TVA/OGM/CG-81/11

MASTER

TVA COAL-GASIFICATION

COMMERCIAL DEMONSTRATION PLANT PROJECT

VOLUME 4

PLANT BASED ON

BABCOCK & WILCOX GASIFIER

FINAL REPORT
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Foster Wheeler Energy Corporation

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PROCESS PLANTS DIVISION

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Table of Contents

Volume 4 Plant Based on BABCOCK & WILCOX Gasifier

3.4 Section 400 Acid Gas Removal

- Description of Flow
- Input/Output Major Stream Flows
- List of Major Equipment
- Flow Diagram

3.5 Section 500 Treated Gas Compression

- Description of Flow
- List of Major Equipment
- Flow Diagram

3.6 Section 600 Sulfur Recovery Plant

- Description of Flow
- Input/Output Major Stream Flows
- List of Major Equipment
- Flow Diagram

3.7 Section 700 Sour Water Stripping

- Description of Flow
- Input/Output Major Stream Flows
- List of Major Equipment
- Flow Diagram

3.8 Section 800 Ash/Slag Handling

- Description of Flow
- List of Major Equipment
- Flow Diagram.

3.9 Section 1200 Utility Area

Raw Water Treatment and Storage

- Description of Flow
- List of Major Equipment
- Flow Diagram

Potable Water Storage & Cond. Treatment

- Description of Flow
- List of Major Equipment
- Flow Diagram

BFW Treatment

- Description of Flow
- List of Major Equipment
- Flow Diagram

Steam Generation & Distribution

- Description of Flow
- List of Major Equipment
- Flow Diagram

SECTION 1.0

INTRODUCTION

TVA Coal Gasification Study
B&W Gasifier

INTRODUCTION

The baseline design of a coal gasification plant producing medium Btu gas, based upon the Babcock and Wilcox gasification process is documented in this report.

The coal gasification plant consists of four identical modules, each with a capacity of approximately 5,000 tons of coal per day as delivered to the gasifiers. The entire plant (four modules) produces 1205.7 Million Standard Cubic Feet per day of gas with a GHV value of approximately 299 Btu/SCF for a total heating value of about 360 billion Btu/day.

The plant location is the rural site of Murphy Hill, located along the Tennessee River, some 30 miles east of Huntsville, Alabama. Section 1 provides more detailed site information.

The desired product gas is a clean, medium-Btu gas suitable for pipeline distribution. The coal used for processing and for auxiliary boilers is a Kentucky No. 9 coal. The product gas specifications and the coal characteristics are listed in Section 2.

The site is accessible by barge and road, with the plant receiving coal primarily by barge. About 5 percent of plant needs are delivered by truck. The site will not be served by rail. The coal receiving facilities are sized to handle the entire needs of the plant.

Water needed for cooling and for process consumption will be drawn from the Tennessee River and will be treated by the plant water treatment facility. The plant will use closed loop cooling. Electricity will be furnished by TVA at the plant boundary.

The plant will be designed to meet all Federal, State, and local standards and guidelines.

A description of the plant by major sections is included as well as flow diagrams, stream balances and lists of major equipment. A key plot plan is presented in Section 5.

Section 6 presents an estimate of emissions and effluents from the Babcock and Wilcox coal gasification plant.

2.1 Discussion of Choice of Processing Sequence

Evaluations and specific studies completed in Task I and the characteristics of the B & W gasifier influence the process selection for both the plant main units and the support facilities. Studies involved in Task I included:

- Gas Cleanup
- Oxygen Purity
- Coal Washing
- Sulfur Recovery

Support facilities studies include:

- Equipment Drives
- Gas Storage and Spares
- Gas Delivery Pressure
- Effects of Scale
- Effects of Load Change

Process selection depends upon economics, experience with the process application and upon the characteristics of the B & W gasifier. In addition to the selection of the process units, there is also the problem of selection of the process configuration involving the arrangement of units, number of trains, multiple part-capacity equipment items all integrated with the optimum plant capacity. Some configuration limitations are due to the state of development of the gasifier, some to equipment size and scale limitations, as well as product demand variation and high risk, high maintenance items.

