BASELINE DESIGN/ECONOMICS FOR ADVANCED FISCHER-TROPSCH TECHNOLOGY. QUARTERLY REPORT, APRIL--JUNE 1993

DEPARTMENT OF ENERGY, PITTSBURGH, PA.
PITTSBURGH ENERGY TECHNOLOGY CENTER

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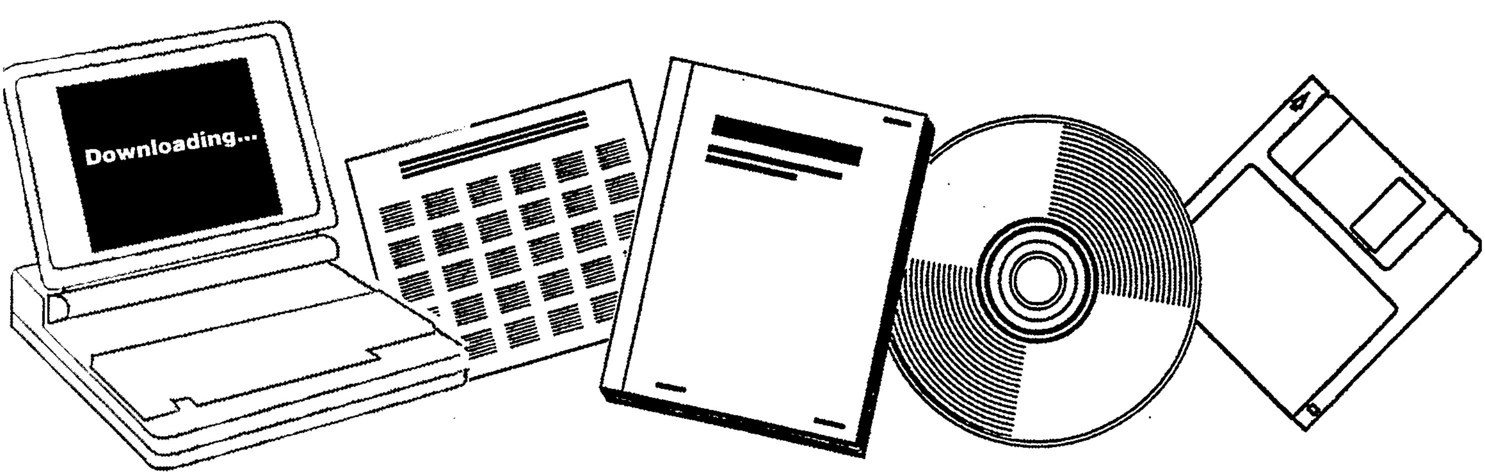

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Baseline Design/Economics for Advanced Fischer-Tropsch Technology

Contract No. DE-AC22-91PC90027

Quarterly Report

April – June 1993

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U.S. Department of Energy
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Section 1

Introduction and Summary

This report is Bechtel's seventh quarterly technical progress report and covers the period of March through June, 1993.

1.1 INTRODUCTION

Bechtel, with Amoco as the main subcontractor, initiated a study on September 26, 1991, for the U.S. Department of Energy's (DOE's) Pittsburgh Energy Technology Center (PETC) to develop a computer model and baseline design for advanced Fischer-Tropsch (F-T) technology. This 24-month study, with an approved budget of $2.3 million, is being performed under DOE Contract Number DE-AC22-91PC90027.

The objectives of the study are to:

- o Develop a baseline design and two alternative designs for indirect liquefaction using advanced F-T technology. The baseline design uses Illinois No. 6 Eastern Coal and conventional refining. There is an alternative refining case using ZSM-5 treatment of the vapor stream from the slurry F-T reactor and an alternative coal case using Western coal from the Powder River Basin.
- o Prepare the capital and operating costs for the baseline design and the alternatives. Individual plant costs for the alternative cases will be prorated on capacity, wherever possible, from the baseline case.
- o Develop a process flowsheet simulation (PFS) model.

The baseline design, the economic analysis and computer model will be major research planning tools that PETC will use to plan, guide and evaluate its ongoing and future research and commercialization programs relating to indirect coal liquefaction for the manufacture of synthetic liquid fuels from coal.

The study has been divided into seven major tasks:

- o Task 1: Establish the baseline design and alternatives.
- o Task 2: Evaluate baseline and alternative economics.
- o Task 3: Develop engineering design criteria.
- o Task 4: Develop a process flowsheet simulation (PFS) model.
- o Task 5: Perform sensitivity studies using the PFS model.

- o Task 6: Document the PFS model and develop a DOE training session on its use.

- o Task 7: Perform project management, technical coordination and other miscellaneous support functions.

1.2 SUMMARY

During the reporting period, work progressed on Tasks 1, 4 and 7. This report covers work done during the period and consists of four sections:

- o Introduction and Summary.
- o Task 1 - Baseline Design and Alternatives.
- o Task 4 - Process Flowsheet Simulation (PFS) Model.
- o Project Management and Staffing Report.

Completed work on Task 1, during the period of this report, consisted mainly of finalizing the Baseline Case design: Offsite specification and design were completed, plant utility balanced. Capital cost estimates were developed. Operating and maintenance requirements and cost were generated. A Topical Report, summarizing the Baseline Case design, is being prepared.

Under Task 4, two individual Fischer-Tropsch reactor loop models were expanded and enhanced. An overall Area 300 product refining section model was developed and it is being integrated into a model consisted of Areas 100 and 200. Also, a Lotus spreadsheet economics model was developed.

Under Task 7, cost and schedule control was the primary activity. A paper on power and coal liquid coproduction is being prepared for the 18th International Technical Conference on Coal Utilization and Fuel Systems at Clearwater, Florida.

Section 2

Task 1 - Baseline Design and Alternatives

Work progressed during this quarter mainly with the Baseline design case. Offsite specifications were completed; plant utility balanced. Capital cost estimates were developed. Operating and maintenance requirements and cost were generated. A Topical Report, summarizing the Baseline Case design, is being drafted.

2.1 BASELINE DESIGN CASE

2.1.1 OFFSITES

2.1.1.1 Plant 19 - Relief and Blowshown

Design Basis, Criteria and Considerations

Plant 19 is for the collection and flaring of relief and blowdown discharges from all applicable plants. It includes two flare systems; a main 42" flare for all hydrocarbon containing discharges and a secondary flare for emissions containing H_2S. Collection piping is not included in Plant 19 but has been included in Plant 21, Interconnecting Piping.

The sizing of the main flare is based on comparison with typical sizing for comparable facilities of the same type. Some consideration has been given to what are typically the controlling discharges for the purpose of flare sizing; power failure, cooling water failure and blocked discharge on compressors. This was strictly for the purpose of finding a good prototype. A full relief and blowdown analysis has not been done for this facility since that would require engineering to a level of detail well beyond the scope of this study.

Vapor relief loads to the flare system are minimized by relieving to atmosphere where practicable without jeopardizing plant safety. In general, API RP-520, "Recommended Practice for the Design and Installation of Pressure-relieving systems in refineries" and API RP-521, "Guide for Pressure Relief and Depressuring Systems", were followed in the prototype design and will be followed for this facility.

Flare Stack Details

Each flare stack has a refractory lined tip, a flame fron generator that provides ignition to the pilot gas burner located atop each flare stack, and molecular seals to prevent air from entering the flare stack. In addition, the main flare feeded is purged with fuel gas.

Smokeless operation is achieved by an automatically controlled injection of steam. The steam provides smoke suppression by promoting more intimate mixing of the flared material with the oxygen in the ambient air to provide more complete combustion.

Knockout Drum Details

The flare knock-out drum is equipped with steam heating lances. These are used to:

- prevent material from freezing in winter conditions
- provide means to vaporize condensed light ends.

2.1.1.2 Plant 20 - Tankage

Design Basis, Criteria and Considerations

Plant 20 provides storage and delivery equipment for products, intermediates, and chemicals.

Products are gasoline, distillate and LPG from Area 300.

Intermediates include hydrocarbon fractions from Area 300, distillate products from plants 301 and 302, wax hydrocracker feed from Plant 204 and sour water feed from Plant 109.

Chemicals include sulfuric acid for Plant 105, caustic for Plants 104 and 109, Amine make-up for Plant 106 and n-butane for Plant 305.

Plant 20 includes tanks and miscellaneous equipment required for product, intermediate, and chemical storage and delivery. Pumps for intermediates and chemicals are included here; product pumps are included in Plants 22 and 23.

Product Storage
Thirty days storage is provided for the gasoline, distillate and propane, 14 days for sulfur. Storage times were chosen to allow for variations in production and shipping rates. The 30 days of propane storage consist of 20 days of refrigerated storage at atmospheric pressure and ten days of pressurized storage at ambient temperature. Both types of storage are provided since refrigerated storage for propane is more cost effective, and pressurized storage is required for shipment in pressurized containers at ambient temperature.

Intermediate Storage

Two days intermediate storage is provided for the wax hydrocracker (Plant 301). The 2-day storage capacity is required to provide feedstock during plant startup (prior to actual delivery of the necessary feed). Additionally, the storage mitigates the effect on downstream plant operations due to brief interruptions in the upstream plant. Interruptions could be as a result of scheduled or unscheduled maintenance or due to operating problems.

The liquid hydrocarbon fractions from Plants 304, 306 and 307 and the distillate intermediates from Plants 301 and 302 have storage time of two days. This provides some additional surge capacity for the product gasoline and distillate.

The sour water feed for Plant 105 has a storage time of 5 days for operation during startup to mitigate the effect of upstream plant interruptions.

Chemical Storage

Thirty days storage is provided for sulfuric acid, caustic and amine. Fourteen days pressurized storage is provided for n-butane.

Tank Sizing

The following factors were considered for tank sizing:

- All tanks are sized to API 650 except for pressurized spherical tanks.
- Tanks are sized for 95% maximum working capacity.
- Two tanks are used for each liquid finished product except sulfur to avoid the problem of running to and shipping from the same tank.
- Due to soil loading considerations, tank height is limited to 48 feet for cylindrical tanks.

Plant Description and Block Flow Diagram

An overview of this plant is shown in block flow diagrams, Figures 2-1, 2-2 and 2-3.

Product Storage

Storage is provided for the following products as shown in Block Flow Diagram, Figure 9.2-1:

- One gasoline product from the Gasoline Pool (Plant 308)

- One distillate product from the Distillate Pool (Plant 308)
- Refrigerated Propane from the Saturated Gas Plant (Plant 308)
- Non-refrigerated Propane from the Saturated Gas Plant (Plant 308)
- Molten sulfur from Sulfur Plant (Plant 107)

Gasoline Product - The gasoline product is a blend cf Alkylate, Isomerate and Reformate delivered from the Intermediate storage area and stored in two 376,000 barrel tanks to provide 30 days storage. Each tank is equipped with a floating roof inside a stiffened dome roof. The gasoline product is pumped via pipeline in 12-hour batches to down stream customers. The product loading pumps are included in Product Shipping (Plant 22).

Distillate Product - The distillate product is a blend of distillate intermediates from Plants 301 and 302 delivered from the Intermediate storage area and stored in two 390,000 barrel cone roof tanks to provide 30 days storage. The distillate product is pumped via pipeline in 12 hour batches to down stream customers. The product loading pumps are included in Product Shipping (Plant 22).

Propane - Propane enters the plant battery limits at 100°F from Plant 308, bypassing the refrigeration unit and going directly to pressurized storage and shipping. Product in excess of shipments is cooled in a refrigeration unit to -48°F and stored in refrigerated tanks at atmospheric pressure.

One 20,000 barrel sphere provides 10 days of non-refrigerated storage. One 40,100 barrel tank provides 20 days of refrigerated storage. The refrigerated tank is equipped with a refrigeration unit and product heater.

When needed, propane product is taken from the refrigerated tank, heated to 66°F, and sent to pressurized storage. The propane product is then loaded onto tank cars or tank trucks for shipment (see Plant 23, Tank Car/Tank Truck Loading). The propane product loading pumps are included in Plant 23.

Sulfur - Molten sulfur from Sulfur Recovery (Plant 107) is received and stored at 300°F. One 26,200 barrel cone roof tank provides 14 days of storage. Steam coils are provided in this tank to maintain the product at a pumpable temperature. The Molten sulfur is then loaded onto tank cars or tank trucks for shipment (see Plant 23, Tank Car/Tank Truck Loading). Sulfur product loading pumps are located in Plant 23.

Intermediate Storage

Storage is provided for the following intermediates as shown in the Block Flow Diagram, Figure 2-2.

- Two distillate fractions from the FT Refining Area (Plants 301 and 302)
- One distillate fraction from the FT Reaction Loop Area (Plant 204)
- One wax fraction from the FT Reaction Loop Area (Plant 204)
- Sour water from Plant 109
- One naphtha fraction from the FT Reaction Loop Area (Plant 204)
- Alkylate from Plant 307
- Isomerate from Plant 306
- Reformate from Plant 304

Distillate Fractions from Area 300 - Two distillate fractions from Area 300 are stored for subsequent blending to produce the final product distillate. Distillate from Plant 301 is stored in two 17,500 barrel cone roof tanks to provide 2 days storage. This distillate fraction is delivered to the product distillate storage tank with pumps designed for 490 gpm at 50 psi. Distillate from Plant 302 is stored in two 8,600 barrel cone roof tanks to provide 2 days storage. This distillate fraction is delivered to the product distillate storage tank with pumps designed for 240 gpm at 50 psi.

Distillate Fraction from Area 200 - One distillate fraction is delivered from Plant 204 and stored in two 8,600 barrel cone roof tanks to provide 2-days storage. The distillate is delivered to the high temperature distillation unit (Plant 302) with pumps designed for 240 gpm at 50 psi.

Wax Fraction - The wax fraction is delivered from Plant 204 and stored in two 22,100 barrel cone roof tanks to provide 2-days storage. The wax fraction is delivered to the wax hydrocracker (Plant 301) with pumps designed for 620 gpm at 50 psi.

Sour Water Feed - Sour water from Plant 109 is delivered to and stored in two 96,300 barrel tanks to provide 5-days storage. Each tank is equipped with a floating roof inside a stiffened dome roof. The tank is equipped with a vapor compressor and recovery system. A skimmer package removes any oil residuals from the sour water. The sour water is delivered to the sour water stripper (Plant 105) with pumps designed for 1070 gpm @ 50 psi.

Naphtha - the naphtha is delivered from Plant 204 for storage in two 10,100 barrel tanks to provide 2-days storage. The tanks are equipped with a floating roof inside a stiffened dome roof. The naphtha intermediate is delivered to the Naphtha Hydrotreator (Plant 303) with pumps designed for 280 gpm at 50 psi.

Alkylate - The Alkylate intermediate is delivered from Plant 307 and stored in two 9,200 barrel tanks to provide 2-days storage. Each tank is equipped with a floating roof inside a stiffened dome roof. The alkylate intermediate is delivered to the gasoline product storage area (Plant 20) with pumps designed for 260 gpm and 50 psi.

Isomerate - The Isomerate intermediate is delivered from Plant 306 and stored in two 6,000 barrel tanks to provide 2-days storage. Each tank is equipped with a floating roof inside a stiffened dome roof. The isomerate intermediate is delivered to the gasoline product storage area (Plant 20) with pumps designed for 170 gpm and 50 psi.

Reformate - The Reformate intermediate is delivered from Plant 304 and stored in two 10,000 barrel tanks to provide 2-days storage. Each tank is equipped with a floating roof inside a stiffened dome roof. The reformate intermediate is delivered to the gasoline product storage area (Plant 20) with pumps designed for 280 gpm at 50 psi.

Chemicals Storage

Storage is provided for the following chemicals as shown in the Block Flow Diagram, Figure 2-3:

- A 25 percent solution of sulfuric acid
- A 25 percent solution of caustic
- Amine make up
- N-butane

Sulfuric Acid, 25 weight percent - The sulfuric acid is stored in one 13,000 barrel cone roof tank to provide 30-days storage. The sulfuric acid is delivered to the sour water stripper (Plant 105) with pumps designed for 50 gpm at 50 psi.

Caustic, 25 weight percent - The caustic is stored in one 18,500 barrel cone roof tank to provide 30-days storage. The caustic is delivered to the Hydrolysis (Plant 104) and to Syngas Wet Scrubbing (Plant 109) with pumps designed for 70 gpm at 50 psi.

Amine - The amine is stored in one 90 barrel cone roof tank to provide 30-days storage. The Amine is delivered to Acid Gas Removal (Plant 106) with pumps designed for one-half gpm at 50 psi.

N-Butane - The n-butane is stored in one 22,500 barrel sphere to provide 7 days of non-refrigerated storage. The N-butane is delivered to Isomerization (Plant 305) with pumps designed for 360 gpm at 150 psi.

2.1.1.3 Plant 21 - Interconnecting Piping System

Design Basis, Criteria and Considerations

Plant 21 includes the interconnecting process and utility piping between process plants and offsites. All above ground and underground piping systems are included except cooling water piping which is included in Cooling Water Distribution (Plant 32), and fire water piping which is included in Fire Systems (Plant 33). Relief and Blowdown Headers are included. In general, water distribution piping is underground and all other piping is located above ground on pipe racks.

Interconnecting Piping

The interconnecting piping consists of all the process lines and racks connecting one process plant to another, the utility headers and the branches to each process. Pipes are sized based on pressure drop and fluid velocity considerations.

The cooling water system is routed underground, and process lines and other utilities are routed on the pipe racks. All the steam, condensate and boiler feedwater lines are insulated. The headers, one for each utility service, include the following:

- 900 psig steam (superheated)
- 600 psig steam (superheated)
- 600 psig steam (saturated)
- 360 psig steam (superheated)
- 360 psig steam (saturated)
- 50 psig steam (saturated)
- Instrument air
- Utility air
- Utility water
- Cooling water supply
- Cooling water return
- 600 psig boiler feedwater

- 65 psig boiler feedwater
- Pctable water
- Nitrogen Gas

Storm sewer, sanitary sewer, and process wastewater lines are included in the scope of Sewers and Wastewater Treating (Plant 34).

2.1.1.4 Plant 22 - Product Shipping

Designed Basis, Criteria and Considerations

Plant 22 provides the pipeline and metering system for delivery of the final oil products to down stream customers. A separate system is provided for delivering gasoline and for delivering distillate.

