Methanol Refining

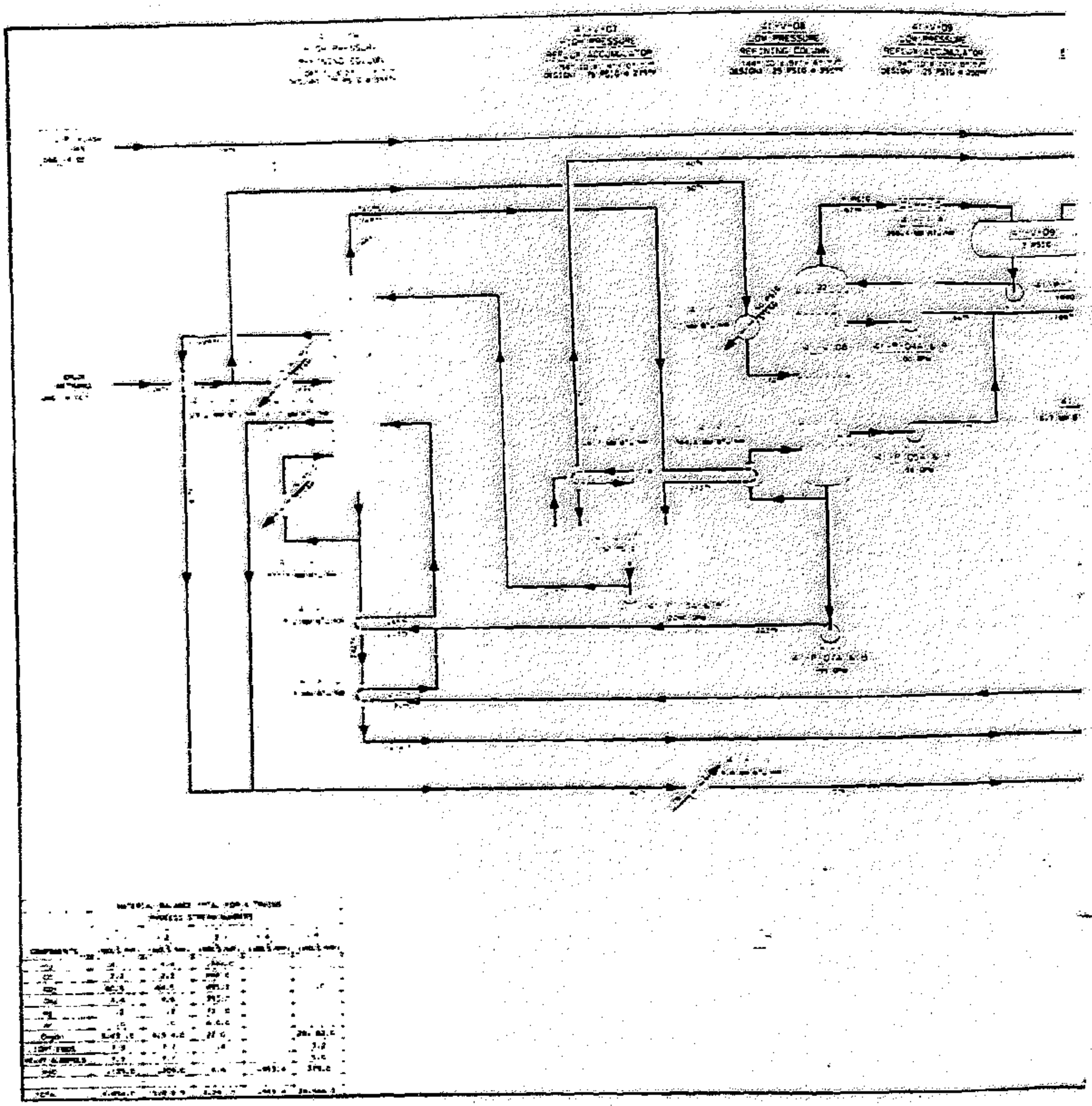
Crude methanol from the synthesis unit is refined to fuel grade methanol product (99+ weight percent) in the methanol refining unit, consisting of four independent processing trains. Each train uses an energy-saving two-pressure two-column fractionation system in which the high-pressure column overheads reboils the low-pressure column bottoms, thereby significantly reducing the total steam requirements for the unit. A water wash column is included to recover methanol from the fuel gas supply stream. The methanol refining unit is shown in Process Flow Diagram 4-008.