2.2 General Description of Flow

Drawing No. 54099-[illegible]-50-27-1 is a block flow diagram illustrating a coal conversion MBG plant using the Babcock and Wilcox gasifier. As shown in the diagram, coal, air, and water are the only raw materials entering the plant. Medium Btu gas is the only product leaving the plant, together with by-products of sulfur, carbon dioxide and slag.

The accompanying Process Block Flow Diagram provides an overview of the main processing units selected for preparing medium Btu gas based on incorporating B & W's gasification reactor. A brief review of the schematic which traces the flow of raw materials into finished product is furnished below, as well as a more detailed description of each individual unit.

Raw coal is received from barges and is transported to coal storage piles. The coal is crushed, screened and dried, and fed to the gasifier, where it is reacted with oxygen from the air separation plant. The gasifier product gas is cooled and scrubbed free of solids, after which the acid gas components, CO_2, H_2S and COS, are removed in the Selexol unit. Slag emanating from the gasifier is removed to a slag disposal area; sour water condensates generated from various processing units is treated by steam stripping. The hydrogen sulfide removed in the acid gas treating step is further processed to recover saleable sulfur, either in molten or prilled form. The resulting clean medium Btu gas is compressed for transmission to the distribution system.

Support facilities common to these various units include: utilities, waste water treating, flare/incineration, and cooling tower.

Air Separation Plant

The B & W gasification system requires approximately 4,200 ST/D of oxidant per module to react with coal. The air separation plant is designed for a capacity of 5% higher than that shown in the material balance. This 5% factor accounts for variations in the coal composition, heating value and carbon content, but does not include any factors associated with licensor's guarantees or with on-stream factors.

Task I evaluation studies indicate a 98% concentration of O_2 is optimum and a low pressure reversing exchanger process is economical.

For B & W gasifiers, a 98% oxygen purity means that the GHV of product gas will be about 296 Btu/SCF.

The B & W Gasifier

The B & W gasifier is based upon the principle of entrained flow, high temperatures and short residence time. Pulverized coal, oxygen and transport gas are fed to the reactor in a multiplicity of feed points or burners, creating a rising stream of hot gas. The "combustion zone" temperature is very high, promoting the melting of the ash which falls by gravity to a central tap hole, then to a quench section. The slag breaks up to a frit in the quench zone and is removed from the gasifier by means of an ash lock hopper. Recycle char from the two stages of cyclones is reinjected into the gasifier, using steam transport. Fine char rises with the hot, high velocity gas. The gas cools due to continued gasification and, also, due to heat transfer to the bare wall evaporator tubes in the upper zone of the gasifier. The gas exits the gasifier together with partially reacted char, the bulk of which is removed in the primary cyclone. Heat is then recovered in the waste heat boiler, which is followed by a secondary cyclone. After heat recovery, the gas is further cleaned of particulates by means of a venturi scrubber.

The gasifier system includes the coal feed lock hoppers, gasifier, ash lock hopper, cyclones, waste heat boiler and scrubber. The gasifier will be designed for 5% increased capacity above the normal material balance to account for coal variations.

Acid Gas Removal

Gas from the scrubbers is sent to a Selexol unit to remove sulfur compounds in the gas. The Selexol system chosen in Task I is a physical absorption acid gas removal system operating at low temperatures of $0^{o}F \pm 20^{o}F$. The Selexol plant will be designed for both 105% of material balance capacity and for 115% of the H_2S and COS concentration to allow for coal variations.

The Selexol system can absorb all sulfur compounds in the gas phase. However, COS solubility in the Selexol solution is lower than that for H_2S. As a result, the solution circulation and utilities are determined by COS. This is evident if the COS concentration is high or if the sulfur specification of the product gas is low. For 200 ppm sulfur, it is economical to hydrolyze COS after the scrubber and then remove H_2S and residual COS in the Selexol unit. The hydrolysis unit is designed for 5% higher capacity and 15% more COS than the normal material balance.