The equipment for this plant includes the appropriate length of 20 in. schedule 40 pipe for each product delivery to down stream customers and a meter for tracking the amount of product transferred for accounting and billing purposes. Each meter is provided with a 16 in. proving loop for meter testing and calibration.

Each pipeline is designed to carry 4375 gpm which allows 75,000 barrels of oil product to be delivered in 12 hour batches. The pressure drop should not exceed 500 psi for every 50 miles of pipe.

Dual meters are required to assure proper recording of product delivery quantities in case of single meter failure.

Plant Description

Pipeline - Two 20 in. schedule 40 pipes are provided for product delivery to down stream customers. The pressure drop in the pipe is 0.15 psi per 100 ft. of pipe at the maximum flow rate of 4375 gpm.

Metering System -Two dual metering systems are provided for tracking the amount of distillate and gasoline products transferred for accounting and billing purposes. Each meter consists of one active and one spare system. Product flow rates are measured by an in-line turbine element which transfers an electronic signal to a microprocessor. The microprocessor converts the electronic signal to digital data which is stored for future retrieval. The meters are provided with a 16 in. pipe diameter by 60 ft. long proving loop for meter testing and calibration.

Pigs - Two 20 in. pigs, one for each product, are provided for periodic cleaning of residuals and debris in the pipelines.

Pumps - For each product, two half-capacity operating pumps without spares are provided to deliver the product to the pipeline. The distillate pumps are designed for 2200 gpm at 1500 psi. The gasoline pumps are designed for 2200 gpm at 1500 psi.

2.1.1.5 Plant 23 - Tank Car/Tank Truck Loading

Design Basis, Criteria and Considerations

The products are generally pumped from the storage tanks to the loading points at the required rate. One pump for each product delivers the required flow rate for propane; however, two pumps are required for pumping molten sulfur. All operating pumps are provided with a spare. Nozzles are provided at both the Tank Car and Tank Truck loading racks such that any product can be loaded at two or more bays.

Each product is piped by a separate line to the loading racks, then branched to different loading nozzles.

Non-refrigerated Propane is loaded at ambient temperatures (100°F), refrigerated propane is loaded at -32°F; molten sulfur is loaded at 300°F.

Catalyst unloading blowers are provided to transfer catalyst from the road receiving point to the storage silo in plant 201.

Plant Description

Rail Tank Car Loading
Standard loading arms with telescopic nozzles and swivel joints are provided for the top loading product molten sulfur. For the volatile propane product, loading arms with hose connections for bottom loading are used.

Tank Truck Loading
Top loading nozzles are used for molten sulfur. Nozzles with bottom loading hose connections are used for propane.

Piping and Valves
Piping and valves are carbon steel and conform to the required design conditions. Hydraulic shock absorbers are provided for sudden shut-offs and static neutralizing devices are used for molten sulfur. Heat tracing and insulation are provided for molten sulfur at 300°F. Vapor lines are provided from the tank truck and tank car loading racks in accordance with the vapor recovery system concept.

The loading nozzles have connections for bleeders and drains. Hand-operated block valves are provided just upstream of the loading nozzles and are accessible from the platforms. Connections for nitrogen purge are provided at the loading nozzles for propane.

Pumps
The propane product loading pumps are designed for 2000 gpm at 290 psi. The sulfur product loading pumps are designed for 1000 gpm at 75 psi.

Catalyst Unloading
The Catalyst unloading blowers are designed to provide 15 psi compressed air using 200 HP motors.

Instrumentation
The following instrumentation is provided at each loading nozzle location:

1. Automatic excess flow shut-off control valves for emergency shut-down in case of a broken hose in the loading nozzles for all products.

2. Positive displacement meters with totalizers are provided for each product.

3. Digital counters with automatic printout are installed at the loading location.

4. Instrument air is provided at the loading racks.

Loading Platforms
These consist of structural steel, grating and handrailing. Swinging catwalks with counterweights are used for each loading bay for operator accessibility.

Tank Car Platform
The products are piped to three loading bays. The loading platform is 340 feet long, 4 feet wide and 12 feet in height. Stairs are provided at the two ends of the platform and on the sides.

Tank Truck Loading Platform
The dimensions of this platform are 10' x 8' x 10' with a 20 foot roof covering the loading area and one set of stairs, and a catwalk on either side.

Tank Truck Scale
A truck scale is provided for weighing both empty and loaded trucks.

Railroad Spur
A railroad system is provided for loading rail tank cars, and for unloading catalyst.

Capacity of tank cars	30,000 gallons
Capacity of tank trucks	10,000 gallons
Loading time	15 minutes
Ambient Temperature	100°F

Loading Arrangement
Propane and liquid sulfur will be shipped in tank cars and/or dedicated tank trucks.

Loading Bays
Based on the filling time required for tank cars/trucks, time required for completing documentation, line-up and position of tank cars/trucks, inclement weather, it is proposed to have:

- Two Loading Bays for tank trucks each with 2 filling positions. One bay will be dedicated to Propane (located at a safe distance from any source of flame or sparks) and one for Liquid Sulfur.
- Three Loading Bays for tank cars, each with one filling position. All bays are capable of filling all products.

Tank Truck Scale
A truck scale is provided for weighing empty and loaded trucks. The products, in general, are loaded per the level marker provided in tank cars and by set stop meters for tank cars. All trucks are weighed in and out. A sump pump is provided in the weighing pit to remove rain and cleaning water.

Sprinkle
A sprinkler fire water system is provided for the tank truck loading rack. The system is automatically energized in case of fire, covering the entire loading rack area with water at a minimum density of 0.25 GPM/ft^2.

Fire Hydrants and Extinguishers
Fire Hydrants and monitor are provided for the tank car loading rack in lieu of a deluge system. Portable chemical fire extinguishes are also provided, at least at two locations for the tank truck loading rack and at fire places for the tank car loading tank.

2.1.1.6 Plant 24 - Coal Ash (Slag) Disposal

Design Basis, Criteria and Considerations

This plant is for the disposal of coal ash, or slag, from the Hydrogen Production by Coal Gasification (Plant 103). The coal slag is transported back to the coal mine via conveyor belt for disposal as land reclamation.

Plant Description

Conveyor belt (24T-1) is provided for transferring coal slag from Coal Gasification Plant (Plant 103) back to the mine site.

2.1.1.7 Plant 25 - Catalyst And Chemical Handling

Design Basis, Criteria and Considerations

This plant provides storage and handling for the catalysts and chemicals used in all the plants. Additionally, it provides a consolidated location for tracking catalyst and chemical start-up and daily consumption requirements.

Plants requiring chemicals or catalysts include 104 (COS Hydrolysis), 105 (Sour Water Stripping), 106 (Acid Gas Removal), 107 (Sulfur Recovery), 108 (Sulfur Polishing), 109 (Syngas Wet Scrubbing), 201 (F-T Synthesis), 202 (CO_2 Removal), 203 (Dehydration/Compression), 206 (Autothermal Reforming), 301 (Wax Hydrocracking), 302 (Distillate Hydrotreating), 303 (Naphtha Hydrotreating), 304

(Catalytic Reforming), 305 (C4 Isomerization), 306 (C5/C6 Isomerization) and 307 (Alkylation).

The equipment for this plant includes an enclosed warehouse for storing chemicals and catalysts and forklifts for transporting pallets of chemicals or catalysts into or out of the warehouse.

A warehouse is required to collect all chemicals into one area for distribution to the various plants as needed. Additionally, the warehouse is used as a temporary storage for spent catalyst that must be returned to the catalyst vendor for regeneration at the vendor's facilities.

This plant identifies all major plant catalyst and chemical requirements for startup and continuous operation.

Plant Description

A 6000 square foot chemical and catalyst warehouse (25R-1) is provided for temporary storage of chemicals. Electric forklifts are provided for transporting pallets of chemicals or catalysts into or out of the warehouse.

2.1.1.8 Plant 30 - Electrical Distribution System

Design Basis, Criteria and Considerations

The plant electrical distribution system receives power from the 115kV high voltage switchyard. The switchyard will generally consist of a minimum four breaker arrangement with two off-site utility sources required to insure high availability of the facility electrical distribution system. The Facility Electrical Single Line Diagram assumes a four breaker ring bus arrangement. Alternate configurations will be examined during detailed design subject to Utility approval.

Two switchyard main transformers transform the 115kV sources to 34.5kV for distribution to the facility substations. The switchyard facility is assumed to be provided by local utility. The main facility 36kV double-bus switchgear (located adjacent to the 115kV switchyard) provides redundant feeders to Substation 1-4. The high voltage switchgear provides the normal running 125MW facility load from 1) in-house generation (= 75MW from the Steam Turbine Generating Plant) source and the balance from 2) off-site purchased power. During periods of start-up, all power may be derived from off-site sources. During normal operation, the facility load will be split between the two 34.5kV switchgear buses.

The high voltage 34.5kV feeders are installed in underground ductbanks. During detailed design, a cost saving overhead distribution system may be considered.

The steam turbine generator is connected to it's main step-up transformer via a local synchronizing breaker (SF6 type). The generator power is delivered to the 34.5kV switchgear in an underground duct bank similar to the high voltage substation feeders.

The following table shows the plant load distribution from the four medium voltage substations:

Substation	Plant Loads
Substation 1	Area 100
Substation 2	Area 200
Substation 3	Area 300 & Tank Farm
Substation 4	OSBL & Power Generation

Substation

Each substation consists of two main transformers per switchgear lineup. One transformer is fed from main distribution switchgear (34.5kV) Bus A and the other from Bus B. Each transformer is capable of the total secondary load with ≈ 15% spare capacity for future growth. The normally open tie breakers connect each dual bus section to maintain services upon loss of either switchgear section or loss of either transformer.

The distribution of loads on the individual plant switchgear buses will be such that equipment with redundancy will be on separate buses minimizing the impact to the facility processes upon failure of one source.

The substation electrical medium and low voltage service levels and associated motor assignment criteria is as follows:

13.8kV	Motors ≥ 2500hp
4.16kV	Motors ≥ 2000hp and ≥ 250hp
0.48kV	Motors ≥ 200hp and ≥ 1/2hp

Similar to the high voltage feeders, in outdoor areas the medium voltage (15kV and 4.16kV) substation feeders are expected to be installed in underground duct banks and/or direct buried cables. However, during detailed design, a cost saving overhead distribution system may be considered.

Attached Table 2-1 lists, by individual unit, the expected electrical large motor loads and other normal running load (low voltage).

Simplified One Line Diagram

The One Line Diagram for the indirect coal liquefaction baseline design is given in Figure 2-4.

Table 2-1
Electrical Load Summary

MW Total	MVA Total @ 90% PF	MVA Service Req'd With 15% Margin	Large Motor Qty @ HP	Large Motor Total MVA (Note 1)	Low Voltage MVA Total Load (Note 2)	Req'd Low Voltage XFMR @ 2.0MVA With 20% Margin
Area: 100						
76	84	97	1@350 12@2500 6@450 16@4000 4@400	0.35 30.00 2.70 64.00 1.60	33	17
			Total Motor Load	98.65		
Area: 200						
13	14	17	8@450	3.60	14	7
			Total Motor Load	3.60		
Area: 300						
14	16	19	2@1250 2@2000 4@2000	2.50 4.00 8.00	9	4
			Total Motor Load	14.50		
Area: Tank Farm						
8	9	11	4@2000	8.00	0	0
			Total Motor Load	8.00		
Area: OSBI						
14	16	19	8@1000	8.00	13	6
			Total Motor Load	8.0		

NOTES:

1. Assumes 1HP = 1MVA
2. Assumes 50% Motors Normal Running

2.1.1.9 Plant 31 - Steam And Power Generation

Design Basis, Criteria and Considerations

The gasification plant and other process plants provide a net generation of steam to the complex. Steam is used to power turbine drivers for all continuously operating power requirements above 150 HP. Low-BTU syngas is used to superheat 360 psig saturated steam. Excess steam from the complex is expanded in a turbogenerator to produce power.

The important design criteria are summarized as follows:

- Primary steam header is 900 psig, 1000°F superheated steam
- Two steam superheaters at 195 million Btu/hr each producing a total of 3,330,000 lbs/hr superheated steam at 360 psig and 600°F
- One turbogenerator producing 68 MW net power
- One 20,000 lb/hr start-up boiler
- Two deaerators each treating 6400 gpm of condensate

Steam Distribution

The overall steam distribution and balance for the plant is shown in Figure 2-5.

2.1.1.10 Plant 32 - Raw, Cooling And Potable Water

Design Basis, Criteria and Considerations

Raw Water Treatment

The principal source of raw water for the plant is from the nearby lake or river. The raw water treatment consists of:

- Clarification of water
- Gravity filtration
- Potable water chlorinator
- Demineralization

Clarified water is used for cooling tower makeup, fire fighting and utilities.

A package potable water system is used to treat water used for drinking, food preparation and sanitary facilities. This water has been clarified and filtered.

Boiler feed water has been clarified, filtered and demineralized.

Overall flow of raw, clarified and potable water is illustrated on Flow Diagram, Figure 2-6.

The process flow sketch is shown on Flow Diagram, Figure 2-7. The water clarification system is designed to treat approximately 10,000 GPM of raw water. The filtration system is designed for 1,200 GPM, demineralization for 1,100 GPM and potable water for 100 GPM. Normal flow rate through the system will vary between 4,000 to 10,000 GPM depending on the rainfall. Rain runoff from building roofs and uncontaminated areas of the plant as well as treated process wastewaters from Plant 34 will be used to supplement lake or river water.

Reactor/clarifiers are used to clarify the water. These units produce a much thicker sludge than is possible in a conventional clarifier. The thickened sludge can be pumped directly to a sludge dewatering press without the need of a thickener.

Because of the water quality, see Table 2-2, conventional cold lime softening and soda ash treatments are not needed to reduce the content of calcium and magnesium as carbonate. Sodium aluminate and a polymer are added to aid settling of the suspended solids. The softened effluent does not require a pH adjustment.

Table 2-2
Raw Water Analysis for Design

Property	Mid Continent Location Raw Water Average	Maximum
Temperature, °F (Range)	48 – 89	
pH	6	8.5
Calcium as $CaCO_3$, ppm	140	180
Calcium as Ca, ppm	38	49
Magnesium as $MgCO_3$, ppm	96	130
Bicarbonate as HCO_3, ppm	137	173
Sulfate as SO_4, ppm	350	570
Silica as SiO_2, ppm	6.5	7.0
Total Dissolved Solids, ppm	662	1,449
Conductivity, MOH	1,000	1,200
Turbidity, Jackson Turbidity Units (JTU)	—	20
Clarified Water		
Turbidity, JTU units		3

About 1,200 GPM of the clarified water is filtered using two dual filter media gravity filters. Approximately 100 GPM of the filtered water is fed to a potable water chlorinator system, and the rest (1,100 GPM) goes to the demineralizer. The balance of the clarified water, about 8,900 GPM goes to storage tanks

Sludge resulting from the clarification (clarifier underflow) is filtered with a filter press and the filter cake is sent to an approved landfill. The small flow of filtrate water is recirculated back to the reactor/clarifier.

Cooling Water System

One conventional, wood cross flow tower with splash type fill cooling water system with mechanical induced-draft cooling tower is provided.

The cooling tower is designed to supply the 3770 MMBTU/hr cooling requirements of the process plants.

An objective of the cooling water system design is to minimize the use of imported water for cooling tower makeup. This results in maximizing the reuse of treated process waste water, including cooling tower makeup. The rest of makeup water is supplied with clarified water.

The cooling water distribution system, as well as individual plant uses and return water temperatures are presented on Cooling Water Balance Flow Diagram, Figure 2-8.

The cooling tower capacity is as follows:

Duty	=	3770 MMBTU/Hr
Inlet Temperature	=	115°F
Outlet Temperature	=	87°F
Circulation Rate	=	238,764 GPM
Water Evaporation Loss	=	0.1% x Delta T Ave.
Drift Loss	=	0.1%
Blowdown	=	4 Cycles

Cooling water system is designed for a supply water temperature of 87°F.

The climatic conditions used for the cooling tower design are:

- Atmospheric press = 14.3 psig
- Air Temperatures
  - Inlet Temperature = -6 to 95°F
  - Wet Bulb Temperature = 78°F
  - Dry Bulb Temperature = 95°F at 45% Relative Humidity

Cooling Tower Makeup

Makeup water to the cooling tower is clarified raw water and treated process waste water from Plant 34. The total makeup requirement is 9,895 GPM.

Cooling Water Requirement

The design cooling requirements for the complex, including power and steam generator plant (Plant 31) is served by a 26 cell cooling tower including three spare cells. The total cooling duty is 3,770 MMBTU/hr including a contingency allowance of 12%.

Overall Plant Water Balance

The overall water balance for the entire Baseline complex is shown in Figure 2-9.

2.1.1.11 Plant 33 - Fire Protection System

Design Basis Criteria and Considerations

Fire protection and control systems for all facilities, structures and equipment within the plant area are designed in compliance with federal, state, and local jurisprudence codes and standards and with the recommendations of the American Petroleum Institute, National Fire Protection Association, Industrial Risk Insurer, and the Oil Insurance Association (OIA).

A comprehensive fire water system is provided for the general fire protection of the entire plant. Chemical and steam fire suppression systems are provided for specific facilities and equipment. These systems cover:

- Fire water to process plants, coal handling, water and waste treatment, and storage tankage
- Fireproofing for vessel supports, pipe racks, etc.
- Sprinkler systems for buildings, part of the process equipment such as pumps or heat exchangers (depending on the location), tank truck, tank car, filling rack.
- Smothering steam for compressor buildings and fired heaters
- Halogen system for computer room and laboratory
- Nitrogen system for sulfur storage tanks

Plant Description

Supply Source
Fire water is supplied from the main pond. This source is capable of supplying 60,000 barrels, or 150% of the total requirements of the system for over 24 hours.

Fire Water Pumps
Four main fire water pumps, each rated for 3,500 GPM at 192 psig, deliver the water to the distribution system. Two vertical pumps are located at the pond. One is dual-driven by electric motor and turbine; a diesel engine powers the second pump. Two

horizontal pumps powered by similar drivers deliver water from the fire water tank.