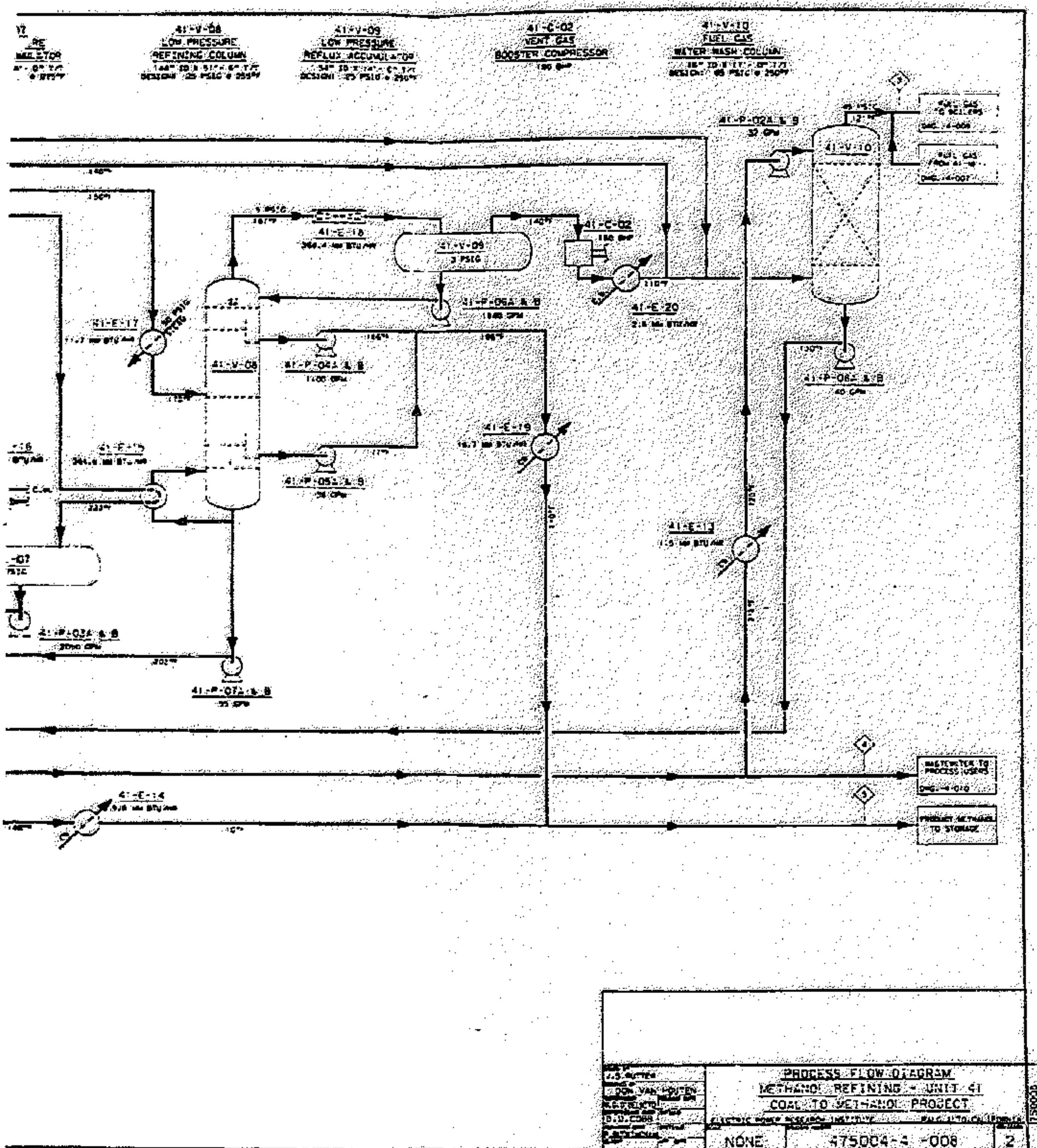
The crude methanol enters the unit and is preheated by exchange with the high-pressure column methanol product. This stream is then split into two streams, supplying feed to both the high-pressure and low-pressure columns.

The high-pressure column processes approximately one-half of the crude methanol, supplies reboiler heat to the low-pressure column and strips methanol from the water present in the feed streams. Crude methanol feed to this column is preheated further by 50 psig steam. An additional feed, the bottoms from the low-pressure column mixed with the fuel gas water wash column return water, is preheated by exchange with the high-pressure column bottoms. Reboiler heat is supplied by 100 psig steam. The high-pressure column bottoms stream consists of water containing only trace amounts of alcohols. A portion of this bottoms stream is used for fuel gas wash water and the remainder is sent to the coal grinding circuit. The column overhead stream is condensed by reboiling the low-pressure column, then flows to the high-pressure column reflux accumulator. The accumulator provides an outlet for noncondensible gases, which are drawn off, cooled, and sent to the water wash column. Reflux is returned to the column. Methanol product is withdrawn two trays below the top of the column to provide a product containing only traces of dissolved gases. To avoid a buildup of higher alcohols, a purge system is provided. A small stream is withdrawn below the feed point where the higher alcohols tend to concentrate. This purge stream is blended with product.

The low-pressure column processes approximately one-half of the crude methanol. Additional feed preheat is supplied by 50 psig steam while reboil heat is supplied by high-pressure column overheads. The column bottoms stream, containing water and about twenty-five percent methanol, is sent to the high-pressure column for further stripping of methanol. The column overhead stream is condensed in an air cooler and collected in the reflux accumulator. Noncondensible gases are drawn off the accumulator, compressed by a reciprocating compressor, cooled, and sent to the water wash column. Reflux is returned to the column. Methanol product is withdrawn, two trays below the top of the column, to provide a product containing only traces of dissolved gases. Higher alcohols tend to concentrate in the middle of the tower and are provided an outlet at a point below the feed tray. This higher alcohols purge stream joins the methanol product stream. The combined product stream is cooled with cooling water and sent to product storage.

Flash streams from the methanol synthesis unit low-pressure flash, the high-pressure column reflux accumulator, and the low-pressure column reflux accumulator are combined and sent to the water wash column. The wash column is a packed column using cooled high-pressure column bottoms to recover methanol from the flash gases. Overhead gases are collected in the fuel gas surge drum, while bottoms liquids are returned to the high-pressure column.


HIGH PRESSURE
REFLUX ACCUMULATOR
LOW PRESSURE
REFINING COLUMN
DESIGN 25 PSIG
LOW PRESSURE
REFLUX ACCUMULATOR
DESIGN 25 PSIG
PROCESS STREAM NUMBER


41-V-08
LOW PRESSURE
REFINING COLUMN
41-V-09
LOW PRESSURE
REFLUX ACCUMULATOR
41-C-02
VENT GAS
BOOSTER COMPRESSOR
41-V-10
FUEL GAS
WATER WASH COLUMN
41-P-02A & B
32 GPM
41-V-10
41-E-18
41-V-09
3 PSIG
41-C-02
41-E-20
41-E-17
41-V-08
41-P-06A & B
41-P-04A & B
1400 GPM
41-E-19
41-P-08A & B
40 GPM
41-E-15
41-P-05A & B
41-E-13
41-P-03A & B
41-P-07A & B
41-E-14
PROCESS FLOW DIAGRAM
METHANOL REFINING - UNIT 41
COAL TO METHANOL PROJECT
D.D.COBB
NONE
475004-4 -008
2
150030

UNIT 51 - EMISSION CONTROL SYSTEMS

Claus Sulfur Plant

This plant is a conventional two-stage Claus plant for converting H_2S to elemental sulfur. The chemistry involves the combustion of one-third of the H_2S to SO_2, followed by the reaction of two moles of H_2S with one of SO_2 to form elemental sulfur over a catalyst which may be activated alumina or bauxite. Elemental sulfur is produced as a liquid, then converted to flakes for shipment.