Sulfur Recovery

The most economical method of sulfur recovery from acid gas is by means of the Claus plus tail gas plant, provided the H_2S concentration in the acid gas is above 15 to 20%. For the B & W gasifier, the H_2S concentration will be better than 20% H_2S concentration regardless of the amount of CO_2 removed from the product gas, which has a low CO_2 concentration. A tail gas cleanup is required with a Claus unit, which only converts 90±% of the H_2S to elemental sulfur. The Beavon-Stretford type was chosen in Task I to remove sulfur compounds from the Claus tail gas. The H_2S concentration in the acid gas is sufficiently high to allow a "split flow" Claus operation. Reasonable concentrations of H_2S are required in order to sustain combustion in the Claus furnace. The Beavon unit converts all the sulfur compounds from the Claus unit back to H_2S. The concentration of H_2S in the tail gas from the Beavon unit is very low. Consequently, a Stretford unit is used to convert the low concentration, low pressure H_2S to elemental sulfur. The tail gas is then vented.

Task I evaluations and studies conclude that elemental sulfur would be the more desirable product rather than to convert H_2S to sulfuric acid. The least expensive way of handling the elemental sulfur would be as a molten liquid. Sulfur can be produced in either molten or solid form; it was concluded that the prilled solid form would be preferable for the TVA design. The Claus-Beavon-Stretford Sulfur Recovery System will be designed for 115% of material balance to account for variations of sulfur content of the coal.

Support Facilities

Support facilities include utilities, coal and ash handling, wastewater treatment and general facilities.

Steam Production and Distribution

Steam production from the gasifier includes 245,000 lbs/hr of 250 psi and saturated, plus 650,000 lbs/hr of 950 psi steam superheated to 750°F. The low pressure steam will be used to drive turbines. However, steam generation in boilers will be small compared to that required for the Lurgi Dry Ash system. For the capacities required, it is believed that the most economical boiler for the B & W gasifier would be a coal fired fluidized bed boiler. This choice would eliminate the stack gas scrubber and also eliminate sludge disposal problems. There would still be a problem of disposal of solid ash plus calcium sulfit-sulfate, a simpler problem than sludge disposal.

Plant Water Treating and Distribution

Plant water is obtained from the river, with each module requiring about 3000 gpm. The systems to which plant water is distributed include:

- o Fire water
- o Boiler feed water
- o Potable water
- o Cooling tower water makeup
- o Ash quench and sluice makeup

Sufficient spare pump capacity is required to account for pump maintenance while operating and for variation in coal properties.

Fire water is simply river water with coarse screening to remove trash and silt.

Boiler feed water, in addition to the above, will have treatment and demineralization sufficient for the purity required for the steam generating pressure and superheat.

Potable water will be treated for purity required for drinking purposes.

Cooling tower makeup must be treated to remove silt and for chemical addition to prevent corrosion and prevent algae growth. Part of the cooling tower makeup water may come from the treated process waste water.

Ash quench and ash sluice water makeup may come from river water. It may also come from treated process waste water or it may come in part from cooling tower blowdown.

Waste Water Treatment

Waste water treatment is a single train system for each module. Process water before disposal must be reduced in dissolved acid gases by means of a sour water stripper. The gas from the sour water stripper is sent to the Claus unit to recover sulfur and the stripped water is sent to the waste water treatment system. Waste water treating consists of clarification, neutralization, aeration, sludge removal, holding tanks and disposal to outfall. In addition to process waste water, the coal pile runoff is also treated in the same system as the process waste water. Other liquid streams which require treatment are sanitary effluents, spent service water, inside battery limits (ISBL) storm runoff, cooling tower blowdown and neutralization water from ion exchange demineralizers.

All the above streams are held in effluent holding basins to measure pH, turbidity, BOD and priority pollutants before sending the water to the river. Cooling tower blowdown must have a chromium destruct system before allowing that water to flow to the river. Sanitary effluent will be treated by conventional package system and ISBL storm runoff will be treated with the normal process waste water system. However, in order to smooth out a large surge in storm water capacity, a holding basin is provided so that storm water may be worked off gradually.

Coal Handling, Treating and Feeding

Coal receiving, unloading, conveying, stacking and reclaiming are not influenced by the gasification process and are the same for all gasification processes with slight variations in amount of coal for each process. The Babcock and Wilcox gasification process differs from the Lurgi type in that all the coal to the gasifier shall be crushed and pulverized to 70% by weight through 200 mesh. The pulverized coal (PC) shall be dried and pneumatically transported to lock hoppers to raise the coal to operating pressures and then the coal must be injected into the gasifier by means of multiple burners.