Two vertical fire water pressurizing "jockey" pumps, each rated for 275 GPM at 192 psig discharge pressure, are installed at the raw water pond for maintaining the pressure in the fire water piping circuit. Only one pump is required to maintain the pressure in the fire water system. The second pump serves as an installed standby spare. Both pumps are powered by electric motors. All pumps are capable of producing 150% rated capacity at 65% rated head and have a shut off pressure of not more than 120% rated head.

Distribution System

Fire water distribution system consists of three loops, one around each of the following areas:

- Process
- Coal handling
- Tank farm

The main loop and the main interconnecting piping are 18 inches in diameter; smaller branches are 12 inches or 10 inches accordingly, distributing water to users.

The fire water mains are coated and wrapped steel pipe and are installed underground. Provisions are made for valving off any loop without interfering with the other two loops.

Fire Hydrants, Fixed Monitors, and Firehouse Stations

Fire water is supplied to fire hydrants and/or fixed monitors spaced at a maximum of 150 feet around each plant. The monitors are 500 GPM units with adjustable fig/straight stream tips and locking devices for both horizontal and vertical adjustment.

Fire hydrants have flanged connections with outside independent shut-off valves for hose connections. All fire hydrants are self-draining.

Each individual process plant has accessibility to at least four firehouse stations, with hose liens stored on reels preconnected to the fire water system.

The requirements are:

- 6-inch hydrants 250 units

- 4-inch hydrants with 3-inch monitor 125 units
- 1-1/2 inch hose on reels 60 units

Deluge System
Deluge systems are provided for propane, butane, and anhydrous ammonia spheres, and pipe racks located within 25 feet of heaters. Pump batteries, towers and major vessels containing flammable materials are also protected with deluge system.

Sprinkler systems are provided for office and storage buildings, tank truck loading rack, coal bins and the coal conveyors. Dry-pipe sprinkler systems are installed for all areas except those sheltered in a building.

Foam Systems
Storage tanks with bottom injection foam systems are provided for products with flash point below 140 °F. The requirements include one 3,000-gallon system for the product tanks. Mobile equipment consisting of Aer-O-Foam Dry Chemical Pumper (or equal) and one Aer-O-Foam Big Brother trailer (or equal) is provided. The pumper is equipped with a balanced pressure foam proportioning system and has a solution pumping capacity up to 1,500 GPM at 6% rate. The trailer is equipped with a 500 gallon tank, a hose bed, portable monitors and a balanced-pressure foam proportioning system.

Halogen System
The chemical laboratory and the computer room are protected by Halon 1301 fire extinguishing system. The systems are fully automatic, energized by thermal detectors, and have personnel alarms.

Nitrogen System
A nitrogen fire extinguishing system is provided for two heated sulfur tanks in the tank farm location. The system is fully automatic and energized by thermal detectors.

Snuffing Steam System
Low pressure snuffing (50 PSIG) steam is provided in the compressor buildings, exchanger rows, pump rows and accumulator decks as well as fire-boxes of heaters.

Fire Extinguishers
Type BC 30 pound extinguishers are provided for process areas, buildings containing pumps and compressors and utility buildings. All other buildings are equipped with type 2A extinguishers. For each process plant area, 150 pound BC type wheeled extinguishers are also provided.

Detectors
Detector units with alarms are utilized in sheltered or enclosed areas handling or processing flammable liquids or gases and buildings where personnel are working.

2.1.1.12 Plant 34 - Sewage And Effluent Water Treatment

Design Basis, Criteria and Considerations

Wastewater Treatment (Plant 34) and Water Systems (Plant 32) are closely related and together constitute the Project Water Management System, the the purpose of minimizing both raw water consumption and effluent discharge to public waters during normal plant operation. Waste water streams are segregated on the basis of their compatibility and treated as necessary to make them suitable for reuse, if practical, in lieu of fresh water.

The majority of the water used in the project eventually goes to the atmosphere as water vapor. Some water is disposed of as moisture associated with the solid wastes going to the landfills. Blowdown streams (Cooling Tower, Boiler and Demineralizer) are sent to an intermediate holding pond before being discharged back to the lake or river.

Individual systems described in this section include:

- Coal Storage Pile Runoff Treatment
- Oily Wastewater Treatment
- Process Wastewater Treatment
- Solids Dewatering
- Sanitary Sewage Treatment

The design basis, process description and block flow diagrams for each of the above treatment systems are given under each treatment system as described herein.

Coal Storage Pile Runoff Treatment

The water management policy is: all rain runoff from developed areas is utilized within the complex. Runoff from uncontaminated areas such as building roofs, is routed without treatment to the utility/firewater storage pond. Runoff from potentially contaminated areas, including the coal storage areas, is treated before being sent to the utility firewater storage pond.

Design Basis

The design of the Coal Storage Pile Runoff Treatment System is based on Bechtel Environmental Division in-house data which approximates the runoff of Illinois coals. The characteristics of the design runoff are summarized in Table 2-3.

Table 2-3
Plant 34 - Illinois Coal Runoff

Parameter	Design
pH	6.0
Total Suspended Solids	1,800
Total Dissolved Solids	800
Sulfate	320
Iron	15
Total Organic Carbon	500
Biochemical Oxygen Demand	5
Chemical Oxygen Demand	2,000

The design is based on the premise that the water will be acidic and therefore bicarbonate alkalinity is insignificant and hardness is entirely noncarbonate. Thus only soda ash is specified to raise the pH and precipitate the calcium and magnesium as carbonates.

Design basis for clarifier:

• Water flow	600 GPM
• Surface flooding	700 GPD/ft^2
• Underflow solids concentration	2% (wt)

Design basis for filters:

- Water flow 600 GPM
- Filtration flux rate 10 GPM/ft^2
- Backwash flux rate 15 GPM/ft^2

The Coal Storage Pile (CSP) Runoff Treatment System is shown in Figure 2-10 and consists of clarification, neutralization and filtration.

The runoff from the coal storage piles is routed to a storm surge pond which acts as a flow and composition equalizer and a feed "tank" for the CSP runoff treatment equipment. Additionally, some of the heavier suspended solids are expected to settle out at this point. From the surge pond, the runoff is pumped at a constant 600 gpm rate to the Reactor/Clarifier where it is neutralized with soda ash and clarified with the aid of a polyelectrolyte. Settled solids are withdrawn and pumped to the sludge dewatering facilities at the treatment plant. Reactor/Clarifier effluent is pumped through two down-flow, pressure-type, dual media filters for residual suspended solids removal. A controlled portion of the filtered water is stored in the Filter Backwash Makeup Tank. Periodically the filters are backwashed using filtered water aided by compressed air for scouring the media. Filter backwash water, laden with suspended solids, is returned for reuse.

Oily Wastewater Treatment

The Oily Wastewater Treatment System consist of API gravity separation followed by dissolved air flotation (DAF). Sludges generated by the API separator and DAF units are disposed of by routing to the gasifiers in Plant 103 for incineration.

Oil-contaminated waste-waters from throughout the plant, including contaminated surface runoff, are collected by an underground sewer system and routed to the wastewater treatment area. Major sources of this wastewater are:

- Contaminated process area runoff
- Runoff from the tank farm area
- Runoff from truck and railroad loading and unloading areas
- Water drains from Oil storage tanks
- Vessel and pump drains

- Pump cooling water
- Laboratory sink drains
- Condensate collected in process drains

The design of the oily water treatment system is based on the following estimated wastewater characteristics and flow:

Influent Characteristics

Flow (Maximum)	1,000 gpm
PH	6-8
Oils (average)	350 mg/I
TSS	150 mg/I
COD	1,200 mg/I
BOD	500 mg/I

The performance requirements for the process units are as follows:

Percent Removal Requirements

Unit	Oils	TSS	COD	BOD
API Separator	50	50	33	30
DAF Units	85	50	40	40

The process is shown in Figure 2-11.

The oily wastewater, on its way to the API Separator flows through a specially designed concrete Static Flow Splitter Box utilizing a combination of weirs and pumps to permit excess flows to be diverted to the oily storm surge tank with a minimum of oil carry-over.

Upon entering the covered and vented API separator forebay, some of the lighter oils float to the surface and the heavier solids settle out. The water then flows on through a 5x10x100 foot channel where the oil droplets float and the solids (sludge) settle out. The floated oil and settled sludge are moved across the length of the channel in opposite directions, by means of motor-operated endless chains with flights, and are concentrated at opposite ends. Oil is skimmed off to a sump and pumped by the Skimmed Oil Pump to a small heated tank nearby for settling and rough phase separation. Water is drained back to the separator, and oil is withdrawn through a floating skimmer and pumped by the Oil Transfer Pump to Plant 204. Bottom sludge is pumped by the API Separator Sludge Pump to a sump where float and bottom sludges from the DAF units are also collected and pumped by the Oily Sludge Sump Pump to the Coal Gasifiers (Plant 103).

The API separator effluent is pumped by the API Separator Effluent Pump through the Flash Mix Tank and Flocculation Tank to the DAF units. Acid or caustic soda is metered to the flash mix tank to automatically adjust the pH. Polymer is also metered to the flash mix tank at a rate commensurate with the wastewater rate. These chemicals form a dense floc into which some of the small, dispersed oil droplets and suspended solid particles (found in the feed to the DAF units) are trapped. This floc is built up in the flocculation tank by means of a slow-speed mixer-agitator.

The floc containing oily water now enters the twin DAF units, where the oily floc is removed with the aid of small air bubbles. The feed is equally split and fed to the central portion of the circular DAF Flotators. A portion (50%) of the clarified effluent from each flotator and compressed air are held for about 30 seconds in the air saturation tank to dissolve the air in the water. The air-saturated water is depressurized and immensely blended with raw feed to the flotators. There is an independent air saturator for each flotator. The microscopic air bubbles that are thereby formed attach themselves or are trapped in the oil coated floc and rapidly buoy it to the surface of the flotators. The resulting material, known as "float", is skimmed off with slowly revolving scrapers into a hopper from which the float flows by gravity to a sludge collection sump. Some solids settle to the bottom of the flotators. These are removed periodically by bottom sludge pumps and added to the oily sludge sump along with other sludges.

Effluent from the Oily Water Treatment System is sent to the next stage of wastewater treatment.

<u>Process Wastewater Treatment</u>

The wastewater from the process units is combined with treated sanitary sewage and deoiled water and sent to a biotreatment system to reduce BOD. This system consists primarily of a trickling filter and an activated sludge unit. The system is shown in Figure 2-12.

The design of the process wastewater treatment system is based on 2300 gpm at 2500 ppm BOD. All process wastewater stream, the oily water treatment system effluent and the sanitary sewer treatment effluent are sent to the treatment system. To reduce the BOD load on this system, process wastewater streams 201.6 and 201.9 are first passed through a column to remove oxygenates. The column overheads (oxygenates) are used to supplement the fuel used in the steam superheater; the column bottoms are sent to the biotreatment system.

As shown in Figure 1-12, the combined wastewater stream first enters an oil separator to remove oil. The oil separator effluent is pumped to a neutralization tank into which acid or caustic is metered to automatically adjust pH. The effluent from the neutralization tank is pumped to an equalization tank which averages out fluctuations in the feed composition.

The wastewater is pumped from the equalization tank to a trickling filter and an aeration tank. Micro-organisms in these two units destroy the carbonaceous BOD. The wastewater overflows the aeration tank into a clarifier. Solid matter sinks to the bottom of the clarifier where slow revolving makes draw it to a sump in the center. Clarified water overflows from the periphery of the clarifier, is collected in a trough, and recycled to the wastewater inlet to maintain the inlet BOD concentration at 2500 ppm or below.

Activated sludge from the center sump of the clarifier is split into two fractions. One part is pumped back to the aeration tank to maintain the proper microorganism concentration. The remainder, which represents net microorganism production, is sent to the digester tank which completes the destruction of the BOD.

The underflow from the digester is sent to the solids dewatering section. The overflow is filtered and chlorinated prior to find use as cooling tower makeup.

Solids Dewatering

The oily wastewater treatment system sludge, sanitary plant sludge, and process wastewater sludge are dewatered by a pressure belt filter. The dewatered sludge is hauled to an approved landfill for disposal. The block flow diagram for this system is shown in Figure 2-13.

The design of the dewatering system is based on the following estimated sludge characteristics and flow:

Influent Characteristics

Flow, gpm (maximum)	150
pH	6-8
Percent solids	3.0

The performance requirements of the process units are as follows:

Cake dryness, %	20-30
Polymer consumption, lb/ton Dry Solids	10
Electrical consumption, kwh/ton DS	15-30

Sludges from the oily wastewater treatment system, the sanitary plant and the process wastewater treatment are routed to a surge/equalization tank where the sludges are blended together. An air operated diaphragm pump moves the blended sludge from the tank to two belt presses. Just prior to the sludge entering the belt filters, a polymer is added to the stream. The polymer conditions the sludge to enhance the dewatering.

The belt presses are located on the second level of a small building to facilitate the filter cake removal by allowing it to drop by gravity into a dumpster. The polymer storage and feed system are on the ground level with the dumpster. When full, the dumpster is hauled off to an approved landfill.

Sanitary Sewage Treatment

Sanitary sewage from the various sanitary facilities throughout the complex is collected in an underground sewer pipe network terminating at the central sewage treatment facility located downhill/downgrade from the project facilities. To avoid excessively deep excavations, with the long sewer runs involved, there is a need to use several sewage lift stations before the sewage reaches its destination. At the terminal end of the sewer network there is a final lift station delivering feed to the above ground sewage treatment plant.

The sanitary sewage treatment plant is a package unit, pre-engineered, shop fabricated, knocked down and reassembled in the field. It is an above ground installation made of the kind used in many industrial plants and small communities.

The package treatment unit is designed to treat 150,000 GPD of sanitary sewage with a maximum five day BOD loading of 250 pounds per day. It is designed to meet the Ten State Standards, which is a widely used basis for municipal sewage treatment design. It is further based on average per capita use of 35 GPD of water and 1,500 employees working the day shift.

The average design feed rate through the system is 104 GPM. The system can tolerate short term hydraulic loadings of up to 400 GPM, which is the design capacity of the pump lift station ahead of the treatment plant.

The process is shown in Figure 2-14.

Sanitary Sewage Treatment Package - The package consists of two above-ground concentric circular tanks. The outer one is divided into three compartments to form an aeration tank, an aerobic digester, an an effluent chlorine contact tank. The inner one is a settling tank.

Sewage is pumped from the Lift Sump into the inner tank, Aeration Basin. The volume of this compartment is 7,510 ft^3 providing nine hours of detention time for the design flow rate of 104 GPM. Air from the air blower is dispersed by special diffusers mounted circumferentially around the wall of the compartment.

Digested sewage overflows the aerator into the Clarifier where suspended solids settle to the bottom and clarified water overflows a circumferential weir into the Chlorine Contact Tank. The clarifier is sized for a minimum of four hours detention time and a rise rate of 700 GPD/ft^2. Sludge is removed via air lift mechanisms for recycle to the aerator and delivery to the Aerobic Digester.

Clarified water is chlorinated in the chlorine contact tank to destroy any remaining bacteria. This tank has a volume of 3,360 gallons. It is divided into three compartments to force flow over and under and avoid short circuiting. The chlorinated water is forwarded to biotreatment. Chlorine gas is automatically controlled by the chlorinator which is sized to deliver up to 30 pounds/day. Chlorine supply is from chlorine cylinders.

The aerobic digester is also supplied with air from the blower. Digested sludge is pumped to the wet oxidation reactor for further decomposition. Holding time in the digester is four hours. Overflow from the digester is pumped by an air lift system back to the aerator.

2.1.1.13 Plant 35 - Instrument And Plant Air Facilities

Design Basis, Criteria and Considerations

The facilities include all equipment necessary to supply instrument and utility air to the process plants and support facilities. Distribution piping is included in Plant 21 (Interconnecting Piping).

Instrument and utility air is dry, oil-free and dirt-free at the following design conditions:

- Pressure 100 psig
- Temperature 100°F
- Dew Point -40°F
- Ambient air summer dry bulb temperature, 95°F
- Ambient air summer wet bulb temperature, 89°F
- Ambient air winter temperature, -6°F
- Ambient air extreme temperatures, -18°F and 104°F

The system consists of three packaged air compressors, two operating and one spare, to supply the requirement of 15,000 inlet scfm. Auxiliary equipment such as filters, knockout drums, air dryer packages, filters and air coolers are included.

Plant Description

Air Compressor Unit
The compressors supply 7,500 scfm each, at 125 psig discharge pressure. The three compressor packages include the following:

- Interstage coolers
- After coolers to keep the air in the range of 100°F, (design temperature)
- Interconnecting piping between the stages.

Knockout Drum
Condensed residual moisture for all three compressors is removed by one knockout drum. The knockout drum is designed for 155 psig at 300°F.

Air Dryer Package
Two air dryer packages are provided. One package is a complete spare. Each package provides for the design flow of 15,000 inlet scfm and for 150 psig. A filter, included in the air dryer package, guards against dessicant breakthrough.

Distribution System

Individual plant and main air distribution headers providing instrument and utility air are included in Interconnecting Piping (Plant 21).

Controls
The air compressor system and air dryer package are fully automatic with the following control features:

- Surge control with excess air vented to the atmosphere
- Dewpoint control by moisture analyzer and instrumentation to energize the regeneration process for the desiccant bed
- Automatic startup of the standby unit in case of low pressure in the header

Noise
Noise emissions by the air compressor is in accordance with OSHA standards.

2.1.1.14 Plant 36 - Purge And Flush Oil System

Design Basis, Criteria and Considerations

Plant 36 delivers a light and heavy flush oil for pump seal flush and instrument purge. Seal flush and instrument purge are required on a continuous basis for plant areas where high solid (e.g., crushed coal or catalyst) content fluids are being transported. In these areas, each pump seal receives a specified flow of flush oil into seal housings, preventing solids from blocking the flow of lubricating fluids at sealing surfaces. Without the seal flush, pumps in these areas could fail in a few hours due to improper lubrication.

Likewise, each instrument receives a specified flow of light flush oil into instrument lines, preventing solids from blocking the lines and rendering the instruments (alarms, gauges, meters, etc.) ineffective.