Sulfur Plant Tail Gas Treating Unit

This unit reduces the sulfur content of the Claus plant tail gas stream to an environmentally acceptable level and produces additional sulfur product.

The Beavon process is employed to achieve very low levels of residual sulfur species. The first step involves catalytic hydrogenation of all sulfur species to H_2S. The second step comprises a Stretford unit where H_2S is converted to elemental sulfur which is blended with the sulfur produced in the Claus plant. The Stretford process employs a treating solution containing anthraquinone disulfonic acid and vanadium salts which absorb H_2S, then promote the oxidation of H_2S to elemental sulfur in an air-blowing operation. Sulfur is separated from the solution as a froth, then filtered and melted to obtain a product with low impurities. Exhaust gas from the Beavon plant is discharged to the atmosphere.

Overall sulfur recovery of the combined Claus and tail gas units exceeds 99.9 percent.

UNIT 61 - STEAM AND POWER GENERATION

The majority of the steam used to generate electric power, provide mechanical drive, and process heating is generated by recovery of process heat in the gasification and shift conversion areas. The balance of steam demands are met by package boilers which burn plant fuel gas available primarily from the methanol synthesis and refining areas, with a smaller portion of the heating needs supplied by one of the Rectisol plant off-gas streams. The gas-fired boiler plant also has the capacity to produce high-pressure steam necessary for initial plant startup operations by burning either LPG or natural gas. Subsequent startups may be effected by burning methanol from the storage areas. Three 50 percent capacity boilers are supplied to permit operation at full capacity when one boiler is out of service for maintenance.

Electric power is generated by a condensing steam turbine generator set. 65 MW is supplied and consumed internally with no import or export of electric power. To ensure protection against shutdown caused by equipment failure, a 100 percent capacity spare steam turbine generator set is provided.

Block Flow Diagram 4-009 depicts the major users and producers of steam throughout the plant. Steam is provided at four levels: 1500 psig, 600 psig, 100 psig, and 50 psig. Interconnecting letdown lines, with automatic letdown valves and desuperheaters are provided between steam headers of successive levels. These devices provide a meens of controlling the pressure levels and transfer steam to lower levels on demand. An excess steam condenser is installed so that excess 50 psig steam does not have to be vented during startup or any occasional upset.

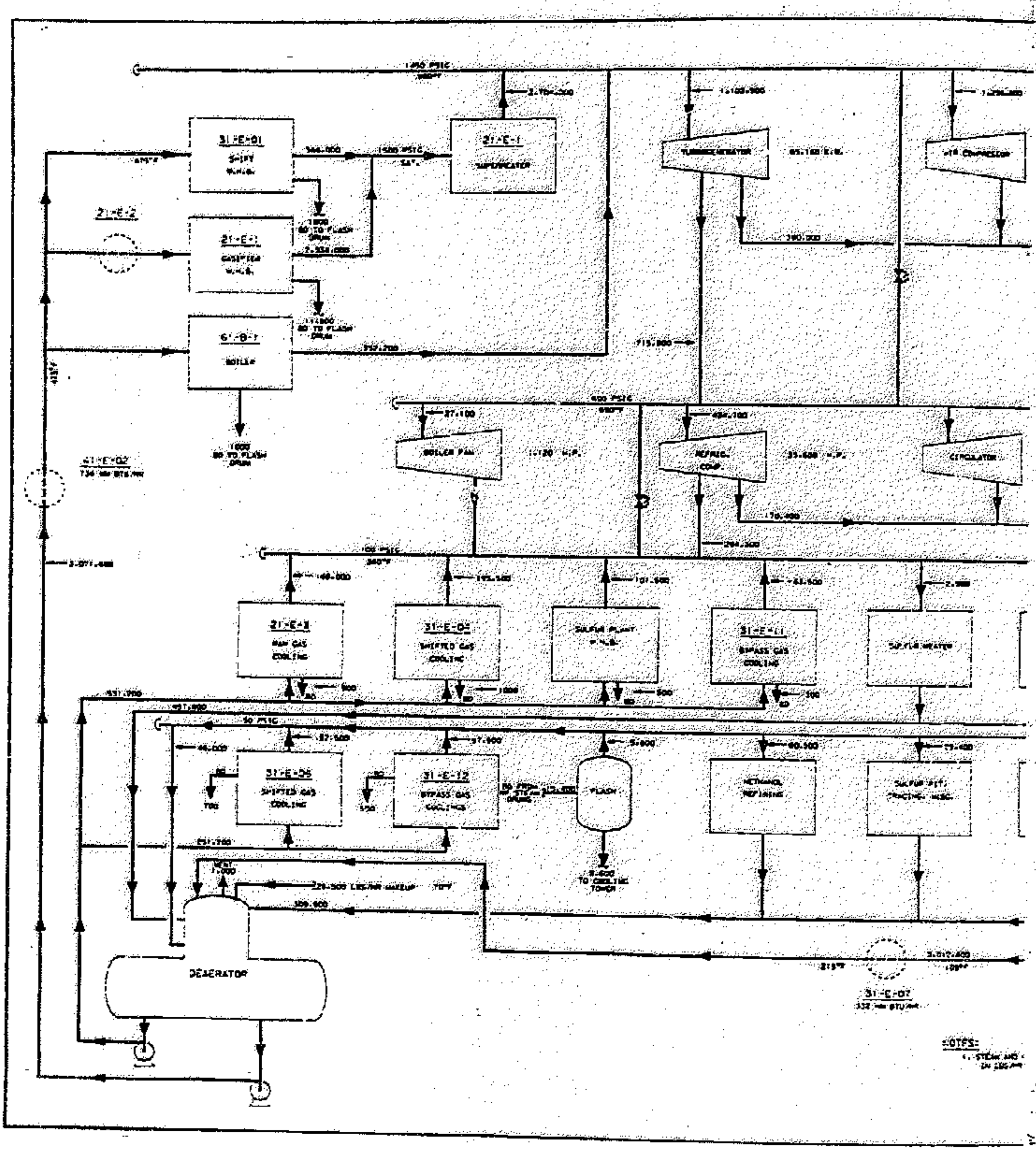
High-pressure steam is used to supply compression power requirements in the air separation unit and is used in the turbogenerator. The turbines exhaust to 2-1/2 inch Hg vacuum created by conventional multistage ejector systems. Extraction of steam from the turbogenerator at 600 psig supplies the intermediate pressure level steam demands.