Coal is reclaimed from the live or long storage piles, screened and crushed to a size of 1¼ x 0. The crushed coal will be further reduced in the pulverizer to 70% through 200 mesh. Hot flue gas enters the pulverizer, drying coal to 2% moisture and lifting the coal to the primary pulverizer cyclone. Hot flue gas is generated in hot air heaters by burning coal.

Pulverized coal is gravity fed from the cyclones and baghouses directly into the coal storage bin. From the storage bin, the coal drops by gravity into lock hoppers where the coal is pressurized and then directed to the feed tank. Coal is transported from the bottom of the feed tank into the gasifier with inert gas.

Slag Handling

Slag is formed when molten ash in the gasifier is quenched with water. The molten slag is broken into small size frit.

A slag slurry from each gasifier lock hopper is gravity fed into a transfer hopper and then sluiced to a sump. The slurry from a number of gasifiers is collected in the sump and pumped to a dewatering bin. Damp ash is conveyed by truck to onsite storage piles together with other solid wastes, such as sludge from stack gas scrubbers or spent limestone (gypsum) from fluidized bed boilers. Water from the dewatering bin is clarified and then returned to the slag lock hoppers for reuse. About 10% by weight of the slag is water remaining after dewatering.

Slag handling equipment is designed at a rate of 25% higher than material balance to account for coal property variations.

Slag Disposal

Slag is trucked from the Slag Handling area dewatering bins, together with spent limestone from the boilers to basins for 20 years of storage. Water is pumped from drainage culverts surrounding the ash piles to a holding pond and then the drainage water is used for slag conveying, quenching and lock hoppers. Excess water is sent to the waste water treating section for disposal. The slag storage area is based upon the material balance with no increased factor for coal variations. Any variation in coal should be smoothed out in 20 years.

2.3 NOMINAL PLANT CAPACITIES

PLANT BASED ON B&W GASIFIERS

2.3 SUMMARY OF CAPACITY OF THE PLANT SECTIONS 11-28-54099

SECTION	SECTION DESCRIPTION	NO. OF PLANTS	CAPACITY 1 MODULE NORMAL	CAPACITY 1 MODULE DESIGN	CAPACITY 4 MODULES NORMAL	CAPACITY 4 MODULES DESIGN	INSTALLED COST MM$
100	COAL PREPARATION	1					
	CRUSH & SCREEN		15,744 T/D	21,168 T/D	62,976 T/D	84,672 T/D	
	COAL STORAGE LIVE		76,000 TONS	76,000 TONS	304,000 TONS	304,000 TONS	
	DEAD		488,000 TONS	488,000 TONS	1,952,000 TONS	1,952,000 TONS	
	PULVERIZE		PART OF SECTION 300				
200	AIR SEPARATION	8-50%					
	O_2 PLANT		4,200 T/D	4,410 T/D	16,800 T/D	17,640 T/D	
	LOX STORAGE			4,500 TONS		18,000 TONS	
	O_2 COMPR		1 Motor Driven	11,744 BHP	4 Motor Driven	4x11,744 BHP	
			1 Turbine "	6.78 lbs.stm/hr-HP	4 Turbine "	6.78 lbs.stm/hr-HP	
	LIQ N_2 STOR			250 TONS		1,000 TONS	
	GAS O_2 STOR			8,400 TONS		33,600 TONS	
	GAS N_2 STOR		NONE		NONE		
300	COAL GASIFICATION	4	5,418 T/D WET	5,418 T/D WET	21,672 T/D WET	21,672 T/D WET	
			5,000 T/D DRIED	5,000 T/D DRIED	20,000 T/D DRIED	20,000 T/D DRIED	
400	ACID GAS REMOVAL	4					
	COMPRESSION						
	HYDROLYSIS (RAW GAS T=200°F)		756,291 lbs/hr	794,106 lbs/hr	3,025,164 lbs/hr	3,176,424 lbs/hr	
			MW = 21.085				
	ACID GAS REMOVAL (ACID GAS		30,911 lbs/hr total	32,457 lbs/hr	123,644 lbs/hr	129,828 lbs/hr	
	T=110°F)		17,484 lbs/hr H_2S	20,107 lbs/hr	69,936 lbs/hr	82,428 lbs/hr	
500	TRT GAS COMPR	4	1 Turbine Driven	29,469 BHP	4 Turbine Driven	4x29,469 BHP	
				6.69 lbs/hr-H.P.		6.69 lbs/hr-H.P.	
600	SULFUR RECOVERY		2 PLANTS IN 1ST MODULE				
	CLAUS PLT	5	198 T/D SULFUR IN FEED	456 T/D SULFUR	990 T/D SULFUR	1140 T/D SULFUR	
	5 BEAVON UNITS:TOTAL TAIL GAS		50,865 lbs/hr total sulfur	116,870 lbs/hr	254,325 lbs/hr	292,475 lbs/hr	
	TAIL GAS CLEANUP,SULFUR:		649 lbs/hr	Equiv. 1,492 lbs/hr	3,245 lbs/hr	3,730 lbs/hr	
	SULFUR PRILLING						
700	SOUR WATER STRIPPING	4	SWS Bottoms =				
			279,893 lbs/hr	293,888 lbs/hr	119,572 lbs/hr	1,175,552 lbs/hr	
	H_2S IN FEED = 22 lbs/hr		SWS Feed =				
			297,883 lbs/hr	312,777 lbs/hr	1,191,532 lbs/hr	1,251,108 lbs/hr	
	NH_3 IN FEED = 31 lbs/hr						