With the Baseline Design, F-T Synthesis (Plant 201) is the only plant requiring some seal flush and instrument purge due to transport of high concentration catalyst slurry, in the catalyst preparation, recycle and disposal streams.

Both the light and heavy flush oils are obtained from the Hydrocarbon Recovery (Plant 204) and stored, filtered, and delivered to offsite Tankage (Plant 20).

Interconnecting Piping (Plant 21) is utilized to transfer the flush oils to specific applications.

Plant Description

The light and heavy flush oils are stored, pumped, filtered, and delivered by two separate systems. These systems are located in Tankage (Plant 20).

The light flush oil is pumped from Plant 204 to a 36,000 barrel storage tank, which provides 10 days of storage capacity. From the tank, pump delivers the oil at 3,300 psig to overcome the highest system pressure of the designated applications. A precoat filter package is utilized to remove particulates from the oil.

The heavy flush oil is pumped from Plant 204 to a 36,000 barrel storage tank which provides 10 days of storage capacity. From the tanks, pump delivers the oil at 250 psig to overcome the highest system pressure of the designated applications. A precoat filter package is utilized to remove particulates from the oil.

2.1.1.15 Plant 37 - Solid Waste Management

Design Basis, Criteria and Considerations

This plant disposes of wastes from Raw, Cooling, and Potable Water (Plant 32), Wastewater Treatment (Plant 34), and miscellaneous sources which include plant refuse and flotsam.

All the solid waste excluding the miscellaneous plant refuse is stored in bins and hoppers and collected daily to minimize on-site storage. Once collected, it is transported to an approved landfill disposal site outside battery limits in off-road trucks.

Table 2-4 below summarizes the quantities of solid wastes.

Table 2-4
Plant 37 - Solid Waste Summary

Waste Source	Waste Type	Waste Flow (TPD)
Raw, Cooling, and Potable H2O (Plant 32)	Filter Cake	20
Wastewater Treatment (Plant 34)	Filter Cake, Sludge, Salts	72
Miscellaneous	Plant Refuse, Flotsam	5

Dewatering of the solid wastes identified above occurs within the battery limits of the source plant. Descriptions of these facilities are included in the source plant process descriptions.

Miscellaneous plant refuse and flotsam is stored in dumpsters. The estimated number of these containers required for the entire plant is 30. Conventional rear loader compactor trucks are used to transport this waste to the approved landfill site outside battery limits. These trucks are fully compatible with the wheeled, rear loader dumpsters used for storage. The trucks make one trip to the disposal site each day.

Plant Description

Plants 32 and 34 Waste Disposals

The waste bins and hoppers for Plants 32 and 34 are included with these plants. A 40 ton and an 85 ton off-road rear-dump hauler truck are provided for transporting waste to the approved landfill disposal site.

Miscellaneous Waste Disposal

Standard 4 cubic yard, wheeled, rear loader dumpsters are provided for storing miscellaneous waste items. Conventional, rear loader, municipal type compactor trucks with 25 cubic yard capacity are provided for transporting waste to the landfill disposal site.

2.1.1.16 Plant 40 - General Site Preparation

Design Basis, Criteria and Considerations

The site is located in Southern Illinois with rail and road accessibility. The plant shall be built on a green field location, which will have to be made suitable for the purposes of building an industrial facility.

Site preparation invclves leveling approximately 600 acre area, adding basic improvements such as roads fencing and drainage needed by the plant as a whole, and the placement of high load-bearing fills, pilings, spread footings and mat foundations for the plant structures in accordance with individual needs.

The general site is graded to a basic elevation of 650 feet above mean sea level (MSL) and the coal storage area is graded to 655 MSL. Most of the overburden removed in this operation is of low strength soil unsuitable for structural fill. It is stockpiled for other uses.

Drainage of contaminated rain runoff from process and offplot areas is directed to ponds for treatment needed before plant usage. Uncontaminated storm runoff from building roofs, parking lots, outdoor storage areas and uncontaminated process plant areas is routed to the raw water storage pond.

Facility Description

Foundations
The low-strength soil extends on an average of 10 feet throughout most of the plant site.

Within plant units, this low-strength soil is completely excavated and stockpiled for other uses. Below the soil is a sandy mixture that is of a satisfactory strength for foundation support. The low-strength soil that was removed below MSL elevation is replaced with suitable structural fill borrowed elsewhere on the property.

Spread footings and mat foundations are placed at appropriate depths in the structural fills formed by compaction of the sand and placement of the structural fill.

Foundations supported by pilings are used instead of footings or mats for unusually heavy and settlement-sensitive structures and equipment. Two different capacity piles are used for foundations: 50 ton and 100 ton. End-bearing-type piling is used and the piles are driven with a design weight driver to "refusal".

Finish Grading and Drainage

Finish grading of the plant site provides the proper shape and contour to the final ground surface. Finish grading includes providing the correct amount of slope for surface drainage without causing erosion.

Upon completion of finish grading, all drainage ditches are constructed to proper size, shape and slope and all roads are brought to the proper elevation and made ready for paving.

Uncontaminated storm water runoff is collected by catch basins and conveyed by means of buried pipes and open ditches to the raw water storage pond to the northeast of the plant, which are included in Sewers and Wastewater Treatment (Plant 34).

Sewers and Ponds

Sewers and containment ponds for treatment of contaminated waters from the process and offplot areas, sanitary effluents, landfill runoff and coal pile runoffs are included in Plant 34. Raw water storage is also covered by Plant 34.

Dikes for Tank Farm

Containment dikes for the tank farm area are of earthen construction with 3 to 1 side slopes. They are constructed from the excess low strength overburden material excavated and stored on the site.

Roads and Bridges

Plant roads are constructed of asphalt concrete on a crushed limestone base course which is placed on a compacted subgrade. Main plant roads are 24 feet wide with 3 feet wide shoulders. Secondary roads have similar cross sections with widths appropriate to their usage. Employee parking lots are within the scope of Plant 40 and are of construction similar to that of plant roads.

A roadway approach embankment is constructed of structural quality fill for a new bridge from the existing highway to crossover existing railroad trackage. The fill is obtained on the property as described above for foundations.

Fencing

Perimeter fencing and gates are provided to restrict access. In addition, certain hazardous areas within the plant are contained by fencing.

Pre-construction Facilities

In order to facilitate site preparation work, temporary power generators, water purification facilities shall be provided. The base course of roads shall be laid out to provide easy access throughout the site. Temporary offices, telephone, canteen and toilet facilities shall be provided as soon as possible.

2.1.1.17 Plant 41 - Buiding

Design Basis, Criteria and Considerations

Five types of buildings are provided for different usages. The type of construction selected for each building is dependent on its location with respect to potential hazards, its criticality for plant operation and its function.

In addition to general good practice, the designs of the buildings include the incorporation of the recommendations or requirements of the following:

- Occupational Safety and Health Administration (OSHA)
- State of Illinois Codes
- Oil Insurance Association (OIA) Publication 101, Hydrorefining Process Units
- National Electrical Codes

Facility Description

The five types of buildings are classified as types A, B, C, D or Administrative according to their major construction features. The types and their construction features are shown below.

Type A
Type A buildings house critical equipment and/or instrumentation for the continuous operation of the plant.

The structures are blast-proof. 3 to 3-1/2 psig design, in accordance with OIA, with air lock entrances and exits. Buildings are pressurized to 0.1 to 0.2 inches of water.

The supporting structure is steel framed with concrete walls on the outside. Bearing walls and steel columns support the roof framing of steel beams and decking. Structural parts are fireproofed with three-hour-rated materials.

Interior walls are plaster boards on metal studs or are concrete block. Ceilings are installed in all rooms except mechanical equipment rooms.

Buildings are provided with heating, air conditioning, lighting, glazing, hardware, carpeting, electrical, plumbing, and sanitary systems.

Type B

Type B buildings are the plant laboratory, the cafeterias, the medical building, and the change house.

The supporting structure is steel framed with masonry walls. Loadbearing walls and steel columns support the roof framing of steel beams and decking. Structural parts are fireproofed with three-hour-rated materials.

Interior walls are plaster boards on metal studs or are concrete block. Ceilings are installed in all rooms except mechanical equipment rooms.

Buildings are provided with heating, air conditioning, lighting, glazing, hardware, carpeting, electrical, plumbing, and sanitary systems.

Type C

Type C buildings serve a number of diverse functions which are generally plant operations or maintenance related. These buildings are steel-framed structures sheathed and roofed with prefabricated-building-type metal panels.

The structure is of rigid steel frame with steel-trussed roof frame of self-framing metal panels. where required, the building frame is designed for the support of cranes and monorails. Roof and wall sheathing is factory finished. Compressor shelters have partial side covering only. Metal sandwich panels are used where buildings require insulation.

Office areas are heated and air conditioned with package units.

Buildings are provided with lighting, hardware, glazing, painting, electrical and plumbing systems. Sanitary facilities are provided only in those buildings in which they are required.

Type D

Type D buildings are for the transformer shelters and chemical storage. They have masonry walls and structural steel-framed roofs with decking cover.

Interior partitions and walls are concrete block. No finished ceilings are required. Buildings are provided with lighting, hardware, glazing, painting, electrical and plumbing systems. Sanitary facilities are provided only in those buildings in which they are required.

Administrative
The Administration Building (which also contains the computer room) is identical in construction to that of type B buildings except that the exterior is finished with brick veneer masonry.

Fire Protection
All buildings have portable fire extinguishers. Some have hand-held extinguishers, and others have these plus wheeled portable extinguishers in accordance with OSHA standards.

The laboratories and the computer room are protected by halogen-type extinguishing systems. Personnel alarms are provided for protection in buildings and halogen-type extinguishing systems. Water sprinkler systems are provided where applicable.

Fireproofing of structural members in building types A and B is in accordance with Specification 14222-N-6. For additional information on fire protection, refer to Fire Systems (Plant 33).

Utilities and Other Services
Drinking water, compressed air and steam are provided where required. Gas is provided to the laboratories. Electric power is provided for general lighting, convenience outlets and air conditioning. Connected load for air conditioning of buildings and control rooms is estimated at 500 KW.

Telephones are provided as shown in Telecommunication Systems (Plant 42).

2.1.1.18 Plant 42 - Telecommunications System

Design Basis, Criteria and Considerations

Plant 42, in serving the telecommunications requirements for the initial phases of mobilization and construction, is designed with sufficient flexibility to allow for conversion to final plant operation.

Master communications central control and monitoring of all subsystems are provided for the plant operation phase.

Reliability, a prime factor in the design of the plant, is achieved through the use of solid-state components, factory burn-in of assemblies, redundant assemblies, alternative traffic flow routing and, where possible, automatic operation.

Maintainability is achieved through modular organization of hardware assemblies, automatic fault detection and alarm systems, standardization of components and procurement sources and a spare inventory based upon mean-time-between-failure (MTBF) data and repair cycle time.

Flexibility is achieved through the usage of central electronic switching, shelterized (transportable) facilities, commonality of subassemblies where possible and a system capacity adequate for all three phases of the development.

Facility Description

Plant 42 includes the equipment and wiring for communication throughout the plant, to offsite locations linking plant data processing systems with offsite computing facilities, and for communication with transportation carriers.

- Interconnecting cables, standby emergency power and grounding
- Computer remote access
- Facsimile
- Fire alarm
- Public address paging
- Medical emergency and life-signs telemetry
- Intraplant party paging
- Land mobile radio
- Radio paging
- Security system
- Telephone, telephone PABX

The communication requirements for the three phases of plant development, mobilization, construction, and operation vary. The requirements for each phase are discussed in the following sections.

Battery Plant
The battery plant supplies standby emergency power to the telephone security, land mobile radio and maritime mobile radio systems. It is maintained in readiness by dual battery chargers.

Outside Cable Plant
The outside cable layout consists of all direct buried telephone cables and computer cables connecting the jobsite system 34 CPU with all work stations.

Computer Remote Access Terminal
The terminal is used for gathering data between the jobsite, the Bechtel design office, and the clients home office. Computer data terminal circuits for 1200/2400/4800/9600 baud rates are provided.

The facilities for long-distance transmissions are required on a 24-hour basis during all courses of the project development. The quality of transmission for the circuits is consistent with the requirement for interconnection with international circuits.

Facsimile Terminal
The requirements of the facsimile terminal are for transmitting drawings, graphics and pictorial information between the three locations.

Fire Alarm and Public Address (PA) System
The system is integrated with the telephone and switching network. It serves only the administration building.

Medical Emergency System and Life-signs Telemetry
These are provided in the ambulance, first-air stations and medical building.

Intraplant Page System
This multichannel page party system is installed in all control rooms, operating equipment rooms, storage, shipping and receiving areas, flare areas, process areas and substations. The permanent installation for all direct dial telephone also includes the following operational areas:

- Administration building and central control room
- Laboratories

- Fire station
- First-Aid unit
- Security office
- Distributed system control room
- Operating equipment room
- Substations
- Cooling tower
- Flare areas
- Utility plants
- Process areas
- Shipping and receiving areas
- Maintenance shop
- Warehouse
- Cafeterias
- Change house
- Gate houses
- Operators shelters
- Switch gear buildings
- Garages

Land Mobile Radio

The land mobile radio system includes communication between mobile units and hand-held portable radios, as well as with the base stations. It includes or supplements other systems, service the vehicle mobile units, plant operations and maintenance, fire and safety, security, the medical emergency system, and communication with railroad operations.

Local Area Mobile Radio Telephone Service
The radio telephone service is used on an urgent basis to provide automatically switched mobile radio telephone communications between site offices, residences and vehicles.

Radio Paging System
Pocket pager units are used for communication by the radio base station to selected personnel during the three phases.

Security System
This system consists of status and alarm reporting systems connected by multipair cables and is supplemented by land mobile radio and by video monitoring systems.

Telephone Service
The telephone facilities provide dial switching service to fill the mobilization task force requirements, and later are expanded to encompass the needs during the construction and operational phases. The telephone service also allows for long-distance calls to any other place in the country. Teleconferencing channels are included.

Telephone Switching System
The PABX system switches all interplant communications. In addition, the system switches construction and operation computer data traffic and telex and facsimile traffic. It also interconnects direct dial-up capability to the radio paging system.

Cellular Telephone Service
The cellular telephone service is used on an urgent basis to provide automatically switched mobile radio telephone communications between site offices, residences and vehicles.

2.1.1.19 Plant 43 - Distributed Control System And Software

The overall concept for Plant 43, the Distributed Control System (DCS) and operator interface, is to have one central control system, except for shipping and loading facilities. The central control room has four operator consoles, one for each area:

Area 1	Syngas Production
Area 2	F-T Synthesis
Area 3	Upgrading and Refining
Area 4	OSBL

There also will be a supervisory computer and a DCS engineering console. Each area console has three double stacked operator stations for each board operator, plus three added operator stations and two printers. The central control building also contains the racks for the controllers and input/output (I/O) serving process equipment located near the central control building.

The shipping and loading building will contain all of the controllers, I/O and operator interfaces serving those facilities.

Each of four satellite buildings will contain the controllers and I/O for the process equipment surrounding that building. Each satellite will also contain one operator station for process information display to the field operators.

The DCS has been scoped to have a separate logic control network (LCN) highway system for each of the four areas. The sizing of the DCS equipment and reundancy philosophy are the same as used on typical prototypes.

2.1.2 OVERALL CATALYST AND CHEMICAL REQUIREMENTS

The catalyst and chemicals requirements for the entire plant are presented in Table 2-5. It is broken down in accordance with the three main process areas. This table lists both the initial requirements as well as the annual consumptions.

Table 2-5
Overall Catalyst and Chemical Requirements

Catalyst	Plant	Initial Requirement	Annual Consumption
Area 100			
COS hydrolysis	104		11,765 cft/yr
(C53-2-01)		35,296 cft	
Caustic, 25 wt%			5,546 lb/hr
Sulfuric acid, 25 wt%	105		6,032 lb/hr
Amine soln (UCARSOL)	106		47,500 lb/yr
Activated carbon		142,600 lb	17,000 lb/yr
Claus (Kaiser S-201)*	107	8,500 lb	2,556 cft/yr
SCOT catalyst*		12,780 cft	904 cft/yr
2" SS Pall rings*		4,520 cft	580 cft/yr
MDEA*		1740 cft	35 gal/d
Sulfur polishing (ZnO)	108	347 lbl	5,535 cft/yr
Caustic, 25 wt%	109	26,288 cft	4,974 lb/hr
Area 200			
FT Ppt. Fe-catalyst	201	2,302,869 lb	11,514 lb/d
MDEA for CO2 removal	202	1,211,580 lb	302895 lb/yr
Molecular sieve	203	160,000 lb	0
Reformer, C14-2	206	2,825 cu ft	565 cft/yr
Area 300			
UOP LPHC Catalyst	301	229,100 lb	32,730 lb/yr
NiMo Based Catalyst	302	33,940 lb	6,790 lb/yr
NiMo Based Catalyst	303	25,1930 lb	5,0340 lb/yr
UOP Platform Catalyst	304	159,000 lb	47,900 lb/yr
3A Molec. Sieve	305	4040 lb	810 lb/yr
Englehard Isom. Catalyst		11,030 lb	2210 lb/yr
1" Raschig Rings Pack		180 ft3	0 ft3/yr
Carbon Tetrachloride		11,030 lb	1330 lb/yr
Caustic		240 lb	140 lb/yr
KOH		810 lb	5 lb/yr
3A Molec Sieve	306	8140 lb	1630 lb/yr
Englehard Isom. Catalyst		44,530 lb	8910 lb/yr
1" Raschig Rings Pack		195 ft3	0 ft3/yr
Carbon Tetrachloride		12,210 lb	150 lb/yr
Caustic		268 lb	165 lb/yr
KOH		895 lb	5 lb/yr
H2SO4 (98.5 wt%)	307	910 ton	37160 ton/yr
Caustic (100% NaOH)		5320 lb	311490 lb/yr

* Prorate from the Direct Baseline Study.

2.1.3 OVERALL PLANT LABOR REQUIREMENTS

The overall staffing plan for the Fischer-Tropsch indirect liquefaction complex is based on the following assumptions:

- The complex is operated by a major oil company with support from corporate engineering.
- The complex is divided into four areas with dedicated operating and maintenance labors for each area.
- Contract maintenance will be utilized during any plant turn-around and other non-routine maintenance.
- The complex is operated from one central control house, except for shipping and loading.

