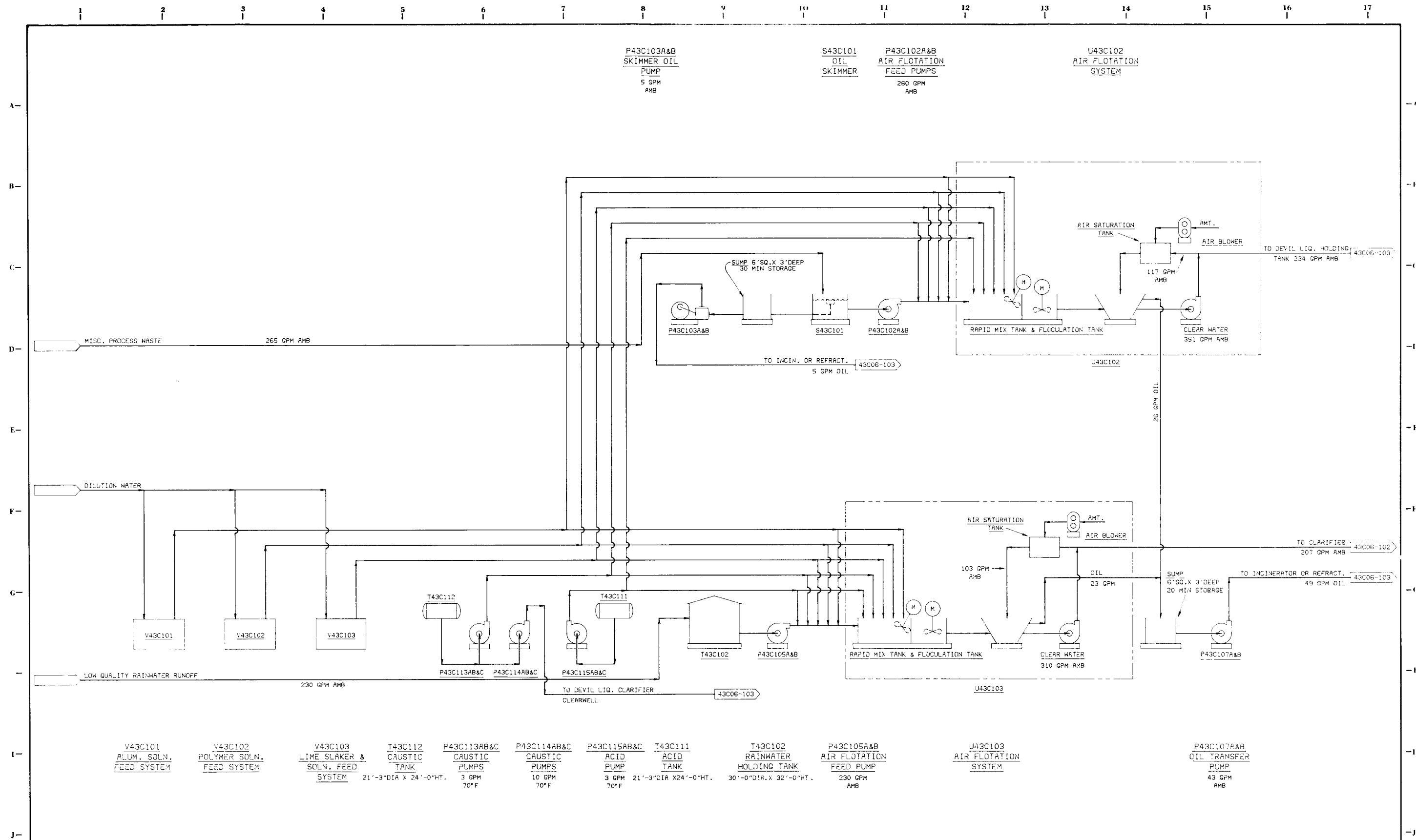
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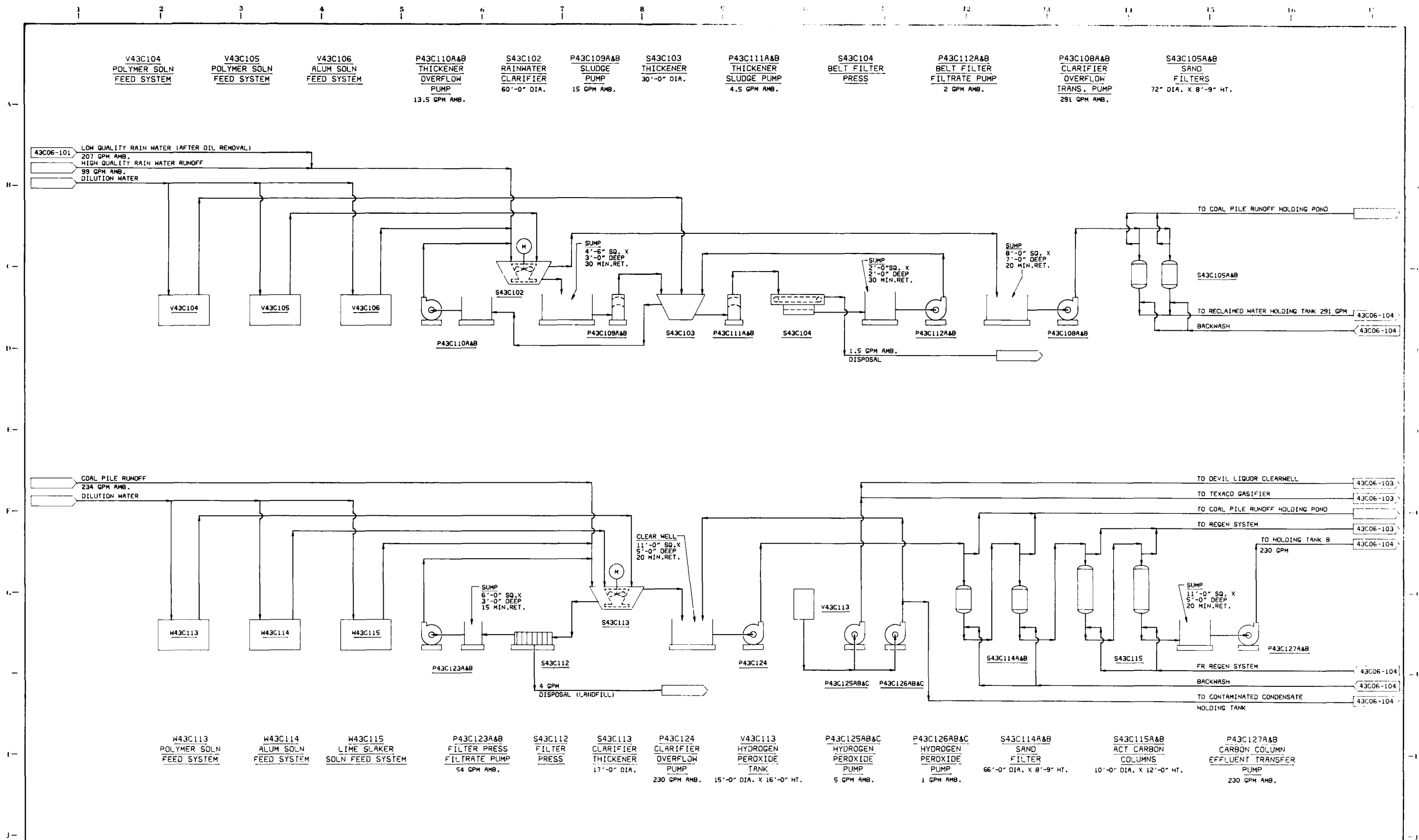
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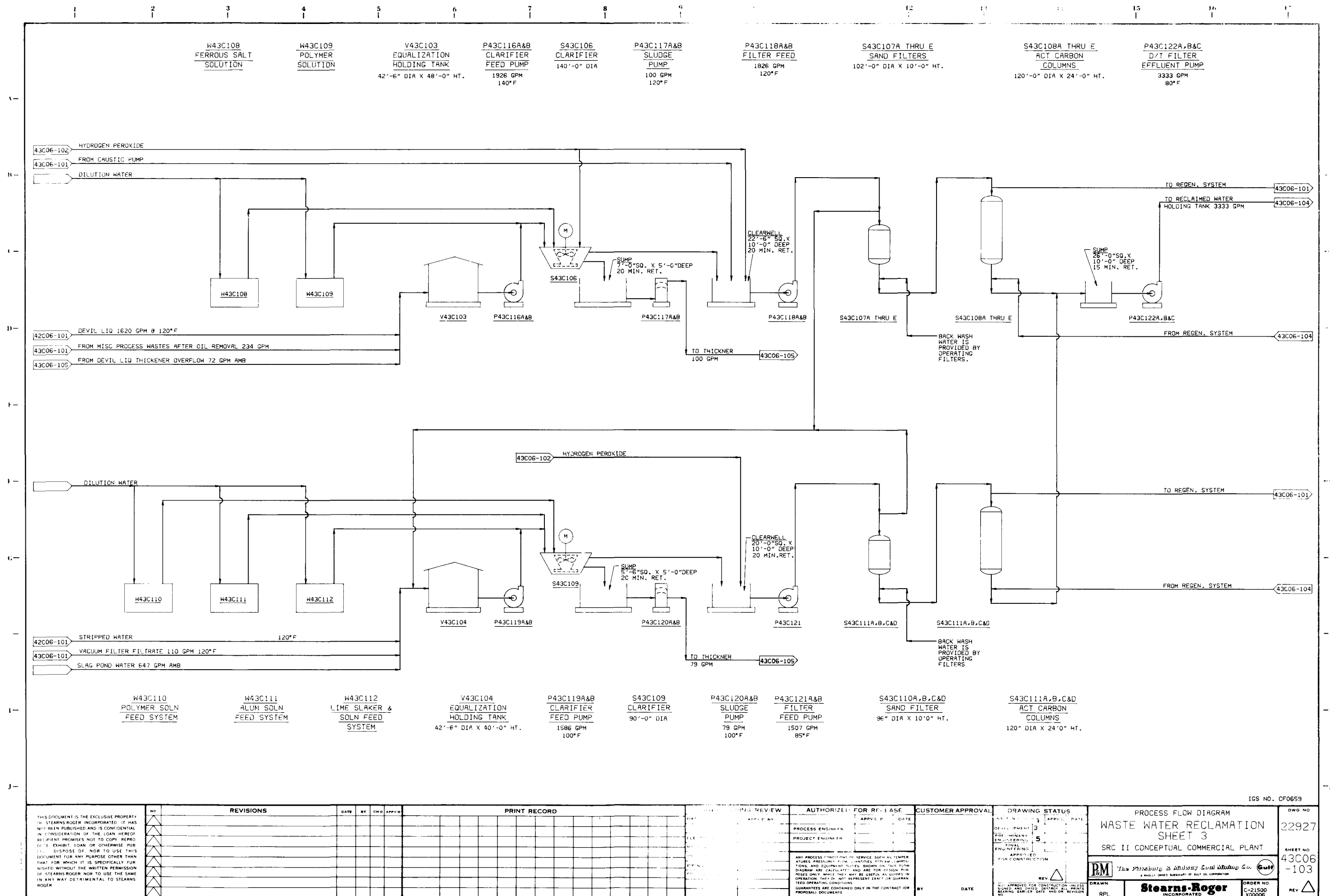
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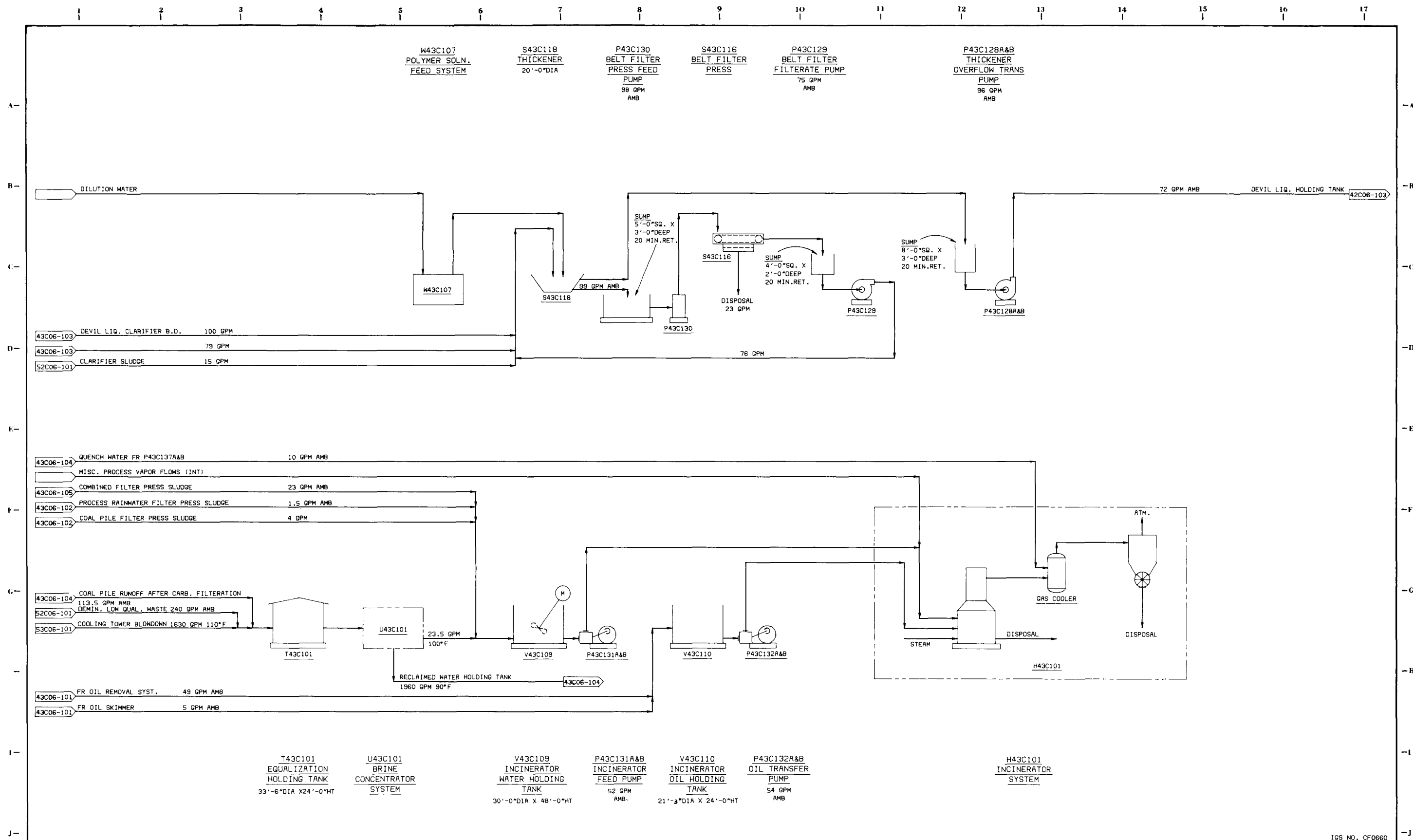
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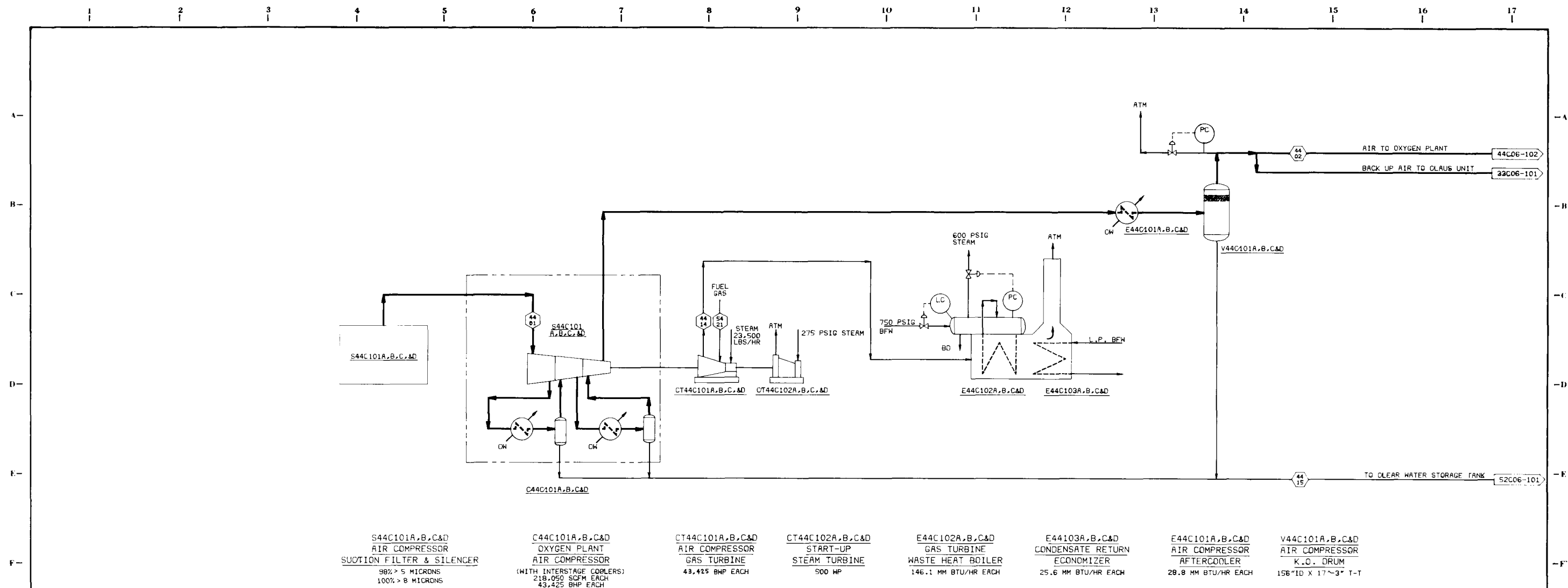


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NOTES:

1. FOUR UNITS OPERATING IN PARALLEL.
2. MATERIAL BALANCE IS FOR THE SUM OF ALL UNITS.

[illegible]

3.7 UNIT 50 - UTILITY SYSTEMS AND GENERAL FACILITIES

Unit Definition. The Utility Systems and General Facilities are divided into five areas according to functions:

- Area 51 - Steam Generation
- Area 52 - Raw Water System
- Area 53 - Cooling Water System
- Area 54 - Miscellaneous Systems
- Area 55 - General Plant Facilities

3.7.1 Area 51 - Steam Generation System

Area Definition. This area provides steam generation, distribution, and condensate-return facilities for process use and motive power. The system is integrated with the process to recover waste heat to improve the overall plant thermal efficiency.

Design Basis. Steam is generated at five different pressure levels to satisfy process requirements and to maximize energy availability. The five pressure levels are: 1500 psig, 600 psig, 250 psig, 100 psig and 50 psig. The 1500, 600, and 250 psig steam are generated at 50 psig above the nominal header pressures to allow for superheating, control, and line pressure drop. Two 300,000 lb/hr, 1500 psig at 950°F, power boilers are provided for startup and to augment waste-heat boiler production. Onsite turbine-generator units are provided to utilize the intermediate (250 psig) steam that is available.

These turbine-generator units provide a convenient method of controlling the 250 and 50 psig header pressures and eliminate the need for numerous small condensing turbines. A supplemental advantage is derived by having two independent sources of electrical power; the onsite power generation and also the commercial power grid.

Process Description. The process configuration is shown on Process Flow Diagrams 51C06-101 and 51C06-102.

Steam at 50 psig is generated in waste heat boilers located in various process areas . This steam is used primarily by process users such as reboilers, strippers, plant heating, and in the deaerators. Pressure in the 50 psig header is controlled by varying the 50 psig extraction rate from the turbines driving the onsite electric generators.

Steam for the 100 psig system is generated in a waste heat boiler in Area 25 Methanation and Dehydration Plant. This production is augmented by reducing 300 psig steam through a letdown station. The 100 psig steam is used primarily as ejector motive steam.

The 250 psig steam is generated in process Areas 22 and 24 and augmented by 600 psig steam expanded through topping turbines. A relatively small portion of this steam is utilized in process reboilers and as NO_x control steam in the gas turbines. The bulk of the 250 psig steam is superheated and used to drive large process compressors and the onsite steam turbo-generator units. The generated electric power is fed into the plant grid. Pressure in the 250 psig steam system is controlled by varying the throttle steam rate to the turbo-generators. The boiler feedwater pumps are normally driven by 600 to 300 psig topping turbines; however, in the event that some of the larger turbines which normally consume 250 psig steam are down, large reductions in the 250 psig steam production are possible by using the motor driven boiler feedwater pumps.

Steam at 600 psig is generated in waste heat boilers located in Areas 11, 22, 25 and 33. In addition to these process waste heat boilers, another source of 600 psig steam is the gas turbine waste heat boilers. A small portion of the 600 psig steam is used in the process for reboilers and stripping but the major portion of it is used for driving topping and condensing turbines. Pressure control of the 600 psig steam header is obtained by varying the extraction rate from the Area 44 oxygen compressor turbine drivers.

The major portion of the 1500 psig steam is generated through waste heat recovery in the dissolver, shift conversion, and methanation areas. Saturated steam produced in these waste heat boilers is superheated in the convection section of the dissolver charge heaters. Makeup 1500 psig superheated steam is provided by the 1500 psig power boilers. The power boilers have been sized to satisfy startup requirements and will normally operate at about 25% of design load.

Design Discussion. The steam production and distribution system design allows for operating flexibility. The 1500 psig power boilers have a total design capacity of 600,000 lbs/hr as dictated by startup requirements. Under normal operation, these boilers are expected to supply steam at a rate of 135,000 lbs/hr.

The oxygen plant oxygen compressors are equipped with both extraction and condensing turbines. Pressure control of the 600 psig header is provided by varying the extraction rate from these turbines. In the event of excessive 600 psig production, the 600 psig steam can be let down into the 250 psig header where it can be expanded through the turbo-generator units.

The 250 psig steam system pressure control is obtained by varying throttle steam to the turbine-generator units.

The 50 psig steam system pressure control is obtained by varying the 50 psig steam extraction rate from the turbine-generator units. Operating flexibility in varying the 50 psig steam requirements can be obtained by varying the 4" Hg condensate-return preheat in the gas turbine economizer.

The equipment in Area 51 is of conventional design and no advanced technology is required. Steam demand, and waste heat boiler production rates of the plant are dependent on many interacting areas of the facility.

3.7.2 Area 52 - Raw Water System

Area Definition. The raw water system includes facilities for the supply, storage, and treatment of the various types of water required in the process and utility areas. These facilities will perform the following specific functions:

- Supply river water to raw water storage;
- Provide raw water storage;
- Supply makeup water to the cooling water system;
- Treat, store, and transfer demineralized water to the steam generation system;
- Treat, store, and transfer utility and potable water to the Process Area.

Design Basis. The design of the raw water system is based on the following design usages for the various types of water:

Boiler Feed Water	2400 gpm
Potable Water	33 gpm
Utility Water	110 gpm
Cooling Water Makeup	9590 gpm
Losses from Regeneration, etc.	<u>267 gpm</u>
 TOTAL	 12,400 gpm

Raw water will be treated to provide the following typical analyses for the different types of water produced. Analyses are expressed as ppm of CaCO_3 unless otherwise noted.

	<u>RAW WATER</u>	<u>COOLING WATER MAKEUP</u>	<u>POTABLE & UTILITY WATER</u>	<u>DEMINERALIZED WATER</u>
Ca	141	141	80	0
Mg	62	62	56	0
Na	36	36	36	0.2
M-Alkalinity	116	116	40	0
SO ₄	77	77	86	0
Cl	39	39	39	0
NO ₃	7	7	7	0
SiO ₂ as SiO ₂	5	5	5	0.010

Boiler Feed Water: Settling, clarification and softening, filtration, and anion/cation demineralization.

Potable and Utility Water: Settling, clarification and softening, filtration, and disinfection.

Cooling Water Makeup: Settling.

Process Description. The process configuration is shown on Process Flow Diagrams 52C06-101 and 52C06-102.

Raw water is delivered to the 56,000,000-gallon raw water storage reservoir via three river water pumps. This earthen reservoir provides 72 hours of storage at the design flow rate and also serves as a primary settling basin.

Cooling water makeup is provided directly from the raw water reservoir without additional treatment. Three cooling tower makeup pumps are used to transfer this water to the cooling tower basins.

Two clarifier/softeners each designed for 1970 gpm, or 70% of the total clarified water requirement, are provided and operate in parallel. Four raw water pumps provide the feed to these units. The feed is periodically chlorinated to prevent bacteriological or algal growth in the system and is

continuously mixed with lime, alum, and polymer at the clarifier/softener inlet. In the clarifier/softener, calcium and magnesium salts, as well as other suspended matter, settle to the bottom forming sludge. This sludge is pumped to the Waste Water Reclamation Plant for further treatment and disposal. Phosphate is added to the effluent clear water for stabilization.

Exiting the clarifier, the stabilized water is split into two streams. The smaller (33 gpm) stream goes to the potable water feed tank while the larger (2777 gpm) goes to the demineralizer suction tank.

From the demineralizer suction tank, clarified water is fed to five identical demineralizer trains operating in parallel. Each demineralizer train consists of a horizontal sand/anthracite filter, a strong acid cation exchanger, and a strong base anion exchanger. The demineralized effluent from each train is sent to the 2,260,000-gallon demineralized water storage tank. Each demineralizer is designed for a 14-hour cycle (10.5 hour operating, 3.5 hour regenerating).

Four identical complete regeneration systems are provided. Each system includes two acid-metering pumps for two-step regeneration, one caustic metering pump, and one caustic dilution water heater. The bulk storage facilities for acid and caustic are common for all regeneration trains. Low-quality regeneration waste water is pumped to Area 43 Waste Water Reclamation Plant while the high quality regeneration waste is returned to the demineralizer feed tank.

Downstream of the sand/anthracite filters in the demineralizer trains, the 110-gpm utility water supply is extracted. This clarified and filtered water is chlorinated and delivered to the utility water header.

Clarified water entering the potable water feed tank is recarbonated for stabilization and pH control. From the feed storage tank, the water is pumped through two parallel sets of filters. Each set of filters contains a sand/anthracite filter for solids removal and an activated carbon filter for

taste and odor removal. Exiting the filters, the water is chlorinated and delivered to the potable water storage tank. From the potable water storage tank, the water is pumped to the pressurized head tank and thence to the various potable water headers. Water from filter regeneration is returned to the inlet of the clarifier/softener.

Because of the internal recycling of several regeneration streams, the raw water system sends only the clarifier/softener sludge and low-quality regeneration water from the demineralizer to Area 43 Waste Water Reclamation Plant.

Design Discussion. The raw water system is designed to provide 100% of the cooling water makeup requirements with two of the three pumps in service. It is also designed to provide a minimum of 70% of the clarified water requirement with two of the four raw water pumps and one of the clarifier/softeners out of service. The 70% minimum can be maintained if two of the five demineralizers are out of service. One potable water filter train can maintain 100% of the potable water requirements.

3.7.3 Area 53 - Cooling Water System

Area Definition. Area 53 provides recirculated cooling water to all process and utility areas as required for plant operation. It consists of cooling towers, circulation pumps, headers, and treatment facilities.

Design Basis. The process design of the cooling water system is based on the following criteria:

- (1) Cooling water circulation and cooling tower dimensions are calculated for the following temperature data:

Design wet bulb temperature 79°F

Design dry bulb temperature 90°F

	<u>SUPPLY TEMP.</u>	<u>RETURN TEMP.</u>
Utility Cooling Water System (for oxygen production)	86°F	116°F
Process Cooling Water System (for other areas)	90°F	120°F

Water temperatures for oxygen production are set lower than those for other areas.

(2) Cooling water supplied to the Oxygen Plant is independent of cooling water supplied to other areas.