PLANT BASED ON B&W GASIFIERS

2,3 SUMMARY OF CAPACITY OF THE PLANT SECTIONS 11-28-54099

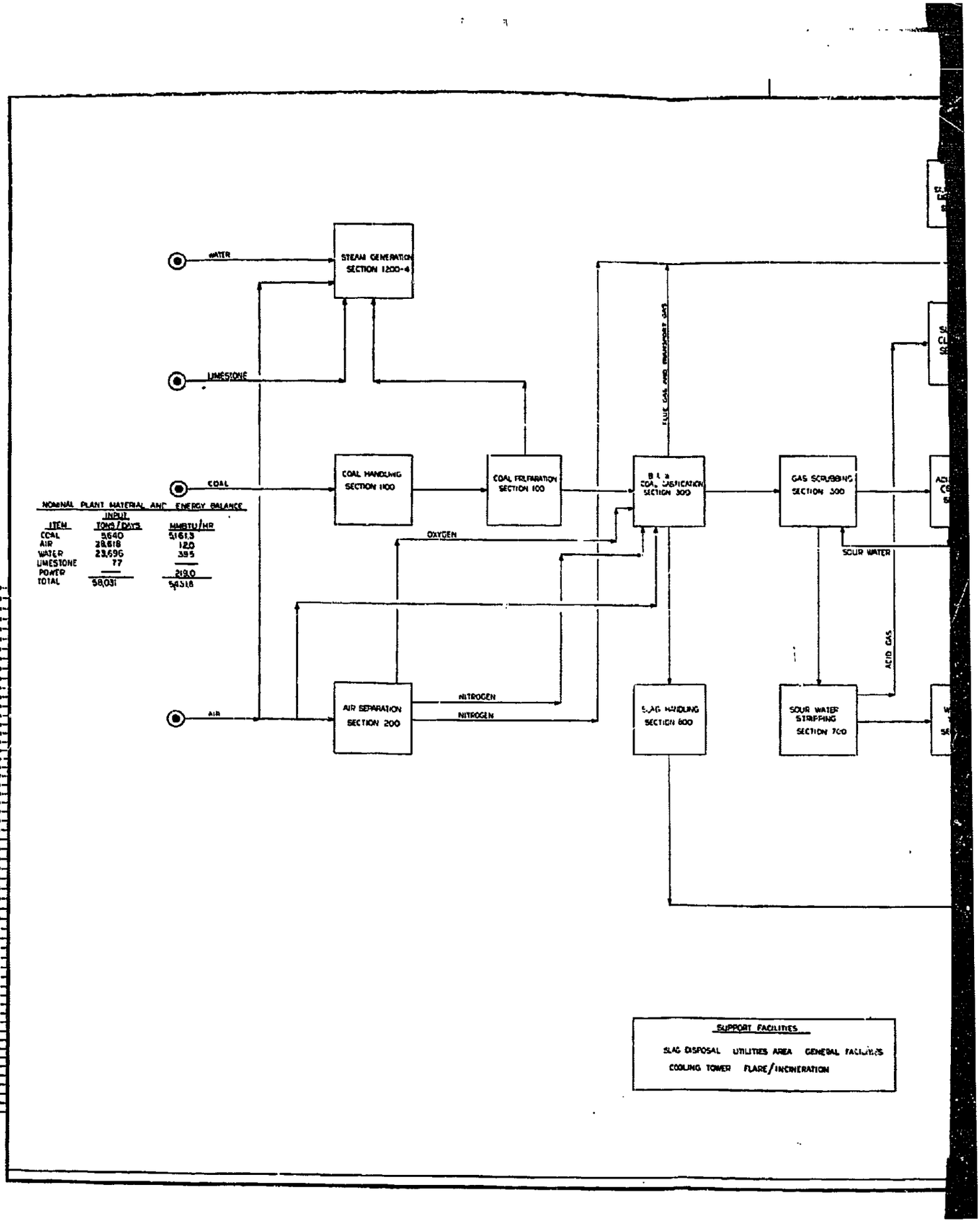
SECTION	SECTION DESCRIPTION	NO. OF PLANTS	CAPACITY 1 MODULE NORMAL	CAPACITY 1 MODULE DESIGN	CAPACITY 4 MODULES NORMAL	CAPACITY 4 MODULES DESIGN	INSTALLED COST MM$
800	ASH/SLAG HANDLING	4					
	DEWATERING		Feed=413,810 lbs/hr Incl. 360,000 H_2O	517,263 lbs/hr Incl. 450,000 H_2O	1,655,240 lbs/hr	2,069,052 lbs/hr	
	HANDLING						
1200	UTILITY AREA						
	RAW WATER STORE TRT	1			4,000 GPM	4,600 GPM	
	POTABLE WATER TRT	1			25 GPM	29 GPM	
	BFW TRT	4	100 GPM	115 GPM	4x100 GPM	4x115 GPM	
	CONDENSATE TRT (1 TURN)	4	1,900 GPM	2,185 GPM	4x1,900 GPM	4x2,185 GPM	
	STEAM GENERATION	4					