Detailed breakdowns in manpower requirement for the overall plant were prorated from the Direct Liquefaction Study.

2.2 ALTERNATIVE REFINING CASE

Preliminary design basis for the alternative refining case and the correlation development to predict ZSM-5 conversion and yield were discussed in Quarterly Report Number 3 (April-June 1992), Section 6.2. Modification of the ASPEN/SP code to include the ZSM-5 reactor has been completed.

The design of the plants in the Syngas Preparation Section remain identical in the Alternative Refining Case to those in the baseline case. Only the plants in the F-T synthesis loop and downstream processing areas are impacted, and many of these plants will be capable of proration.

2.3 WESTERN COAL ALTERNATIVE CASE

Detailed process design information for Area 100 of the Western Coal Alternative Case were reported in Quarterly Report Number 5 (October-December 1992). No further work is planed for this case study until the third quarter of 1993.

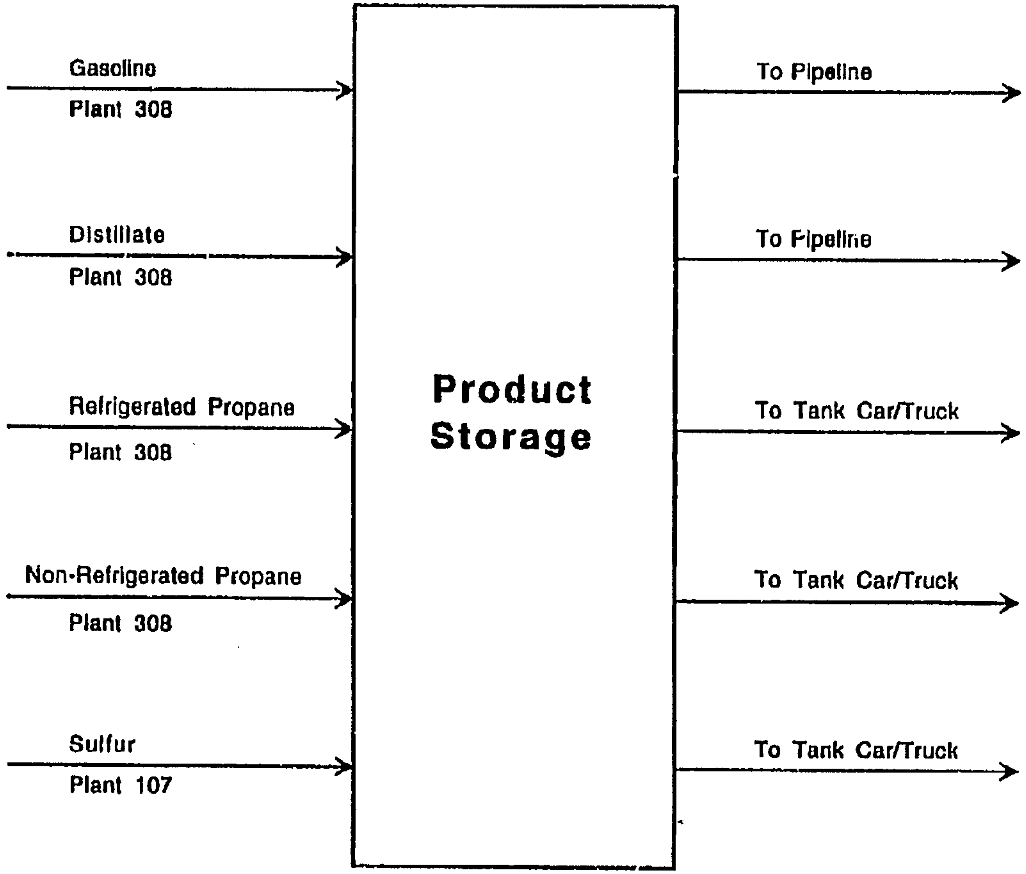


Figure 2-1 Block Flow Diagram - Plant 20 (Product Storage)

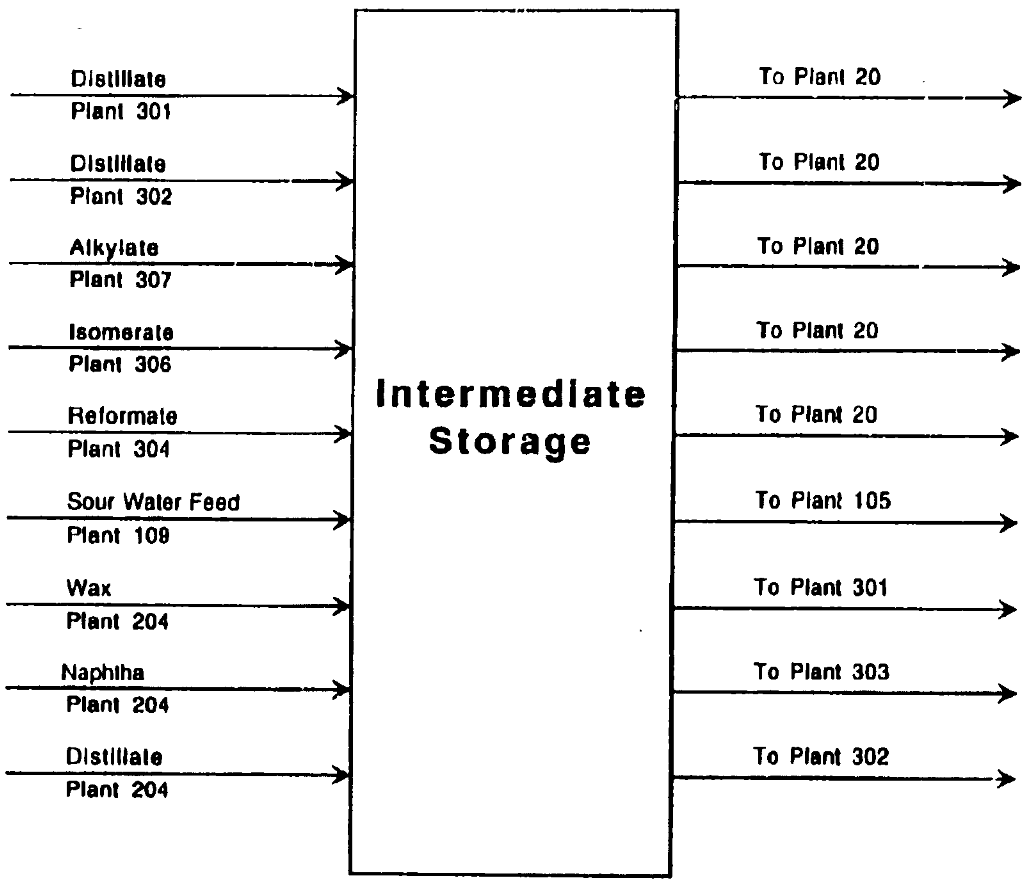


Figure 2-2 Block Flow Diagram - Plant 20 (Intermediate Storage)

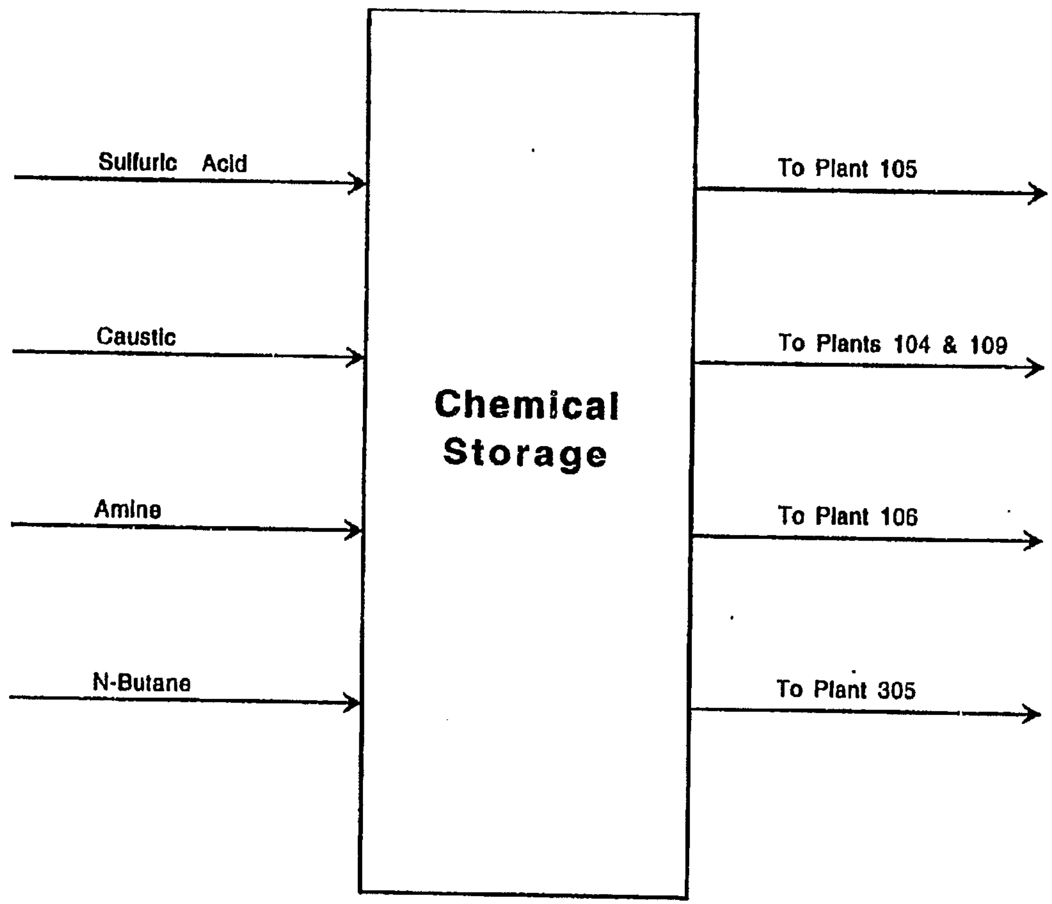
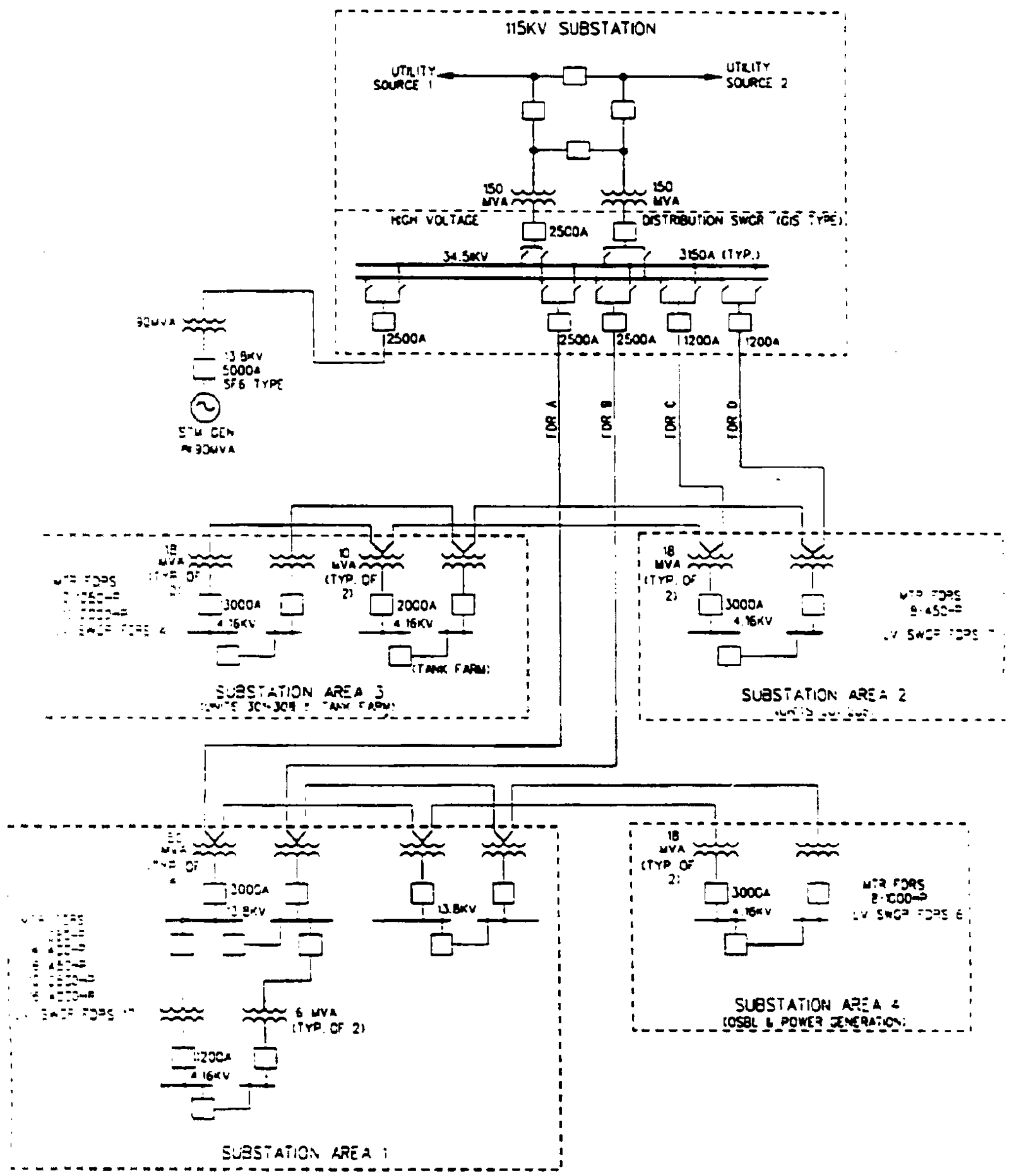


Figure 2-3 Block Flow Diagram - Plant 20 (Chemical Storage)



NOTES:

1. TRANSFORMER LISTED MVA IS TOP RATING
2. LV FEEDERS ARE BASED ON 2.0MVA
3. MEDIUM VOLTAGE MOTOR ASSUMED @ [illegible]
4. 13.8KV BUS MOTORS ≥ 2500HP
5. 4.16KV BUS MOTORS ≥ 350HP AND ≤ 2000HP