(3) Both the utility and process cooling systems employ induced draft, cross-flow cooling towers having a drift loss of approximately 0.1% of circulated flow.

(4) Makeup cooling water quality allows the system to operate at 5.0 cycles of concentration.

(5) Total cooling tower blowdown is 1640 gpm based on 5.0 cycles of concentration. Blowdown is routed to Area 43 Waste Water Reclamation Plant.

Process Description. The process configuration is shown on Process Flow Diagram 53C06-101.

The process cooling system has a circulation rate of 277,000 gpm at supply and return temperatures of 90°F and 120°F, respectively. To accomodate this heat load, induced-draft cross-flow cooling towers (4066 MM Btu/hr) are employed. As a safety factor, the equipment is sized to handle 110 percent of design.

Water flows from the cooling tower basin to a 12-foot deep well where six cooling water pumps (five operating, one spare), at 55,400 gpm/pump, circulate the cooling water through the system to individual operating areas.

Three of the six cooling water pumps are powered by condensing steam turbines and three are powered by electric motors. In the event of an electric power outage, or trouble with the steam system, cooling water circulation can be maintained for plant operation at a reduced rate or for an orderly shutdown.

Recirculated cooling water is treated with 66° Baume sulfuric acid to control pH. Chlorine is also added for control of bacteria and algae. The chlorine treatment is based on a shock treatment of 3 ppm of chlorine for 1 hr/day. An inhibitor is added to control scale formation and to inhibit corrosion.

Makeup water from Area 52 Raw Water System is provided at 5872 gpm, an additional 3421 gpm of makeup water is supplied from Area 43 Waste Water Reclamation Plant.

The utility cooling system has a circulation rate of 104,485 gpm at supply and return temperatures of 86°F and 116°F, respectively. The cooling towers are similar in design to those in the process cooling system and have a heat load of 958 MM Btu/hr. As with the process cooling water system, the utility cooling system equipment is also sized to handle 110 percent of design operating capacity.

The utility cooling water pumps take suction from a 12-foot deep well. Circulation is provided by five pumps at 26,130 gpm/pump (four operating, one spare). Three of the pumps are driven by steam turbines and two are driven by electric motors. In the event of an outage of either power system, water circulation can be maintained at a reduced rate. The hot water return flow is

fed to the top of the cooling tower bays. Treatment of the recirculated utility cooling water is the same as that for recirculated process cooling water. Makeup water from Area 52 Raw Water System is rated at 2311 gpm.

Design Discussion. The components of the process and utility cooling water systems use standard technology. No unusual startup or shutdown problems are be anticipated.

3.7.4 Area 54 - Miscellaneous Systems

Area Definition. This area consists of the following systems:

- Product Storage and Shipping
- Fuel System
- Flare System
- Fire Water System
- Sanitary Sewer System
- Miscellaneous Utility Systems
(plant air, instrument air and nitrogen)
- Electrical Generation, Supply and Distribution
- Overall Instrumentation and Controls

Product Storage and Shipping Systems. The process configuration is shown on Process Flow Diagrams 54C06-101 and 54C06-102.

These systems provide for storing, metering, and shipping plant products. Shipments are made by pipeline, railcar, and truck. Barge shipments are not anticipated but final site selection may prove this method to be practical. Vapor recovery systems are provided for atmospheric storage tanks where needed. Relief valves discharging to the plant flares are provided for the spheres and pressure tanks.

Fuel System. The process configuration is shown on Process Flow Diagram 54C06-103.

This system supplies the fuel requirements of the plant. The system is fed by five gas streams from the plant and contains a fuel mixing drum, pressure control system, and a plant distribution header system.

Flare System. The process configuration is shown on Process Flow Diagram 54C06-104.

This system includes the flare header system and disposal facilities for flammable and noxious gases vented during normal and emergency plant operations.

Fire Water System. The process configuration is shown on Process Flow Diagram 54C06-105.

This system provides fire water supply and distribution for the entire plant complex. It consists of fire water storage, pumping and header facilities.

Sanitary Sewer System. The process configuration is shown on Process Flow Diagram 54C06-106.

This system consists of sanitary sewer facilities for the plant complex. Main sewer lines and laterals are shown schematically on the system flow diagram.

Miscellaneous Utility Systems. Plant Air, Instrument Air and Nitrogen Systems. The process configuration is shown on Process Flow Diagram 54C06-107.

These systems provide plant air, instrument air and nitrogen facilities to supply the plant requirements.

Electrical Distribution. This system distributes power via an underground feeder network to ten substations located throughout the plant. Purchased power is required for startup and backup.

Overall Instrumentation and Controls. This system includes data acquisition, production reporting and environmental monitoring. The control side of the system includes process, fire alarm and suppression, area lighting, safety and security. The system is utilized throughout all process areas and includes the capability of interface with outside systems.

Design Basis

Product Shipping and Storage.

Blended fuel oil storage is provided for approximately 10 days' production. Fuel oil is shipped by pipeline on a one shift/day basis.

Naphtha storage capacity provides for 15 days' production. Naphtha is shipped via pipeline.

Butane storage capacity is 10 days' production. Approximately half of the butane is revaporized and used as plant fuel. The remaining butane is shipped via pipeline. The pipeline pumping system is designed to pump the total daily butane production in about 3 hours.

Sulfur storage provides for 10 days' production. Sulfur is shipped by railcar at a rate of about 80 cars per week.

Ammonia storage capacity is provided for 12 days' production. Ammonia is shipped by railcar at a rate of about 21 cars per week.

Tar acids storage is about 12 days' production. Shipment of tar acids is by truck at about 11 truck loads per week.

Fuel oil and naphtha are stored in API design cone roof tanks. Four 140,000 bbl tanks are provided for fuel oil storage and two 125,000 bbl tanks are provided for naphtha storage.

Butanes are stored in two 20,000 bbl spheres. Storage pressure is approximately 60 psig.

Liquid sulfur is stored in one steam heated and insulated 40,000 bbl API design cone roof tank.

Ammonia is stored as a liquid in two 10,000 bbl spheres. A refrigeration system on each sphere keeps the ammonia at about 40°F, or 60 psig.

Tar acids are stored in two 1,500 bbl API design cone roof tanks.

A vapor recovery system is provided on the fuel oil, tar acids and naphtha storage tanks. Recovered vapors are returned to the refining area. Nitrogen is used to blanket and purge the storage tanks and shipping facilities.

Fuel System. The fuel system utilizes five process streams: syngas from Area 24 Syngas Purification Plant, hydrogen-rich gas from Area 32 Product Gas Plant, butane from Area 54 Product Storage, methane-rich gas from Area 12 Hydrogen Treating and Recovery Plant, and flash gas from Area 31 Low Pressure Gas Compression and Treating Plant. The process streams will be backed up by pipeline gas during startup and emergency periods.

The five process streams, plus backup pipeline gas, enter the fuel system through a mixing drum. The fuel supply is balanced with demand by vaporizing liquid butanes into the system. Overpressure is vented to the flare.

	<u>NORMAL PLANT FUEL GAS SUPPLY</u>		
	<u>SCFH</u>	<u>LHV BTU/SCF</u>	<u>TOTAL HEAT MM BTU/HR</u>
Syngas	6,352,000	275.5	1,750.0
Hydrogen-Rich Gas	188,000	388.6	847.1
Flash Gas	6,224	854.3	5.3
Methane-Rich Gas	2,648,100	724.3	1,918.0
Butane	173,775	3,001.0	<u>521.5</u>
	TOTAL		5,041.9

PLANT FUEL GAS USERS

AREA	EQUIPMENT	SERVICE	EFFICIENCY	ALL UNITS MM BTU/HR (LHV)		
				DESIGN FIRED DUTY	OPERATING ABSORBED DUTY	OPERATING FIRED DUTY
11	H11C101 A-H	Dissolver Charge Heater	90%	N/A	N/A	N/A
33	H33C103	Inline Burner/Mixer	--	N/A	N/A	N/A
33	H33C105	Incinerator	--	N/A	N/A	N/A
34	H34C132	Fractionator Reboiler	80%	481.3	342.4	428.0
34	H34C133	Fractionator Feed Heater	80%	78.8	57.0	71.3
43	H43C101	Incinerator	--	61.0	60.5	60.5
44	CT44C101 A-D	Air Compressor Gas Turbine	--	1,314.7	1,314.7	1,314.7
51	B51C101 A-B	Power Boiler	90%	412.0 ⁽¹⁾	151.4	168.2
51	H51C101	250 psig Superheater	90%	348.0	272.4	302.7
51	H51C103	600 psig Superheater	90%	245.7	192.2	213.6
54	H54C131	Clean Hydrocarbon Flare	--	1.0	1.0	1.0
54	H54C132	Heavy Hydrocarbon Flare	--	1.0	1.0	1.0
54	H54C121	Syngas Heater	90%	<u>172.5</u>	<u>135.0</u>	<u>150.0</u>
TOTAL				5,766.1	4,638.9	5041.9

NOTES:

(1) Sized by startup requirements

Flare System The flare installation utilizes a clean flare system and a heavy flare system. The clean system vents light hydrocarbons which are composed of relatively clean gases while the second system vents heavy hydrocarbons which contain noxious gases and hydrocarbons which solidify at ambient conditions.

The clean flare system is based on relief of the atmospheric fractionator in Area 34 Refining Plant. The heavy flare system is based on relief requirements from a single gasifier or dissolver.

Vent gases and vapor/liquid mixtures with high hydrocarbon content are received in the clean-hydrocarbon flare knockout tank. Cold mixtures are received in a separate cold hydrocarbon flare knockout tank. The vapors and other incoming gases are then burned in the clean hydrocarbon flare. Steam is injected at the flare to achieve smokeless combustion. Hydrocarbons and water which have not been vaporized are routed to a storage tank. From this point, the hydrocarbons are pumped to the Area 34 Refining Plant while the water is pumped to the Area 43 Waste Water Reclamation Plant.

Heavy hydrocarbon vapors, or those containing H_2S and other noxious gases, are routed to the heavy hydrocarbon flare knockout drum where they are scrubbed and cooled by a water spray and routed to the heavy hydrocarbon flare for combustion. Water and hydrocarbon liquids accumulating in the knockout drum are pumped to storage, where they are separated and routed to Areas 43 and 34, respectively, for processing.

Fire Water System. Two fire water systems are provided, one for the process area and one for the coal handling area. The two areas are separated by a rather large distance and separate systems are appropriate.

Pressure in the loops is maintained by a jockey pump. Should fire water pressure fall below 170 psig, an alarm sounds and additional pumps are automatically put into operation.

Both systems have backup diesel-driven pumps in case of power outages.

The two systems loop the entire process and coal storage areas. Fire water storage and pumping facilities for the process area provide for a pumping rate of 5000 gpm for 8 hours. Similar facilities in the coal storage area provide for a pumping rate of 3000 gpm for 8 hours. Each system is independent of the other, but an interconnecting line has been provided for emergencies.

Sanitary Sewer System. The sanitary sewer system is designed for 500 plant personnel. The size of the tertiary system is 25,000 gal/day.

The sewage treatment facility is a package unit. The effluent is acceptable for recovery in Area 43 Waste Water Reclamation Plant. Included in the system are holding ponds, aeration tanks, biotreatment system, clarifiers and filtration equipment to achieve tertiary treatment of all sewage. Sludge is incinerated and the residue is disposed of in the landfill area.

Miscellaneous Utility Systems: Plant Air, Instrument Air and Nitrogen.

Instrument air requirements are based on the predominant use of electrical or electronic instruments. There are two operating air compressors and one backup spare. The instrument air driers provide -40°F dewpoint air.

The nitrogen system receives gaseous nitrogen from the Oxygen Plant with a liquid nitrogen source for backup. Nitrogen will be used as backup instrument air in case of air failure.

Plant air and instrument air are supplied from two of three 2000 scfm centrifugal air compressors on an oil-free basis at 100 psig. The third compressor serves as a spare. All three compressors are driven by electric motors. Header pressure for both systems is designed to be 80 psig at the farthest points from supply. After compression and cooling, instrument air is dried to -40°F dewpoint in dual driers. These driers automatically switch over from drying to regeneration. In addition to the spare compressor capability, three air receiver tanks and 16 surge bottles are included to provide surge capacity between supply and use rates.

Nitrogen for purging during coal preparation and for startup and purging of process equipment is received from two sources of supply:

- (a) Gaseous nitrogen at 80°F and 65 psig from Area 44 Oxygen Plant. Approximately 4200 scfm are available from this source.
- (b) Liquid nitrogen from storage at -300°F, and a nominal 300 psig pressure.

The nitrogen is compressed to a nominal 300 psig and cooled to 100°F, and is routed to users through a receiver which provides surge capacity. The relatively high nitrogen header pressure is specified in order to pressure test and purge process equipment during startup and maintenance. When additional nitrogen is called for, liquid nitrogen from storage is vaporized and heated to ambient temperature as needed.

Nitrogen also serves as an emergency backup for the plant air/instrument air system, with adequate provision to prevent instrument air from entering the nitrogen system.

Electrical Generation and Distribution. The power system provides for two sources of power, in-plant generation and purchased power. In-plant generation is the prime source, with a single-circuit purchased power backup. Purchased power is stepped down from transmission voltage to plant primary distribution voltage at a main substation. A feeder is provided from the main substation to the generating facility substation, where purchased power is synchronized with onsite generated power. Primary power originates at and is distributed from, the generating facility substation switchgear via an underground duct system to the ten substations in the plant electrical power system.

In the event of purchased power failure during normal operation, shedding load equivalent to 8700 kVA of purchased power is possible (or a purchased power double-circuit line could be another alternative to be defined by further study). With the possibility of a purchased power failure during a

generator failure-purchased power backup mode, the plant could be shut down safely with small generators strategically located at the load center substations.

The in-plant generating station is located near the steam generating plant. It consists of two 18,000 kW low-pressure steam turbine-generators and one 20,000 kW syngas expander gas turbine-generator. All units generate at 13.8 kV.

The in-plant station consists of main switchgear at 13.8 kV nominal voltage class, 750 mVA interrupting rating with 1200 ampere continuous-rated generator and reactor breakers, and 2000 ampere main generator load buses. Generator load bus short-circuit duty is limited by a synchronizing bus and reactors. The synchronizing bus also provides a preferred method of connecting to purchased power. A future 20,000 kW generator may be added to the station without major changes to the switchgear synchronizing bus or main transformer.

Total plant normal operating demand is approximately 66,700 kVA, assuming a plant power factor of .95. Generating capability is 58,000 kVA with machine power factors of .85; thus, purchased power normal operating demand is approximately 8700 kVA. In the event of a generator failure, or because of routine maintenance, total purchased power demand will be 29,700 kVA with generator contingency (21,000 kVA) added to normal operating demand (8700 kVA).

Purchased power for the plant is available at a main substation. The local power company will construct a single 13.8 kV transmission line into the plant and terminate at the main substation dead-end structure. The plant requires a 20,000 kVA main transformer equipped with automatic cooling fans and oil pumps. The transformer provides a 37,300 kVA contingency load capability with both fans and pumps in operation. This feature allows normal operation of the plant in the event of a generator failure, during maintenance operations, and for plant startup.

Primary distribution voltage is 13.8 kV. This voltage level permits use of an underground installation for the primary cabling system. Parallel radial circuits will be used for each substation primary source. Normally the two circuits share the total load demands of each substation. If a primary feeder should fail, however, the remaining feeder is sized for the total substation load. This arrangement assures good reliability for the critical processes by providing quick restoration of services if a primary feeder fails, and it allows the purchase of standard primary distribution equipment and 15 kV cabling.

A single radial overhead ACSR transmission line of 13.8 kV originating at the power generating station will be built to serve the substations outside the process areas.

At the substations two 13.8 kV primary source feeders are connected to the line-side of two interrupter switches, which are connected to a bus divided into two sections by a bus-tie switch. Automatic or manual operation is provided by switch operators and an automatic control device. Under normal operating conditions, the bus-tie switch is open and each bus section receives power from its normal source. Should one of the source circuits fail, the interrupter switch associated with that source is automatically or manually opened and the bus-tie switch closed, permitting the remaining source to serve the entire load.

Secondary selectivity is provided with double-ended 480-volt and 4160-volt transformers and switchgear employing manual or automatic bus selectivity in the event of single load-center transformer operation. Motor control centers are fed from this switchgear and provide circuit protection and motor control capability for all 480-volt and 4160-volt loads.

Transformer rating is limited where possible (or standard current-limiting techniques will be employed) in order to limit the interrupting ratings of the switchgear and motor control centers to 350 mVA and 4160 volts and 22,000 rms symmetrical amperes at 480 volts. For all double-ended transformer

arrangements, the transformer will be provided with 65°C fan cooling equipment so that maximum capability can be realized from a given transformer in the event of contingent single-transformer operation. Minimum load shedding is required in most of these operations.

Insofar as possible, all major electrical equipment is located outside hazardous areas.

Overall Instrumentation and Controls. Instrumentation and controls are treated as a system, both because the processes and utilities are interactive and because the same control system is utilized throughout the whole plant.

The system is cathode ray tube (CRT) based and is intrinsically safe. For economy of installation, it employs a "data highway" concept of field wiring to a central control room. The central control room includes a "supervisory" control console and a number of interactive but separate consoles each having CRT's, a keyboard, alarms, etc. Each console has access to related information from other unit areas, but operator action will be restricted to a specific unit.

The CRT's provide grouping of loops according to process requirements. Plant overview and unit displays are used in addition to individual loop displays. The system is capable of generating:

- P&ID displays for process units giving live data;
- Both present and historical trending in graphic form.

Process alarms are also displayed via CRT (a separate CRT may also be required for hard-wired alarms). The system is fully computer compatible and is capable of operating in a computer supervisory set point control mode. The computer system handles such data as required for plant performance monitoring, material balance and computing etc.

Plant performance data is recorded in a mass-storage device, where it is available for periodic transfer to a computer-based data storage facility. In

addition, a certain number of conventional strip chart recorders are provided for short-term trend recording. Dedicated strip chart recorders may also be used.

The system is capable of optimization of:

- Plant Throughput
- Product Quality
- Energy Usage
- Environmental Controls

The system is capable of performing all of the above for an estimated 2000 select loops.

The system is flexible and easily modified to meet changing process needs and/or optimization. A number of changes can be effected without reworking the wiring.

3.7.5 Area 55 - General Plant Facilities

Area Description. The overall site for the Conceptual Commercial Plant is of sufficient size to provide a minimum of 280 acres for the process plant and 100 acres for the coal unloading and storage facilities. Approximately 300 acres will be required for slag disposal. An overall area of approximately 2500 acres would be desirable.

In addition to normal grading and surface preparation, there are roads, sidewalks, parking lots, and other paved areas. The process area is enclosed by a security fence, as are other areas which require fencing because of security considerations.

The main process area drain system consists of catch basins and underground piping to contain oil and chemical spills, wash water, and initial rain water runoff. Drainage contained in this system is diverted to the

retention basin in Area 43. The other plant areas (coal supply and handling systems, product storage and shipping) have self-contained drain systems. These systems consist of ditches, catch basins, underground piping, and diversion boxes with control gates.

General Buildings and Facilities.

Administration Building. This is a two-story structure with approximately 12,000 square feet of floor area. The building includes a reception room, library, conference room, lavatory facilities for men and women, fire-resistant vaults on each floor, a mechanical room for central air conditioning, heating equipment, and storage rooms. It is a steel-frame building with concrete block walls; the facade is faced with brick. The interior walls are painted drywall on steel studs. Floors are concrete with vinyl asbestos tile, and the roof is of low-profile concrete construction with 1" rigid insulation.

Guard House. A guard house is provided at the main plant entrance. It includes an office for the plant security supervisor, along with office, lockers, and toilet facilities for the security guards. The building is heated and air conditioned. It is single-story, of masonry construction, with approximately 480 square feet of floor area.

Change House. This building contains shower, lavatory, and locker facilities sufficient to handle a peak day shift of 200 people. The building is heated and air conditioned. It is of steel-frame construction with concrete block walls, concrete floors, and concrete roof with a built-up tar and gravel seal. It has a floor area of 9000 square feet.

Chemical Storage Building. This structure provides for warehousing of chemicals, catalysts, etc., used in processing, water treatment, and other areas of the plant. This building is of prefabricated steel construction and has approximately 2800 square feet of floor area, with a truck unloading dock and ramp on the 70-foot side.

Control Building. The main control room is in a separate single-story building with 7500 square feet of space. In addition to the control room the building contains office space for the operating supervisors, lunchroom facilities for shift personnel, and sanitary facilities. Additional areas are provided for computer facilities and minor electronic instrument repair. The building is heated and air conditioned and is blast-resistant. The fresh air system for heating and air conditioning prevents the entrance of hazardous gases from the surrounding area.

All satellite control buildings have the same design standards, except for office, computer and instrument repair space.

Maintenance Building. The Maintenance Building is a structure of 28,800 square feet. It is of prefabricated construction, with 20-foot high bays for large truck repair and low bays for pickup truck and car repair. The building includes a pipe shop, electrical shop, instrument shop, warehouse, and machine shop. A block of 10 air-conditioned offices is provided for supervisory and record keeping personnel.

Laboratory. This building is of masonry construction. It is one story high with approximately 5000 square feet of floor space. The building is blast-resistant. Air-conditioning and heating units provide for closing the fresh air intake upon detection of hazardous or flammable gases in the area.

Fire Station/First Aid Building. This structure houses one fire truck, an ambulance, and other fire fighting and emergency equipment. It includes air-conditioned office space for the safety supervisor, and first aid facilities with a nurse's office, waiting room, and examining room. There are also restrooms and miscellaneous storage and utility areas. The building is of prefabricated steel construction. Partitions and ceilings in the first-aid area and in the offices are similar to the administration building. Approximately 2000 square feet of floor space is provided.

Warehouse. This building provides for storage of spare parts, for maintenance, and for general plant warehousing. There is air-conditioned

office space for warehouse and clerical personnel, and there are lavatory facilities. This building is of prefabricated steel construction with a total of 13,200 square feet of floor area and a truck-loading dock and ramp.

Auxiliary Building. This structure provides equipment for potable water treating, testing, and miscellaneous services. It includes an area for Electrical Unit Substation No. 3. It is of prefabricated steel construction with a total of 9000 square feet of floor space.

Load Center Substations. These substations house the switchgear for stepping-down from 13.8 kV primary voltage level to site utilization levels (4160V and 480V), and for servicing distribution lines and motor-control centers.

Normal operating demand is 66,700 kVA, which requires substations rated at approximately 7000 kVA each.

The substations are of masonry construction with flat built-up roofs and are equipped with full cable vaults. HVAC in these buildings meets specific requirements of the electrical equipment.

Final design will determine the exact specifications of each substation and its equipment.

Maintenance Shop #2. This structure houses facilities for the repair and maintenance of all general plant equipment, including areas for mechanical work, piping, welding, electrical work, etc. The structure is constructed of steel frame and concrete block walls with a concrete roof and floor. A 10-ton overhead bridge crane with 20-foot minimum hook clearance is provided. There are offices for shop and maintenance personnel, and there are restrooms, locker rooms, and lunch rooms. The total area is 17,600 square feet.

Steam Generation Building - Area 51. This structure contains facilities for steam generation, including power boilers, boiler feedwater pumps, chemical

additive systems, etc. The structure is of prefabricated steel construction. A 50-ton overhead bridge crane with a minimum hook clearance of 20 feet is provided. The total floor area is 6000 square feet.

Raw Water Treatment Building - Area 52. This structure contains facilities for adding lime and alum to raw water, for filtration and chlorination of potable water, and for the demineralization of boiler feed water. The structure is of prefabricated steel construction and has a total floor area of 15,000 square feet.

Utility Building - Area 54. This structure contains the facilities for the plant air, instrument air, and nitrogen supply to the plant utility systems. The structure is of prefabricated steel construction and has a total floor area of 4800 square feet.

TABLE 3-36
AREA 51 - STEAM GENERATION SYSTEM

EQUIPMENT LIST

<u>EQUIPMENT NUMBER</u>	<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>DESIGN</u>	
			<u>TEMPERATURE (F)</u>	<u>PRESSURE (PSIG)</u>
<u>Boilers</u>				
B51C101 A/B	Power Boiler	1500 psig @ 950°F 300,000#/hr each - Design 370.7 MMBtu/hr Absorbed - Design each 412.0 MMBtu/hr Fired - Design each BFW @ 259°F @ Startup, 370°F Normally 90% Efficiency	605/1000	1600/1650
<u>Exchangers</u>				
E51C101	Blowdown/Makeup Water Heat Exchanger	6.8 MMBtu/hr Duty - Area 370 ft2 Boiler Makeup in @ 60°F out @ 68°F, Boiler Blowdown in @ 259°F out @ 70°F, Carbon Steel	SS/TS 60/259	SS/TS 50/50
<u>Turbine-Generator Unit</u>				
G51C101 A/B	Onsite Electric Generator	Steam Turbine Generator Set, 1800 KW Generator @ 0.85 PF, Turbine Driven Steam @ 240 psig and 700°F, Exhausting to H" Hg. Turbine also has extraction stage at 50 psig and capable of supplying 100,000 lb/hr. to 50 psig header. Includes surface condenser, condensate pumps and auxiliaries.		
<u>Fired Heaters</u>				
H51C101	250 psig Superheater	300 psig Sat., Heated to 700°F @250 psig, 90% Efficiency 1,875,000#/hr Flow Rate - Design 313.2 MMBtu/hr Absorbed - Design 348.0 MMBtu/hr Fired - Design	750	330

TABLE 3-36
AREA 51 - STEAM GENERATION SYSTEM

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
H51C103	600 psig Superheater	650 psig Sat., Heated to 750°F @ 600 psig, 90% Efficiency 1,087,000#/hr Flow Rate - Design 221.1 MMBtu/hr Absorbed - Design 245.7 MMBtu/hr Fired - Design	800	700
<u>Pumps</u>				
P51C101 A/B	95 psig Boiler Feed Water Pump	2967 gpm @ 75 psi Δ P, 175 BHP A Motor Driven, B Steam Turbine Driven. Motor Nameplate 200 HP		
P51C102 A/B	370 psig Boiler Feed Water Pump	2615 gpm @ 350 psi Δ P, 742 BHP A Turbine Driven, B Motor Driven Motor Nameplate 900 HP		
P51C103 A/B	750 psig Boiler Feed Water Pump	3138 gpm @ 730 psi Δ P, 1928 bhp A Turbine Driven, B Motor Driven Motor Nameplate 2250 HP		
P51C104 A/B/C/D	2200 psig Boiler Feed Water Pump	1853 gpm @ 2180 psi Δ P, 3185 bhp A/B Turbine Driven, C/D Motor Driven Motor Nameplate 3500 HP		
P51C105 A/B	Hydrazine Feed Pump	0.1 gph, 25 psi Δ P, 0.1 bhp Motor Nameplate 0.25 bhp Chemical Metering Pump		
P51C106 A/B	Amine Feed Pump	0.1 gph, 25 psi Δ P, 0.1 bhp Motor Nameplate 0.25 bhp Chemical Metering Pump		

TABLE 3-36
AREA 51 - STEAM GENERATION SYSTEM

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
Vessels				
V51C101	A/B	Dearator with Two Storage Drums 192" ID x 120' TT, Storage Drums 5.6 MMBtu/hr Deaerator, Carbon Steel with SS Trays	650	50
V51C102		650 psig Flash Drum 36" Dia. x 12' TT, Carbon Steel	650	700
V51C103		300 psig Flash Drum 42" Dia. x 14' TT, Carbon Steel	650	330
V51C104		20 psig Blowdown Flash Drum 36" Dia. x 12' TT, Carbon Steel	650	50
V51C105		300 psig Blowdown Flash Drum 24" Dia. x 8' TT, Carbon Steel	650	330
V51C106		650 psig Blowdown Flash Drum 24" Dia. x 8' TT, Carbon Steel	650	700
V51C107		Hydrazine Feed Tank 55 Gal. Chemical Feed Drum	60	Atmos.
V51C108		Amine Feed Tank 55 Gal. Chemical Feed Drum	60	Atmos.