	8 Boilers - H.P.STM		56,300 lbs/hr	143,000 lbs/hr x2	4x56,300 lbs/hr	8x143,000 lbs/hr	
	@ 150°F From Pulv. Coal Baghouse		908,074 lbs/hr	1,044,285 lbs/hr x2	4x908,074 lbs/hr	8x1,044,285 lbs/hr	
	STACK GAS CL.		MW=28,367				
	PLT/INTR AIR-IG N_2		FROM SECTION 200 - AIR SEP. PLANT				
1300	COOLING WATER SYS						
	COOLING TWR SYS	4	103,800 GPM Circ., $\Delta t=15^{\circ}F$	124,560 GPM	415,200 GPM	498,240 GPM	
	COOLING WATER TRT	4	550 GPM Blowdown	660 GPM	2,200 GPM	2,640 GPM	
1400	FLARE AND INCIN.	4					
1500	SERVICE WATER+C.P. RUNOFF+ STR SOUR WATER-		954 GPM	1,002 GPM	3,816 GPM	4,008 GPM	
	WASTE WATER TRT	4					
2000	GENL FACILITIES						
	L.T.SOLID WASTE STORAGE						
	BYPROD & CHEM STOR						
	SULFUR 198 T/D Produced Per Plant		6,000 TONS	6,000 TONS	24,000 TONS	24,000 TONS	