INDIRECT COAL LIQUEFACTION
BASELINE DESIGN

SINGLE LINE DIAGRAM

Figure 2-4

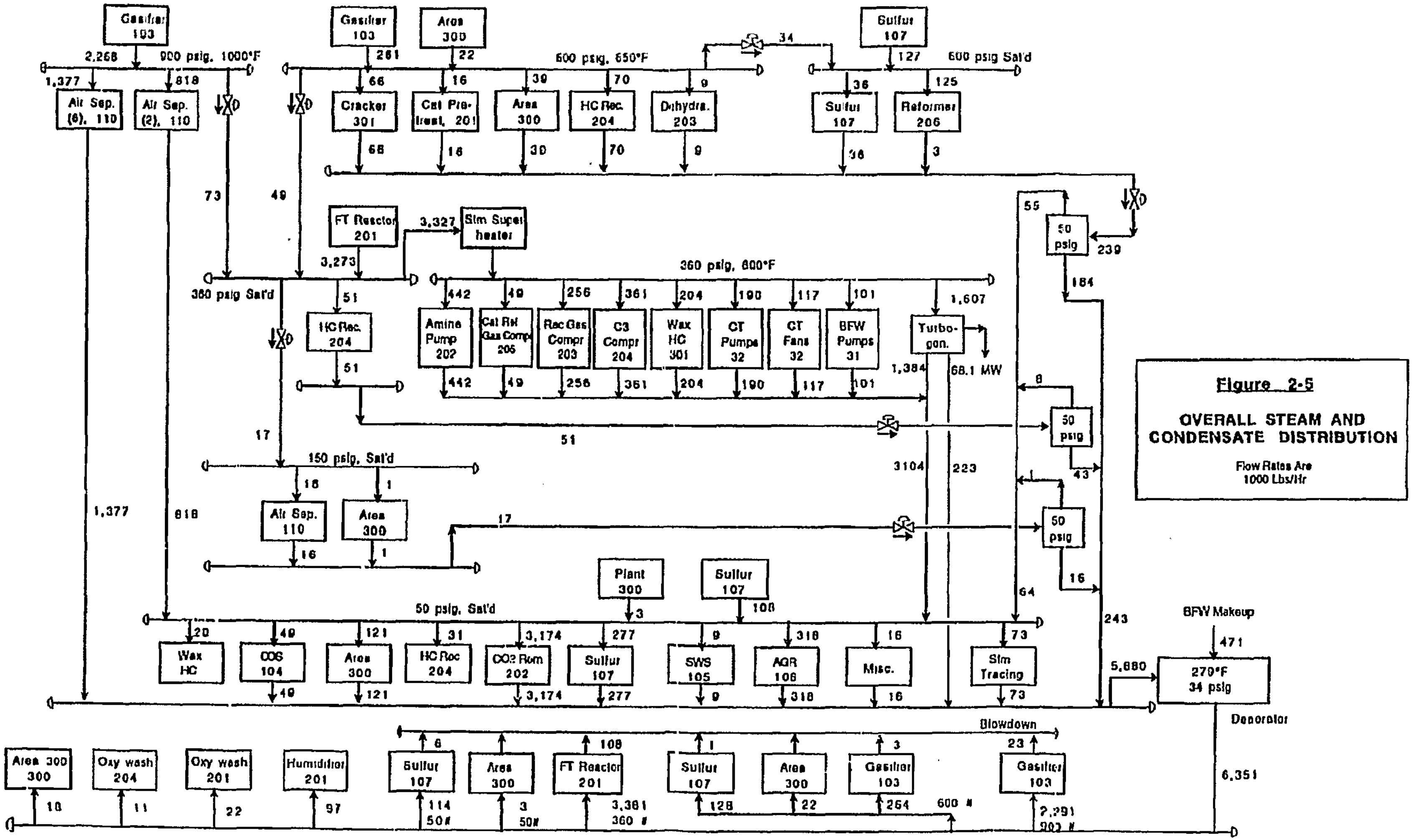


Figure 2-5

OVERALL STEAM AND CONDENSATE DISTRIBUTION

Flow Rates Are 1000 Lbs/Hr

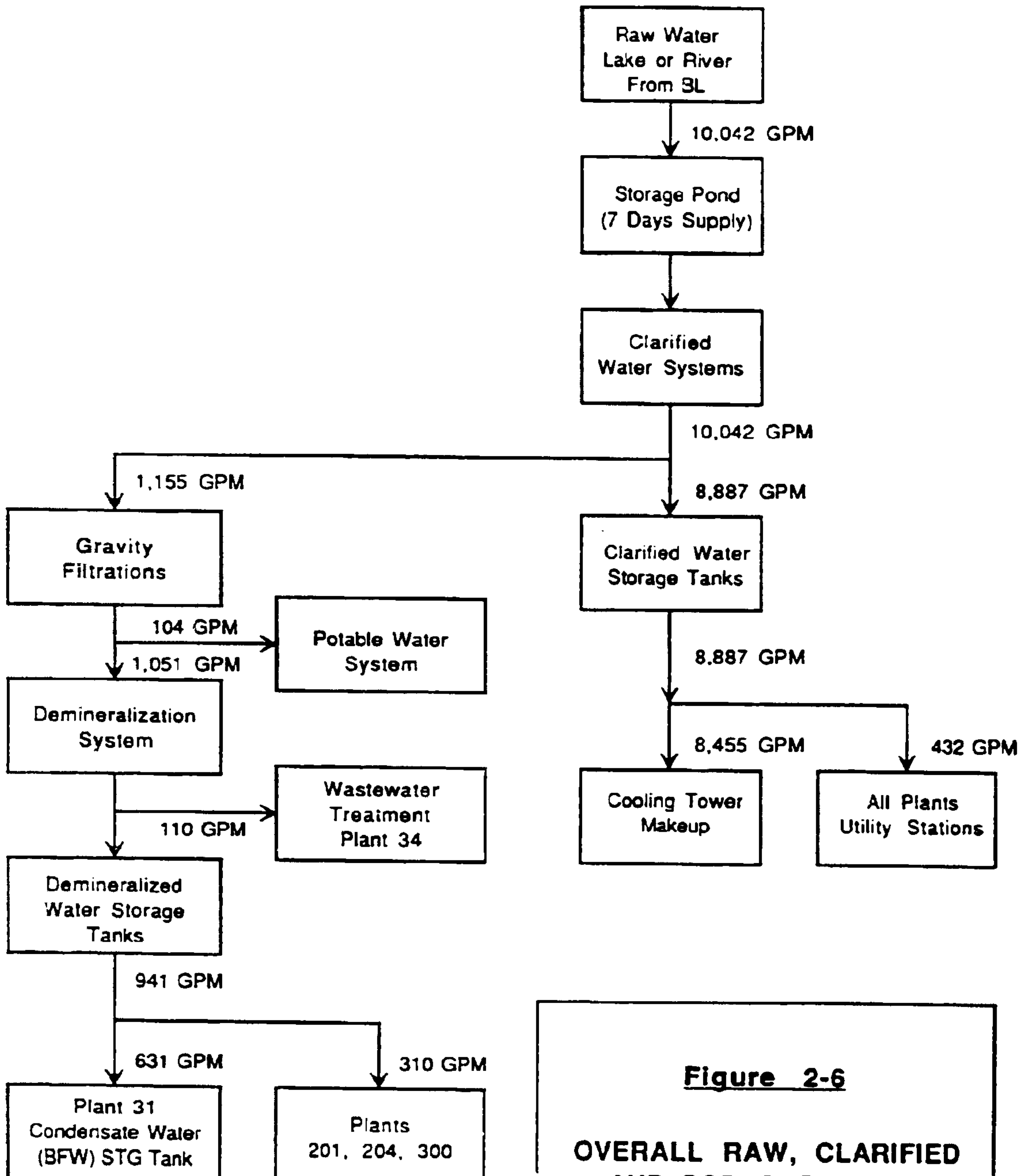


Figure 2-6

OVERALL RAW, CLARIFIED AND POTABLE WATER DISTRIBUTION

Note: Flows are for normal operation.

Clarifier System Package	
32-Z1A/B Clarifiers (2)	32-D4 Alum Day Tank
32-D5 Polymer Day Tank	32-G4A/B Alum Feed Pumps (2)
32-D1 Rapid MixTank	32-G2A-D Clarifier Sludge Recycle Pumps (4)
32-G5A/B Polymer Feed Pumps (2)	32-G3A-D Filter Press Sludge Feed Pumps (4)
32-Z9A/B Sludge Filter Press (2)	

32-D6
Cake Storage Bin

32-G9A-C
Raw Water Intake Pumps (3)

32-G10A-C
Clarified Water Stg. Feed Pumps (3)

32-G13A/B
Potable Water Pumps (2)

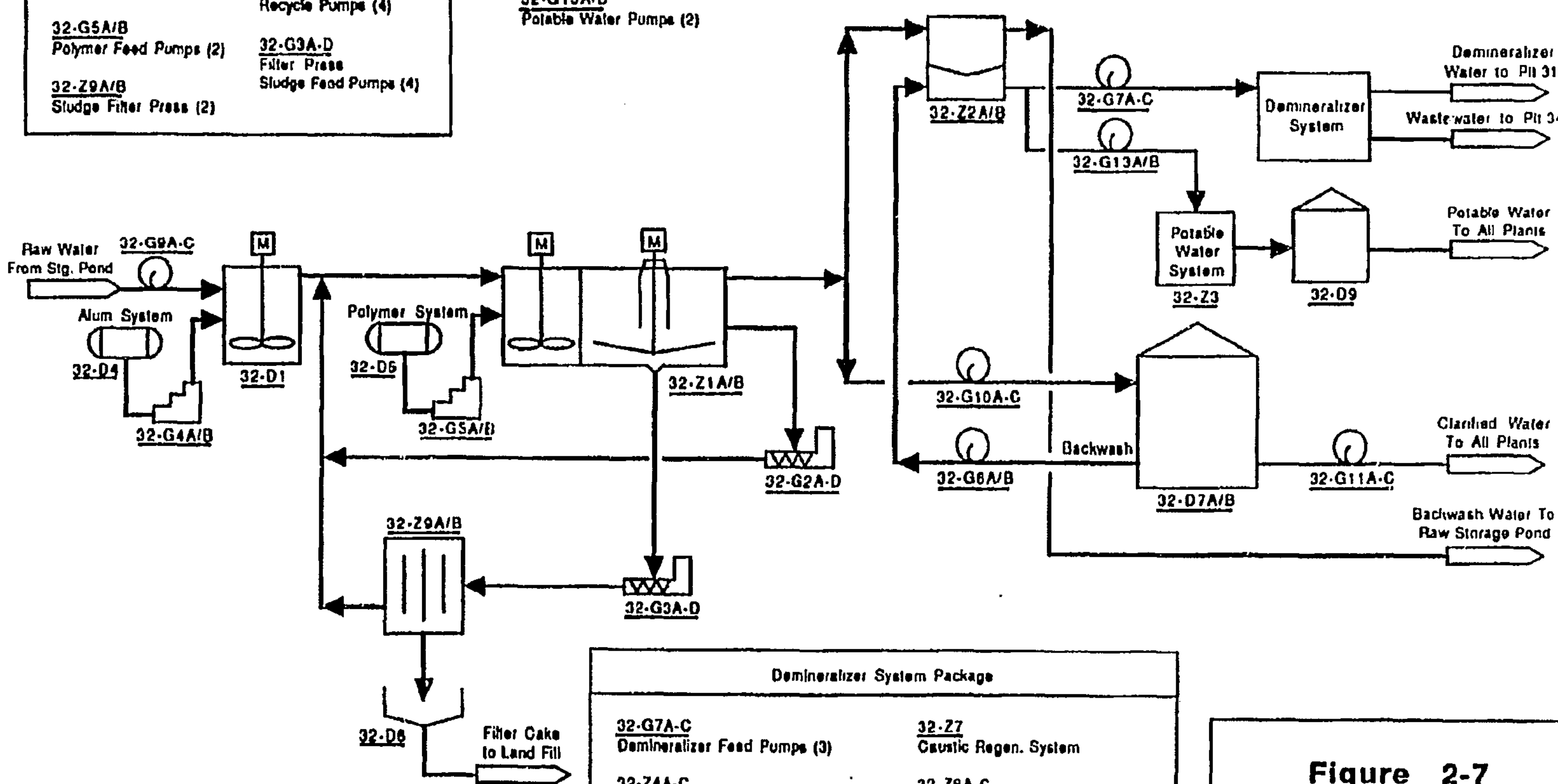
Filtration System Pkg
32-Z2A/B Gravity Filters (2)
32-G6A/B Gravity Filter Backwash Pumps (2)

Potable Water System Pakage
32-Z3 Potable Water Chlorinator

32-D9
Potable Water Storage Tank

32-D7A/B
Clarified Water Stg. Tanks (2)

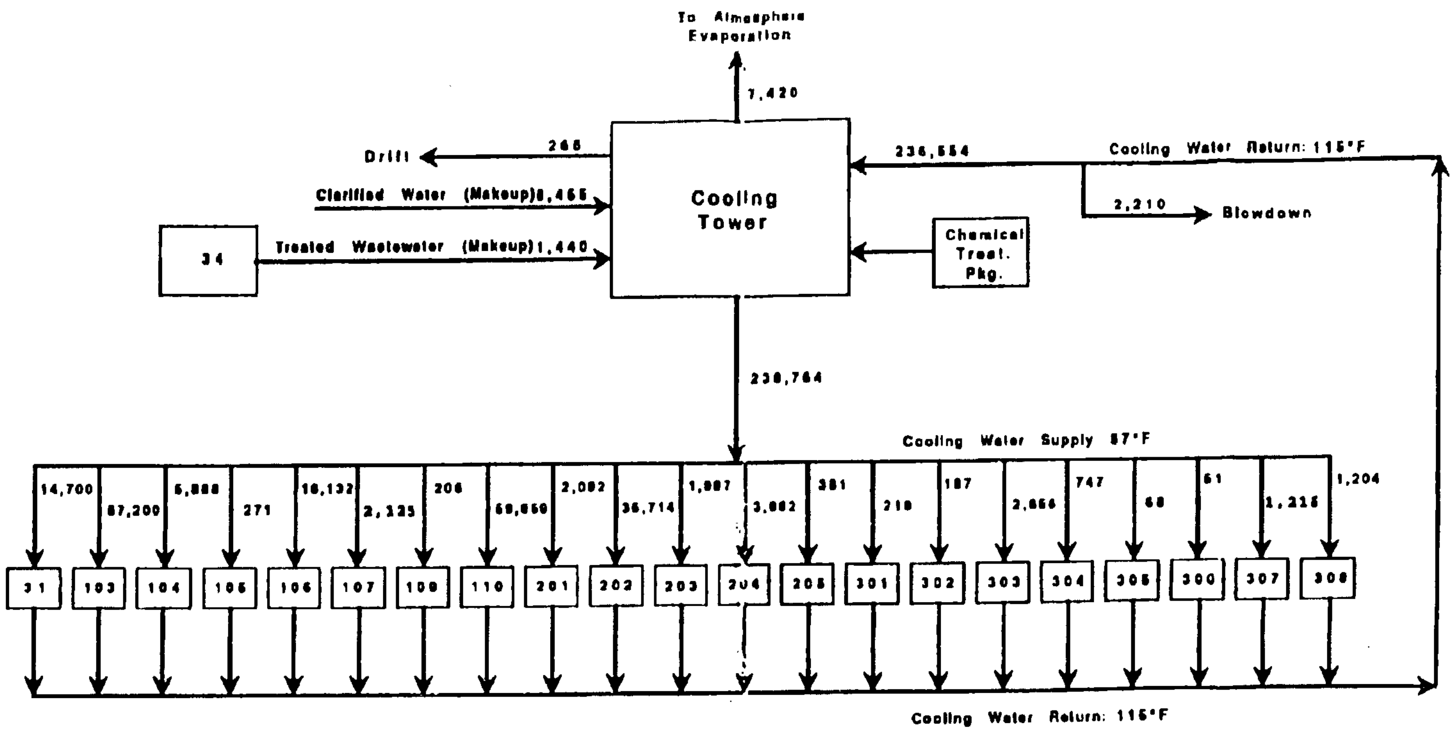
32-G11A-C
Clarified Water Trans. Pumps (3)



Demineralizer System Package	
32-G7A-C Demineralizer Feed Pumps (3)	32-Z7 Caustic Regen. System
32-Z4A-C Strong Acid Cation Exch. Systems (3)	32-Z8A-C Mixed Bed Polishers (3)
32-Z5A-C Strong Base Anion Exch. Systems (3)	32-K1 Forced Draft Degasifier
32-Z6 Acid Regen. System	32-G8A-C Degassified Water Trans.Pumps (3)