TABLE 3-38
AREA 52 - RAW WATER SYSTEM
EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Compressors</u>				
C52C101	Pressure Tank Air Compressor	3scfm, 65 psiΔP, 0.5 hp.	60	65
<u>Pumps</u>				
P52C101 A,B,C	River Water Pump	7100 gpm, 150 psiΔP, 1000 hp. Carbon Steel	60	150
P52C102 A,B,C,D	Raw Water Pump	1400 gpm, 20 psiΔP, 30 hp. Carbon Steel	60	20
P52C103 A,B,C	Cooling Tower Makeup Pump	6250 gpm, 25 psiΔP, 150 hp. Carbon Steel	60	25
P52C104 A,B,C	Demineralizer Supply Pump	2250 gpm, 40 psiΔP, 100 hp. Carbon Steel	60	40
P52C105 A,B,C,D	Clarifier Sludge Pump	105 gpm, 50 psiΔP, 5 hp. Lined Carbon Steel	60	50
P52C106 A,B	Potable Water Treatment Pump	40 gpm, 50 psiΔP, 2 hp. Carbon Steel	60	50
P52C107 A,B	Potable Water Filter Backwash Pump	170 gpm, 20 psiΔP, 3 hp. Carbon Steel	60	20
P52C108 A,B	Potable Water Supply Pump	120 gpm, 70 psiΔP, 10 hp. Carbon Steel	60	70
P52C109 A,B	Regeneration Wastes Pump	600 gpm, 50 psiΔP, 30 hp. Alloy 20	60	50

TABLE 3-38
AREA 52 - RAW WATER SYSTEM

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
P52C110 A,B,C	Lime Feed Pump	5 gpm, 20 psi Δ P, 0.25 hp. Rubber Lined Carbon Steel		
P52C111 A,B,C	Alum Feed Pump	5 gpm, 20 psi Δ P, 0.25 hp. Bronze		
P52C112 A,B,C	Polymer Feed Pump	2 gpm, 20 psi Δ P, 0.50 hp. Stainless Steel		
P52C113 A,B	Demineralized Water Supply Tank	2700 gpm, 50 psi Δ P, 125 hp. 304 Stainless Steel, "A" Turbine Driven Spare, "B" Motor Driven		
<u>Storage Tanks</u>				
T52C101	Potable Water Storage Tank	15'-0" Dia. x 18'-0" high, 23,800 gal., Carbon Steel	100	ATM
T52C102	Potable Water Pump Suction Tank	8'-0" Dia. x 16'-0" high, 6000 gal., Carbon Steel	100	ATM
T52C103	Demineralizer Pump Suction Tank	16'-0" Dia. x 16'-0" high, 24,000 gal., Carbon Steel	100	ATM
T52C104	Demineralized Water Storage Tank	98'-0" Dia. x 40'-0" high, 2,260,000 gal., Aluminum	100	ATM
T52C105 A,B	Acid Storage Tank	144" ID x 23'-0" TT, 19,500 gal., Carbon Steel	100	15
T52C106 A,B	Caustic Storage Tank	144" ID x 21'-6" TT, 18,000 gal., Plasite Lined Carbon Steel	100	15

TABLE 3-38
AREA 52 - RAW WATER SYSTEM

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Vessels</u>				
V52C101	Potable Water Pressure Tank	84" ID x 10'-0" TT, 3000 gal., Carbon Steel	100	100
<u>Water Treatment Equipment</u>				
W52C101	Raw Water Chlorinator	V-Notch gas chlorinator		
W52C102	Potable Water Chlorinator	V-Notch gas chlorinator		
W52C103	Utility Water Chlorinator	V-Notch gas chlorinator		
W52C104	Polymer Preparation Unit	Packaged storage, mixing, and aging unit with 3/4 hp. mixer		
W52C105	Lime Storage/Feeder Unit	4000 ft ³ lime silo with integral feeder and slurry tanks with 1 hp. mixer		
W52C106	Alum Feeder	Volumetric Dry Feeder with Solution tank and 0.25 hp. mixer		
W52C107	Phosphate Feeder	Packaged solution preparation and storage tank with two 1/4 hp. metering pumps and a 0.75 hp. mixer		
W52C108 A,B	Clarifier/Softener	65'-0" Dia. x 16'-0" high, with 5 hp. mixer and 1.5 hp. scraper, Carbon Steel	100	ATM
W52C109 A-E	Demineralizer Filter	96" ID x 25'-0" T-T, 800 gpm each, Sand/Anthracite Media, Carbon Steel	100	100

TABLE 3-38
AREA 52 - RAW WATER SYSTEM

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
W52C110	Demineralizer Unit	2400 gpm, five-train package unit which includes:		
W52C110 (E1 A-D)*	Caustic Dilution Water Heater	Shell and Tube Type Heat Exchanger 1,800,000 Btu/hr, 100 sq. ft., Stainless Steel	350	100
W52C110 (P1 A-H)*	Acid Feed Pump	5 gpm, 100 psi Δ P, 2 hp, Hastelloy C		
W52C110 (P2 A-D)*	Caustic Feed Pump	4 gpm, 100 psi Δ P, 2 hp, Stainless Steel		
W52C110 (V1 A-E)*	Strongly Acidic Cation Exchanger	132" ID x 15'-0" TT, 800 gpm, Rubber Lined Carbon Steel	100	10
W52C110 (V2 A-E)*	Strongly Basic Anion Exchanger	126" ID x 10'-0" TT, 800 gpm, Rubber Lined Carbon Steel	150	100
W52C111 A,B	Potable Water Filter	42" ID x 4'-0" TT, 33 gpm, Carbon Steel	100	100
W52C112 A,B	Potable Water Carbon Filter	42" ID x 4'-0" TT, 33 gpm, Activated Carbon Media, Lined Carbon Steel	100	100
W52C113	Potable Water CO ₂ Feeder	V-notch Gas Recarbonator		

TABLE 3-38
AREA 52 - RAW WATER SYSTEM

EQUIPMENT LIST

<u>EQUIPMENT NUMBER</u>	<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>DESIGN</u>	
			<u>TEMPERATURE (F)</u>	<u>PRESSURE (PSIG)</u>
<u>Miscellaneous Equipment</u>				
X52C101	Raw Water Reservoir	500' x 700' x 30' deep, 2:1 side slope, 56,000,000 gal.	100	ATM
X52C102	Regeneration Wastes Sump	30' x 30' x 15' deep, 100,000 gal., Plasite Lined Concrete	150	ATM

*Subsystem

TABLE 3-40
AREA 53 - COOLING WATER SYSTEM

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Air Cooled Equipment</u>				
A53C101	Process Cooling Tower	303,200 gpm 4473 MMBtu/hr, 29 bays 200 HP/Bay Fans, Wet Bulb 79°F, Approach 11°F Cooling Tower Basin 51' x 1044'	120/90	Atmos.
A53C102	Utility Cooling Tower	114,540 gpm, 1054 MMBtu/hr, 11 Bays 250 HP/Bay Fans, Wet Bulb 79°F, Approach 7°F, Cooling Tower Basin 51' x 396'	116/86	Atmos.
<u>Heat Exchangers</u>				
E53C101 A/B/C	Process C.W. Pump Turbine Surface Condensers	15.34 MMBtu/hr, 1660 sq. ft, Carbon Steel	SS/TS 125/90-120	SS/TS 4"Hg/50
E53C102 A/B/C	Utility C.W. Pump Turbine Surface Condenser	7.3 MMBtu/hr, 594 sq. ft, Carbon Steel	125/86-116	4"Hg/50
<u>Jet Equipment</u>				
J53C101 A/B/C	Process Turbine Steam Ejectors	4" Hg. Absolute with Jets and Condensers	338	100
J53C102 A/B/C	Utility Turbine Steam Ejectors	4" Hg. Absolute with Jets and Condensers	338	100
<u>Pumps</u>				
P53C101 A/B/C/D/E/F	Process Cooling Tower Cooling Water Pump	60,920 gpm, 50 psiΔP, 2150 hp Carbon Steel A/B/C Turbine Driven (Operating) D/E/F Motor Driven (2 Operating, 1 Spare) Motor Nameplate 2500 hp		

TABLE 3-40
AREA 53 - COOLING WATER SYSTEM

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Pumps - Contd</u>				
P53C102 A/B/C/D/E	Utility Cooling Tower Cooling Water Pump	28,750 gpm, 50 psi Δ P, 1013 hp Carbon Steel A/B/C Turbine Driven (Operating) D/E Motor Driven (1 Operating, 1 Spare) Motor Nameplate 1250 hp		
P53C103	Sulfuric Acid Transfer Pump	60 gpm, 40 psi Δ P, 2.8 hp Carbon Steel Motor Nameplate 3.0 hp		
P53C104 A/B/C/D/E/F	Process Turbine Steam Condensate Pump	36 gpm, 57 psi Δ P, 1.7 hp, Carbon Steel B/D/F Turbine Driven (Spare) A/C/E Motor Driven (Operating) Motor Nameplate 3 hp		
P53C105 A/B/C/D/E/F	Utility Turbine Steam Condensate Pump	16 gpm, 57 psi Δ P, 0.8 hp, Carbon Steel B/D/F Turbine Driven (Spare) A/C/E Motor Driven (Operating) Motor Nameplate 1 hp		
P53C106 A/B	Process Hotwell Condensate Pump	2 gpm, 42 psi Δ P, 0.08 hp Carbon Steel Motor Nameplate 0.25 hp		
P53C107 A/B	Utility Hotwell Condensate Pump	2 gpm, 42 psi Δ P, 0.08 hp Carbon Steel Motor Nameplate 0.25 hp		
P53C108 A/B	Process Cooling Tower Sulfuric Acid Metering Pump	0.5 gpm, 66 $^{\circ}$ Be, H ₂ SO ₄ , 0.25 hp Motor		
P53C109 A/B	Utility Cooling Tower Sulfuric Acid Metering Pump	0.5 gpm, 66 $^{\circ}$ Be, H ₂ SO ₄ , 0.25 hp Motor		

TABLE 3-40
AREA 53 - COOLING WATER SYSTEM

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Tanks</u>				
T53C101	Process Cooling Tower Sulfuric Acid Day Tank	6'0" Diameter x 26' Long Drum, 5500 Gal. Carbon Steel	60	Atmos.
T53C102	Utility Cooling Tower Sulfuric Acid Day Tank	5'0" Diameter x 12' Long Drum, 1760 Gal.	60	Atmos.
T53C103	Sulfuric Acid Storage Tank	16' Diameter x 23' High, 34,600 Gal.	60	Atmos.
<u>Vessels</u>				
V53C101	Process Hotwell	18" Diameter x 6' Long Drum, Carbon Steel	150	Atmos.
V53C102	Utility Hotwell	18" Diameter x 6' Long Drum, Carbon Steel	150	Atmos.
<u>Water Treating Equipment</u>				
W53C101	Process Cooling Tower Scale & Corrosion Inhibiting Feed System	Chemical Treating Package Unit with Metering Pumps and 6' Diameter x 18' High Storage Tank	60	Atmos.
W53C102	Process Cooling Tower Chlorinator	Packaged Chlorinator System	90	Atmos.
W53C103	Utility Cooling Tower Scaley Corrosion Inhibiting Feed System	Chemical Treating Package Unit with Metering Pumps and 6' Diameter x 18' High Storage Tank	60	Atmos.
W53C104	Utility Cooling Tower Chlorinator	Packaged Chlorinator System		

TABLE 3-40
AREA 53 - COOLING WATER SYSTEM

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Miscellaneous Equipment</u>				
X53C101	Process Cooling Tower Pump Well	100' Long x 36' Wide x 12' Deep, Reinforced Concrete	90	Atmos.
X53C102	Utility Cooling Tower Pump Well	100' Long x 36' Wide x 12' Deep, Reinforced Concrete	86	Atmos.

TABLE 3-42
AREA 54 - PRODUCT STORAGE AND SHIPPING
EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
<u>Compressors</u>				
C54C171 A,B,C	Air Compressor	200 scfm, 100 psiΔP, 500 hp. with Intercoolers. A, B & C Motor Driven, Carbon Steel	315	125
C54C172 A,B	Nitrogen Compressor	2400 scfm, 245 psiΔP, 400 hp Motor Driven, Carbon Steel	360	340
G54C121	Generator	18,000 kW, 0.85 power factor. Expander Gas Turbine Generator, 24,000 hp Extracting Expanders.		
<u>Heat Exchangers</u>			<u>SS/TS</u>	<u>SS/TS</u>
E54C121	Butane Vaporizer	4.1 MMBtu/hr, 800 Ft ² . Carbon Steel	200/300	200/100
E54C131	Cold HC Flare Vaporizer	2.1 MMBtu/hr, 44 Ft ² . Stainless Steel	-50/320	50/125
E54C171	Nitrogen Vaporizer	4800 scfm, 1.9 MMBtu/hr. Finned Stainless Steel	Amb./-260	- /340
E54C172 A/B	Compressed Air Cooler	0.49 MMBtu/hr, 350 Ft ² . Carbon Steel	210/150	125/100
E54C173 A/B	Compressed Nitrogen Cooler	0.66 MMBtu/hr, 260 Ft ² . Carbon Steel	230/150	340/100
<u>Fired Heaters</u>				
H54C131	Clean HC Flare Stack	30" ID x 225' high, CS, 1.0 MMBtu/hr, Gas Pilot		
H54C132	Heavy HC Flare Stack	78" ID x 250' high, CS w/ceramic lining, 1.0 MMBtu/hr. Gas Pilot		

TABLE 3-42
AREA 54 - PRODUCT STORAGE AND SHIPPING

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
H54C121	Syn Gas Heater	135 MMBtu/hr absorbed, alloy tubes, 1200°F gas temp.		
<u>Pumps</u>				
P54C101 A,B	Fuel Oil Pipeline Pumps	2800 gpm, 300 psiΔP, 700 hp. Carbon Steel		
P54C111 A,B	Naphtha Transfer Pumps	600 gpm, 70 psiΔP, 35 hp. Carbon Steel		
P54C114 A,B	Butane Pipeline Pumps	700 gpm, 500 psiΔP, 250 hp. Carbon Steel		
P54C115 A,B	Butane Vaporizer Pumps	90 gpm, 40 psiΔP, 5 hp. Carbon Steel		
P54C116	Ammonia Loading Pump	1450 gpm, 75 psiΔP, 100 hp. Carbon Steel		
P54C117	Tar Acids Loading Pump	200 gpm, 75 psiΔP, 15 hp. Carbon Steel		
P54C118 A,B	Sulfur Loading Pumps	1000 gpm, 75 psiΔP, 75 hp. Carbon Steel		
P54C131	Cold HC Flare Recirc. Pump	30 gpm, 20 psiΔP, 1 hp. Stainless Steel		
P54C132 A,B	Heavy HC Flare Recirc. Pump	150 gpm, 40 psiΔP, 10 hp. Rubber Lined Carbon Steel		
P54C133	Clean HC Flare Liquid Transfer Pump	60 gpm, 30 psiΔP, 3 hp. Carbon Steel		

TABLE 3-42
AREA 54 - PRODUCT STORAGE AND SHIPPING

EQUIPMENT LIST

EQUIPMENT NUMBER	SERVICE	DESCRIPTION	DESIGN	
			TEMPERATURE (F)	PRESSURE (PSIG)
P54C134	Heavy HC Flare Liquid Transfer Pump	60 gpm, 30 psi Δ P, 3 hp. Rubber Lined Carbon Steel		
P54C135	Clean Flare Recirc. Pump	30 gpm, 20 psi Δ P, 1 hp. Carbon Steel		
P54C141	Process Fire Water Jockey Pump	250 gpm, 170 psi Δ P, 50 hp. Carbon Steel		
P54C142 A,B	Process Fire Water Main Pump	2500 gpm, 170 psi Δ P, 350 hp. Carbon Steel, Diesel Driven w/600 gal. fuel tank		
P54C143	Process Fire Water Main Pump	2000 gpm, 170 psi Δ P, 300 hp. Motor Driven, Carbon Steel		
P54C144	Coal Prep. Fire Water Jockey Pump	250 gpm, 170 psi Δ P, 50 hp. Carbon Steel		
P54C145 A,B	Coal Prep Fire Water Main Pump	3000 gpm, 170 psi Δ P, 400 hp. Carbon Steel "A" Diesel Driven w/600 gal. fuel tank. "B" Electric Motor Drive.		
P54C146	Diesel Fuel Transfer Pump	30 gpm, 40 psi Δ P, 3 hp. Carbon Steel		
<u>Storage Tanks</u>				
T54C101 A,B,C,D	Fuel Oil Storage Tanks	160' diameter x 40' high, 140,000 bbl. Carbon Steel, API	150	ATM
T54C111 A,B	Naphtha Storage Tanks	150' diameter x 40' high, 125,000 bbl. Carbon Steel, API	150	ATM
T54C114 A,B	Butane Storage Tanks	60' diameter sphere, 20,000 bbl. Carbon Steel	100	75

TABLE 3-42
AREA 54 - PRODUCT STORAGE AND SHIPPING

EQUIPMENT LIST

<u>EQUIPMENT NUMBER</u>	<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>DESIGN</u>	
			<u>TEMPERATURE (F)</u>	<u>PRESSURE (PSIG)</u>
T54C115 A,B	Ammonia Storage Tanks	48' diameter sphere. 10,000 bbl. Carbon Steel	40	75
T54C116 A,B	Tar Acids Storage Tanks	26' diameter x 16' high, 1500 bbl. Carbon Steel, API	150	ATM
T54C118	Sulfur Storage Tank w/higheater	85' diameter x 40' high, 40,000 bbl. Carbon Steel, API, 1 MMBtu/hr higheater	300	ATM
T54C131	Cold HC Flare K.O. Tank	144" ID x 30'-0" TT. 25,000 gal. Stainless Steel	-100	50
T54C132	Heavy HC Flare K.O. Tank	144" ID x 30'-0" TT. 25,000 gal. Epoxy Lined Carbon Steel	300	50
T54C133	Clean HC Flare Storage Tank	16'-0" ID x 28'-0" high, 42,000 gal. Carbon Steel, API	100	ATM
T54C134	Heavy Flare Storage Tank	16'-0" ID x 28'-0" high, 42,000 gal. API. Epoxy Lined Carbon Steel	100	ATM
T54C135	Clean HC Flare K.O. Tank	144" ID x 30'-0" TT, 25,000 gal. Carbon Steel	300	50
T54C141	Process Fire Water Storage Tank	100'-0" ID x 40'-0" high, API. 2.35 MM gal. Carbon Steel	100	ATM
T54C142	Coal Prep. Fire Water Storage Tank	80'-0" ID x 40'-0" high, API., Carbon Steel	100	ATM
T54C143	Diesel Fuel Storage Tank	11'-0" ID x 22'-0" high, API. 15,000 gal. Carbon Steel	100	ATM

TABLE 3-42
AREA 54 - PRODUCT STORAGE AND SHIPPING

EQUIPMENT LIST

<u>EQUIPMENT NUMBER</u>	<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>DESIGN</u>	
			<u>TEMPERATURE (F)</u>	<u>PRESSURE (PSIG)</u>
<u>Package Process Units</u>				
U54C112	Ammonia Storage Refrig. Package	40 tons, two-125 hp compressors 1 operating, 1 spare	100	250
U54C171 A,B	Instrument Air Dryer	-40°F dew point. 2700 scfm, with Electric Heater. Carbon Steel	110	100
U54C141	Foam System	3000 gpm Package System		
<u>Vessels</u>				
V54C121	Fuel Gas Mixing Drum	180" ID x 54'-0" TT, Carbon Steel	200	75
V54C171	Compressed Air Receiver	168" ID x 36'-0" TT, Carbon Steel	200	125
V54C172	Instrument Air Receiver	132" ID x 30'-0" TT, Carbon Steel	200	125
V54C173	Plant Air Receiver	96" ID x 30'-0" TT, Carbon Steel	200	125
V54C174	Nitrogen Receiver	156" ID x 28'-0" TT, Carbon Steel	200	340
V54C175 A-P	Area Surge Bottles (16 Units)	30" ID x 26'-0" TT, Carbon Steel	200	125
<u>Water Treating Equipment</u>				
W54C161	Sanitary Sewage Treatment Package	19,000 gpd Capacity with tertiary treatment and sludge incineration	80	

TABLE 3-35

AREA 51 STEAM GENERATION SYSTEM
UTILITY SUMMARY

<u>Electric Power</u>		<u>KW</u>	
Connected		8020	
Operating		143	
<u>Steam</u>		<u>LB/HR</u>	<u>PSIG</u>
Consumption:			
P51C101B	95 psig BFW pump	(Spare)	600 to 300
P51C102A	370 psig BFW pump	32,350	600 to 300
P51C103A	750 psig BFW pump	84,060	600 to 300
P51C104A	2200 psig BFW pump	138,870	600 to 300
P51C104B	2200 psig BFW pump	138,870	600 to 300
	ID & FD fans	13,080	600 to 300
V51C101 A/B	Heating/Stripping Steam Deaerator	200,000 8,925	50 20
G51C101 A/B	Turbine Generator Unit	355,360 92,810	250 to 4" 250 to 50

TABLE 3-35
AREA 51 STEAM GENERATION SYSTEM

UTILITY SUMMARY -Cont.

Steam - contd.

Generation:		<u>LB/HR</u>	<u>PSIG</u>
B51C101A	Power Boiler	67,630	1500 at 950°F
B51C101B	Power Boiler	67,630	1500 at 950°F

<u>Fuel</u>		<u>MM BTU/HR</u>
B51C101A	Power Boiler	84.1
B51C101B	Power Boiler	84.1
H51C101	250 psig 700°F Superheater	302.7
H51C103	600 psig 750°F Superheater	213.6

<u>Cooling Water (30°F Rise)</u>	<u>GPM</u>
Turbogenerator Condenser	22,420

Chemicals

Amine	0.9 lbs/sd
Hydrazine (35 wt % sol)	4.8 lbs/sd

TABLE 3-37
AREA 52 - RAW WATER SYSTEM

UTILITY SUMMARY

<u>Electric</u>	<u>KW</u>	
Connected	3095	
Operating	1540	
<u>Steam</u>	<u>LB/HR</u>	<u>PSIG</u>
Consumption:		
W52C110 Caustic Dilution Water Heater	509	50 to Condensate
<u>Fuel, Cooling Water, Miscellaneous</u>		
None		
<u>Catalysts and Chemicals</u>		
Hydrated Lime (93%)	3330 lb/sd	
Alum	560 lb/sd	
Polymer	55 lb/sd	
Phosphate	7 lb/sd	
Chlorine	11 lb/sd	
Carbon Dioxide	4 lb/sd	
Sulfuric Acid (66°F Be)	14,500 lb/sd	
Sodium Hydroxide (50%)	11,200 lb/sd	
Cation Resin	2 cu. ft./sd	Prorated
Anion Resin	2 cu. ft./sd	Prorated
Activated Carbon	4 lb/sd	Prorated
Filter Sand	230 lb/sd	Prorated
Filter Anthracite	110 lb/sd	Prorated

TABLE 3-39
AREA 53 - COOLING WATER SYSTEM

UTILITY SUMMARY

<u>Electric Power</u>		<u>KW</u>	
Connected		13,850	
Operating		9,458	
<u>Steam</u>		<u>LB/HR</u>	<u>PSIG</u>
Consumption:			
P53C101	Process Cooling Tower	48,184	600 to 4"Hg
A/B/C	Cooling Water Pump Turbine		
P53C102	Utility Cooling Tower	24,016	600 to 4"Hg
A/B/C	Cooling Water Pump Turbine		
J53C101	Process Turbine Steam	900	100 to Condensate
A/B/C	Ejectors		
J53C102	Utility Turbine Steam	900	100 to Condensate
A/B/C	Ejectors		
<u>Cooling Water (300F Rise)</u>		<u>GPM</u>	
E53C101	Process Turbine Surface	3,102	
A/B/C	Condenser		
E53C102	Utility Turbine Surface	1,464	
A/B/C	Condenser		
J53C101	Process Turbine Steam	60	
A/B/C	Ejector Condensers		
J53C102	Utility Turbine Steam	60	
A/B/C	Ejector Condensers		

TABLE 3-39
AREA 53 - COOLING WATER SYSTEM

UTILITY SUMMARY - Cont.

Chemicals

*Corrosion/Scale Inhibitor	970 Lbs/sd

*Sulfuric Acid	66 ⁰ Be	11,434 Lbs/sd

Chlorine	100 %	572 Lbs/sd

*Based on utilization of 40 ppm scale/corrosion inhibitor and maintenance of a recirculating water pH of 7.8-8.3.