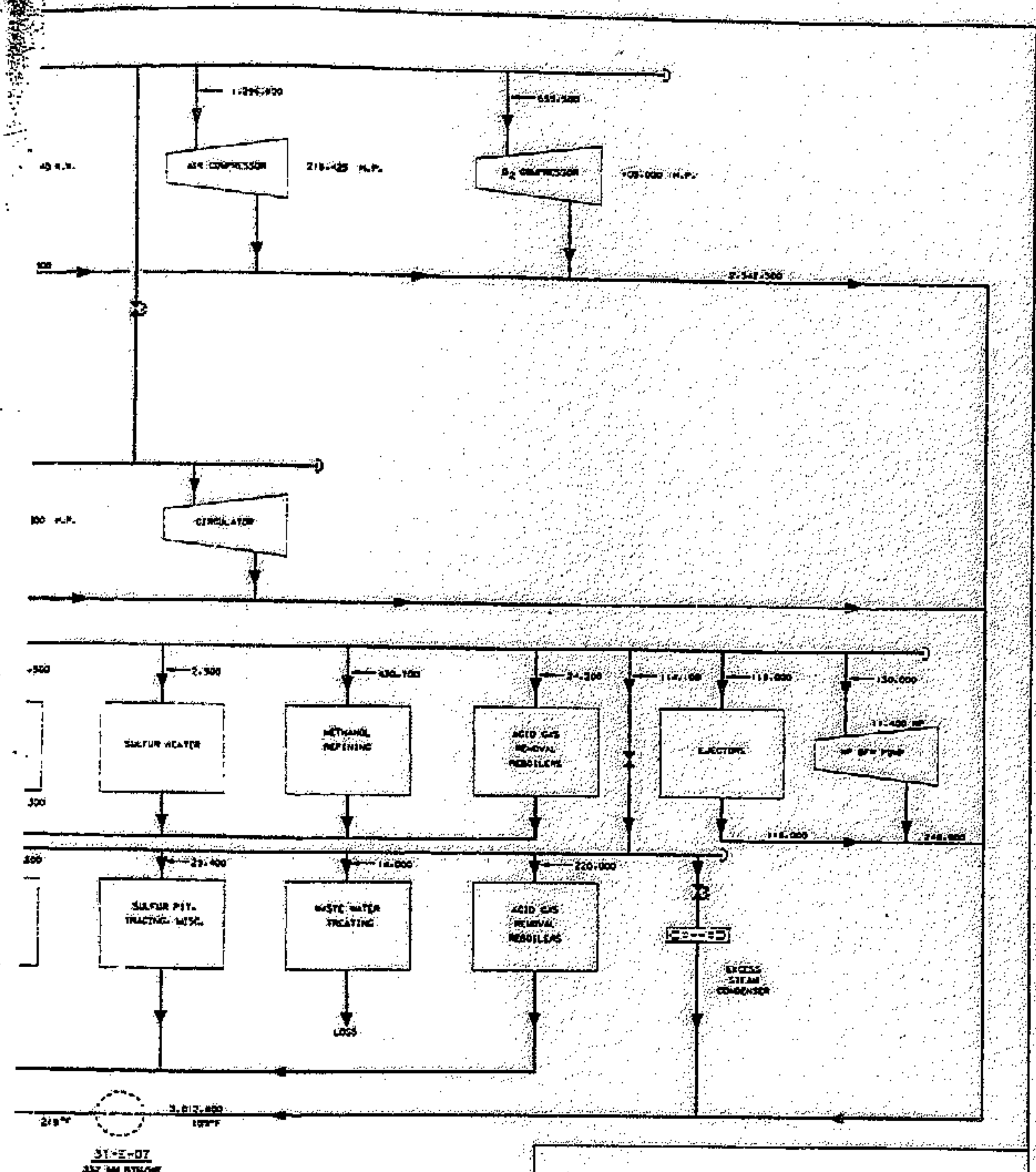
Intermediate pressure steam supplies power requirements for the package boiler fans, the refrigeration unit compressors, and the methanol synthesis unit recycle compressors. Back-pressure steam from the boiler-fan turbines and extraction steam from the refrigeration compressor turbines supply additional 100 psig steam to the medium-pressure level.

Medium-pressure steam supplies the high-pressure boiler feedwater pump turbine power requirements, supplies motive steam for the ejector systems, and supplies process heating needs. A portion of the medium-pressure steam is let down to the 50 psig level to supply part of the low-pressure steam demands.