Figure 2-7

RAW WATER TREATMENT PLANT 32



Notes:
1. Flows are for normal operation and in GPM
2. Plant Number in the Box

Figure 2-8

COOLING WATER BALANCE
PLANT 32

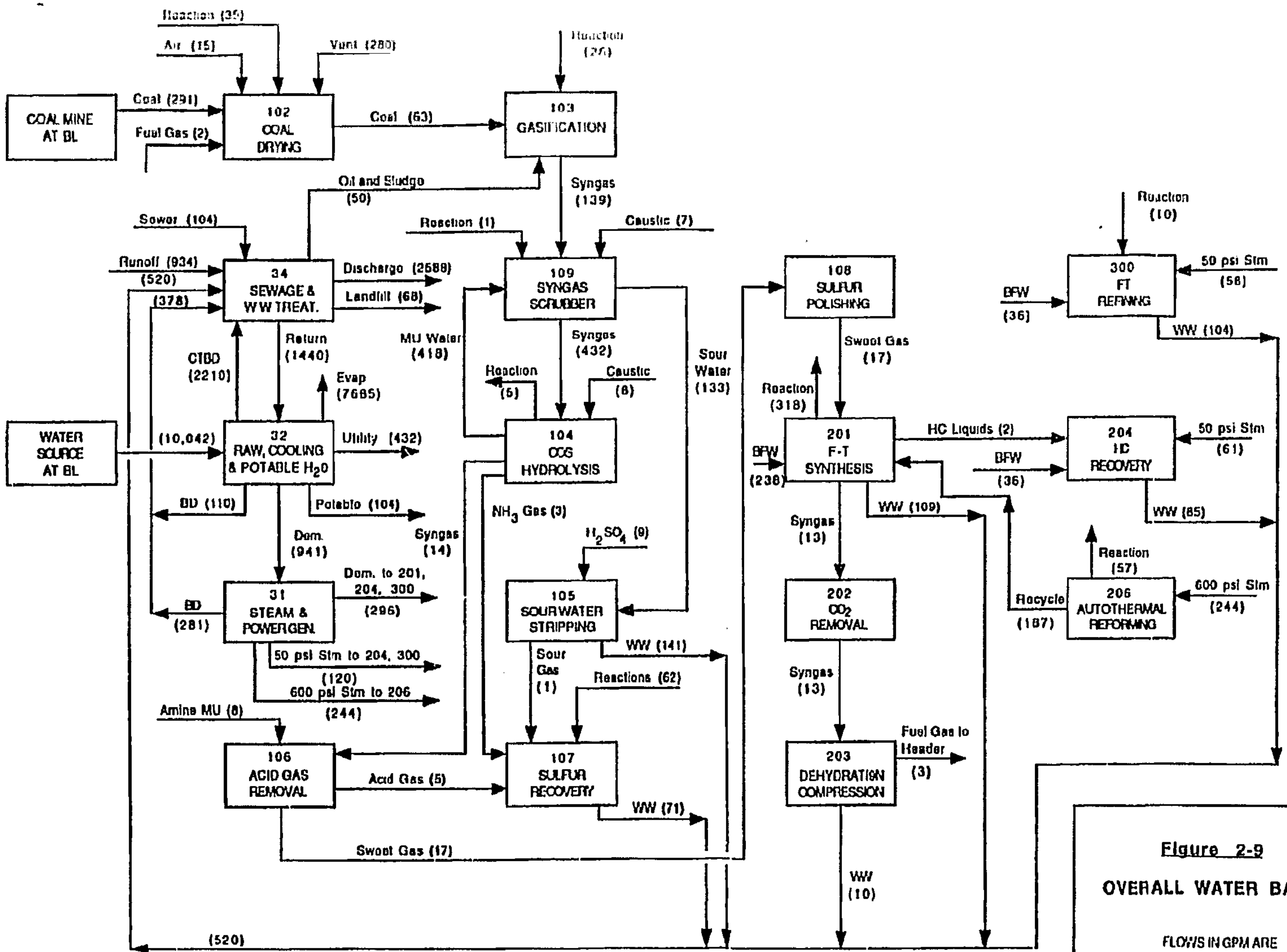


Figure 2-9

OVERALL WATER BALANCE

FLOWS IN GPM ARE IN PARENTHESIS

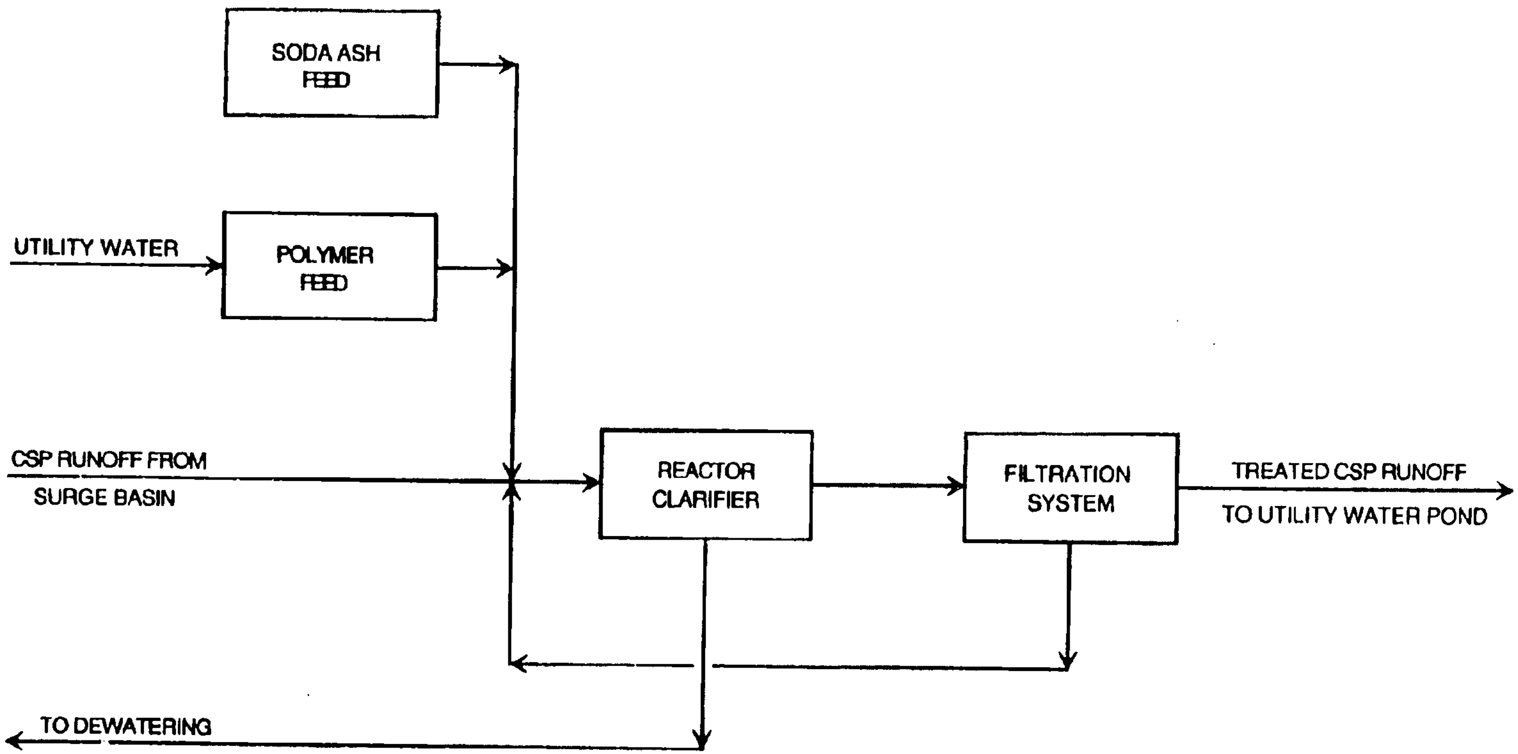


Figure 2-10 Block Flow Diagram - CSP Runoff Treatment

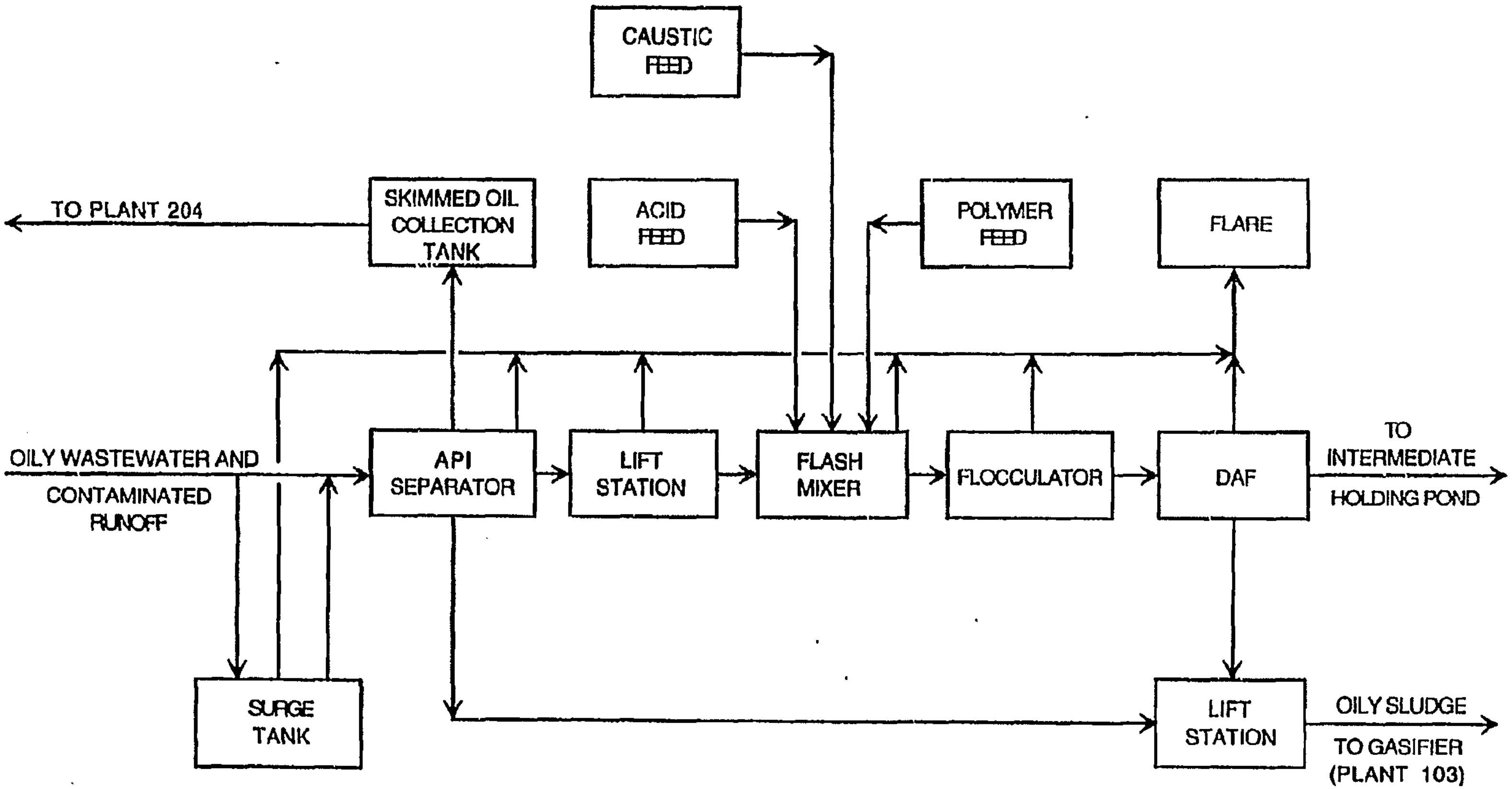


Figure 2-11 Block Flow Diagram - Oily Water Treatment System

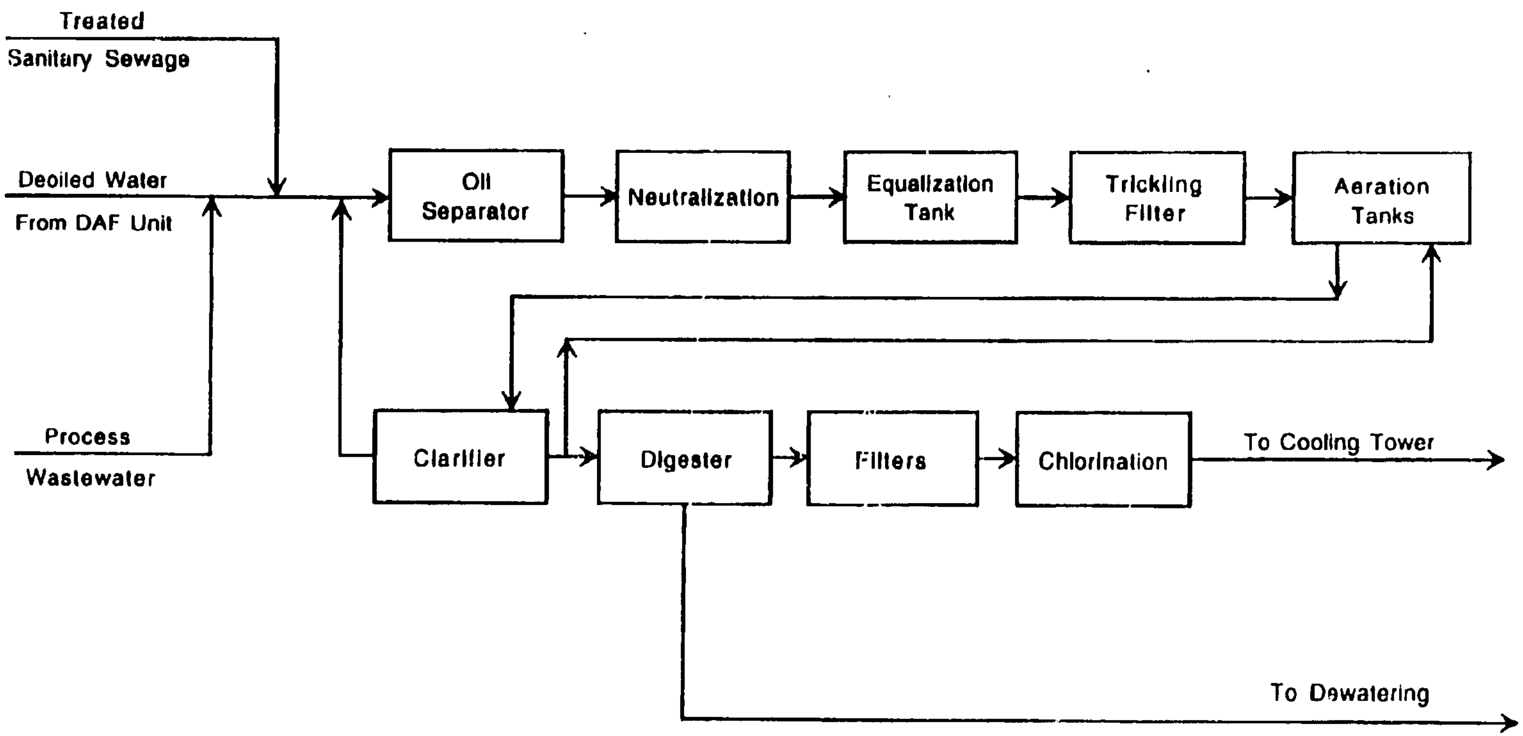


Figure 2-12 Block Flow Diagram - Process Wastewater Treatment

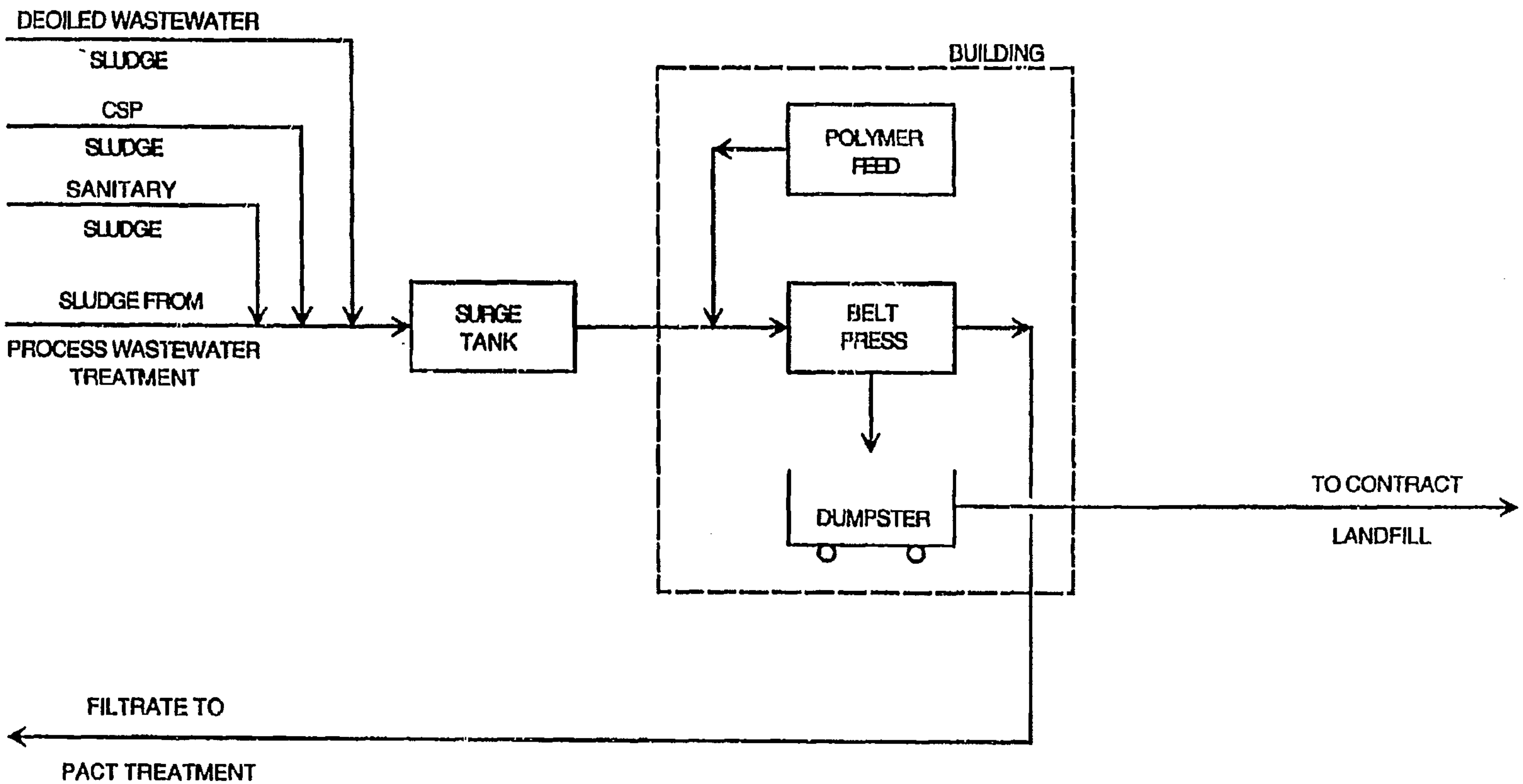


Figure 2-13 Block Flow Diagram - Solids Dewatering

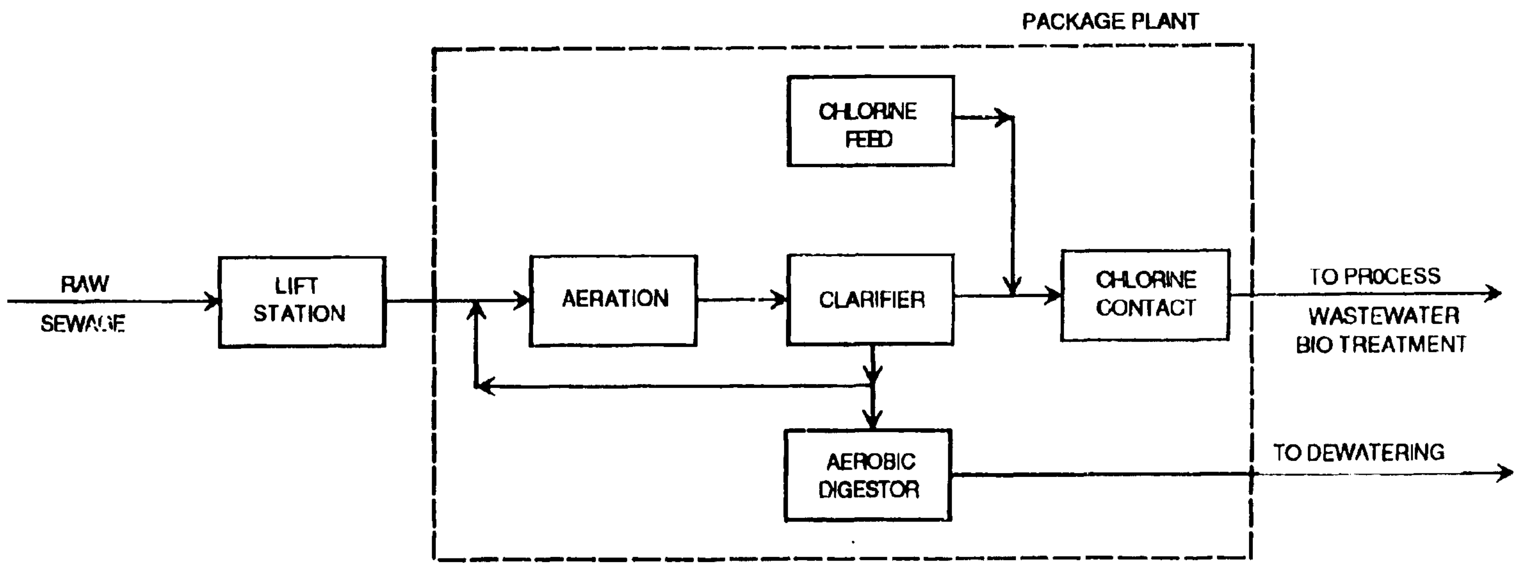


Figure 2-14 Block Flow Diagram - Sanitary Sewage Treatment

Section 3

Task 4 - Simulation Model Development

Previous quarterly progress reports described the development of a preliminary process simulation model for the Area 100 syngas production section of the plant, an equilibrium gasifier model, and a preliminary Fischer-Tropsch reactor loop (Area 200) model. During this quarter, two individual Fischer-Tropsch reactor loop models were expanded and enhanced, an overall Area 300 product refining section model was developed, and a Lotus spreadsheet economics model was developed.

3.1 BASELINE ASPEN/SP MODEL

3.1.1 Area 100 Syngas Production Area

The integrated ASPEN process simulation model for Area 100, the syngas production area, was tuned to match the utilities reported at the March 4th technical progress meeting at San Francisco.

3.1.2 Area 200 Fischer-Tropsch Reactor Loop Model

Plant 201, The Fischer-Tropsch Reactor Model

The Fortran user block model for the Fischer-Tropsch reactor was expanded and enhanced by allowing a variable wax yield between 9.6 and 76 wt%. Previously, the model was only capable of predicting yields at the baseline design wax yield of 50 wt% wax. The wax yield correlation described in the Second Quarterly Report for January-March, 1992 was implemented in such a manner so that the user can now specify a desired wax yield within the allowable range.

Implementation of the above described wax yield correlation was not straight-forward because the alpha parameter that is generated by it does not exactly produce the desired wax yield. This problem was overcome by adding a second correlation to correct the originally calculated alpha so that the desired wax yield is obtained.