TABLE 3-41
AREA 54 - MISCELLANEOUS SYSTEMS

UTILITY SUMMARY

Electric Power

KW

Consumption:

Connected 4,368

Operating 3,032

Generation

Operating 18,000

Steam

LB/HR

PSIG

Consumption:

E54C131 Clean Flare Vaporizer 2,400 100 to Condensate

H54C131 Flare Stacks 1,000 100

H54C132 Miscellaneous Users 5,800 50 to Condensate

Fuel

MM BTU/HR

Total Users 152.4

Cooling Water (30°F Rise)

GPM

285

Miscellaneous

Nitrogen

Blanketing & Unloading

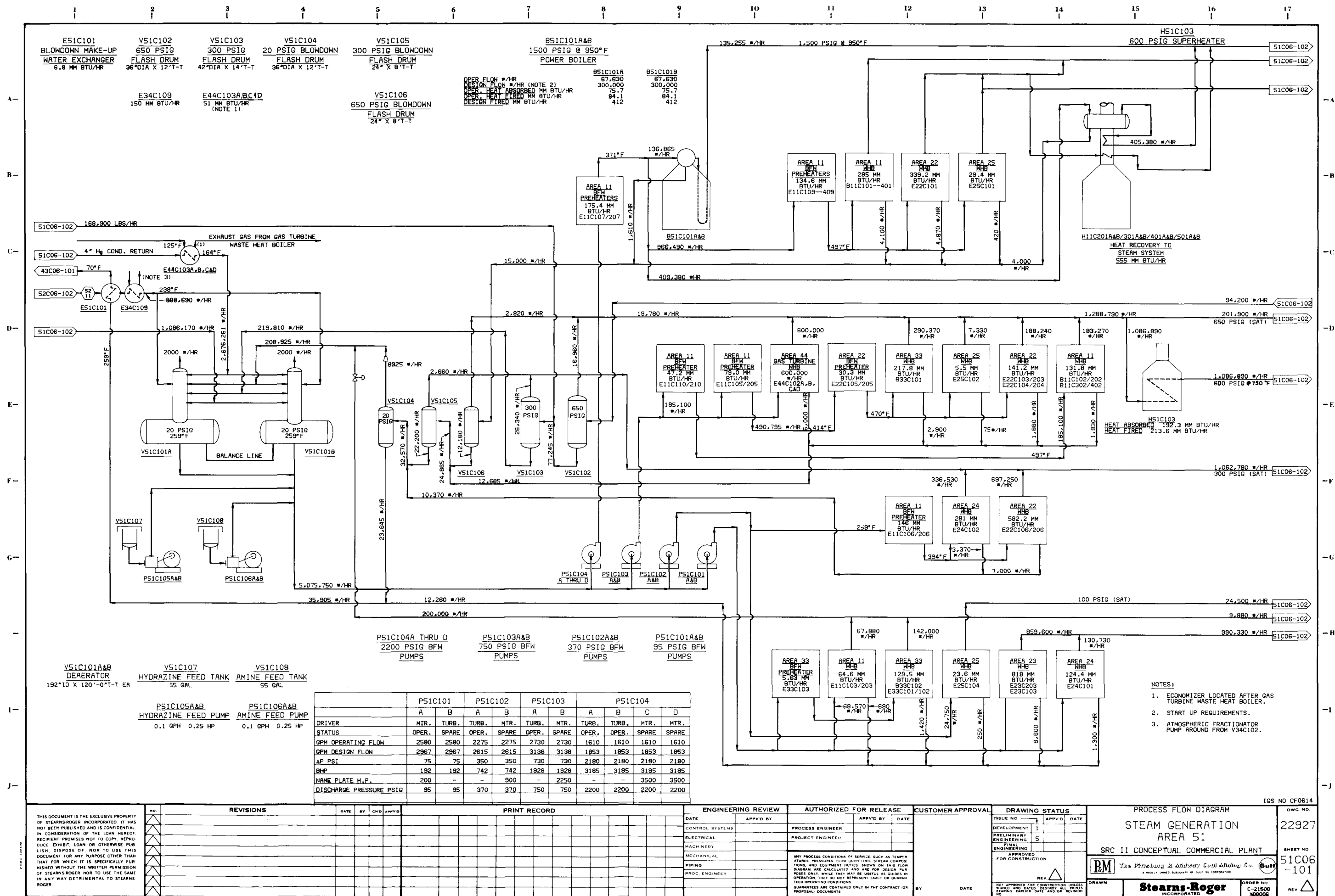
Diesel Fuel

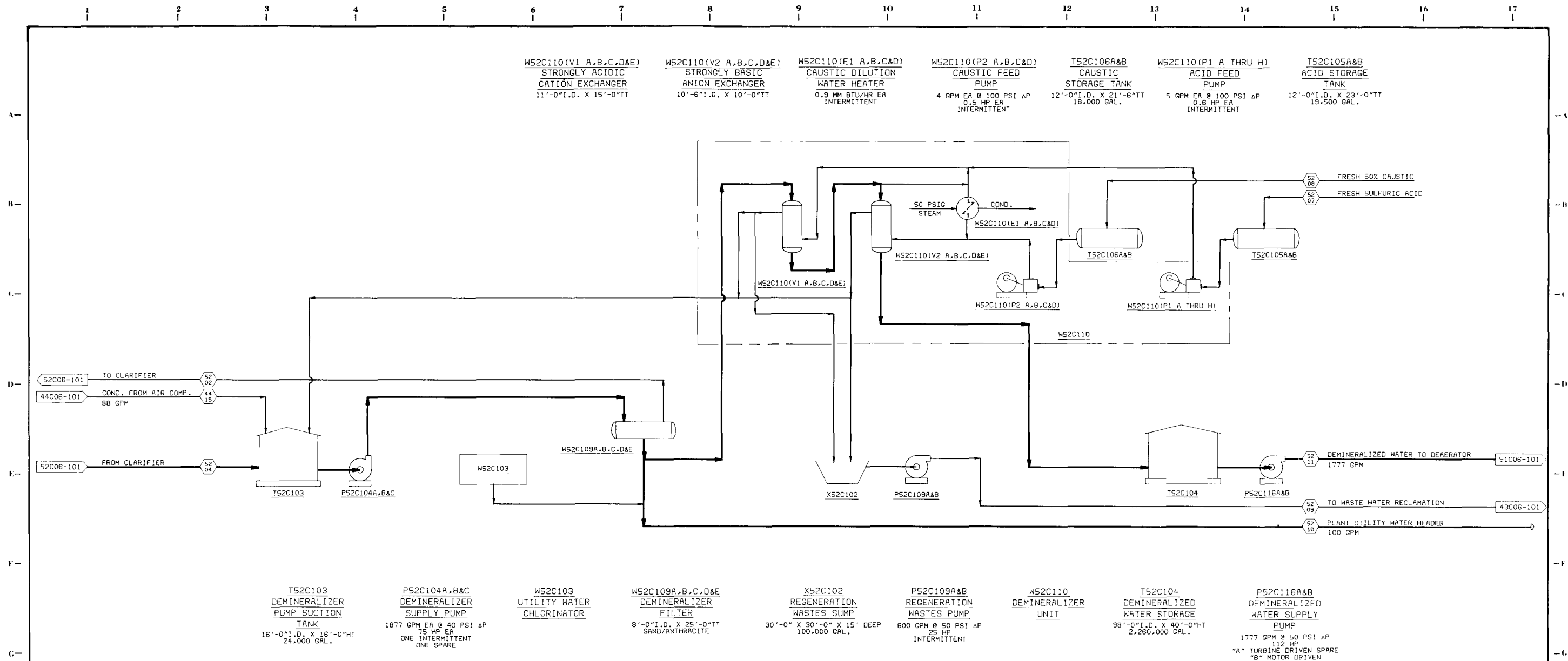
500 gal/yr

Chemicals

Fire Fighting Foam

100 gal/yr





MATERIAL BALANCE		INCOMING				OUTGOING			
STREAM NUMBER		44 15	52 04	52 07	52 08	52 02	52 09	52 10	52 11
IDENTIFICATION	COMPONENT	COND. FROM AIR COMP.		CLEAR WATER TO DEMIN.		FRESH SULFURIC ACID		FRESH CAUSTIC	
		44 02	44 15	52 04	52 07	52 02	52 09	52 10	52 11
WATER (M/HR)		44.021	1.006,829	41	234	23.000	89.540	50.000	888.690
SOLIDS (M/HR)		-	237	562	234	5	911	11	0
TOTAL (M/HR)		44.021	1.007,066	603	468	23.005	90.452	50.011	888.690
SP. GR., 60°F		1.0	1.0	1.83	1.53	1.0	1.01	1.0	1.0
GPM		88	2013	0.66	0.61	46	179	100	1,777
PRESSURE (PSIA)		30	15	15	15	50	65	50	65
TEMPERATURE (°F)		100	60	60	60	60	70	60	60

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																							SHEET NO. 52C06-102	

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DATE

BY

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DATE

BY

ISSUE NO. 1

DEVELOPMENT 2

PRELIMINARY ENGINEERING 5

FINAL ENGINEERING

APPROVED FOR CONSTRUCTION

REV. 1

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED, DESIGN, AND DRAWING REVISION NUMBER, DATE, AND OR REVISION.

DATE

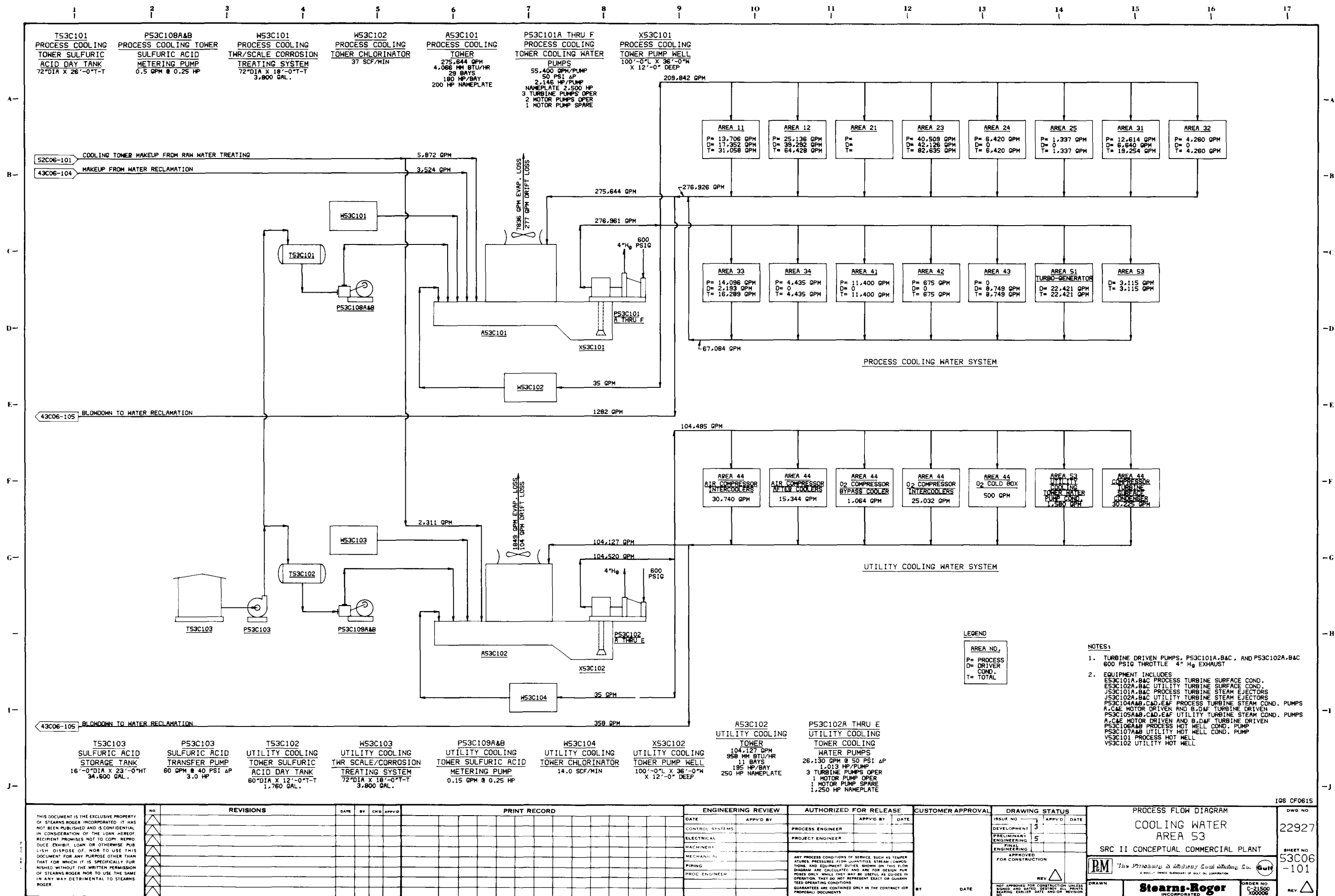
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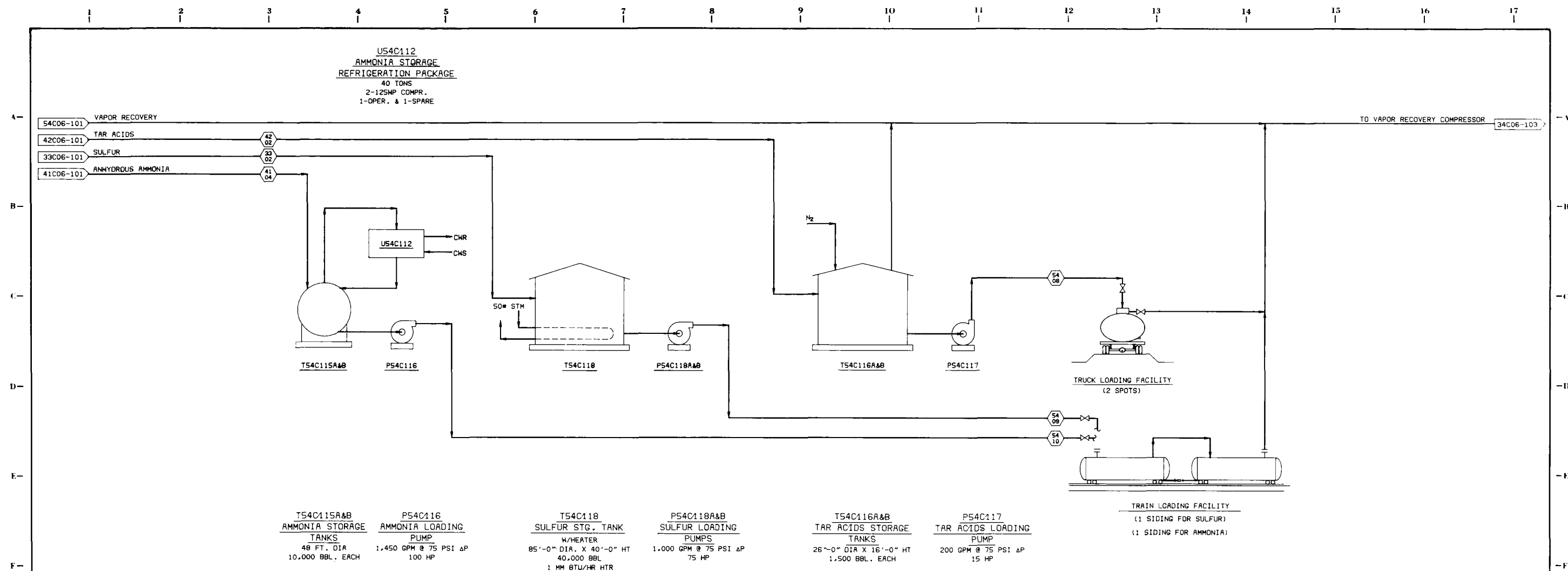
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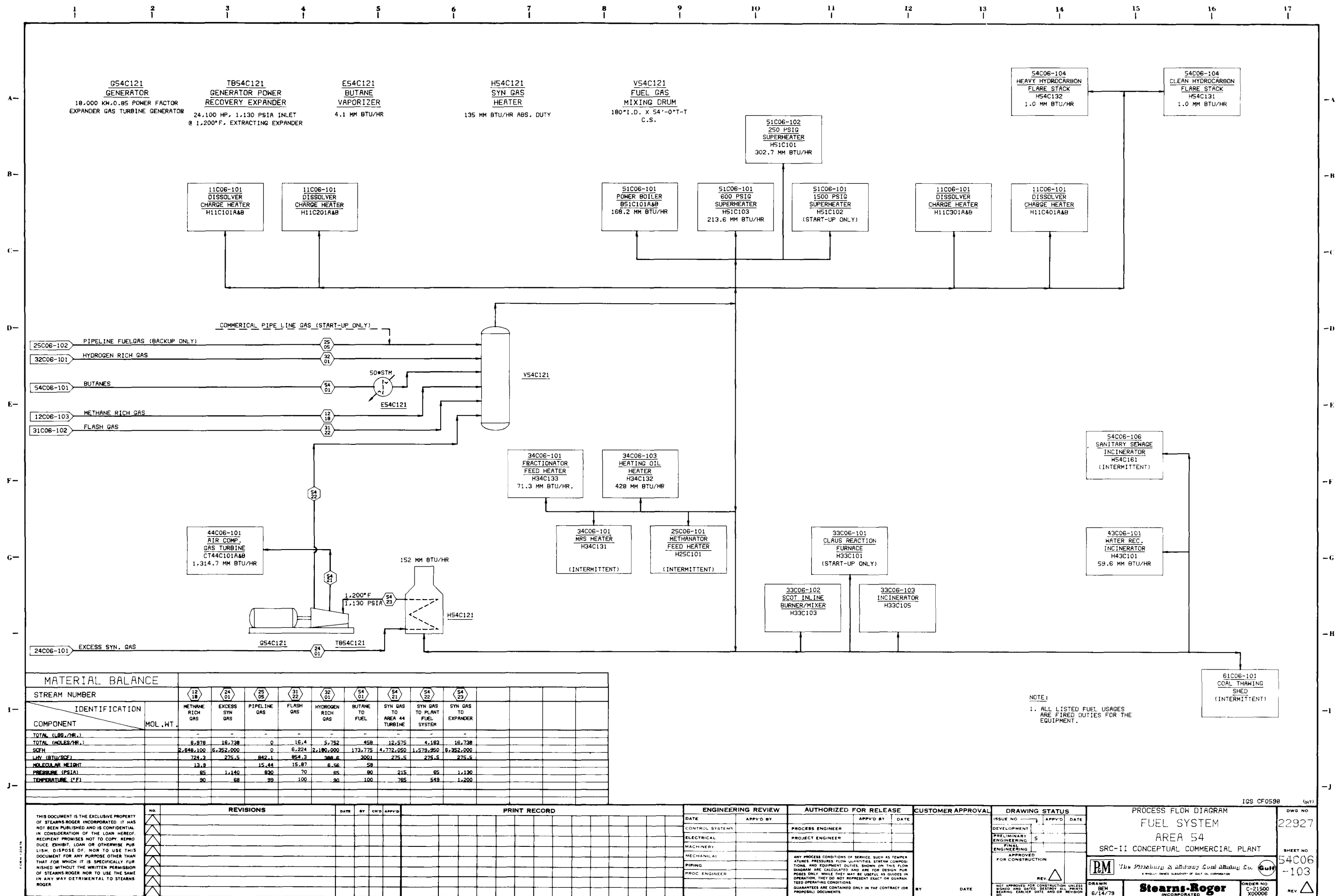
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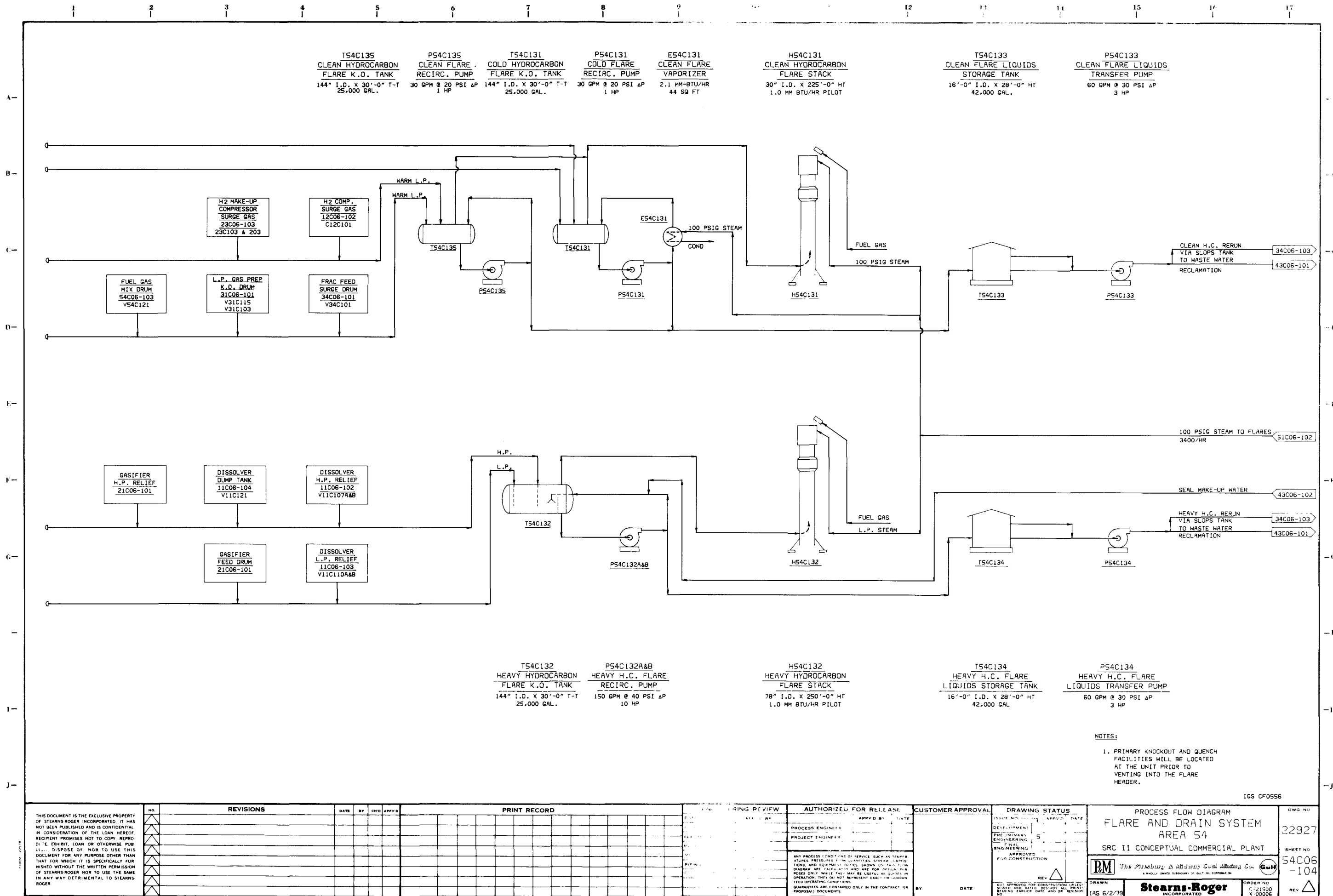


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- NOTES:**
1. TAR ACIDS ARE LOADED AT A RATE OF ABOUT TWO 150 BBL TRUCKS PER DAY. LOADING TIME IS ABOUT ONE HOUR.
 2. SULFUR IS LOADED AT A RATE OF ABOUT SIXTEEN 350 BBL TANK CARS PER DAY. LOADING TIME IS ABOUT FOUR HOURS.
 3. AMMONIA IS LOADED AT A RATE OF ABOUT ELEVEN 550 BBL TANK CARS TWICE A WEEK LOADING TIME IS ABOUT THREE HOURS.
 4. THE TRUCK AND RAIL LOADING FACILITIES WILL VENT BACK TO THEIR RESPECTIVE TANKS DURING LOADING.

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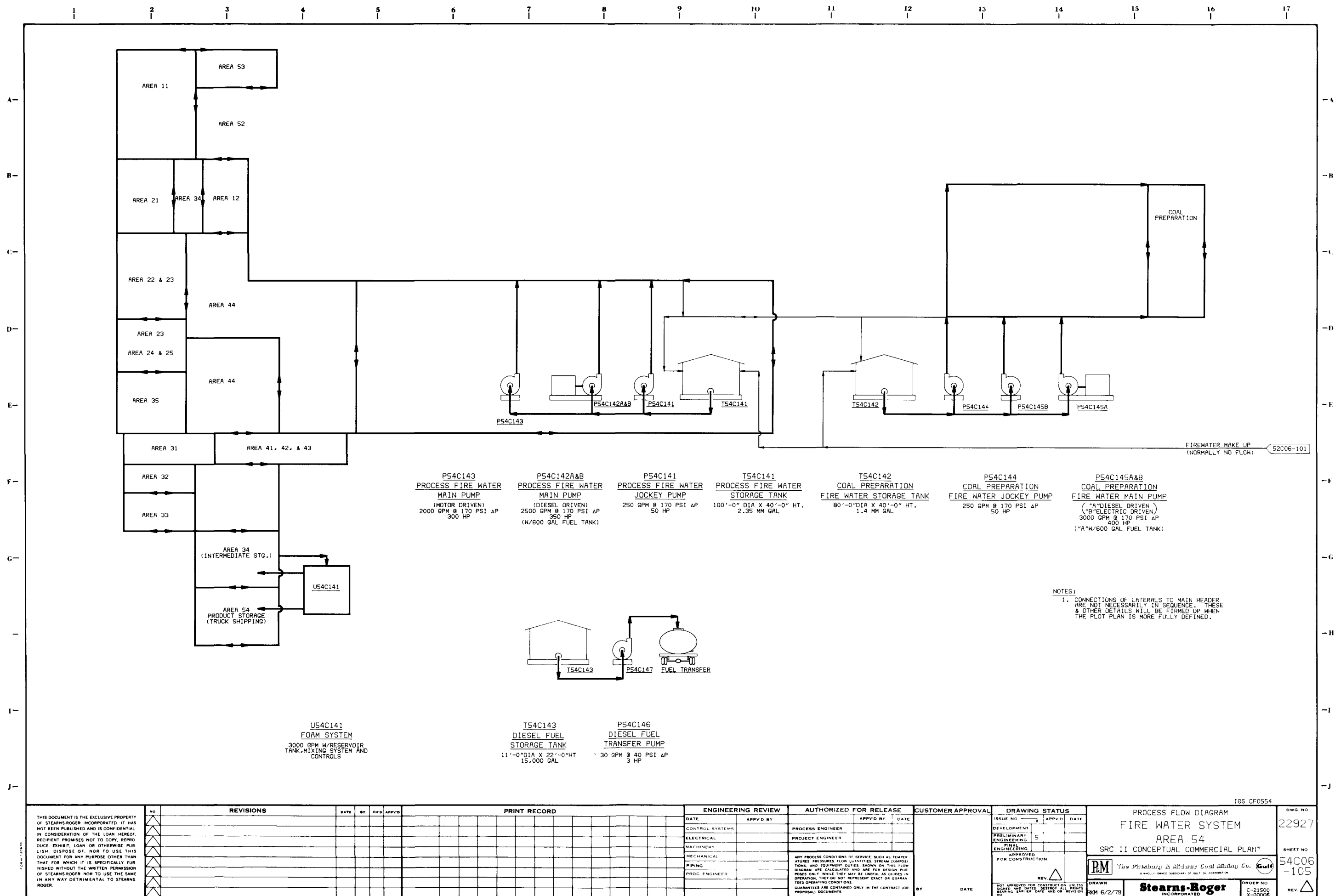