Low-pressure steam supplies process heating and deaerator heating requirements. A small quantity of low-pressure steam is supplied by flashing boiler blowdown. Liquids from this blowdown flash are sent to the cooling water system.

Boiler feedwater makeup is drawn from the demineralizer and sent to the deaerator. Chemical treating of the boiler feedwater is required to ensure proper corrosion control and to provide protection for the steam generation equipment against solids deposition and sludge formation. Morpholine and hydrazine are added to the storage section of the deaerator to control pH and scavenge dissolved oxygen, respectively. Phosphates are injected in the high-pressure steam drums.


1450 PSIG
21-E-1
SUPERHEATER
31-E-01
SHIFT
21-E-2
21-E-1
6-B-1
BOILER
400 PSIG
BOILER FAN
REFRIG. COMP.
CIRCULATOR
TURBOGENERATOR
HTR COMPRESSOR
41-E-02
100 PSIG
21-E-3
RAW GAS COOLING
31-E-05
SHIFTED GAS COOLING
SULFUR PLANT
31-E-11
BYPASS GAS COOLING
SULFUR HEATER
50 PSIG
31-E-06
SHIFTED GAS COOLING
31-E-12
BYPASS GAS COOLING
FLASH
TO COOLING TOWER
METHANOL REFINING
DEAERATOR
31-E-07
NOTES:



NOTES:
1. STEAM AND CONDENSATE FLOW RATES INDICATED IN LBS/HR ON A TOTAL PLANT BASIS.

J.S. RUTTER	BLOCK FLOW DIAGRAM STEAM AND ELECTRIC POWER GENERATION UNIT-61 COAL TO METHANOL PROJECT		
D.D. COBB	ELECTRIC POWER RESEARCH INSTITUTE	PALO ALTO, CALIFORNIA	
	NONE	475004-4-009	2

p

UNIT 71 - PRODUCT STORAGE AND SHIPPING

Storage capacity, equivalent to twenty-one days of production, is provided for methanol product in floating roof-type storage tanks which are also provided with cone roofs for weather protection. Sulfur flakes from Unit 51 are stored in hoppers prior to shipment. Storage volumes are indicated below.

Methanol	1,650,000 bbls
Sulfur	10,500 tons

Facilities are included to ship products by rail or truck.

UNIT 81 - UTILITIES

Various utility systems are required to produce a self-supporting facility. These systems are described in the following subunits.

Description

Raw Water Storage and Filtration

BFW Preparation

Cooling Water System

Utility and Potable Water Systems

Fire Water System

Plant and Instrument Air and Inert Gas Systems

Flare System

Storm Water Collection

Oily Water Treatment

Sanitary Treatment

Raw Water Storage and Filtration

Raw water, free from sediment, is assumed to be available for plant use. The water management scheme is depicted in Block Flow Diagram 4-010.

The calculated water use rate under expected conditions results when maximum reuse of water is achieved. Consumption in summer months might exceed the calculated average consumption due to increased concentration of dissolved salts in the raw water.

Water is assumed to be received in a pipeline. This water is first sent to storage. The storage capacity is adequate to supply one day's maximum plant usage. This reservoir protects against brief interruptions of raw water supply and provides water supply for fire fighting purposes.

Water is pumped from the reservoir through granular-media filters for removal of small amounts of sediment as pretreatment for the boiler feedwater makeup. Backwash is sent to the cooling tower systems.

Boiler Feedwater Preparation

A boiler feedwater treating scheme has been provided which will minimize the effluent and which will produce high-purity water required for 1500 psig steam generation. The selected scheme involves the use of reverse osmosis (RO) as an initial treating step followed by a polishing unit employing conventional mixed-bed ion exchange methods. The reverse osmosis section rejects about 95 percent of the dissolved solids and the ion exchange eliminates the remaining solids. At the same time, the quantity of caustic soda and sulfuric acid used for resin regeneration is reduced to a fraction of that needed for a straight ion-exchange system. This decrease results in a substantial reduction in the amount of soluble salts in the demineralizer regeneration waste stream. Water from raw water storage and filtration is first filtered in a micron filter to remove final traces of suspended solids and is then sent to the reverse osmosis unit. At the operating pressure of 400 to 600 psig, the water molecules pass through the membrane while the larger sized ions, the dissolved salts, are for the most part rejected. The membrane permeate, containing very low concentrations of total-dissolved solids, is then purified in the mixed-bed demineralizer to approximately one micromho specific conductance. The demineralized water is delivered to storage and deaeration.

The reverse osmosis concentrate is sent to the cooling tower systems. Wastes from the demineralizer are sent to aqueous disposal, while backwash and rinse streams are recycled to the primary reverse osmosis unit.

Cooling Tower and Cooling-Water System

This unit provides cooling water for process heat rejection, condensation of steam from turbines and cooling of mechanical equipment. Two cooling-water systems are provided. The first system serves the utility and off-site areas and the air separation unit and is free from oil contamination. Only oil-free raw water and some treated process aqueous effluent are acceptable as makeup water. Water is concentrated about seven times in this tower. The other cooling-water system provides cooling water for the process users throughout the plant. This process cooling tower system, which may be oily contaminated, receives blowdown from the utility cooling tower system as makeup. Other makeup flows include filter backwash, reverse osmosis concentrate, sanitary unit effluent, boiler blowdown and deoiled oily water wastes. These are softened by the cold lime soda process to permit increased concentration of water without encountering scaling in as much as twenty concentration cycles. Blowdown from the process cooling tower is sent to a collection pit and then to the final disposal system.

Sulfuric acid will be injected into the cooling water system for pH control Proprietary chemicals will also be injected for corrosion inhibition, scale control, and sludge dispersion. Biocide agents compatible with ammonium ions will be injected to maintain clean heat transfer surfaces.