PLANT BASED ON B&W GASIFIERS

2.3 SUMMARY OF CAPACITY OF THE PLANT SECTIONS 11-28-54099

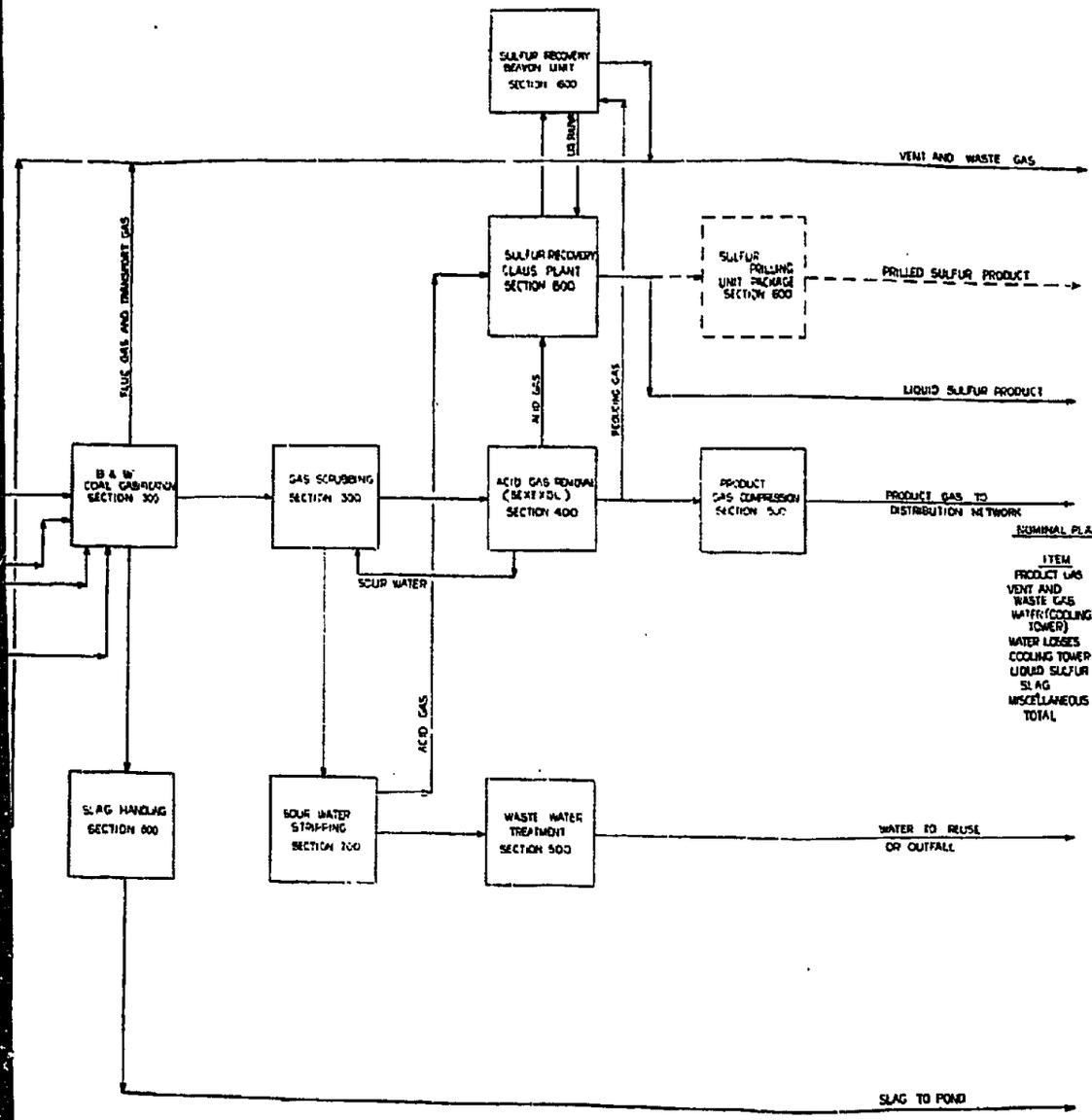
SECTION	SECTION DESCRIPTION	NO. OF PLANTS	CAPACITY 1 MODULE NORMAL	CAPACITY 1 MODULE DESIGN	CAPACITY 4 MODULES NORMAL	CAPACITY 4 MODULES DESIGN	INSTALLED COST MM$
2000	GENL FACILITIES (cont'd)						
	LIMESTONE 4,000 lbs/hr Usage per plant		56,000 TONS	56,000 TONS	224,000 TONS	224,000 TONS	
	WATER CHEMICALS						
	ELECT PWR DIST						
	SPARE PARTS						
	LIGHT & COMM						
	ROADS AND FENCES						
	FIREWATER SYSTEM						
	SEWAGE PLANT						
	INTERCONN PIPING						
2100	BUILDINGS						
2200	DOCK FACILITIES						
	100-1000 SUB TOTAL						
	1100-2200 SUB TOTAL						
	TOTAL						