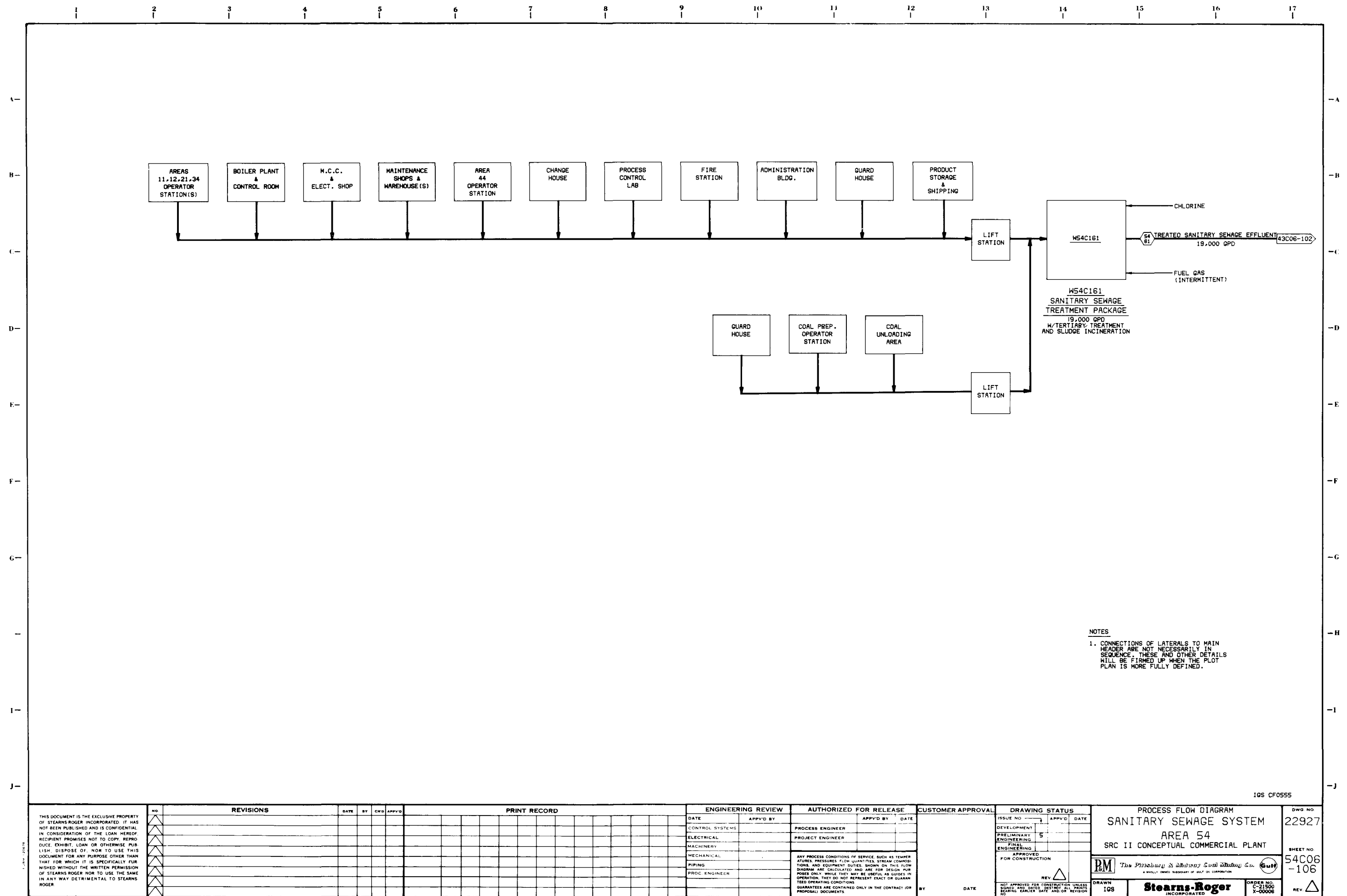


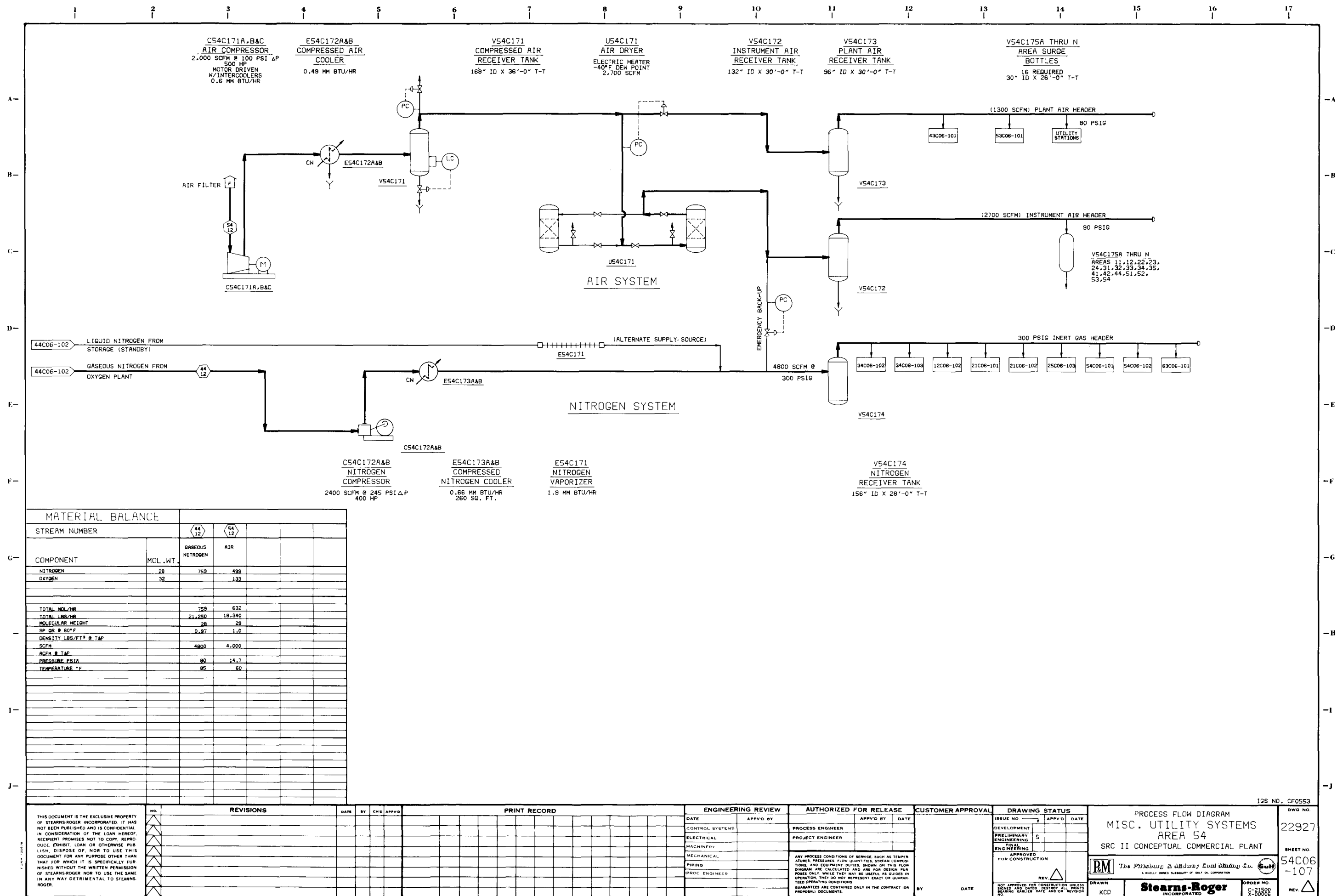
NOTES:
1. PRIMARY KNOCKOUT AND QUENCH FACILITIES WILL BE LOCATED AT THE UNIT PRIOR TO VENTING INTO THE FLARE HEADER.

IGS CF0556

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3.8 POSSIBLE COMPANION PLANTS

The companion plants would be capable of processing the products of the Conceptual Commercial Plant. The principal products from the plants would be high octane gasoline blending stock, high purity ethylene and chemical grade propylene. Useful by-products would also be produced.

The companion plants consists of two plants: a High Octane Blending Stock Plant and an Ethylene Plant.

3.8.1 High Octane Blending Stock Plant

High Octane Blending Stock Plant Definition. The High Octane Blending Stock Plant is intended to be completely isolated from the Conceptual Commercial Plant and operated as an independent company. It would consist of all facilities necessary to receive naphtha product from the CCP and produce a high quality gasoline blending stock. This blending stock is suitable for blending into either leaded or unleaded gasoline.

Design Basis The plant is designed to process 17,120 barrels per day of CCP naphtha and to produce 15,631 barrels per day of debutanized gasoline blending stock with unleaded motor and research octane numbers of 85 and 97, respectively. The by-products produced include high purity hydrogen (94%), refinery fuel gas, and a sour water stream which can be further processed to produce ammonia, sulfur, and reusable water.

Typical feedstock requirements and product yields expected for the combined pretreating and catalytic reforming operations are given in the following tabulation. The yields are based on using Gulf's Hydrotreating process to pretreat the CCP naphtha and using UOP Inc.'s Platforming R process with bimetallic catalyst to reform the pretreated naphtha.

<u>FEEDSTOCK</u>	<u>WEIGHT %</u>	<u>VOLUME %</u>	<u>BPSD</u>	<u>MMSCF/SD</u>
Raw SRC-II				
Naphtha	100.0	100.0	17,120	--
<u>PRODUCT YIELDS</u>				
Gasoline Blend				
Stock	90.9	91.3	15,631	--
Refinery Fuel				
Gas (FOE)	3.7	5.7	973	--
Hydrogen (94%)	2.1	--	--	9.680
Sour Water	3.3	--	474	--

At the yields shown in the preceding tabulation, the debutanized gasoline blending stock will have the following properties:

Debutanized Gasoline Blending Stock

Gravity, °API	38.7
Research Octane Number, Clear	97.0
Research Octane Number, +3 cc TEL	103.2
Motor Octane Number, Clear	84.9
Motor Octane Number, +3 cc TEL	91.3
Aromatics Content, Vol %	68.7
True Vapor Pressure, psi	1.8

Other design parameters are typical of hydrotreating and catalytic refining processes found in refineries and no special design considerations are required to receive and process the CCP naphtha product.

Process Description. The process configuration is shown on the "High Octane Blending Stock Plant" block diagram.

Naphtha from CCP plant storage is pumped to the Gulf Hydrotreating feed surge drum which is kept under an inert gas blanket.

Hydrogen makeup gas supplied from the catalytic reformer is compressed to reaction loop pressure with a reciprocating compressor. The compressed makeup gas is combined with the high pressure recycle gas to form the total reactor charge gas, which in turn is mixed with the naphtha feed to form the total reactor charge. This mixture is first heated by exchange with hot reactor effluent and then is further heated to reaction temperature in the fired reactor feed heater before flowing to the top of the hydrotreating reactor.

The desired hydrogenation reactions occur in the reactor. Sulfur, nitrogen and oxygen present in the hydrocarbon molecules are converted to hydrogen sulfide, ammonia, and water and the hydrocarbon molecules which contain sulfur, nitrogen, and oxygen are saturated with hydrogen. In addition, some of the aromatic hydrocarbons in the feedstock are converted to naphthenes. These reactions are exothermic and result in a substantial heat release in the reactor. In order to limit the temperature rise across the reactor, the reactor is provided with a number of catalyst beds with intermediate quench zones between the catalyst beds. Cold recycle hydrogen is injected into these quench zones to control the temperature rise across each catalyst bed.

The total reactor effluent is first cooled by exchange with reactor feed, then by exchange with feed to the product stripper. Final cooling of the reactor effluent is accomplished with an air cooler, followed by a trim water cooler. The cooled two-phase mixture is flashed in the high pressure separator to separate the vapor and liquid phases. The vapor from the high pressure separator goes through a knockout pot to the steam turbine driven centrifugal recycle gas compressor where it is compressed back up to the reaction loop operating pressure. A portion of the compressed recycle gas is

used for reactor quench, and the remainder of the recycle gas is combined with makeup hydrogen and the naphtha feed and is returned to the hydrotreating reactor.

A circulating wash water stream is injected into the reactor effluent downstream of the feed/effluent exchanger. This wash water dissolves all of the hydrogen sulfide and most of the ammonia produced in the reactor. The circulating wash water, together with the water produced from the naphtha feed in the reactor, is separated from the liquid hydrocarbon product in the high pressure separator by gravity. Most of the wash water is recirculated back to the reactor effluent. The net production of water from the reactor, containing dissolved H_2S and NH_3 produced in the reactor, is drawn off from the high pressure separator and is sent to an offsite two-stage sour water stripper for separation of hydrogen sulfide and ammonia from the water. The recovered hydrogen sulfide could be sent to a sulfur plant along with other acid gases for production of elemental sulfur. The recovered ammonia could be used for ammonia production. The stripped water, which is essentially free of hydrogen sulfide and ammonia, can be reused or discarded.

The hydrocarbon liquid which is collected in the high pressure separator flows to a low pressure separator where additional gas is flashed from the liquid. The gas product from the low pressure separator goes to the refinery fuel gas system. The liquid from the low pressure separator is heated, first by exchange with reactor effluent and then by exchange with stripper bottoms, and is sent to the product stripper. The purpose of the product stripper is to remove small quantities of dissolved hydrocarbon gases still remaining in the hydrotreated product naphtha. The stripper is provided with a fired reboiler and an overhead condenser and reflux accumulator and is operated as a debutanizer. Essentially all of the C_4 and lighter hydrocarbons in the stripper feed are taken overhead and sent to the refinery fuel gas system. The stripper bottoms product, essentially free of butane and lighter hydrocarbons, is pumped to the catalytic reforming unit. In addition to the removal of light hydrocarbon gases from the pretreated naphtha, the stripper

operation also serves to remove any traces of hydrogen sulfide, ammonia, and water that may remain in the hydrotreated naphtha product. This ensures that these compounds will not be present in the naphtha feed to the catalytic reformer and will not cause poisoning of the reformer catalyst.

The low octane pretreated naphtha product from the Gulf Hydrotreater is pumped to the catalytic reformer feed surge drum, which is inert gas blanketed. The reformer feed is then mixed with recycle hydrogen and heated, first by exchange with hot reactor effluent and then to reaction temperature in a fired heater, before flowing to the top of the first catalytic reforming reactor. The dehydrogenation of naphthenes to aromatics, and the other reactions which occur in the reactor, are endothermic. Thus, the temperature of the mixture of feed and hydrogen decreases rapidly as the mixture passes through the reactor. As the temperature decreases, the reaction rate also decreases. Therefore, the effluent from the first reactor is reheated to reaction temperature in a second fired heater before entering the second reactor. Similarly, the effluent from the second reactor is reheated in a third fired heater before entering the third and final reactor.

The effluent from the third reactor is cooled first by exchange with the mixture of naphtha feed and recycle hydrogen and then by exchange against cooling water. The cooled reactor effluent is then flashed in the product separator to separate the gaseous and liquid products. A portion of the hydrogen rich gas product is sent to the catalytic reformer recycle gas compressor where it is recompressed to the required feed inlet pressure and mixed with incoming naphtha feed. Another portion of the hydrogen rich product gas is sent to the Gulf Hydrotreater makeup gas compressor and is used to supply the hydrogen required for the pretreating step. Excess hydrogen rich gas not required for pretreating and reforming is delivered to battery limits for use in other processing units.

The liquid product recovered from the product separator is heated by exchange against stabilizer bottoms and then enters the stabilizer. The stabilizer is used to remove C_4 and lighter hydrocarbons from the feed and

to produce a debutanized reformat as the bottoms product. The stabilizer is provided with an overhead condenser and reflux accumulator and with a fired reboiler. The hydrocarbon vapors from the reflux accumulator go to the refinery fuel gas system. The debutanized stabilizer bottoms are cooled by exchange against stabilizer feed and by exchange against cooling water and are then sent to the high octane catalytic reformat product storage tanks. The amount of storage would depend on the marketing requirements of the products.

In addition to the process facilities described above, this plant would also require the usual support facilities associated with a refinery installation.

Design Discussion

The Gulf licensed hydrotreating process and catalyst was selected to pretreat the CCP naphtha to produce a catalytic reformer feedstock containing 0.5 ppm of sulfur, 0.2 ppm of nitrogen, and essentially no oxygen. Except for the catalyst and operating conditions, the Gulf Hydrotreating process is similar to other pretreating and desulfurization processes using hydrogen. The primary desulfurization, denitrogenation, and deoxygenation reactions which occur in the hydrotreating reactor result in production of hydrogen sulfide, ammonia, and water. In addition to these reactions, substantial conversion of aromatic hydrocarbons to naphthenic hydrocarbons occurs. Thus, hydrogen consumption in the hydrotreater is relatively high. However, the subsequent catalytic reforming operation produces considerably more hydrogen than is consumed in the hydrotreater so that there is a net production of hydrogen from the combined operations.

Although a number of reactions take place during catalytic reforming, the predominant one is the dehydrogenation of naphthenic hydrocarbons to form aromatic hydrocarbons. Production of these aromatic compounds accounts, in large measure, for the high octane numbers of the gasoline blending component produced from the catalytic reformer.

The octane ratings of the gasoline blending stock product can be varied over a considerable range simply by adjusting the severity of the catalytic reforming operation. Increasing reforming severity and octane number will reduce the yield of blending stock produced, whereas decreasing reforming severity and octane number will increase the yield of blending stock produced.

3.8.2 Ethylene Plant

Ethylene Plant Definition.

The Ethylene Plant is intended to be completely isolated from the Conceptual Commercial Plant and operated as an independent company. It would consist of all facilities necessary to receive the ethane-propane product from the CCP and produce ethylene and other petrochemical feedstocks.

Design Basis

The Ethylene Plant is designed to produce one billion pounds per year of high purity, 99.9% ethylene and approximately 150 million pounds per year of chemical grade (94%) propylene as the major products. The by-products produced are hydrogen, butadiene concentrate and a benzene, toluene, xylene (BTX) concentrate.

The following are typical feedstock requirements and product yields.

<u>FEEDSTOCK</u>	<u>WEIGHT %</u>	<u>MM LB/YR.</u>	<u>VOLUME %</u>	<u>BPCD</u>
Ethane	50	802	57.6	16,768
Propane	<u>50</u>	<u>802</u>	<u>42.4</u>	<u>12,368</u>
Total	100	1,604	100.0	29,136

<u>PRODUCT YIELDS</u>	<u>WEIGHT %</u>	<u>MM LBS/YR</u>	
Hydrogen		3.8	60
Methane (95%)	16.7	268	
Ethylene		62.3	1,000
Propylene	9.3	150	
Butadiene			
Concentrate	3.5	55	
BTX Concentrate	3.7	60	
Liquid Fuel	<u>0.7</u>	<u>11</u>	
TOTAL	100%	1,604	

Other design parameters are typical of an ethylene plant and no special design considerations are required to receive and process the CCP ethane-propane product.

Process Description and Discussion. The process configuration is shown on the "Ethylene Plant" block diagram.

The ethane-propane feedstock mixed with recycle gas is introduced with dilution steam into the cracking heaters. Ten operating heaters, one swing heater, and one spare heater are provided for a total of twelve. All heaters are identical and can co-crack any mixture of ethane and propane, including 100% ethane recycle. Each heater consists of a firebox, boiler feed water preheat coil, high-pressure steam drum, preheat convection and radiant sections for cracking feedstock, two effluent water quench pots, and two transfer line exchangers.

The effluent gas streams for each cracking heater are quenched in the transfer line exchangers which generate high pressure steam. The transfer line exchanger is designed for the cracking furnace effluent conditions. Steam is generated at 1500 psig and 610⁰F in these exchangers and steam drums.

The effluents from the transfer line exchangers are combined and sent to the quench tower. By direct contact water cooling, the greater part of the dilution steam and heavier hydrocarbons is condensed. Net overhead vapor flows to the compressor system. Quench water plus condensed steam are separated from the condensed hydrocarbon in a quench water surge drum. The circulating hot water is used to reboil the propylene fractionator and heat process streams. The quench water is then further cooled against cooling water.

The dilution steam condensed in the water quench system is filtered, then is sent through a coalescer to remove oil, followed by stripping in the process water stripper to remove volatile hydrocarbons. The stripped water is revaporized to be reused as dilution steam.

The quench tower overhead vapors are compressed in four centrifugal compressor stages. Between the third and fourth stages, the total gas is treated for acid gas removal in a regenerative amine system, followed by a caustic soda cleanup absorber. The amine system, which removes all but about 100 ppm of the hydrogen sulfide and carbon dioxide, is included to reduce the consumption of caustic soda and to reduce the quantity of spent caustic which must be treated in the waste treatment unit. The amine system is capable of operation with MEA or DEA as the solvent.

Charge gas from the top of the MEA absorber passes through a caustic wash tower to ensure complete removal of the remaining acid gases. The caustic wash tower is designed to remove all of the acid gases in the charge gas in case the amine system is out of service. The bottom section of this tower can be taken out of service for cleaning while the unit is in operation. The tower has a water wash section in the top to prevent caustic carryover. The wash water is a circulating system with a net makeup and withdrawal to purge contaminating caustic. Charge gas from the wash tower is cooled and returned to the suction of the fourth compressor stage. The fourth stage discharge is cooled with water and with propylene refrigerant. Liquid condensate is separated out and the vapor is sent to the dessicant dryers.

Interstage hydrocarbon and water condensates from the first three stages are sent to an oil/water separator. Fourth stage condensate (after heating and flashing with vapors being recycled) is sent to the condensate stripper. The bottoms product, stripped of ethane and lighter components, is pumped to the depropanizer. Overhead vapors are recycled to the compressor. Aqueous condensate from the fourth stage is sent back to the third stage discharge drum.

The final compressor discharge gas at 60°F and about 525 psig is dried in packed bed dryers before passing to the low temperature recovery section. Both regeneration and cooling of the dryers are accomplished using methane off-gas on a once-through basis. A regeneration heater and a cooler are provided for the regeneration operation.

The dried gas is progressively chilled and partially condensed. The remaining vapor is then purified in a cryogenic hydrogen purification unit. This hydrogen provides the requirements for acetylene removal. The methane off-gas is used for fuel after refrigerant recovery. The ethylene recovered is recycled to the charge gas compressor suction. Chilling is achieved with propylene and ethylene refrigeration, by vaporizing ethane and propane feeds, and by reheating purified hydrogen and methane off-gas streams.

The demethanizer operates at approximately 445 psig. The column is reboiled with propylene refrigerant and reflux is condensed with ethylene refrigerant. The demethanizer overhead is sent to the fuel gas system. The bottoms flows to the deethanizer where C₂'s are separated from C₃ and heavier fractions. The deethanizer reboiler utilizes low pressure steam and reflux is condensed by propylene refrigeration. The bottoms product is sent to the depropanizer and the net overhead vapor flows to the acetylene removal system.

The deethanizer overhead vapor, after feed-effluent exchange and preheat, is sent to the acetylene convertor. Acetylene is hydrogenated over a catalyst in a packed bed reactor. High purity hydrogen product is injected into the

converter feed to provide the hydrogen requirements. Two vessels are provided, one onstream, the other a spare. A heater is provided for regeneration. The converter effluent is used to preheat the feed and is sent to the ethylene fractionator.

The feed to the ethylene fractionator consists of ethylene, ethane, and unreacted hydrogen and methane from the acetylene removal system. Condensing and reboiling are done by propylene refrigerant. The liquid bottoms ethane product is vaporized against the demethanizer feed, superheated against propylene refrigerant, and is recycled to the cracking heaters. The ethylene product is withdrawn as a sidestream from the tower, and unreacted hydrogen and methane from the acetylene removal system are recycled from the reflux drum to the charge compressor.

The high pressure ethylene product is heated against refrigerant and quench water and then delivered to customers via pipeline.

The depropanizer receives feed from the deethanizer bottoms and condensate stripper bottoms. Steam and propylene refrigerant are the reboiling and condensing mediums respectively. The net overhead liquid containing the C_3 's is pumped, vaporized, and then sent to the propadiene removal system. The bottoms product containing C_4 's and heavier is sent to the debutanizer.

The debutanizer utilizes cooling water for reflux condensing medium and steam for reboiling. The overhead liquid is the butadiene concentrate product which is sent to purification, and the bottoms product is the aromatic distillate product which is cooled, combined with the net hydrocarbon liquid in the quench water deoiling system, and sent to the battery limit.

The depropanizer overhead is dried in packed bed dryers, preheated and sent to the propadiene converter. Propadiene and methyl acetylene are hydrogenated over a catalyst in a packed bed reactor. High purity hydrogenproduct is injected into the converter feed to provide the hydrogen

requirements. Two vessels are provided, one onstream, the other a spare. The regeneration heater for acetylene converter regeneration is also used to regenerate the propadiene converter.

The propylene fractionator utilizes cooling water to condense reflux while hot circulating water from the quench water surge drum is the reboiling medium. Liquid propane bottoms are vaporized against quench water and recycled to the cracking heaters. Unreacted hydrogen and methane from the propadiene removal system are sent through a vent condenser to the charge compressor. The high purity propylene product is pumped to storage.

The butadiene concentrate from the debutanizer is hydrogenated selectively over a catalyst to remove acetylene compounds. An alternate system allows hydrogenation of both butadiene and acetylenic compounds. The hydrogenation process would utilize a Lurgi or equal process. The hydrogen used in this hydrogenation system is further purified to a low carbon monoxide level in a packed bed reactor.

The propylene refrigeration system is a closed, multistage system using a centrifugal compressor. It provides refrigeration at four levels. The compressor effluent is cooled and condensed against cooling water and sub-cooled against various product and process streams. Some interstage condensing is obtained from reboiling the demineralizer and the ethylene fractionator.

The ethylene refrigeration system is a closed, multistage system using a centrifugal compressor. The ethylene system has three levels of refrigeration. The compressor effluent is desuperheated against cooling water and is condensed against propylene refrigerant.

In addition to the processing facilities described above, the plant would also include the usual support facilities associated with a "grass roots" installation.

TABLE 3-44
AREA 80 - HIGH OCTANE BLENDING STOCK PLANT
EQUIPMENT LIST

	<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
			<u>TEMPERATURE</u> <u>(F)</u>	<u>PRESSURE</u> <u>(PSIG)</u>
<u>COMPRESSORS</u>				
	Recycle Gas Compressor	N/A	N/A	N/A
	Hydrotreater Recycle Compressor	N/A	N/A	N/A
	Hydrotreater Make-Up Compressor	N/A	N/A	N/A
<u>HEATERS</u>				
	No. 1 Reactor Heater Charge Heater	N/A	N/A	N/A
	No. 2 Reactor Heater Intermediate Heater	N/A	N/A	N/A
	No. 3 Reactor Heater Intermediate Heater	N/A	N/A	N/A
	Stabilizer Reboiler Heater	N/A	N/A	N/A
	Reactor Feed Heater	N/A	N/A	N/A
	Stripper Heater	N/A	N/A	N/A
<u>HEAT EXCHANGERS</u>				
	Combined Feed Exchanger	N/A	N/A	N/A

TABLE 3-44
AREA 80 - HIGH OCTANE BLENDING STOCK PLANT

EQUIPMENT LIST

<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
		<u>TEMPERATURE</u> <u>(F)</u>	<u>PRESSURE</u> <u>(PSIG)</u>
Reactor Products Condenser	N/A	N/A	N/A
Stabilizer Feed/Bottoms Exchanger	N/A	N/A	N/A
Stabilizer O. H. Condenser	N/A	N/A	N/A
Feed/Effluent Exchanger	N/A	N/A	N/A
Reactor Effluent/STripper Feed Exchanger	N/A	N/A	N/A
Effluent Air Cooler	N/A	N/A	N/A
Effluent Trim Cooler	N/A	N/A	N/A
Steam Condenser	N/A	N/A	N/A
Surface Condenser	N/A	N/A	N/A
Stripper Feed/Bottoms Exchanger	N/A	N/A	N/A
Stripper Overhead Condenser	N/A	N/A	N/A
Stripper Bottoms Cooler	N/A	N/A	N/A

TABLE 3-44
AREA 80 - HIGH OCTANE BLENDING STOCK PLANT
EQUIPMENT LIST

	<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
			<u>TEMPERATURE</u> <u>(F)</u>	<u>PRESSURE</u> <u>(PSIG)</u>
<u>PUMPS</u>				
	Reactor Charge Pump	N/A	N/A	N/A
	Stabilizer Bottoms Pump	N/A	N/A	N/A
	Stabilizer Reflux Pump	N/A	N/A	N/A
	Naphtha Feed Pump	N/A	N/A	N/A
	Wash Water Makeup Pump	N/A	N/A	N/A
	Wash Water Circulating Pump	N/A	N/A	N/A
	Condensate Discharge Pump	N/A	N/A	N/A
	Stripper Bottom Product Pump	N/A	N/A	N/A
	Reboiler Recirculation Pump	N/A	N/A	N/A
	Stripper Reflux Pump	N/A	N/A	N/A
<u>REACTORS</u>				
	No. 1 and No. 2 Reactor	N/A	N/A	N/A
	No. 3 Reactor	N/A	N/A	N/A
	Reactor	N/A	N/A	N/A

TABLE 3-44
AREA 80 - HIGH OCTANE BLENDING STOCK PLANT

EQUIPMENT LIST

	<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
			<u>TEMPERATURE</u> (F)	<u>PRESSURE</u> (PSIG)
<u>TANKS</u>				
	Reformer Feed Storage Tank One each API Floating Roof Storage Tank - 100'-0" Dia. x 40'-0" high. Capacity 56,000 barrels.	N/A	N/A	N/A
	Reformat Storage Tanks Two each API Floating Roof Tanks. 200'-0" Dia. x 48'-0" high. Capacity of <u>each</u> 268,584 barrels. Total capacity of 537,168 barrels.	N/A	N/A	N/A
<u>TOWERS</u>				
	Product Stripper	N/A	N/A	N/A
<u>VESSELS</u>				
	Reactor Products Separator	N/A	N/A	N/A
	Stabilizer Tower	N/A	N/A	N/A
	Stabilizer O. H. Receiver	N/A	N/A	N/A
	Feed Surge Drum	N/A	N/A	N/A
	Naphtha Surge Drum	N/A	N/A	N/A

TABLE 3-44
AREA 80 - HIGH OCTANE BLENDING STOCK PLANT
EQUIPMENT LIST

<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
		<u>TEMPERATURE</u> <u>(F)</u>	<u>PRESSURE</u> <u>(PSIG)</u>
High Pressure Separator	N/A	N/A	N/A
Recycle Compressor Suction	N/A	N/A	N/A
Condensate Drum	N/A	N/A	N/A
Low Pressure Flash Drum	N/A	N/A	N/A
Stripper Reflux Pump	N/A	N/A	N/A