Utility and Potable Water Systems

The utility water system distributes water to the utility stations located throughout the plant. The potable water system is a packaged system which includes filtration, chlorination, and an air-pressurized surge tank for distribution of potable water throughout the plant. Normal capacity of the unit is 60 gpm.

Fire Water System

A fire water loop is provided throughout the plant. A jockey pump is provided to keep the system under pressure. A total pumping capacity of 3500 gpm is furnished by four fire water pumps, two driven by electric motor and two by diesel engine.

These pumps take suction from the raw water storage reservoir and are started automatically in case of loss of pressure in the fire water loop. Pumps are designed to deliver water at the design flow rate to the hydrant at a pressure not less that 125 psig. Coverage is provided on all equipment and storage tanks by a system of hydrants and monitors in accordance with accepted refinery practice.

Plant Air, Instrument Air, and Inert Gas Systems

2400 SCFM air is compressed to 100 psig and distributed throughout the plant for use as utility air. 2000 SCFM of the utility air is dried and distributed as instrument air. Standby compression is provided to ensure continuity of operation. Inert gas consisting of nitrogen derived from the oxygen plant is used for methanol solvent stripping and purging process equipment prior to maintenance.

Nitrogen from the cold box in the oxygen plant is at essentially atmospheric pressure and is compressed to 10 psig and a major portion is used in the Rectisol unit for stripping. A portion is further compressed to 700 psig and fed into the intermediate pressure nitrogen receiver designed for a five-minute surge volume.

Flare System

A relief system is provided to protect the process equipment from overpressure in conformance with accepted practice. Relief lines will carry away process fluids from the processing areas to the elevated flare stacks where ignition will occur in case of release. Separator drums are provided at the base of each stack to capture liquids. Molecular seals are provided in each stack to prevent air intrusion into the relief system.

Storm Water Collection

Storm water from the process and methanol tankage area is directed in underground storm sewers to the forebay of the storm water holding basin. After the initial period in a rainstorm, the normal practice would be to divert storm water directly to the main basin. Utility waste waters used for such purposes as hosedowns, etc. are also directed to the forebay of the holding basin. Storm water collected from areas of the plant where contamination will not occur flows directly to the holding basin.

Oily Water Treatment

Contaminated water from the storm basin forebay is treated in this unit for oil removal and is then filtered in a deep-bed filtration unit. Effluent water is then used as makeup to the cooling-water system.

Sanitary Treatment

Sanitary sewage is treated in a packaged unit which employs extended aeration with a tertiary filter. Effluent from this unit is combined in a collection pit with boiler blowdown and is then pumped to the softening unit in the cooling-water system.

Table 5-1 summarizes utility production and consumption for the plant.