Because the Fischer-Tropsch reactor temperature controls the wax yield, the specification of the wax yield indirectly specifies the reactor temperature. Thus, the Fischer-Tropsch reactor temperature is calculated from the wax yield by the following equation.

$$T = 275 - 0.4375 * WAX$$

where T is the Fischer-Tropsch reactor temperature in degrees Celsius, and WAX is the wax yield in wt%.

In addition, the C7 through C19 olefin/paraffin pseudocomponents were separated into individual 1-olefin and n-paraffin pure components to allow specification of variable olefin/paraffin molar ratios and allow a better ZSM-5 reaction model for Plant 207. The previous olefin/paraffin pseudo-component procedure only allowed for a single olefin/paraffin ratio since a single value had to be assumed for the calculation of the pseudo-component properties. Now the user specifies a single molar olefin/ paraffin ratio for the C7 through C19 hydrocarbons. In the future, the model may easily be enhanced to allow specification of the olefin/paraffin molar ratio as a function of carbon number.

Plant 207, The ZSM-5 Reactor Model

The Fortran user block model for the ZSM-5 oligomerization reactor model was explanded to allow for the additional olefin and paraffin components that were added to the Fischer-tropsch reactor model. This revision was necessary so that this model would recognize and convert these components as appropriate.

3.1.3 Area 300 Product Refining Section Plant Models

The simplified Fortran user block models that were developed during the last quarter were combined into a preliminary ASPEN simulation model of the product refining section. Figure 3-1 is the ASPEN block flow diagram for this model of the product refining section.

Plant 301, the wax hydrocracker, is modeled by blocks P301M and block P301F. The wax feed stream, 204S24, is mixed with a make-up hydrogen stream, 300S1, in the feed mixer, block P301M, to produce stream 300S6 which goes to the Fortran user block model, block P301F. There are five product streams, a C4 and lighter gas stream (stream 301S1) which goes to the saturated gas plant, a C5 and C6 stream (stream 301S2) which goes to the C5/C6 isomerization plant, a naphtha stream (stream 301S3) which goes to the naphtha reformer, a distillate stream (stream 301S4) which goes to the diesel pool, and a sour water stream (stream 301S5). Not shown in the diagram is Fortran control block SETUP301 which sets the makeup hydrogen flow rate in stream 300S1 as a function of the flow rate of wax feed stream.

Similar modeling techniques are used for Plant 302 (the distillate hydrotreater), Plant 303 (the naphtha hydrotreater), Plant 305 (the C4 isomerization plant), and Plant 306 (the C5/C6 isomerization plant). Each plant has a Fortran control block which sets the flow rate of the makeup hydrogen going to that plant as a function of the flow rate of the hydrocarbon feed stream.

Because the Fischer-Tropsch reaction section does not make sufficient butanes to alkylate all the C3, C4 and C5 olefins that are produced, additional butanes are purchased and sent to Plant 305 in stream 300S4. Fortran control block SETUP307 sets the makeup butanes flow rate in stream 300S4 to that required to alkylate the olefins. Because of the interaction of Plant 307 with Plants 305 and 308, a convergence block around these three plants is required to converge all the streams within this loop.

Plant 304, the naphtha reformer, has two feed streams, streams 301S3 and 303S3. It produces three product streams, a reformate product stream (stream 304S1) which goes to gasoline blending, a C3 and C4 gas stream (stream 304S3) which goes to the saturated gas plant, and a C2 and lighter gas stream (stream 304S2) which will be recycled back to Plant 205. The recycling of this hydrogen rich stream back into the Fischer-Tropsch recycle loop has two advantages; first, a purer hydrogen stream is produced by the PSA unit, and second, the rejected hydrocarbons are converted back to syngas in the autothermal reformer.

Plant 308, the saturated gas plant, is modeled by three ASPEN mixing blocks, a simple user Fortran block model which predicts the plant cost and utilities consumptions, and an ASPEN separator SEP block. This separator block generates the three light product streams; the C2 and lighter fuel gas stream, the C3 LPG stream, and a butanes stream which is recycled back to the C4 isomerization plant. Two of the ASPEN mixing blocks combine the gasoline and diesel streams produced by the other plants into the finished product streams.

A separate subroutine was written that estimates the properties of the blended gasoline and diesel streams. This routine calculates the Research octane, motor octane, RM/2 octane, Reid vapor pressure, specific gravity, benzene content, aromatics content, and elemental composition of the gasoline. Linear blending models are used for all properties except the Reid vapor pressure. Octanes are blended using blending octane values. This routine also calculates the pour point, cetane index, specific gravity and elemental composition of the diesel product by linear blending.

Another Fortran subroutine was prepared to write the process simulation model results to a small ASCII output file for transfer to the LOTUS spreadsheet economics model. This ASCII output file is called ICL.PRN. It contains the flow rates of all the major input streams, output streams, byproduct streams, the total number of operators and maintenance workers, total installed capital cost, and the annual catalyst and chemicals cost. This file can be imported directly into the LOTUS spreadsheet economics model to simplify the economic evaluation procedure.

3.2 LOTUS SPREADSHEET ECONOMICS MODEL

General Description of the Model

A LOTUS 2.2 spreadsheet economics model was developed to analyze the economics of various coal liquefaction process scenarios using the output generated by the ASPEN process simulation model. This economics model does detailed discounted cash flow calculations using the flowrates, utilities, labor, and total capital information output from the ASPEN process simulation model to allow the user to study the economic sensitivities of the economic and technical parameters discussed below.

The LOTUS 2.2 economics model is a two-dimensional spreadsheet into which the user imports an ASCII file generated by the ASPEN coal liquefaction process simulation model. The ASPEN model output file thus becomes an input for the LOTUS spreadsheet economics model, and along with other user controlled input parameters, drives the calculation of operating costs, capital costs, and revenues. These parameters are escalated as specified by user input parameters to generate a cash flow summary including the calculations of revenues, expenses, capital costs, depreciation, taxes, cash flows, internal rate of return, and net present value. Highlights of the cash flow summary are reported. These results allow the user to perform manual iterations to achieve, for example, a required rate of return or to check the sensitivities of various parameters on the project economics.

Figure 4.1 shows the layout of the LOTUS economics spreadsheet model.

The INPUT section at the top of the spreadsheet contains the results generated by the ASPEN model for a particular run (imported from the ASPEN output file), a series of default economic parameters which can be overridden by the user, a set of user specified economic parameters, and a small set of fixed parameters as required by the spreadsheet structure.

The project summary section of the model reports selected basis information and spreadsheet calculation results. The basis information consists of base year, base year coal, natural gas, electricity, product and byproduct prices, and total initial installed capital. Product and major byproduct prices (butanes and LPG) may be supplied as current prices which are escalated with time, as a syncrude premium factor (i.e., the ratio of the value relative to the reference crude oil price), or as a delta from the reference crude oil price. The calculated results are the crude oil equivalent price and the cost of production, both at the specified rate of return.

Finally, the indicators that may be of key interest in evaluating project economics are reported, the discrete and continuous internal rates of return (IRR), and the 15% IRR net present values.

The cost calculations section of the model calculates and reports costs and revenues based on default or user specified year-by-year escalation factors. Separate escalation factors are included for general inflation, cost of construction, and the prices for coal, oil and natural gas. The operating costs consist of variable operating costs (coal, butanes, other feedstocks, and utilities), and fixed operating costs (labor, sales, administration, research, taxes, maintenance, and insurance). Revenues derive from the sale of the primary liquid hydrocarbon products (gasoline and diesel), and the by-products (liquid propane, sulfur, and others).

The cash flow summary section of the model calculates total revenue (product revenues plus earned interest), total expenses (owner's, variable, fixed, and loan interest costs), gross income (total revenue minus total expenses), total capital costs (equity, sustaining, and working capital), imputed interest and depreciation of capital investments (according to 1986 Tax Reform Act and IRS Code #263A), taxable income (gross income plus imputed interest minus depreciation), state income tax on taxable income, federal income tax on taxable income minus state income tax credit, cash flow in each year, discrete rate of return, and discrete net present value at a 15% discrete IRR. The cash flow summary also contains totals of certain items to allow for verification of the calculations.

The ASPEN simulation model creates a data file containing eighteen flowrate, utilities, labor, and total capital parameters which may be imported into the LOTUS 2.2 spreadsheet economics model.

Figure 3-1
ASPEN/SP Model Flow Diagram for Area 300

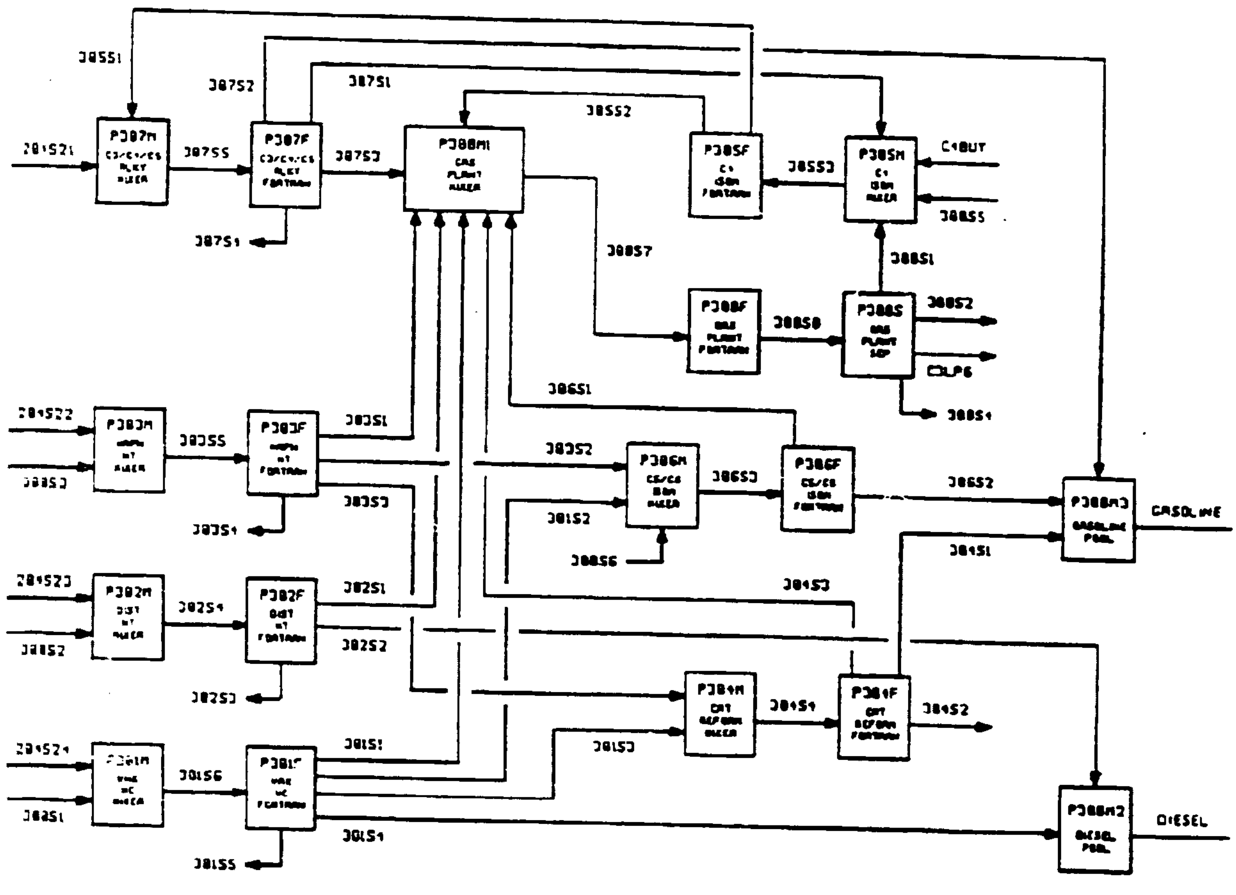
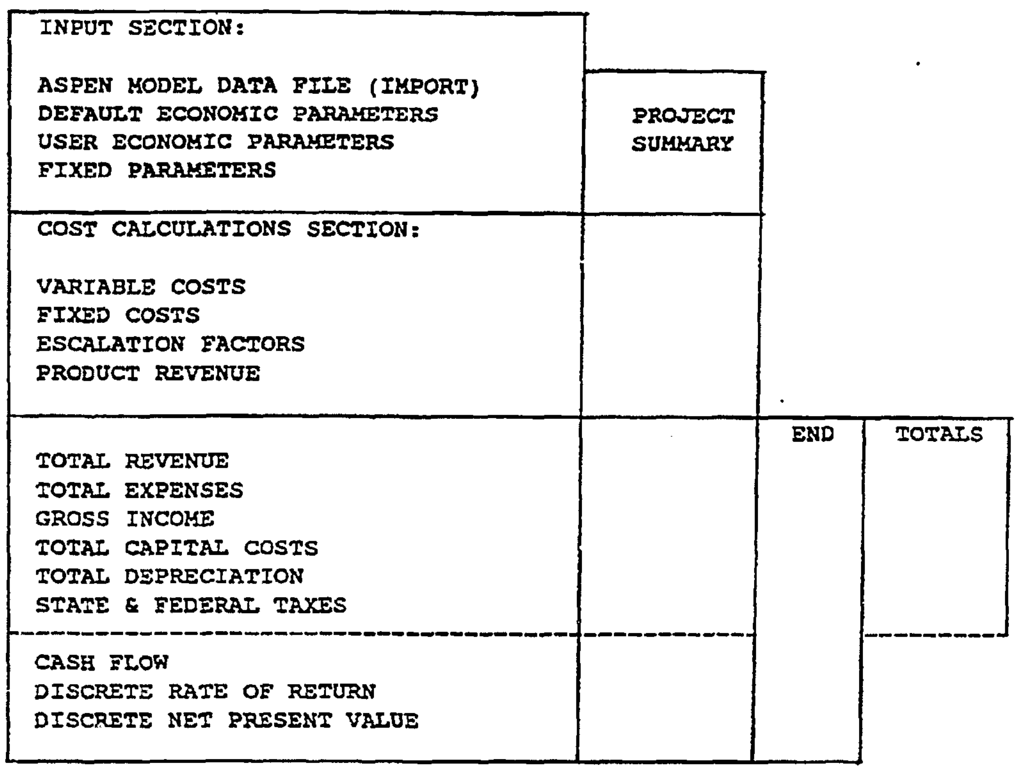


Figure 3-2
Layout of LOTUS Economics Model Spreadsheet



Section 4

Project Management & Staffing Report

4.1 TASK 7 - PROJECT MANAGEMENT

During this reporting period, cost and schedule control was the primary activity. A paper on power and coal liquid coproduction is being prepared for the 18th International Technical Conference on Coal Utilization and Fuel Systems at Clearwater, Florida.

4.2 KEY PERSONNEL STAFFING REPORT

The key personnel staffing report for this reporting period as required by DOE/PETC is shown below:

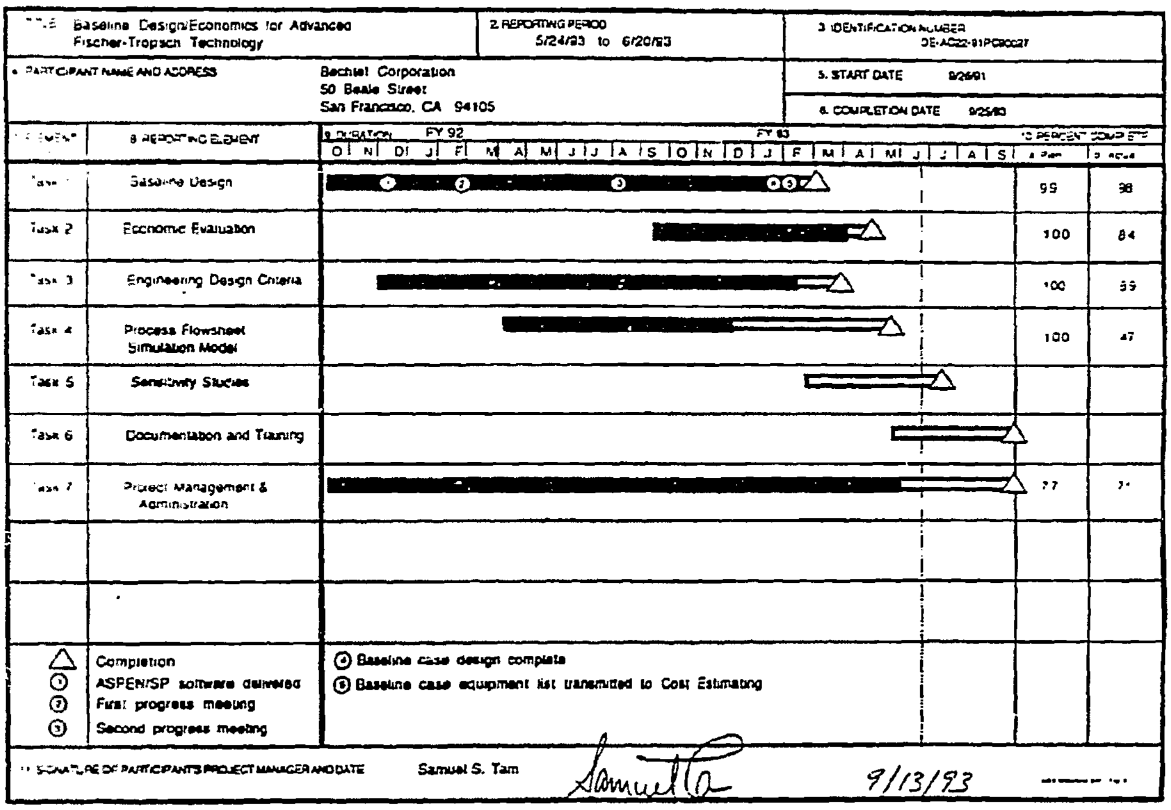
Name	Function	% Time Spent[a]
Bechtel		
Yang L. Cheng	Process Supervisor	80
Samuel S. Tam	Project Manager	31
Amoco		
R.D. Kaplan	Subcontract Manager	5

(a) Number of hours spent divided by the total available working hours in the period and expressed as a percentage.

Figure 4-1

Overall Milestone Schedule

(as of June 21, 1993)



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