TABLE 3-46
AREA 70 - ETHYLENE UNIT

EQUIPMENT LIST

<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
		<u>TEMPERATURE</u> (F)	<u>PRESSURE</u> (PSIG)
<u>Compressors</u>			
Charge Gas Compressor	Centrifugal Compressor, 579 psi Δ P, 37,333 bhp, -- Steam Turbine Driven		585.0
Propylene Refrigeration Compressor	Centrifugal Compressor, 261.1 psi Δ P, 38,100 bhp, Steam Turbine Driven	--	267.3
Ethylene Refrigeration Compressor	Centrifugal Compressor, 447.1 psi Δ P, 9,415 bhp, Steam Turbine Driven	--	447.8
Hydrogen Booster Compressor	Centrifugal Compressor, 200 psi Δ P, 2,123 bhp, Steam Turbine Driven	--	660.3
Ethane Feedstock Charge Compressor	Reciprocating Compressor, 55 psi Δ P, 1,500 bhp, Electric Motor Driven	--	120.3
C ₂ /C ₃ Feedstock Charge Compressor	Recipricating Compressor, 40 psi Δ P, 500 bhp, Electric Motor Driven	--	100.3

TABLE 3-46
AREA 70 - ETHYLENE UNIT

EQUIPMENT LIST

<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>			
		<u>TEMPERATURE</u> <u>(F)</u>	<u>TEMPERATURE</u> <u>(F)</u>	<u>PRESSURE</u> <u>(PSIG)</u>	<u>PRESSURE</u> <u>(PSIG)</u>
		<u>SS</u>	<u>TS</u>	<u>SS</u>	<u>TS</u>
<u>EXCHANGERS</u>					
Transfer Line Exchangers	11.6 MMBtu/hr, Shell, C.S., Tubes C-1/2 Mo	609/611	1526/700	1500	15
Quench Water Coolers #1	175 MMBtu/hr C.S.	158/130	104/120	135	60
Quench Water Coolers #2	27 MMBtu/hr, C.S.	130/105	93/105	130	60
Feed Vaporizer #1	11.5 MMBtu/hr C.S.	65/65	130/105	105	155
Feed Vaporizer #2	12.0 MMBtu/hr, C.S.	55/73	130/93	325	155
Feed Preheater #1	5.5 MMBtu/hr, C.S.	80/160	180/160	125	155
Feed Preheater #2	6.0 MMBtu/hr, C.S.	75/175	180/177	325	155
Feed Preheater #3	4.6 MMBtu/hr, C.S.	65/160	180/160	105	155

TABLE 3-46
AREA 70 - ETHYLENE UNIT

EQUIPMENT LIST

<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>			
		<u>TEMPERATURE</u> <u>(F)</u>		<u>PRESSURE</u> <u>(PSIG)</u>	
		<u>SS</u>	<u>TS</u>	<u>SS</u>	<u>TS</u>
Feed Preheater #4	3.1 MMBtu/hr, C.S.	40/160	180/160	125	155
DPG Feed Heater	7.6 MMBtu/hr, C.S.	40/90	281/281	225	35
Bypass Gas Heater	7.9 MMBtu/hr, C.S.	297/281	-71/80	50	100
Charge Gas Comp.1st Stage Aftercooler	33.4 MMBtu/hr, C.S.	237/110	93/110	35	60
C.G.C. 2nd Stage Aftercooler	27.0 MMBtu/hr, C.S.	237/110	93/110	95	60
C.G.C. 3rd Stage Aftercooler	25.5 MMBtu/hr, C.S.	232/110	93/100	235	60
C.G.C. 4th Stage Aftercooler	34.0 MMBtu/hr, C.S.	219/100	93/100	533	60
Dryer Feed Chiller #1	8.58 MMBtu/hr, C.S.	70/70	110/80	130	530
Dryer Feed Chiller #2	8.50 MMBtu/hr, C.S.	45/45	80/60	90	531
Condensate Stripper	2.0 MMBtu/hr, C.S.	60/120	156/130	525	130

TABLE 3-46
AREA 70 - ETHYLENE UNIT

EQUIPMENT LIST

<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>			
		<u>TEMPERATURE</u> <u>(F)</u>		<u>PRESSURE</u> <u>(PSIG)</u>	
		<u>SS</u>	<u>TS</u>	<u>SS</u>	<u>TS</u>
Condensate Stripper Reboiler	1.9 MMBtu/hr, C.S.	281/281	125/160	50	155
Rerun Propylene Vaporizer	3.2 MMBtu/hr, C.S.	40/109	311/281	237	35
Hydrogen Comp. Feed Preheater	5.6 MMBtu/hr, Tubes, SS, Shell SA-516-GR 70 to A-300-1	60/47	-100/42	515	465
Demethanizer Feed Chiller #1	24.9 MMBtu/hr, Tubes a-214, Shell SA-516-Gr 70 to A-000-1	-5/-5	43/0	29	515
Ethane Recycle Vaporizer	7.5 MMBtu/hr, Tubes A334 Shell C.S. A-300-1	-26/-26	0/19	130	506
Demethanizer Feed Chiller #2	7.5 MMBtu/hr, Tubes A334 Shell C.S. A-300-1	-35/-35	-18/-3	8	506
Demethanizer Feed Chiller #3	10.2 MMBtu/hr, Tubes A-249, TP-304, Shell 3 1/2% Ni	-65/-65	-30/-60	121	501
Demethanizer Feed Chiller #4	12.0 MMBtu/hr, Tubes A-249, TP-304, Shell 3 1/2% Ni	-100/-100	-60/-95	51	498

TABLE 3-46
AREA 70 - ETHYLENE UNIT

EQUIPMENT LIST

<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>		<u>SS</u>	<u>TS</u>
		<u>TEMPERATURE</u> (F)	<u>PRESSURE</u> (PSIG)		
Demethanizer Feed Chiller #5	4.75 MMBtu/hr, Tubes A-249, TP-304, Shell 3 1/2 % Ni	-150/-150	-113/-145	2.3	491
Dryer Regeneration Cooler	6.05 MMBtu/hr (Cooling) 8.29 MMBtu/hr (Condensing) C.S.	425/110	93/110	97	60
Hydrogen Dryer Feed Chiller	2.6 MMBtu/hr, C.S.	45/45	105/50	90	642
Methanator Feed-Effluent Exchanger	21.2 MMBtu/hr, Tubes & Shell C+ 1/2 MO	115/550	714/280	660	653
Methanator Feed Preheater	8.0 MMBtu/hr, Tubes C+ 1/2 MO, Shell C.S.	794/515	300/500	763	657
Methanator Effluent Cooler	17.1 MMBtu/hr, C.S.	425/105	93/120	645	60
Off Gas Exchanger #2	2.5 MMBtu/hr, Tubes T-304 SS, Channel, Tube Sheets 3 1/2 % Ni, Shell C.S.	47/43	-11/35	512	120

TABLE 3-46
AREA 70 - ETHYLENE UNIT

EQUIPMENT LIST

<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>			
		<u>TEMPERATURE</u> (F)		<u>PRESSURE</u> (PSIG)	
		<u>SS</u>	<u>TS</u>	<u>SS</u>	<u>TS</u>
Demethanizer Condenser	4.16 MMBtu/hr, Tubes A-249, TP-304, Shell 3 1/2% Ni	-150/-150	-132/-144	2.3	445
Demethanizer Reboiler	30.0 MMBtu/hr, C.S.	70/68	45/55	136	450
Deethanizer Condenser	27.0 MMBtu/hr, C.S.	-5/-5	17/14	29	360
Deethanizer Reboiler	56.0 MMBtu/hr, C.S.	297/281	154/156	35	365
Acetylene Converter Feed Eff. Exchanger #1	8.9 MMBtu/hr, C.S.	10/84	110/34	335	285
Acetylene Converter Feed Eff. Exchanger #2	7.7MMBtu/hr, C.S.	82/149	239/170	330	310
Acetylene Converter Feed Preheater	5.4 MMBtu/hr, C.S.	297/281	149/200	35	330
Acetylene Converter Eff. Cooler	6.6 MMBtu/hr, C.S.	170/110	93/110	285	60

TABLE 3-46
AREA 70 - ETHYLENE UNIT

EQUIPMENT LIST

<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>			
		<u>TEMPERATURE</u> <u>(F)</u>		<u>PRESSURE</u> <u>(PSIG)</u>	
		<u>SS</u>	<u>TS</u>	<u>SS</u>	<u>TS</u>
Ethylene Fractionator Condenser	95.0 MMBtu/hr, Tubes A-334-GR I Shell A-300 GR I	-35/-35	-20/-30	8	275
Ethylene Fractionator Reboiler	62. MMBtu/hr , C.S.	40/38	21/21	81	285
Depropanizer Condenser	38.0 MMBtu/hr, C.S.	40/40	63/54	83	110
Depropanizer Reboiler	30.0 MMBtu/hr, C.S.	297/281	164/176	35	115
Propadiene Converter Vaporizer	17.8 MMBtu/hr, C.S.	54/141	297/281	325	35
Debutanizer Condenser	4.6 MMBtu/hr, C.S.	130/116	93/120	85	60
Debutanizer Reboiler	4.7 MMBtu/hr, C.S.	297/281	247/265	35	88
Demethanizer Vent Condenser	1.44 MMBtu/hr, S.S., TP-304	-192/-155	-144/-149	130	
Propadiene Converter Effluent Cooler	8.8 MMBtu/hr, C.S.	266/135	93/120	305	60

TABLE 3-46
AREA 70 - ETHYLENE UNIT

EQUIPMENT LIST

<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>			
		<u>TEMPERATURE</u> (F)		<u>PRESSURE</u> (PSIG)	
		<u>SS</u>	<u>TS</u>	<u>SS</u>	<u>TS</u>
Propylene Fractionator Condenser	147.0 MMBtu/hr, C.S.	114/102	93/102	260	60
Propylene Fractionator Reboiler	124.0 MMBtu/hr, C.S.	137/137	180/152	281	155
Propylene Fractionator Vent Condenser	0.7 MMBtu/hr, C.S.	70/70	102/90	138	245
Ethylene Product Heater	4.2 MMBtu/hr, C.S.	85/120	156/130	1478	150
Feed Chiller	0.570 MMBtu/hr, C.S.	43/43	116/50	86	295
Propylene Frac. Aux. Reboiler	50.0 MMBtu/hr, C.S.	298/281	137/137	35	281
Product Recycle Chiller	.153 MMBtu/hr, C.S.	70/70	104/86	146	540
Propylene Refrigerant Condenser	253.0 MMBtu/hr, C.S.	175/112	93/105	267	60
Ethylene Product Superheater	14.0 MMBtu/hr, C.S.	112/90	-20/85	267	1478

TABLE 3-46
AREA 70 - ETHYLENE UNIT

EQUIPMENT LIST

<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>			
		<u>TEMPERATURE</u> <u>(F)</u>		<u>PRESSURE</u> <u>(PSIG)</u>	
		<u>SS</u>	<u>TS</u>	<u>SS</u>	<u>TS</u>
Ethane Feed Superheater	7.3 MMBtu/hr, C.S.	96/88	-22/80	267	130
Ethylene Refrig. Desuperheater #2	5.4 MMBtu/hr, C.S.	70/70	105/75	138	445
Ethylene Refrig. Desuperheater #3	5.2 MMBtu/hr, C.S.	40/40	75/45	83	442
Ethylene Refrig. Condenser	38.0 MMBtu/hr, C.S.	-5/-5	45/10	29	60
Ethylene Refrig. Desuperheater #1	9.0 MMBtu/hr, C.S.	163/105	93/105	448	60
L.P. Condensate Flash Vent Condenser	10.5 MMBtu/hr, C.S.	212/212	130/160	ATM	77
Dry Flare Liquid Vaporizer	5.0 MMBtu/hr, Tubes A-249, TP-304, Shell C.S.	281/281	-30/-30	35	11

TABLE 3-46
AREA 70 - ETHYLENE UNIT

EQUIPMENT LIST

<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
		<u>TEMPERATURE</u> (F)	<u>PRESSURE</u> (PSIG)
<u>Pumps</u>			
Deoiling System Charge Pump	475 gpm, 104 psi Δ P, 39 bhp, Motor Driven	--	115
Quench Water Pump	13,900 gpm, 144 psi Δ P, 1,313 bhp, Motor/ Steam Turbine Driven	--	155
Deoiler Settler	150 gpm, 40 psi Δ P, 5.2 bhp, Motor Driven	--	94
Aromatic Distillate Product	42 gpm, 175 psi Δ P, 17.2 bhp, Motor Driven	--	188
Deoiler Condensate	150 gpm, 97 psi Δ P, 13.7 bhp, Motor Driven	--	95
Caustic Circulation 2nd Stage	200 gpm, 24 psi Δ P, 39.4 bhp, Motor Driven	--	287
Caustic Makeup	37 gpm, 291.3 psi Δ P, 39.4 bhp, Motor Driven	-	290
Caustic Circulation Pump	200 gpm, 40 psi Δ P, 7.7 bhp, Motor Driven	--	270

TABLE 3-46

AREA 70 - ETHYLENE UNIT

EQUIPMENT LIST

<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
		<u>TEMPERATURE</u> (F)	<u>PRESSURE</u> (PSIG)
Condenser Stripper Reboiler Pump	51 gpm, 39 psi Δ P, 2.9 bhp, Motor Driven	--	166
Injection Oil Pump	1-120 gpm, 560 psi Δ P, 2 bhp, Motor Driven	--	559
Charge Compressor Hot Well Condensate Pump	582 gpm, 90 psi Δ P, 36 bhp, Motor Driven	--	77
Spent Caustic Pump	40 gpm, 115 psi Δ P, 6 bhp, Motor Driven	--	115
Slop Oil Pump	65 gpm, 115 psi Δ P, 12 bhp, Motor Driven	--	115
H ₂ Booster Compressor Hot Well Condensate Pump	95 gpm, 90 psi Δ P, 8.2 bhp, Motor Driven	--	77
Demethanizer Reflux Pump	254 gpm, 61 psi Δ P, 17 bhp, Motor Driven	--	503
Deethanizer Reflux Pump	1150 gpm, 58 psi Δ P, 48 bhp, Motor Driven	--	416
Ethylene Tower Reflux Pump	3260 gpm, 97 psi Δ P, 240 bhp, Motor/Turbine Driven	--	360
Ethylene Product Pump	550 gpm, 1200 psi Δ P, 620 bhp, Motor/Turbine	--	1478

TABLE 3-46
AREA 70 - ETHYLENE UNIT

EQUIPMENT LIST

<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
		<u>TEMPERATURE</u> (F)	<u>PRESSURE</u> (PSIG)
Depropanizer Reflux Pump	530 gpm, 66 psi Δ P, 29.1 bhp, Motor Driven	--	164
Propadiene Converter Charge Pump	445 gpm, 267 psi Δ P, 125 bhp, Motor Driven	--	365
Debutanizer Reflux and Product Pump	120 gpm, 280 psi Δ P, 53 bhp, Motor Driven	--	352
Propylene Fractionator Reflux Pump	5510 gpm, 95 psi Δ P, 374 bhp, Motor/Turbine Driven	--	344
Propylene Fractionator Inter TWR Transfer Pump	5300 gpm, 78 psi Δ P, 297 bhp, Motor/Turbine Driven	--	352
Methanol Injection Pump	180-600 gpm, 600 psi Δ P, 7.5 bhp, Motor Driven		-- 600
Propylene Product Pump	200 gpm, 768 psi Δ P, 194 bhp, Motor/Turbine Driven	--	1030
Aromatic Distillate Product Pump	45 gpm, 29 psi Δ P, 2 bhp, Motor Driven	--	120

TABLE 3-46

AREA 70 - ETHYLENE UNIT

EQUIPMENT LIST

<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
		<u>TEMPERATURE</u> (F)	<u>PRESSURE</u> (PSIG)
Debutanizer Feed Pump	95 gpm, 14 psi Δ P, 1.6 bhp, Motor Driven	--	132
Butadiene Concentrate Pump	95 gpm, 325 psi Δ P, 64 bhp, Motor Driven	--	580
Propylene Compressor Hot Well Pump	600 gpm, 90 psi Δ P, 37.5 bhp, Motor Driven	--	77
Propylene Pumpout Pump	450 gpm, 140 psi Δ P, 76 bhp, Motor Driven	--	282
Ethylene Compressor Hot Well Pump	163 gpm, 90 psi Δ P, 13.6 bhp, Motor Driven	--	77
Ethylene Pumpout Pump	150 gpm, 143 psi Δ P, 345 bhp, Motor Driven	--	146
H.P. Condensate Pump	990 gpm, 1090 psi Δ P, 818 bhp, Motor/Turbine Driven	--	1105
L.P. Condensate Pump	900 gpm, 124 psi Δ P, 87 bhp, Motor Driven	--	130
Flare Drum Transfer Pump	756 gpm, 66 psi Δ P, 5.75 bhp, Motor Driven	--	67

TABLE 3-46
AREA 70 - ETHYLENE UNIT
EQUIPMENT LIST

	<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
			<u>TEMPERATURE</u> (F)	<u>PRESSURE</u> (PSIG)
<u>Heaters</u>	Ethane-Propane Cracking Heaters	Special Heaters based on final feedstock specifications, approximately 60 MMBtu/hr heat absorbed	1600	15
	Steam Superheater	Vertical Unit, 125 MMBtu/hr	900	1500
	Dryer Regeneration Heater	Vertical Unit, 12.5 MMBtu/hr Methane Gas feed	800	160
	Converter Regeneration Heater	Vertical Unit, 12.8 MMBtu/hr Steam/Air Feed	825	100
	Flare Stack	3'-0"/5'-0" Dia. x 264'	Ambient	Atmospheric
<u>Vessels</u>	Quench Tower	16'-0" Dia./20'-0" Dia. x 56'-3"	180	9
	Process Water Stripper	6'-0" Dia./11'-0" Dia. x 47'-6"	240	11
	Caustic & Water Wash Tower	10'-0" Dia. x 147'-0"	110	230
	Condensate Stripper Tower	3'-0" Dia. x 41'-6"	150	155
	Amine Absorber	10'0" Dia. x 72'-6"	118	230
	Amine Stripper	4'-0" Dia. x 66'-6"	236	10
	Demethanizer Tower	7'-0"/11'-6" Dia. x 156'-5"	-131/41	450
	Deethanizer Tower	10'-6"/14'-6" Dia. x 138'-10"	13/160	365

TABLE 3-46
AREA 70 - ETHYLENE UNIT
EQUIPMENT LIST

<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
		<u>TEMPERATURE</u> (F)	<u>PRESSURE</u> (PSIG)
Ethylene Tower	14'-0" Dia. x 237'-0"	-20/20	285
Depropanizer Tower	8'-6" Dia. x 90'-6"	61/81	115
Debutanizer Tower	3'-0" Dia. x 73'-4"	130	90
Propylene Tower #1	18'-0" Dia. x 224'	120	280
Steam Drums	5'-0" Dia. x 14'-0'	610	1500
Ethane/Propane Feed Drum	10'-0" Dia. x 24'-0"	65	105
D. P. G. Knockout Drum	3'-0" Dia. x 7'-0"	100	225
Blowdown Drum	2'-0" Dia. x 7'-0"	240	10
Superheater Feed K.O.	7'-0" Dia. x 12'-7"	530	845
De-Oiling Settler	9'-6" Dia. x 30'-0"	180	35
Distillation Drum	6'-0' Dia. x 12'-6"	110	10
Quench Water Settler	22'-0" Dia. x 70'-0"	180	10
De-Oiler Condensate Surge Drum	16'-0" Dia. x 20'-0"	180	Atmospheric
Charge Gas Comp. 1st Stage Suction Drum	12'-6 Dia. x 26'-6"	110	7
2nd Stage Suction Drum	10'-0" Dia. x 16'-6"	110	32
3rd Stage Suction Drum	8'-6" Dia. x 15'0"	110	90

TABLE 3-46
AREA 70 - ETHYLENE UNIT
EQUIPMENT LIST

<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
		<u>TEMPERATURE</u> (F)	<u>PRESSURE</u> (PSIG)
3rd Stage Discharge Drum	8'-0" Dia. x 13'-0"	110	230
1st Stage Water Degassing Drum	4'-6" Dia. x 17'-0"	110	10
Cracked Gas Comp. 4th Stage Suction Drum	8'-0" Dia. x 13'-0"	110	225
Cracked Gas Comp. 4th Stage Discharge Drum	7'-0" Dia. x 18'-0"	60	525
Condensate Stripper Feed Flash Drum	5'-0" Dia. x 12'-6"	90	230
Spent Caustic Degassing Drum	4'-0" Dia. x 10'-0"	110	10
Amine Stripper Reflux Drum	2'-0" Dia. x 4'-0"	120	5
2nd Stage Water Degassing Drum	3'-0" Dia. x 8'-0"	110	(-7)
Process Dryers	10'-0" Dia. x 32'-6"	60/550	525/115
Demethanizer Feed Separator #1	10'-0" Dia. x 27'-0"	(-30)	500
Demethanizer Feed Separator #2	7'-0" Dia. x 21'-0"	(-95)	500

TABLE 3-46
AREA 70 - ETHYLENE UNIT
EQUIPMENT LIST

<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
		<u>TEMPERATURE</u> (F)	<u>PRESSURE</u> (PSIG)
Demethanizer Feed Separator #3	5'-0" Dia. x 13'-6"	(-145)	490
Fuel Gas Drum	4'-0" Dia. x 8'-0"	100	50
Dryer Regeneration K. O. Drum	3'-0" Dia. x 8'-0"	100	100
Methanator	5'-6" Dia. x 18'-2"	900	750
Water K. O. Drum	3'-0" Dia. x 7'-6"	50	640
Hydrogen Dryer	5'-6" Dia. x 20'-6"	425	640
Demethanizer Reflux Drum	4'-0" Dia. x 11'-0"	-150	435
Demethanizer Reflux Drum	5'-6" Dia. x 16'-6"	-150	440
Deethanizer Reflux Drum	9'-0" Dia. x 24'-0"	15	355
Acetylene Converters	9'-0" Dia. x 27'-0"	250/950	315/5
Ethylene Tower Reflux Drum	13'-0" Dia. x 31'-6"	-30	260
Green Oil K. O. Drum	6'-6" Dia. x 14'-0"	35	285
Depropanizer Reflux Drum	7'-0" Dia. x 18'-6"	55	95
Debutanizer Reflux Drum	6'-0" Dia. x 14'-6"	120	70
Propadiene Converter	8'-0" Dia. x 24'-6"	250/950	315/10

TABLE 3-46
AREA 70 - ETHYLENE UNIT
EQUIPMENT LIST

<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
		<u>TEMPERATURE</u> (F)	<u>PRESSURE</u> (PSIG)
Propylene Fract. Reflux Drum	3'-0" Dia. x 7'-5"	90	240
Propylene Fract. Reflux Drum	13'-0" Dia. x 41'-6"	100	245
Ethane Recycle Surge Drum	10'-0" Dia. x 21'-0"	-10	175
Ethane Product Pump Suction Drum	9'-0" Dia. x 25'-0"	-20	275
Propylene Product Suction Drum	7'-0" Dia. x 19'-0"	120	260
Propylene Fract. Feed Dryers	5'-6" Dia. x 13'-0"	135/550	290/115
Separator	4'-6" Dia. x 13'-9"	85	255
Methanator K. O. Drum	2'-0" Dia. x 6'-0"	110	600
Secondary Methanator	2'-0" Dia. x 6'-6"	600	605
Separator	4'-6" Dia. x 13'-9"	100	425
Propylene Refrig. 1st Stage Drum	14'-6" Dia. x 25'-0"	-35	7
Propylene Refrig. 2nd Stage Drum	14'-0" Dia. x 27'-6"	-5	27
Propylene Refrig. 3rd Stage Drum	12'-6" Dia. x 35'-0"	40	80

TABLE 3-46
AREA 70 - ETHYLENE UNIT
EQUIPMENT LIST

<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
		<u>TEMPERATURE</u> (F)	<u>PRESSURE</u> (PSIG)
Propylene Refrig. Surge Drum	16'-0" Dia. x 43'-0"	70	136
Ethylene Refrig. 1st Stage Surge Drum	5'-0" Dia. x 14'-0"	-150	1.3
Ethylene Refrig. 2nd Stage Surge Drum	4'-6" Dia. x 15'-0"	-100	50
Ethylene Refrig. Surge Drum	7'-0" Dia. x 27'-0"	-65	120
Ethylene Refrig. Condenser Drum	4'-6" Dia. x 23'-6"	10	435
L. P. Condensate Flash Drum	10'-0" Dia. x 16'-0"	215	Atmospheric
Steam Blowdown Drum	3'-0" Dia. x 7'-0"	215	Atmospheric
Instrument Air Receiver	5'-0" Dia. x 16'-0"	95	90
Wet Flare Drum	17'-0" Dia. x 34'-0"	325	11
Dry Flare Drum	16'-0" Dia. x 32'-0"	-150	11

TABLE 3-46
AREA 70 - ETHYLENE UNIT

EQUIPMENT LIST

<u>SERVICE</u>	<u>DESCRIPTION</u>	<u>OPERATING</u>	
		<u>TEMPERATURE</u> (F)	<u>PRESSURE</u> (PSIG)
<u>TANKS</u>	Amine Drain & Mix Tank 5'-0" Dia. x 6'-0"	100	Atmospheric
	Caustic Storage Tank 16'-0" Dia. x 21'0"	110	Atmospheric
	Injection Oil Storage Tank 12'-0" Dia. x 15'-6"	110	Atmospheric
	Amine Storage Tank 12'-6" Dia. x 16'-6"	110	Atmospheric

TABLE 3-43
HIGH OCTANE BLENDING STOCK PLANT
UTILITY SUMMARY

<u>Electrical</u>	<u>KW</u>	
Connected	3,575	
Operating	2,543	
<u>Steam</u>		
Consumption:	<u>LB/HR</u>	<u>PSIG</u>
Hydrotreater Recycle Compressor	18,325	600 to 4" Hg
Recycle Gas Compressor	21,315	600 to 4" Hg
<u>Cooling Water (200F Rise)</u>	<u>GPM</u>	
Effluent Trim Cooler	700	
Surface Condenser	25	
Stripper Overhead Condenser	400	
Reactor Overhead Condenser	6,000	
Stabilizer O. H. Condenser	6,125	
Stabilizer Bottoms Cooler	1,600	
Reactor Feed Heater	15.8	
Striper Heater	15.8	
Reactor Heaters	203.9	
Stabilizer Reboiler Heater	41.6	