Table 5-1

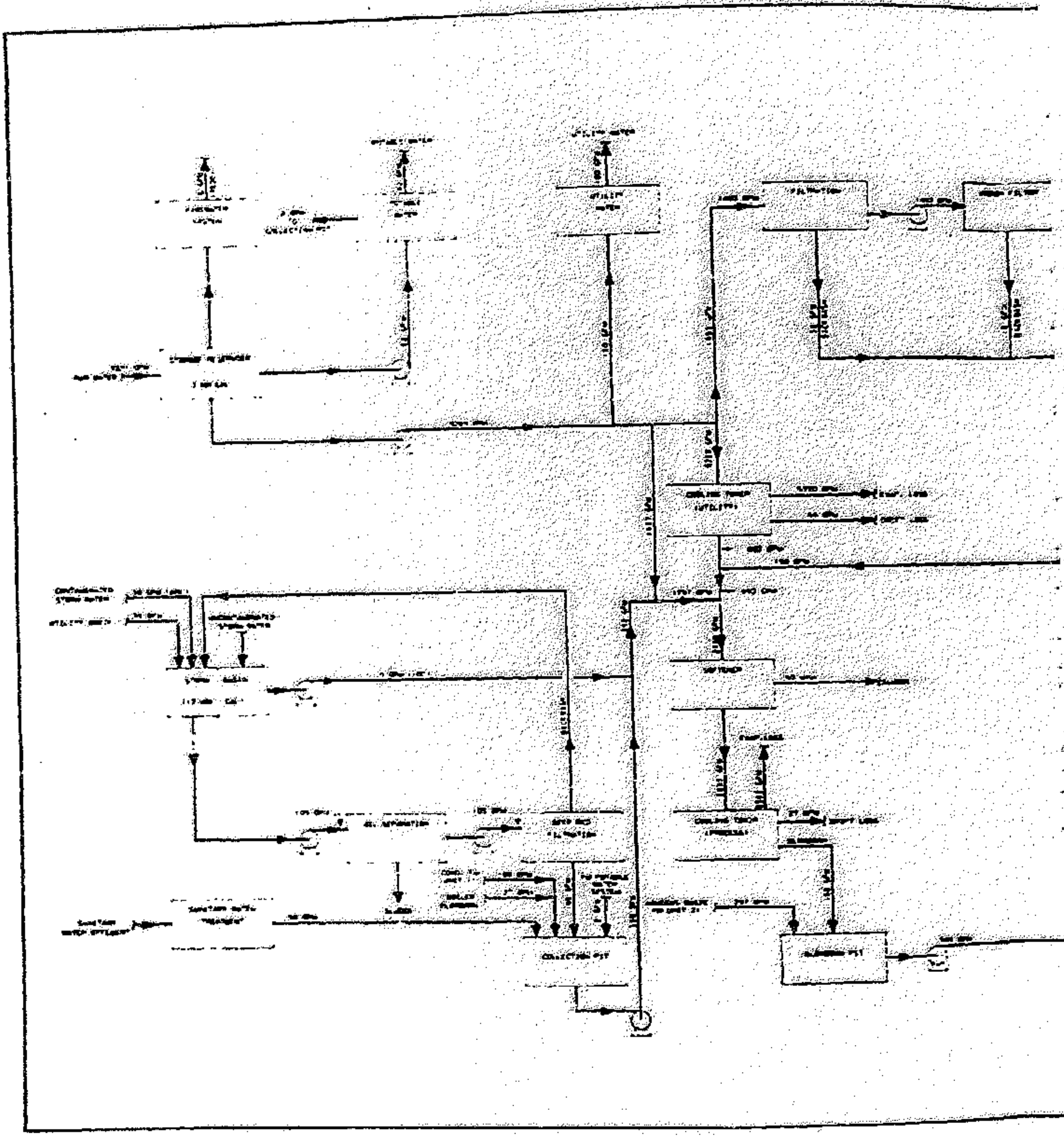
UTILITY SUMMARY

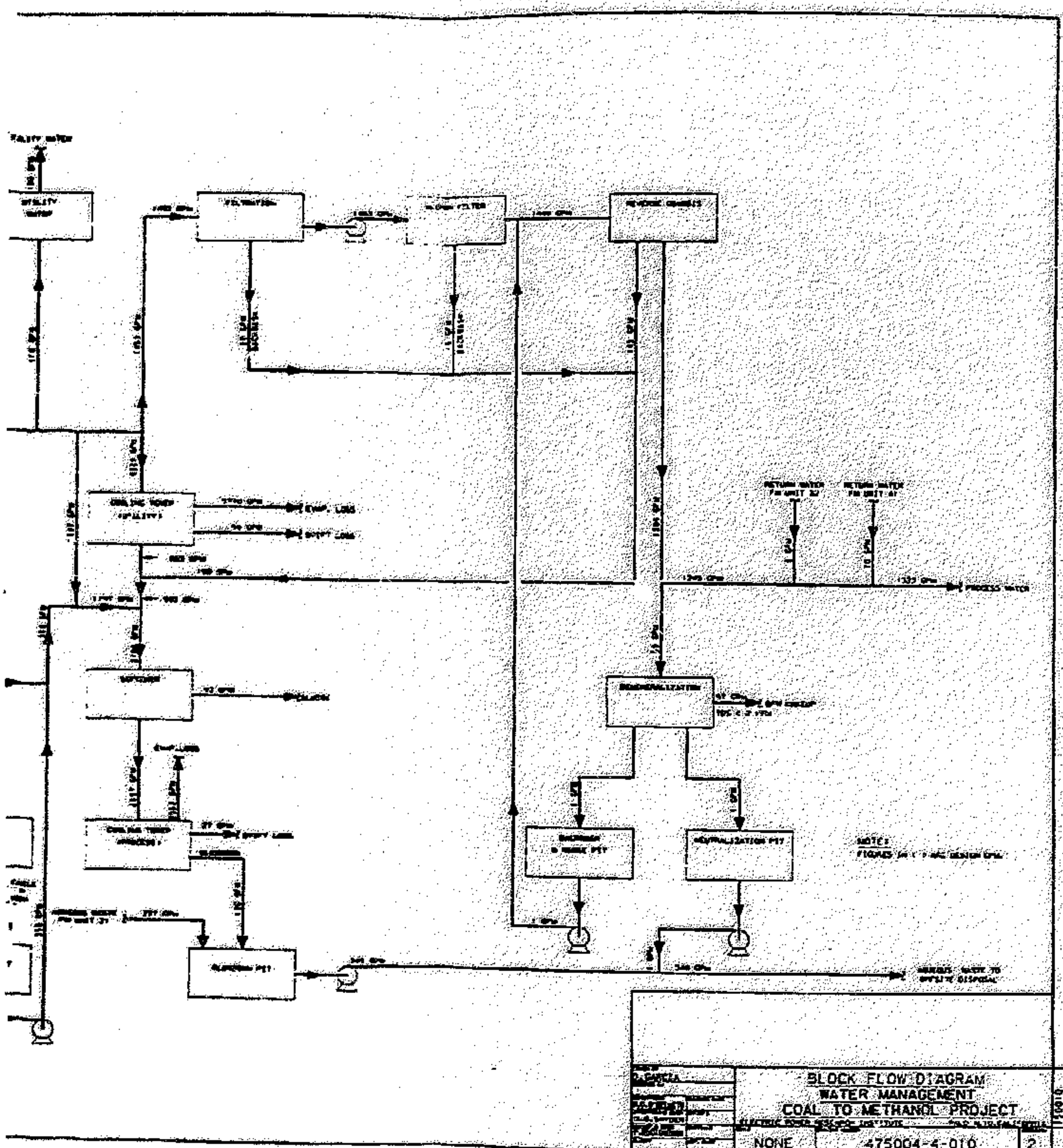
	Unit 01 Coal Preparation	Unit 11 Air Separation	Unit 21 Coal Gasification	Unit 31 Shift, COS Hydrolysis, and Gas Cooling	Unit 32 Acid Gas Removal	Met … Ref.
Electric Power, kW						
Produced		2,440				
Consumed	12,600	1,000	9,950	1,200	9,250	
Cooling Water, gpm						
Produced						
Consumed		260,940	21,000	3,100	24,050	
Fuel Gas, 10^6 Btu/hr HHV						
Produced					67.8	
Consumed						
Raw Water, gpm						
Produced						
Consumed						
1500 psig steam, lb/hr						
Produced			2,338,000	366,000		
Consumed		1,952,300				
600 psig Steam, lb/hr						
Produced						
Consumed					434,700	2.
100 psig Steam, lb/hr						
Produced			168,000	259,000	264,300	
Consumed					24,200	4.
50 psig Steam, lb/hr						
Produced				250,000		
Consumed			14,000		220,000	
BFW, lb/hr						
Produced						
Consumed			2,518,700	879,300		
Condensate, lb/hr						
Produced		1,952,300			414,600	7.
Consumed						
Demineralized Water, lb/hr						
Produced						
Consumed						

Table 5-1

UTILITY SUMMARY

Unit 21 Coal Gasification	Unit 31 Shift, COS Hydrolysis, and Gas Cooling	Unit 32 Acid Gas Removal	Unit 41 Methanol Synthesis and Refining	Unit 51 Emission Control	Unit 61 Steam and Power Generation	Units 81 and 91 Utilities, Off-Sites, and Misc.	Plant Total
9,950	1,200	9,250	2,720	3,630	65,140 730	26,500	67,580 67,580
21,000	3,100	24,050	45,560		61,090		415,740
		67.8	389.8	23.0	434.6		457.6 457.6
						9,331	9,331
2,338,000	366,000				352,200 1,103,900		3,056,200 3,056,200
		434,700	252,100		713,900 27,100		713,900 713,900
168,000	259,000	264,300 24,200	430,700	101,500 2,900	27,100 248,000		819,900 705,800
14,000	250,000	220,000	60,500		5,800 46,000	29,400	255,800 369,900
2,518,700	879,300			102,000	3,854,000 354,000		3,854,000 3,854,000
		414,600	743,300	2,900	638,000 3,780,500	29,400	3,780,500 3,780,500
					28,500	28,500	28,500 28,500




BLOCK FLOW DIAGRAM
WATER MANAGEMENT
COAL TO METHANOL PROJECT
NONE
475004-4-010
2

UNIT 91 - OFF-SITES

Various systems and services in the off-sites are described in the following subunits.

Electrical Systems

The complete electrical system provides a two bus arrangement for continuity, economy and reliability of service. The 13.8 kV generated voltage is stepped to a nominal 69 kV in an outdoor switchyard and utilized directly for in-plant distribution and transmission. At the area substations 69 kV is transformed to lower voltages. Uninterruptible power system units shall be employed for all critical instruments and control. The units consist of a rectifier, battery charger, and a static inverter. Emergency generators are provided for standby power and will be driven by steam or internal combustion units. Motors are rated as follows:

Size	Rating
Above 5000 hp	13.2 kV, 3 phase
Above 200 hp to 5000 hp	4000 V, 3 phase
Above 1 hp to 200 hp	460 V, 3 phase
Below 1 hp	120 V, 1 phase

Interconnecting Piping

All major process and utility lines are to be carried on overhead pipeways or sleeperways. Pipeway supports are to be constructed of structural steel with fireproofing, where required. Sleepers will be constructed of reinforced concrete. An overhead clearance of 21 feet above primary access roads and 10 feet over secondary access roads will be maintained. The interconnecting piping design would reflect piping flexibility analyses for the most severe temperature conditions.

Site Preparation

For the conceptual design of the plant the following soil conditions have been assumed:

- The site is clear and level

- Spread foundations located approximately 4 feet below grade are suitable for 3000 lbs/ft^2 net soil bearing under operating conditions

- No piling is required, no blasting is required

- There are no hidden underground voids that must be located and filled

- Native excavated soils will be available for compacted fill on underground installations, paving, and roads

- The frost line is 3 feet below grade

- The water table is below all required excavations, especially lined ponds, and no dewatering is required

Perimeter Fencing

The plant will be enclosed at the perimeter with an eight-foot high chain link fence topped with V-shaped extension arms. Each arm will support three strands of barbed wire. Gates will be provided at plant entrances.

Roads and Parking Areas

A public road is assumed to exist adjacent to the main entrance of the plant, so that no access roads are required. Plant roads and parking areas will be designed to resist HS20 wheel loading. The plant roads will have a twenty-foot riding surface with five-foot shoulders. A twelve-inch base course thirty-foot wide will be provided over twelve inches of compacted subgrade. The riding surface will be paved with three inches of asphalt, and the shoulders will not be paved. The parking areas will have a similar subbase but only two inches of asphalt.

Maintenance Equipment

A lump sum allowance for maintenance equipment is included in this estimate. This allowance was based on Fluor in-house data collected from similar projects.

It is intended that this allowance would cover such equipment as hand tools, lathes, welding machines, grinders, boring mills, power saws, shapers and drill presses.

Laboratory Equipment

A lump sum allowance for laboratory equipment is also included in this estimate. The amount of this allowance also comes from Fluor's cost data bank. There will be continuous monitoring of all major process streams with periodic sampling for quality control. Equipment would be provided to perform all the necessary laboratory tests.

Mobile Equipment

An allowance for mobile equipment is included in this estimate. This allowance is based on the mobile equipment costs from previous projects of comparable size.

Fire Protection Equipment

An allowance for fire protection equipment is included in this estimate. This equipment is in addition to the fire water system described under Utilities. The following items are considered in the allowance:

- Fire equipment vehicles
- Fire trucks
- Hose carts, hose sheds, ladders, and firehouse equipment

Buildings and Furnishings

Buildings provided include administration building, control house, operator shelters, switch gear housing, laboratory, change house, cafeteria, first aid building, fire station, guard house, warehouse, and maintenance building.

Communications System

The commercial plant would be provided with a complete in-plant telephone system connecting all processing units with the main control house and other principal buildings. The system would be a multichannel unit complete with all wiring and conduit suitable for the unit area electrical classification and weather. The system would be connected by a central switchboard to the outside-of-plant telephone system serving the area. A plant audio paging system would be provided with on-shift access from the main gate guard shelter and Shift Superintendent office which would be located at the main control house.

Railroads

Rail loading and unloading facilities will be provided. Included in the estimate are track, switches and bumpers. The design of the rail spurs and sidings will be in accordance with the standards of the local railroad company. It is assumed this local rail company will provide the railroad tracks immediately adjacent to the plant site. The rail facilities are located to allow efficient unloading of coal and supplies and loading of the products.