TABLE 3-45
ETHYLENE PLANT
UTILITY SUMMARY

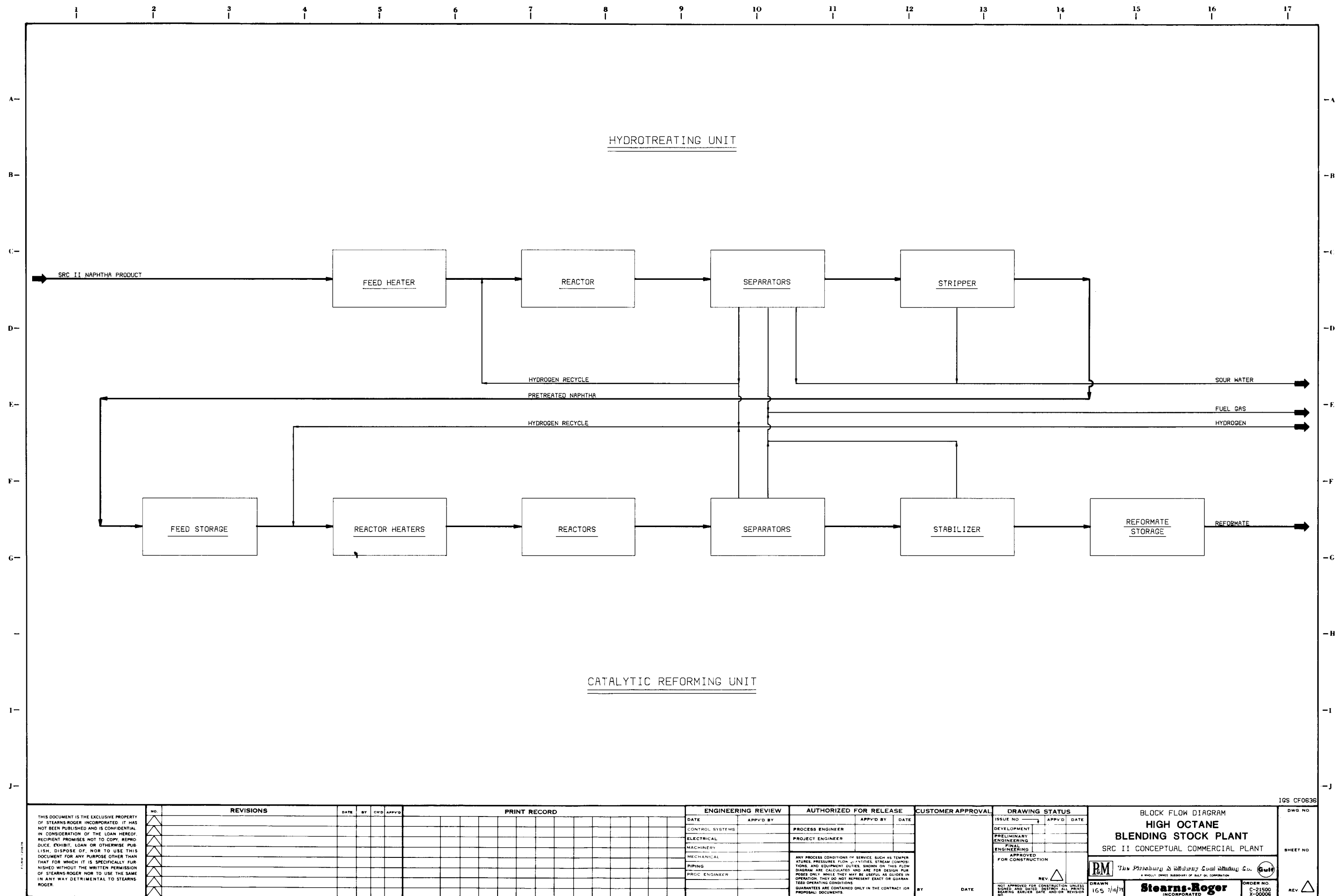
<u>Electrical</u>	<u>KW</u>	
Connected	14,700	
Operating	11,760	
<u>Steam</u>		
Consumption:	<u>LB/HR</u>	<u>PSIG</u>
Steam Turbines & Exchangers	395,000	1,500
Offsite Boiler	140,000	1,500
<u>Cooling Water (200F Rise)</u>	<u>GPM</u>	
Process Equipment	95,000	
<u>Fuel</u>	<u>MM BTU/HR</u>	
Consumption:		
Cracking Heaters	858	
Boilers	185	
Generation:		
Process Equipment	964	

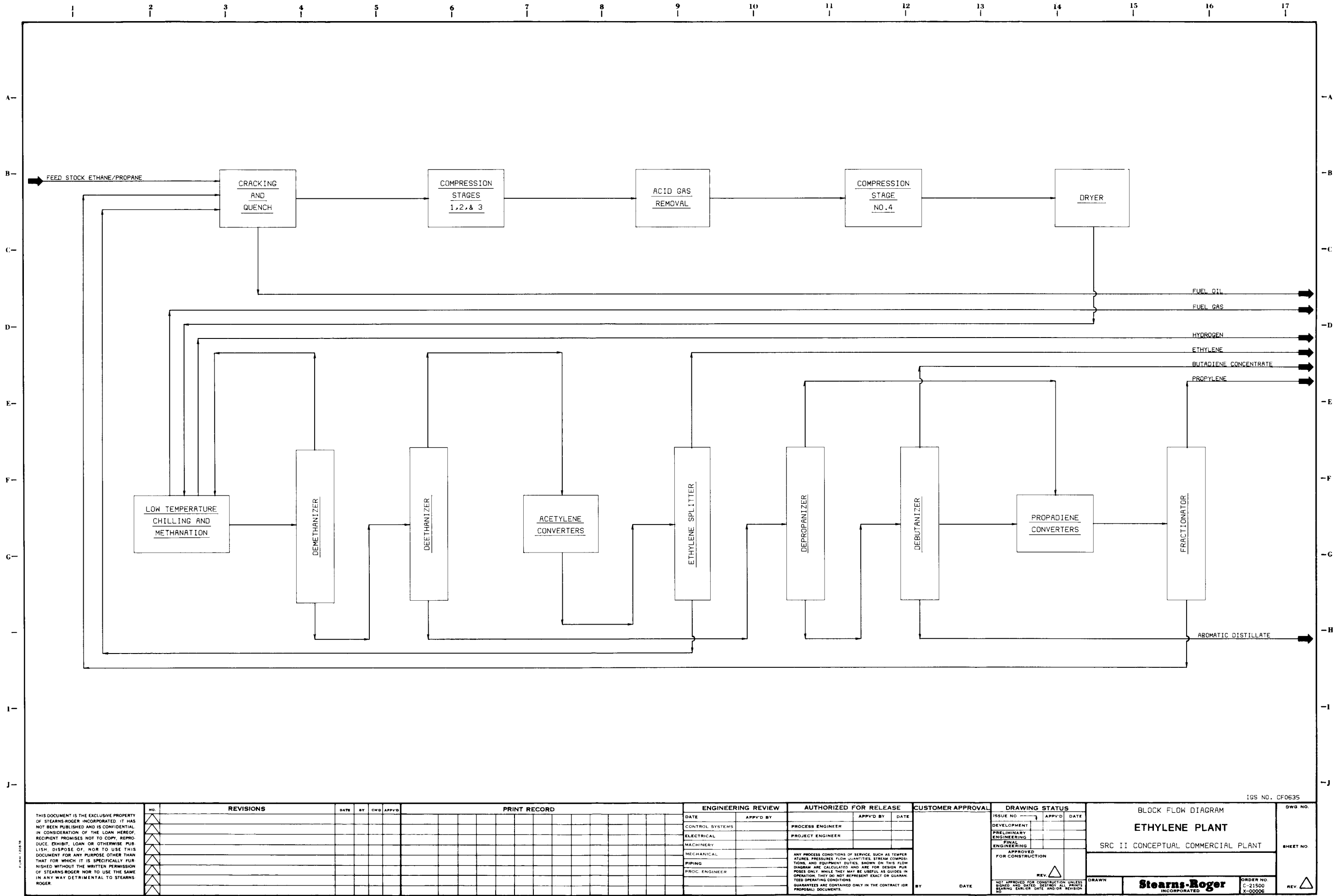
TABLE 3-45
ETHYLENE PLANT

UTILITY SUMMARY -Contd

Catalyst and Chemicals

Methanators	Catalyst, Girdler Type G655
Acetylene Converters	Catalyst, Girdler Type G58B
Propadiene Converters	Catalyst, CCI Type C-31-1A
Secondary Methanator	Catalyst
Caustic (NaOH)	1,456,000 lbs/year
MEA	35,000 lbs/year
Methanol	3,000 gallons/year





SECTION 4

COST ESTIMATES

4.1 BASIS OF CAPITAL COST ESTIMATE

Direct Capital Costs are those costs which would normally be incurred for engineering, procurement, and construction. The Direct Capital Costs estimated by Stearns-Roger for the Conceptual Commercial Plant are presented in Table 4-1, broken down by Cost Elements, and in Table 4-2, broken down by Areas. The estimate was developed in November 1978 dollars. It has been prepared in accordance with instructions from the Department of Energy.

4.1.1 Direct Field Costs

The Direct Field Costs were developed using the Stearns-Roger Computer-Aided Preliminary Estimating System (CAPES). CAPES uses basic equipment design information and preliminary conditions of service to develop the complete installed cost for each piece of equipment through simulation based on a volumetric model technique. The volumetric models are typical mechanical flow diagrams (P&ID's) for specific types of equipment. These models are used in conjunction with size and service data to generate material takeoffs and labor requirements for all direct field accounts. Direct field accounts include process equipment, foundations, structures and structural supports, piping, electrical, instrumentation, insulation, and painting; they are stated in terms of direct labor, direct material, and direct subcontract costs, based on user definition. These are then priced on the bases of user-specified material costs, labor and productivity, and subcontractor unit costs which together determine Direct Field Costs. CAPES has the capacity to develop prices on common types of process equipment; prototype or specialized equipment items for this plant were priced using in-house information or vendor telephone quotations.

Preliminary quantity takeoffs were made for several items, primarily the civil, structural, and equipment accounts in Unit 60. Other preliminary quantity takeoffs include site preparation requirements, structures, and interconnecting piping. Spread footings were assumed for all foundations. Because the actual soil conditions are unknown, no piling costs are included. Site preparation and excavation costs are based on 100% earthwork. It was assumed that the costs for construction and/or improvement of the main access roads to the site would be borne by others. No costs for infrastructures have been included, such as for schools, hospitals, and recreational facilities which would be required to support construction, operation, maintenance, and administrative work forces. Incoming power to the main plant substation was assumed to be provided by others. Several areas include battery-limits unit estimates supplied by others, in lieu of estimates built up from equipment requirements. The suppliers of the estimates, which have been assumed to be all-inclusive lump-sum subcontracts, are as follows:

- Area 21 - Texaco Development Corp.
- Area 43 - Resources Conservation Co.
- Area 44 - Air Liquide

The overall estimate is based on a single-shift, 40 hour work week. An allowance has been made for casual overtime (for completing a pour of concrete). All craft labor rates assume a merit shop or a project agreement basis.

The total construction labor effort is estimated to require approximately 20,668,000 craft hours; this includes all equipment and material installation, as well as supporting craft requirements such as warehousing, temporary facilities construction, and construction equipment operation and maintenance. Based on a 42-month construction effort, peak loading would be about 5,400 craft workers; the average craft work force would be about 3,100 workers.

Estimates were calculated on the basis of normal Stearns-Roger preconstruction and construction management procedures. The differences in cost for a third-party construction management contractor have not been considered.

4.1.2 Indirect Field Cost

Indirect Field Costs include field staff costs, field office expenses, payroll taxes, insurance, performance bonds, consumable supplies, temporary facilities, construction equipment rental, and small tools. There is a direct relationship between Direct Field Labor Costs and Indirect Field Costs for this estimate, Indirect Field Costs were estimated at 146 percent of Direct Field Labor Cost. No precommissioning or commissioning costs have been included.

4.1.3 Engineering Costs

Engineering Costs were estimated as a percentage of Total Field Cost (the sum of Direct and Indirect Field Costs). Markups appropriate to commercial projects were used. The total estimate includes approximately 3,964,000 engineering hours for the engineering/construction contractor. Various engineering subcontractors will be required during the design and engineering effort and the associated fees are included in the estimate. Quotations were received from several subcontractors early in 1978; others were estimated by Stearns-Roger. These costs were escalated to November 1978 dollars and are assumed to be lump sum. The areas and subcontractors are as follows:

Area 11	- Kinetics Technology, Inc.
Areas 12, 32, 44	- Air Liquide
Area 21	- Texaco Development Corp.
Area 22, 23, 24, 25	- Haldor-Topsoe A/S
Area 33	- Shell Development Corp. (Goar, Arrington & Associates, Inc.)
Area 41	- U.S.S. Engineers and Consultants, Inc.
Area 42	- ChemPro
Area 44	- Air Liquide
Area 55	- Soils Tests and Mapping Subcontractor

Costs for third-party technical support to establish the basis of design are not included.

4.1.4 Indirect Capital Costs

Indirect Capital Costs include land, initial charges of catalysts and chemicals, license fees, owner management costs, and working capital. These costs are listed on Table 4-3. Detailed estimated costs for the initial charge of catalysts and chemicals are listed in Table 4-4.

TABLE 4-1

DIRECT CAPITAL COSTS

(Breakdown by Cost Elements)
(November 1978 Dollars)

	<u>MILLIONS OF DOLLARS</u>
<u>I. Engineering Costs</u>	
A. Prime Contractor	\$ 92.000
B. Subcontractors	4.000
Subtotal, Engineering Costs	\$ 96.000
<u>I. Equipment & Materials Costs</u>	
A. Shop-Fabricated Equipment	436.000
B. Field-Fabricated Equipment	251.000
C. Construction Materials	246.000
D. Battery Limits Units (1)	140.000
Subtotal Equipment & Materials	\$1,073.000
<u>III. Construction Costs</u>	
A. Direct Field Labor	\$ 114.000
B. Indirect Field Costs	162.000
C. Installation Subcontracts	80.000
D. Battery Limits Units (1)	35.000
Subtotal, Construction Costs	\$ 391.000
DIRECT CAPITAL COSTS	\$1,560.000

NOTE: All of the costs above include a pro rata share of contingency (20%) in accordance with DOE guidelines.

(1) Provided by Licensors

TABLE 4-2
DIRECT CAPITAL COSTS
(Breakdown by Areas)
(November 1978 Dollars)

MILLIONS OF
DOLLARS

Unit 10-Primary Process Plants

Area 11 - Dissolver Plant	\$ 489.600
Area 12 - Hydrogen Treating & Recovery Plant	125.600
Subtotal, Unit 10:	\$ 615.200

Unit 20 - Hydrogen Purification Plants

Area 21 - Syngas Production Plant	\$ 91.700
Area 22 - Syngas Shift Conversion Plant	36.800
Area 23 - Hydrogen Purification & Compression Plant	84.900
Area 24 - Syngas Purification Plant	13.500
Area 25 - Methanation and Dehydration Plant	10.100
Subtotal, Unit 20:	\$ 237.000

Unit 30 - Refining & Gas Plants

Area 31 - L.P. Gas Compression & Treatment Plant	\$ 18.600
Area 32 - Product Gas Plant	18.400
Area 33 - Sulfur Recovery Plant	50.900
Area 34 - Refining Plant	52.400
Subtotal, Unit 30	\$ 140.300

Unit 40 - Secondary Recovery & Oxygen Plants

Area 41 - Ammonia Recovery Plant	\$ 13.300
Area 42 - Tar Acid Recovery Plant	16.100
Area 43 - Waste Water Reclamation Plant	52.700
Area 44 - Oxygen Plant	180.200
Subtotal, Unit 40:	\$ 262.300

Unit 50 - Miscellaneous Systems

Area 51 - Steam Generation System	\$ 38.500
Area 52 - Raw Water System	16.200
Area 53 - Cooling Water System	47.700
Area 54 - Miscellaneous Systems	109.600
Area 55 - General Plant Facilities	18.500
Subtotal, Unit 50:	\$ 230.500

Unit 60 - Coal & Slag Systems

Area 61 - Coal Supply System	\$ 45.700
Area 62 - Coal Crushing System	21.600
Area 63 - Plant Slag Handling System	4.200
Area 64 - Slag Disposal System	3.200
Subtotal, Unit 60:	\$ 74.700

TOTAL DIRECT CAPITAL COSTS: \$1,560.000

NOTE: All of the costs above include a pro rata share of contingency (20%) in accordance with DOE guidelines.

TABLE 4-3
INDIRECT CAPITAL COSTS
(November 1978 Dollars)

	<u>MILLIONS OF DOLLARS</u>
I. Catalysts and Chemicals	\$ 20.100
II. License Fees	13.200
III. Owner Management Costs	8.000
IV. Land	7.800
V. Working Capital	
A. Raw Coal Inventory	\$ 26.900
B. Finished Products Inventory	10.600
C. Catalysts and Chemicals Inventory	.600
D. Spare Parts and Maintenance Materials	<u>24.800</u>
Subtotal Working Capital	\$ <u>62.900</u>
TOTAL INDIRECT CAPITAL COST ELEMENTS:	\$ 112.000

NOTE: All of the above costs include 20% contingency where appropriate in accordance with DOE guidelines.

TABLE 4-4
INITIAL CATALYST & CHEMICAL COSTS
(November 1978 Dollars)

<u>AREA</u>	<u>MILLIONS OF DOLLARS</u>
12	1.940
22	8.870
23	2.180
24	.589
25	1.037
31	.044
32	.049
33	1.170
41	.091
42	.012
51	.005
52	.528
53	.134
54	<u>.122</u>
	16.771
CONTINGENCY	<u>3.354</u>
TOTAL	20.125

NOTE: The contingency (20%) is in accordance with DOE guidelines.

4.2 BASIS OF OPERATING COST ESTIMATE

Annual Operating Costs were estimated as described below in November 1978 dollars. Appropriate contingencies have been included in accordance with DOE guidelines.

4.2.1 Operating Labor and Supplies

Table 4-5 shows the estimated number of operators required for plant operation. The average operator rate is based on \$18,242 per year plus adjustments for idle time, fringe benefits, and contingency. Operating supplies were calculated at 10% of operating labor.

4.2.2 Maintenance Labor

Table 4-6 shows the estimated direct-hire plant maintenance work force requirements. The average annual rate for the maintenance work force is \$26,125 per year, plus adjustments for idle time, fringe benefits and contingency.

4.2.3 Maintenance Materials

The annual costs for maintenance materials were calculated at 2% of total depreciable investment including catalysts and chemicals and owner management costs but excluding license fees and land.

4.2.4 Contract Maintenance

Contract Maintenance was estimated to require the same number of workers as the direct-hire plant maintenance work force. The annual rate, covering wages, overheads, fees and contingency, was estimated as \$63,000 per worker.

4.2.5 Catalysts and Chemicals

The annual replacement quantities, unit costs and net annual replacement costs for catalysts and chemicals are shown in Table 4-7.

4.2.6 Electricity

The annual purchased power requirement based on annual demand of 11,600 KVA and a power factor of 0.9, is 10.43 MW: this was priced as \$0.03 per KWH.

4.2.7 Property Taxes and Insurance

These costs were estimated as 1.5% of fixed capital investment (Direct Capital Cost).

4.2.8 Annual Operating Costs

Table 4-8 presents the summation of annual operating costs, as determined above. They are expressed in November 1978 dollars and have been estimated in accordance with DOE guidelines including a 20% contingency where appropriate.

TABLE 4-5
PLANT OPERATIONS WORK FORCE

	<u>REQUIREMENTS*</u>
Process Areas	20 x 4.2 = 84.0
Utility Areas	9 x 4.2 = 37.8
Materials and Handling	11 x 4.2 = 46.2
and Offsite Areas	13 x 2.0 = 26.0
Shift Supervisors	15.0
TOTAL REQUIREMENTS:	209.0

*Around-the-clock operation requires 3 shifts per day, 7 days per week or 21 shifts per week. Since each operator works 5 shifts per week (40 hours), 4.2 operators are required for each around-the-clock position. Several positions require only 2-shift, 5 days per week coverage.

TABLE 4-6

PLANT MAINTENANCE WORK FORCE

<u>CRAFT</u>	<u>NUMBER REQUIRED</u>
Boilermakers	8
Carpenters	4
Electricians	15
Finishers/Insulators	3
Ironworkers	2
Laborers	8
Millwrights	26
Operators	6
Pipefitters	49
Teamsters	<u>8</u>
TOTAL REQUIREMENTS	129

TABLE 4-7
ANNUAL CATALYST & CHEMICAL COSTS
(November 1978 Dollars)

<u>AREA</u>	<u>MILLIONS OF DOLLARS</u>
12	.609
22	2.960
23	.388
24	.105
25	.542
31	.074
32	.009
33	.296
41	.243
42	.052
51	.010
52	.588
53	.822
54	<u>.005</u>
Contingency	6.673
	<u>1.334</u>
	8.007

NOTE: The above total includes a contingency of 20% in accordance with DOE guidelines.

TABLE 4-8
ANNUAL OPERATING COSTS
(November 1978 Dollars)

	<u>MILLIONS OF DOLLARS</u>
I. <u>Coal</u>	\$322.7
II. <u>Direct Expense Elements</u>	
Operating Labor	6.5
Operating Supplies	.6
Maintenance Labor	5.8
Maintenance Materials	31.8
Contract Maintenance	9.8
Catalyst and Chemicals	8.0
Electricity	<u>3.0</u>
Subtotal, Direct Expense Elements	65.5
III. <u>Indirect Expense Expense</u>	
Property Taxes and Insurance	23.4
IV. <u>Overhead</u>	6.9
TOTAL ANNUAL OPERATING COST ELEMENTS	<u>\$418.5</u>

NOTE: The Annual Operating Costs have been estimated in accordance with DOE guidelines and include 20% contingency allowance in Direct Expense Elements.

SECTION 5

OPERATIONAL ANALYSIS

5.1 EXTRAPOLATION OF EXISTING TECHNOLOGY

Consistent with the conceptual description of an SRC-II coal conversion facility, circa 1990's, certain processing features and equipment items have been incorporated which are not now commercially available. Correspondence from licensors of processes used in the CCP is included in Volume 3 of Deliverable No. 8 explaining the current state-of-the-art. Correspondence from equipment vendors is also included in the same volume stating the development programs now underway or to be taken to provide equipment for the SRC-II process. The following sections are presented in order to define these areas of developmental technology or equipment fabrication.

The following sections will describe the status of present-day technology, and expectations for its development. There remains alternate currently available technology which could be utilized if development falls short of expectation.

In addition, it is reasonable to expect that developments in technology not anticipated here will be available to further improve the operability, maintainability and perhaps the economy of this conceptual design.

5.1.2 Dissolver Feed Pumps

The SRC-II process requires a high-volume, high-pressure coal slurry feed system. Currently, low-volume reciprocating plunger pumps are the only types available to handle abrasive slurry at the elevated temperature and pressure required by this service. Attention has turned to the development of a high-volume, high-pressure centrifugal slurry pump capable of withstanding the abrasive properties of the slurry. The intent is to develop centrifugal pumps with sufficient flow capability to reduce the total number of pumps required.

Under the sponsorship of the Electric Power Research Institute (EPRI), the Rocketdyne Division of Rockwell International is conducting a design-development program for a centrifugal slurry pump suitable for use in the CCP. An extensive materials testing program has been completed by Rocketdyne along with a detailed hydrodynamic analysis to identify the hydraulics of pump erosion and to select materials to minimize wear.

The Rocketdyne design utilizes six dual-stage pump modules (six cases) operating in series to serve each preheater, compared to four plunger pumps for the same service. Each of the twelve impellers is designed to develop 250 psi differential at 3550 RPM. Rocketdyne's study concludes that the modular

two-stage concept is the optimum design between the two extremes of the twelve single-stage modules in series versus a single casing machine containing twelve impellers. The dual-stage casing design facilitates quick replacement of failed or worn parts and minimizes thermal expansion problems.

In general, analysis of the technical features of the Rocketdyne pump shows the design philosophy to be correct and it is reasonable to assume that if a reliable centrifugal pump can be designed for this service, Rocketdyne has the expertise required for the task.

It appears that Rocketdyne has taken the best approach possible in the design of a centrifugal pump for this application. A full scale test of this centrifugal pump design in a demonstration facility must be done to establish the long-term reliability of the pump. If the test results do not meet expectations, the option is to use reciprocating pumps for this service.

5.1.3 Slurry Metering and Control

At the present time no adequate measuring system exists for measuring the flow rate of coal slurries under the CCP operating conditions.

To date the flow rate of coal slurries has been determined by using flow meters. These devices are subject to the erosive and corrosive effects of the slurry. Special materials such as tungsten carbide can reduce erosion problems, but wear still occurs and calibration cannot be maintained.

Ultrasonic and thermal measurement devices are not subject to erosion and have successfully measured coal-slurry flows at low temperature, but not at the elevated temperatures of the SRC-II process.

At this time, both the ultrasonic and thermal devices need additional testing and evaluation under actual service conditions before a proper selection can be made. It is reasonable to assume that these devices can be successfully adapted to the applications in the SRC-II process.

5.1.4 Dissolver Charge Heaters

There are eight dissolver charge heaters in the Conceptual Commercial Plant, two heaters for each dissolver.

The absorbed duty of each radiant cell of the commercial unit would be 25% greater than for the SRC-II Demonstration Project. The individual cell size of the Demonstration Project dissolver charge heater is limited by present technology. It appears justified to assume that the 25% extrapolation of current maximum radiant cell size can be realized. Additional design data relating to practical heater design for coal slurries, and correlation of data to theoretical design equations, will be developed during operation of the SRC-II Demonstration Project.

5.1.5 Dissolvers

The SRC-II reaction takes place in a vessel known as a dissolver. The required residence time could be satisfied by a large number of small vessels, but operational complexity is less with fewer vessels.

The dissolvers are vertical vessels designed for 2200 psig. The metallurgy of the dissolvers must provide protection against a high hydrogen partial-pressure, corrosion by H_2S , cyanide, phenols, sulfur, chlorides, and other minor contaminants, and the mineral residues of silica and alumina.

It is expected that the dissolver vessels will be fabricated from 2-1/4% Chrome - 1% Moly material with an internal weld overlay of type 347 stainless steel for corrosion protection. The base metal was selected from the latest Nelson Curves which establish operating limits for steels in hydrogen service at elevated temperatures and pressures.

The ASME Pressure Vessel Code consists of two design classifications, Section VIII, Division 1 and Division 2, for unfired pressure vessels. Of these, Division 2, has more stringent design and inspection requirements than

Division 1, but allowable design stresses do not include the effects of high-temperature creep and rupture. Division 1 allowables are based on yield strength up to 850⁰F, and at higher temperatures the allowables are based on creep data. Because of the critical nature of the hydrogen containment, Division 1 allowable stress for Class 1 material is used for the design of the dissolver but the vessel would be fabricated, inspected, and tested to Division 2 rules. Using this allowable stress results in a required wall thickness of 17-3/4 inches for the CCP dissolvers.

Although these vessels are beyond general practice in wall thickness, the pressure vessel code does not limit material thickness. The Code states that materials are limited only by their ability to meet the required minimum physical properties at the design thickness. A study by the Metal Properties Council has begun to demonstrate the ability of materials to meet specified mechanical properties up to the 18-inch thickness.

Lukens Steel Company is the only domestic steel mill known which produces 2-1/4% Chrome - 1% Moly material in heavy plate thicknesses. Lukens can produce a plate which has a maximum thickness of 15 inches. Heavier thicknesses are produced by two overseas steel mills: Japan Steel Works and Marrell of France which have produced plate and forgings in thicknesses up to 18 inches.

There are three domestic vessel fabricators with significant experience in the fabrication of large heavy-walled vessels. They are Combustion Engineering, Chicago Bridge & Iron, and Babcock & Wilcox. These fabricators have fabricated and welded plates of a different composition with thicknesses greater than 20 inches. The procedures for welding this material will vary from one fabricator to another because there are several weld procedures which can be qualified in accordance with the ASME Code. These procedures also vary if final assembly is made in the shop or in the field. Experience has shown that a high-quality vessel can be produced in either the shop or the field. Nuclear reactors which require the very highest level of quality have been assembled in the field with no reduction in level of quality compared to shop fabrication.

The dissolvers could be produced from rolled plates, each having a weight of 80 to 100 tons. Each ring thus formed would have three vertical weld seams. Another method is to forge the subassembly rings. Rings are now available in the required diameter and wall thickness and with a finished weight of up to 250 tons. If the vessels are made from ring forgings, there would be no vertical seams.

There are two alternates for fabricating, shipping, and erecting the dissolvers. Selection must be based on site accessibility, construction schedule and total cost. The construction alternates are complete shop fabrication or partial shop fabrication with the remaining work completed at the job site.

In order for complete shop fabrication to be feasible, direct barge shipments from the fabricator's plant to the jobsite must be possible. This alternate is viable only where navigable rivers are maintained with a 9-foot minimum channel depth.

Partial shop fabrication should be considered even if the plant site is on a navigable river. As vessels become larger, field fabrication becomes more attractive from a cost and scheduling standpoint. For sites not on water, some field fabrication is necessary. The extent of this field fabrication is dependent on the availability, accessibility and capacity of overland transportation. It would be necessary to make horizontal or girth welds in the field.

The ASME Code requires that all pressure boundary shell welds be radiographed. Extremely heavy walls require the use of a linear accelerator in order to produce radiographs which are acceptable. Suitable methods of radiation shielding in the field must be developed.

5.1.6 Dissolver Letdown System

The control valves presently being used in the SRC-II Pilot Plant to control the dissolver letdown system have experienced considerable erosion damage and mechanical breakage.

The valves required for the CCP will be larger and it is expected that this increase in size may alleviate some of the mechanical problems. Larger valves may improve the erosion resistance by providing a more rigid support for the hardened trim surfacing. The larger sizes will permit investigation of alternate valve body designs which would provide a flow path less susceptible to erosion.

5.1.7 Oxygen Compressors

The CCP would have four centrifugal oxygen compressors in Area 44. Compressors of this capacity and pressure-rating are not now commercially available.

The largest operating oxygen compressors to date in terms of flow and discharge pressure have been manufactured by Demag in West Germany and by Sulzer in Switzerland. Veba-Chemie in West Germany has centrifugal oxygen compressors at two installations, each delivering 1700 tpd of oxygen at 974 psia. The suction pressure is approximately atmospheric. One installation is located at Gelsenkirchen, West Germany, and has been operating since 1972. These compressors each have two multi stage cases in series, with a speed increaser between the two cases. The Veba-Chemie compressors were manufactured by Demag, in their facility at Duisburg, West Germany.

Messer Griesheim GmbH has several large oxygen compressor installations in West Germany. One, at Oberhausen, has two three-case trains, each delivering 1075 tpd at 480 psia and one two-case train delivering 1614 tpd at 580 psia. Another, at their Dillingen Plant, has two two-case machines, each delivering 1075 tpd of oxygen at 728 psia. The Messer Griesheim three-case and two-case compressors were manufactured by Sulzer at their facility in Zurich, Switzerland.

Sulzer is furnishing seven two-case oxygen compressors to SASOL for the coal conversion plant now under construction at Sasolburg, South Africa. Each unit is designed to deliver 2500 tpd of oxygen at 535 psia.

Demag has offered to build a barrel-type case which would be a third case added to an enlarged and updated version of their presently operating two-case unit design operated by Veba-Chemie. This compressor would satisfy the requirement of the CCP. This third case is offered on loan to DOE for testing. It is proposed that the testing be done by Rocketdyne under the direction of DOE.

Both Demag and Sulzer, based on their knowledge and operating experience to date, are confident that they can manufacture an oxygen compressor which will meet the requirements for the CCP. They have stated that their compressors would be manufactured in accordance with the applicable sections of the European Working Panel's Third Printing (1978) of Turbo-Compressors for the Oxygen Service Code of Practice.

It is expected that the oxygen compressor for the SRC-II Demonstration Plant will have been operated by the time the CCP is engineered. The operating pressures required for the CCP are the same as those for the Demonstration Project but the flow quantity may be slightly greater.

5.2 OPERABILITY AND MAINTAINABILITY

5.2.1 Unit 10 - Primary Processing Plant.

The slurry mix system in Area 11 consists of two low-residence-time tanks.

Slurry from each of the tanks is fed to four parallel disc mills for additional coal size reduction and then to four centrifugal slurry charge pumps also operating in parallel. Four separate lines feed the disc mills and slurry pumps. This eliminates mainfolding and potential dead legs. Each centrifugal pump feeds a slurry preheater. Each line of disc mill, charge pump and preheater can be isolated for maintenance with only a slight reduction in coal charged to the plant. The outlet from each of two preheaters is separately fed to a single dissolver. There are a total of four dissolvers. Separation and high-pressure gas cooling is accomplished in four trains of equipment.

The valves in the slurry service in the effluent separator letdown are subject to severe erosion. Experimental work at the Fort Lewis Pilot Plant and other locations and experience from the Demonstration Project should alleviate the problem. A pumparound of sour water is provided in the second high pressure flash drum to prevent plugging. Also, the third and the fourth high pressure flash drums will be provided with wash water spray for the same purpose. A temporary loss of one of the lines should still allow operation at 75% of the plant capacity.

Except for the uncertainties related to the nature of the coal chemicals which could cause operational difficulties in the cold box sections of the cryogenic unit, the unit operations in this area employ conventional technology. Both the oil scrubbing unit and the DEA treating unit have two parallel trains. These units should not pose any unusual operating problems. The design for the high pressure cryogenic unit is by Air Liquide. It is anticipated that development work done at Fort Lewis, experience from the Demonstration Project and data from other units, will provide a guide for handling coal chemicals in the cold box. Air Liquide proposes four parallel high-pressure cold boxes. This should enhance the operability and maintainability of this area.

5.2.2 Unit 20 - Hydrogen Production Plant.

The Hydrogen Production Plant includes gasification, shift conversion, hydrogen purification and compression, syngas purification, and methanation areas. Sparing of units and inclusion of parallel trains in these areas have been aimed toward assuring uninterrupted operation.

The gasification area consists of four gasifiers having 33% excess capacity. Maintenance work can be carried out in any one gasifier while still allowing for continuous operation of the gasification area at normal capacity. Slag handling systems associated with these gasifiers include spare equipment to permit sustained operation. Turndown in the gasification area is expected to be good since each gasifier can be run at 50% of capacity.

The shift conversion area consists of two parallel trains of equipment, each capable of handling 50% of the total gas flow. Since the shift conversion process is well-proven, no unusual problems are expected to occur in equipment used in this area. Routine operations such as renewal of catalyst charges can be performed during scheduled shutdowns of the unit.

The hydrogen purification area also consists of two parallel trains of equipment. The Selexol process used is expected to be free from unusual problems.

Two 50% makeup hydrogen compressors are included in the hydrogen compression area. Preventive maintenance during scheduled shutdowns is expected to keep operating problems at a minimum.

The syngas purification and methanation areas include one train of equipment. In the event of equipment malfunction in the methanation area, the feed gas can be routed to fuel.

5.2.3 Unit 30 - Refining and Gas Plants. The Refining and Gas Plants process the hydrocarbon gases and liquids produced throughout the SRC-II plant. Area 31 consists of one train of gas compression and DEA treating equipment. A variable feed rate of 50% to 110% of design can be handled in this Unit. Area 32 consists of a cryogenic separation unit, a depropanizer and a debutanizer

in a single train. A fixed bed adsorber containing molecular sieves is provided to remove residual water, CO_2 , H_2S , and other components that could freeze in the cryogenic unit. If a severe upset condition or problem arises in the cryogenic unit or other equipment in this area, the feed gas could be diverted to the fuel system or flare without significantly affecting the operation of the rest of the Plant. Approximately 30% to 50% of the ethane-propane product and the butane product would be lost during shutdown of the Unit.

The Sulfur Recovery Unit, is a single train which consists of a Claus Unit, a SUPERSHOT Unit, and an incineration unit. The design and equipment sizes used are all of commercially proven reliability. Existing units have not shown the need for excessive maintenance or down time. The design and nature of the processes involved allow for flexibility in handling variations in the sulfur content of the raw coal feed and upsets which result in the plant running below capacity. In extreme instances when shutdown of part or all of the Sulfur Recovery Plant is needed, the acid gas can be incinerated for short periods without affecting the rest of the Plant.

The Refining Plant, consisting of a single fractionator, a single debutanizer and two vacuum flash drums, is similar in design to equipment found in a petroleum refinery. This equipment would be expected to have operating and maintenance characteristics similar to that found in refineries.

5.2.4 Unit 40 - Secondary Recovery and Oxygen Plant

The Secondary Recovery Plants recover ammonia and treat the waste water for reuse within the plant. The Oxygen Plant supplies all of the CCP oxygen requirements. The operability of the ammonia recovery and tar acid recovery areas is expected to be similar to those presently in operation in the steel industry. Feed storage is provided in the event that these areas are down for minor maintenance. Plant waste water storage is also provided to allow maintenance in the Waste Water Reclamation Plant.

The Oxygen Plant consists of four trains of equipment. Liquid oxygen is provided to allow for minor oxygen cold box outages and periodic gas turbine inspection without affecting overall plant operation. A major gas turbine outage would require a plant turndown to approximately 75% to 80% of design capacity. A complete warehouse spare is also provided in the event of major damage to one of the installed oxygen compressors.

5.2.5 Manning

The estimate of manpower required for each Area is based on the equipment involved and its operating complexity. Process areas are all manned around the clock. Based on a 40-hour workweek, each around-the-clock job requires 4.2 persons on the payroll. Certain operations, however, are manned on a two-shift, 5 day basis. These require only two operators per job. The estimated number of operators is 209.

The personnel required to cover shift operations, by Areas, is shown on Table 5-1 following this section.

Plant maintenance is performed by a permanent complement of 129. Table 5-2 lists the Plant maintenance force. During shutdowns and turnarounds, the permanent maintenance force will be augmented by contract labor as required.

Table 5-3 lists the non-craft plant personnel required to administer the Conceptual Commercial Plant. This staff includes Management, Administrative, and Human Resources Managers and staff as well as the Operation, Maintenance, and Technical Services Managers and staff. The total number of non-craft Plant personnel is estimated at 169.

The Conceptual Commercial Plant complement is estimated at 507.

TABLE 5-1

SHIFT OPERATOR REQUIREMENTS

(Around-the-Clock Coverage)

<u>AREA</u>	<u>DESCRIPTION</u>	<u>NO. OF OPERATORS</u>
11	Dissolver Plant	5
12	Hydrogen Treating & Recovery Plant	1
21	Syngas Production Plant	2
22	Syngas Shift Conversion Plant	3
23	Hydrogen Purification and Compression Plant	3
24	Syngas Purification Plant	2
25	Methanation and Dehydration Plant	2
31	Low-Pressure Gas Treating & Compression Plant	1
32	Product Gas Plant	1
33	Sulfur Recovery Plant	1
34	Refining Plant	4
41	Ammonia Recovery Plant	2
42	Tar Acids Recovery Plant	2
43	Waste Water Reclamation Plant	1
44	Oxygen Plant	2
51	Steam Generation System	2
52	Raw Water System	1
53	Cooling Water System	1
54	Miscellaneous Systems	4
62	Coal Crushing System	4
63	Slag Handling System	3
--	Miscellaneous Functions	1
--	Control Room	<u>5</u>
	TOTAL OPERATORS EACH SHIFT	45
	(Two-shift, 5-day Coverage)	
61	RR Dumpers, Conveyors, Crushers, Stockpile	10 (per shift)

TABLE 5-2

PLANT MAINTENANCE FORCE

<u>CRAFT</u>	<u>NUMBER REQUIRED</u>
Boilermakers	8
Carpenters	4
Electricians	15
Finishers/Insulators	3
Ironworkers	2
Laborers	8
Millwrights	26
Operators	6
Pipefitters	49
Teamsters	<u>8</u>
TOTAL REQUIREMENTS	129

TABLE 5-3

NON-CRAFT PLANT PERSONNEL

<u>FUNCTION</u>	<u>NUMBER REQUIRED</u>
<u>Plant Management</u>	
Manager	1
Assistant Manager	1
Secretary	<u>1</u>
<u>Subtotal</u> , Plant Management	3
<u>Plant Administration</u>	
Manager	1
Administrative Services Personnel	19
Purchasing Personnel	7
Material Control Personnel	7
Secretary	<u>1</u>
<u>Subtotal</u> , Plant Administration	35
<u>Human Resources</u>	
Manager	1
Human Resources Personnel	5
Safety and Security Personnel	24
Health Protection Personnel	6
Public Relations Personnel	2
Secretary	<u>1</u>
<u>Subtotal</u> , Human Resources	39

TABLE 5-3
(Continued)

Plant Operations

Manager	1
Plant and Shift Supervisors	7
Technical Personnel	5
Secretary	<u>1</u>
<u>Subtotal</u> , Plant Operations	14

Plant Maintenance

Manager	1
Technical Personnel	9
Craft Supervisors	5
Secretary	<u>1</u>
<u>Subtotal</u> , Plant Maintenance	16

Technical Services

Manager	1
Plant Laboratory Personnel	28
Plant Engineering Personnel	19
Process Evaluation Personnel	8
Environmental Personnel	5
Secretary	<u>1</u>
<u>Subtotal</u> , Technical Services	62

TOTAL REQUIREMENTS:	169

5.3 PROCESS VERSATILITY

5.3.1 Variable Feedstock

The SRC-II Conceptual Commercial Plant is designed to charge blended Powhatan coal, just as an oil refinery is designed for a specific crude oil. The detailed design of this plant could include the ability to process, at the design rate, a range of feed coals.

Powhatan coals vary in quality. The SRC-II process is inherently versatile and is capable of processing varying coals. Some coals consume more hydrogen and therefore produce a lighter hydrocarbon yield, (more 350°F and lower boiling material and less 350°F and higher boiling material) than the design coal. A bottleneck would probably be in the recycle gas treating and separation and the gas plant areas of the plant. Over-capacity has been included in the design of the equipment and it is expected that close to design throughput could be achieved.

Other coals consume less hydrogen and therefore produce a heavier hydrocarbon yield (less 550°F and lower boiling material and more 550°F and higher boiling material) than the design Powhatan coal. There is a limit in the ability to handle the mineral residue. Although the Plant is capable of processing the coal, the amount of coal charged might be less than the design rate.

5.3.2 Turn-down

The Conceptual Commercial Plant is designed as a base loaded plant, i.e., it would run at full capacity most of the time. The plant is capable of turn-down in the event of major equipment failure or if the coal supply becomes insufficient to run at full capacity. Most of the major processing areas of the plant consist of two or more trains of equipment. Based on the present design, it is expected that the plant could be turned-down to approximately 50 to 60 percent of design capacity. The major limit on turn-down is the single large fractionator.

SECTION 6

ENVIRONMENTAL SUITABILITY

6.1 PROTECTION OF THE ENVIRONMENT

The impact of the Conceptual Commercial Plant on the environment will be planned to avoid adverse effects on the community and its surroundings and to comply with the then current federal, state and local regulations pertaining to ambient air quality and liquid and solid waste disposal. The Conceptual Commercial Plant incorporates various processing means for control of emissions and effluents. Specific measures employed are discussed in the following sections.

6.1.1 Community Impact

The establishment of the SRC-II Conceptual Commercial Plant will be the beginning of a substantial industrial complex, even if the plant is built in an area remote from existing population centers. Planning for such a complex and its supporting community will not be left to chance.

The community requirements, as well as the industrial and service needs of the SRC-II Conceptual Commercial Plant and its downstream satellite industries will receive careful planning well in advance of start of construction. The technology for such planning exists and has been applied successfully in many parts of the world. Both community and industrial master planning will be made to meet the physical and social needs of a technologically sophisticated society. Plans will be prepared for housing, schools, public utilities and services, hospitals and other social services, governmental organizations, recreation and cultural activities. The high level of education and technical ability of the personnel required to manage and operate the Conceptual Commercial Plant will be recognized so that competent personnel are attracted to, and kept in, the community. Successful resolution of these problems, coupled with the industrial development brought about by the SRC-II process, will mean a new era of prosperity for the area in which the plant is established.

6.1.2 Air Emissions Control

Acid gas produced in treating the dissolver recycle gas is fed to the Area 33 Sulfur Recovery Plant for sulfur removal. The Claus process employs a two-stage reactor design followed by a selective hydrogen sulfide removal step utilizing the Shell process which reduces the SO_2 content in the incinerator off-gas to less than 100 ppm. This SO_2 concentration is believed to be within the environmental standard for any plant site selected.

Most of the plant fuel requirement is met by burning excess internally produced syngas. The hydrocarbon-rich and hydrogen-rich gases are treated within these plants by absorption processes to produce a sweet fuel with only trace amounts of hydrogen sulfide or other sulfur-bearing gas compounds.

The combustion units within the plant will have high combustion efficiencies to eliminate hydrocarbon and carbon monoxide emissions from plant combustion stacks. All hydrocarbons which are normally vented from the process will be completely and cleanly burned in the plant flare system.

The storage and shipping facilities within the plant incorporate closed-system designs. The API cone roof tanks used for storage of naphtha and fuel oil are connected to vapor recovery systems which prevent the release of hydrocarbons to the atmosphere.

The coal preparation and handling facilities are equipped with dust suppression and collection equipment to prevent the release of fugitive coal dusts to the atmosphere. Dust suppression water is contained and is reused for dust suppression on the coal storage piles.

6.1.3 Waste Water Reclamation

The Conceptual Commercial Plant is designed for zero discharge of contaminated liquid effluents. All liquid waste streams are reclaimed and

recycled to the extent practicable. Those portions of the waste streams that are not recycled are either dewatered or incinerated. Dewatered solids are disposed of in an environmentally acceptable disposal site.

The major waste streams going to the waste reclamation area include cooling tower blowdown, dissolver area wastes, gasifier blowdown wastes, and contaminated rainwater runoff.

Rainwater runoff includes coal pile runoff, gasifier slag pile runoff, and miscellaneous plant area runoff. The rainwater runoff guideline used was taken from the proposed EPA power plant coal pile runoff regulation. The collection ponds and treating equipment are sized to retain and treat the amount of water equivalent to the 10-year 24-hour storm. Any rainfall in excess of this amount is diverted from the holding pond and is discharged into the river. The slag disposal area is sealed and all rainfall into it is collected and treated.

6.1.4 Solids Disposal

The gasifier slag is transported by trucks to the slag disposal site which consists of a sealed disposal basin. The basin capacity is approximately 33 million cubic yards which will contain 25 years of slag production allowing for 5 feet of freeboard. Experience gained in the operation of the Demonstration Plant may show that other approaches are feasible, however this approach should accommodate the worst situation.

Sanitary sewage will be given primary, secondary, and tertiary treatment with any remaining solids being incinerated. Solids that remain following evaporation of process waters are oxidized in an incinerator.

Sludge from the waste water treatment systems will be disposed of in suitable landfill sites. Analysis of the sludge from the Demonstration Plant will establish whether special disposal precautions are required.

6.2 SAFETY

The ultimate goal of a safety program is the prevention of accidents, fires, explosions, or other hazardous situations which result in loss of life, injury and destruction of property.

The approach to accomplishing this important aspect in the SRC-II Conceptual Commercial Plant is:

- (1) Design for safe operation and containment or safe release of gases and liquids during upsets;
- (2) Operate always within safe limits and provide automatic shutdown in the event of excursions;
- (3) Provide multiple means for containing and fighting fires or flammable releases from equipment.

In developing the plant layout for the Conceptual Commercial Plant, safety considerations, to a large extent, determine the plant arrangement. The following considerations are included:

- (1) A grid type of layout with road and fire water systems serving all sides of each hazardous area, with all fire water systems looped and dually fed. Separate but interconnecting fire water tanks and pumps are provided for the Coal Storage Area and the Process Area.
- (2) In conformance with the National Fire Codes, dikes for liquid storage tanks are designed so that the capacity of the diked area will hold the contents of the largest tank within the diked area. Flammable-liquid tanks will have permanently installed foam protection. Flammable-gas spheres will have permanently installed water fog systems.
- (3) Flares are located on the prevailing downwind side of the plant sufficiently remote to protect personnel and property from heat radiation.

- (4) Isolated storage areas are provided for coal, liquid products and by-products (sulfur, tar acids, ammonia).
- (5) Fired heaters are located near the battery limits. Their distance from operating equipment will conform to accepted refinery practice.

The SRC-II Conceptual Commercial Plant has some process hazards which will be addressed during the final design of the plant:

- (1) The interrelationships between the various areas of the plant which cause a potentially unsafe "domino" effect because of inability to maintain proper control;
- (2) Potential line-plugging due to high solids content, coking tendency, and/or high freezing points of certain liquid streams and the potential formation of solid ammonium compounds in some vapor streams;
- (3) Corrosive and erosive properties of many of the plant streams.

Detailed safety, operating, and maintenance procedures will be developed and published in manuals for each plant area. Special procedures will be included, such as:

- (1) Unusual and critical operating conditions;
- (2) Safety work permits;
- (3) Equipment lockout;
- (4) Equipment tagging;
- (5) Hot work permits;
- (6) Vessel entry;
- (7) Handling of hazardous or toxic materials;
- (8) Operation and repair of radioactive sources;
- (9) Purging, flushing and blinding.

Experience gained at the SRC-II Demonstration Plant will be utilized as well as experience gained in the operation of large refineries and chemical plants.

An intensive training program will be conducted for operating, maintenance, laboratory, and support personnel prior to plant commissioning. Additional training will be conducted for new or modified procedures as the need develops.

The original cadre is expected to contain a large number of experienced personnel, those with SRC-II experience at the Demonstration Plant and those with commercial refining and chemical plant experience. For those with no SRC-II experience, a training period at the Demonstration Plant would be scheduled.

After the initial training period, safety meetings will be held on a regular basis. In these meetings, the importance of following established safety, operating, and maintenance procedures will be stressed. Suggestions and recommendations by the workers will be a vital part of these meetings and will be utilized to improve procedures.

Process conditions will be monitored continually by operating personnel and the instrumentation and control system to detect the development of potential problems so that appropriate corrective action can be initiated.

Onstream monitoring will be performed to determine the extent of corrosion and erosion to allow planned and orderly shutdowns for repairs. During periods in which the plant or individual equipment is shut down, inspections will be performed which cannot be performed while the plant or equipment is operating. Shutdowns can then be scheduled on the basis of collected historical data on corrosion and erosion.

Preventive maintenance will be performed on a regularly-scheduled basis. Major emphasis will be given to high-energy rotating equipment and equipment operating at high pressures and temperatures. Highest priority will be given to equipment and systems which are required during emergency and/or upset conditions. Scheduled plant shutdowns will be conducted to inspect and repair equipment on which work cannot be performed while it is in operation.

Because the SRC-II Conceptual Commercial Plant handles large quantities of hydrocarbon materials and toxic compounds, and contains very large equipment operating at high temperatures and pressures, the potential of fires, explosions, or release of hazardous gases and liquids must be recognized.

Well thought out emergency procedures must be prepared. In addition to specifying the actions to be taken, the responsibilities and authorities of various individuals and groups must be clearly defined, including coordination with off-plant emergency assistance such as fire departments, police, ambulance, helicopter service, hospitals, doctors, and news media.

Training programs for employees will be conducted to prepare them to take the proper plant operational actions. Training programs also will be conducted in first aid, fire fighting, and the use of protective equipment. Refresher training will be performed on a regularly-scheduled basis.

In addition to the permanently installed equipment, such as fire water and foam systems, mobile firefighting apparatus, and ambulance, protective equipment, including various types of breathing apparatus will be provided and employees will be trained in their operation.

6.3 HEALTH PROTECTION

6.3.1 Toxic Gases

Some of the health hazards associated with the SRC-II Conceptual Commercial Plant will be similar to those encountered in a large petroleum refinery or chemical plant. Specifically, each handles large quantities of toxic gases: hydrogen sulfide and carbon monoxide. Each has the potential, under certain conditions, of producing nickel carbonyl. The same procedures will be followed as are used in refineries and chemical plants to protect employees from these materials.

6.3.2 Coal Chemicals

There has been considerable speculation about the potentially adverse health effects of organic compounds, primarily polynuclear aromatics, that might be encountered in coal conversion operations. However, there is presently a lack of appropriate data developed through animal bioassay and epidemiological studies which could be used to determine whether a hazard exists. Work carried out during the operation of the SRC-II Demonstration Plant will help to define the hazards which may arise.

During World War II, Germany produced synthetic fuels from coal. However, no medical records are available from these operations which could be used to properly assess potential health risks. During the period 1952-1956, a medical surveillance program was conducted at the Union Carbide Chemicals Company Coal Hydrogenation Plant at Institute, West Virginia, with subsequent continuing examinations of the workers. A statistical evaluation of the data led to the conclusion that an increased incidence of skin cancer was found in workers exposed nine months or more to contact with coal hydrogenation chemicals.

Based largely on the results of the Institute study, it was concluded, prior to the startup of the SRC Pilot Plant at Fort Lewis, Washington, that an effective health protection program was necessary. A program was developed and placed in operation in 1974 and has continued since then.

6.3.3 Health Protection Program

The principal objectives of the Plant Health Protection Program are the protection of the workers from exposure to materials which could possibly result in adverse health effects; monitoring of the workers' environment to measure the extent and nature of exposure from a health standpoint and to identify the need for additional controls or process modifications; and assessing the toxic characteristics of the SRC-II materials through extensive bioassay studies.

The program consists of:

- An industrial hygiene monitoring program;
- An employee hygiene and education program;
- A medical surveillance program;
- A toxicology program.

6.3.4 Industrial Hygiene Monitoring Program

The Industrial Hygiene Monitoring Program is an air sampling and analysis program to attempt to determine the health hazard to workers as the result of airborne materials. At the Fort Lewis Pilot Plant it has been determined that:

- (1) Airborne concentrations of organic vapors and hydrocarbon gases are generally less than 0.1 ppm and benzene is far below one ppm.
- (2) Free silica in mineral residue dust is a potential health problem.
- (3) Concentrations of hydrogen sulfide, carbon monoxide, and phenols are very low. However, due to their presence in various plant streams, phenols pose an occupational skin-contact hazard necessitating preventive measures and good personal hygiene.
- (4) Settlable particulates in the Plant were generally lower than in a nearby community.

- (5) Fumes generated while cutting or welding contaminated equipment and piping pose a potential health hazard.

6.3.5 Employee Hygiene and Education Program

The Employee Hygiene and Education Program has the following objectives:

- (1) To inform the employee of the known and potential hazards in the work environment, particularly those associated with exposure to coal-derived materials.
- (2) To motivate the employee to use available protective measures.
- (3) To provide the employees with the protective equipment, clothing, facilities and operating techniques needed to minimize the potential hazard.

The employee educational program consists of new-employee orientation and continuing education. The new-employee orientation will consist of an audio/visual slide presentation describing the plant, potential exposures in the plant, and appropriate protective techniques. After the slide presentation, the new employee will be given the SRC-II Health Protection Manual and will be required to read it.

Each process area employee will be issued rubber boots and/or leather safety shoes, work uniforms, underclothing, socks, work coats, hard hat, barrier cream, and skin emollient. Employees working in areas of possible exposure will be required to wear the company-supplied clothing, shoes, and appropriate safety equipment.

All process area employees will be required to change into company-supplied clothing before going into their work area and to remove that clothing, shower and change to street clothing before leaving the plant. The

change facilities are divided into dirty areas, shower areas, and clean areas in that order, to minimize contamination of individuals and their clothing when leaving the plant.

6.3.6 Medical Surveillance Program

Each process exposed employee will be given a detailed pre-employment medical examination and an annual followup examination. These consist of a medical history, a complete physical examination, a complete blood count, blood chemistries, urinalysis, chest x-rays, and careful examination of the skin for lesions. Treatment of occupational injuries and illnesses will be carried out by physicians as needed.

6.3.7 Toxicology Program

Initial consideration to the development of a toxicological testing program on SRC materials was begun in early 1975. Actual animal testing began at a contract laboratory in 1977. This initial program was devoted to SRC-I products and process materials. Due to several problems experienced by the toxicological laboratory, the contract was terminated in June, 1978. A revised toxicological program, which includes SRC-II materials, has been proposed to DOE and funds have been allocated. A complementary program has been developed at the Battelle Pacific Northwest Laboratory.

It is anticipated that appropriate information on any potential health issues associated with SRC-II materials will be available before the time of full commercialization.