2.4 BLOCK FLOW DIAGRAM



NOMINAL PLANT MATERIAL AND ENERGY BALANCE

	INPUT	
ITEM	TONS/DAYS	MMBTU/HR
COAL	5,640	5161.3
AIR	28,618	12.0
WATER	23,696	39.5
LIMESTONE	77	
POWER		21.0
TOTAL	58,031	5431.8



NOMINAL PLANT MATERIAL AND ENERGY BALANCE

ITEM	OUTPUT TONS/DAYS	MMBTU/HR
PRODUCT GAS	8,249	3,764.7
VENT AND WASTE GAS	24,722	29.2
WATER (COOLING TOWER)	6420	18.7
WATER LOSSES	1,520	2.6
COOLING TOWER	15,960	1290.0
LIQUID SULFUR	198	65.2
SLAG	646	20.0
MISCELLANEOUS	316	241.5
TOTAL	58031	5831.8

SUPPORT FACILITIES

SLAG DISPOSAL UTILITIES AREA GENERAL FACILITIES
COOLING TOWER FLARE/INCINERATION

BLOCK FLOW DIAGRAM
TVA COAL GASIFICATION STUDY
8 B&W GASIFIERS-ONE MODULE

DWG-54099-ZH-50200

TVA Coal Gasification Study
B&W Gasifier

SECTION DESCRIPTION

3.1 SECTION 100 COAL PREPARATION

A. Reference Material:

- Process Flowsheet — FWEC Dwg. No. 54099-27-1-50-1
- Elevation Drawing — FWEC Dwg. No. 54099-27-1-01-1
- Equipment List

B. Description of Flow

The unit is designed to receive, store, prepare and transport coal/limestone to the coal gasification units.

Sized coal 3" x 0" (8" maximum) will be delivered to the site via 1500 ton barges. Each barge will be unloaded using a 5600 TPH* free digging barge unloader. The barge unloader (27-UD101) will feed belt conveyor 27-CR102 which will convey the coal to a 600 ton surge bin (27-TK101). Prior to entering the surge bin, tramp iron will be removed by magnetic separator 27-S101. Vibrating feeders 27-FD101 and 27-FD102 located under the surge bin will feed belt conveyors 27-CR103 and 27-CR104 conveying the material to sampling stations 27-SS101 and 27-SS102. Prior to entering the sampling stations an inventory of the material will be made by belt weigh scales 27-WS101 and 27-WS102.

An alternate feed arrangement will be provided using dump trucks. Trucks delivering coal to the site will be weighed, for inventory, using truck scale 27-WS103 located at the unloading site. The trucks will dump the material into a 25 ton receiving hopper 27-TK102. The material will then be removed from the hopper using vibrating feeder 27-FD103 and will be conveyed to the sampling tower. Prior to sampling, tramp iron will be removed using magnetic separator 27-S102.

After sampling the material will be fed to 4 coal breakers (27-SR101 thru 27-SR104) where the coal will be reduced to 1-1/4" x 0" lumps and then fed to 2 collecting conveyors (27-CR108 and 27-CR109) transporting the coal to a transfer tower. Refuse material discharged by the coal breakers will be collected by refuse conveyors 27-CR106 and 27-CR107 which will convey the refuse out of the breaker tower and discharge to grade.

* Barge unloading at 6 times average coal usage to allow for daylight unloading, five days per week, minor repairs & for pulling the barges into position.

TVA Coal Gasification Study
B&W Gasifier

At the transfer tower the material will either be directed to four 14,500 ton coal storage silos (27-TK103 thru 27-TK106) or to the load out area. Coal discharged to the silos will be weighed for silo inventory by belt scale 27-WS105 and then conveyed by belt conveyor 27-CR114 to a cascaded conveyor system (27-CR111, 27-CR112 and 27-CR113) on top of the silos.

Coal will then be removed from the silos using either 3 to 4 belt feeders per silo (27-FD104A-G thru 27-FD107A-G). They will be feeding belt conveyor 27-CR115 discharging the material to the gasifier and steam generator feed conveyors 27-CR117A/B. Prior to this the material will be weighed on belt scale 27-WS106 and tramp iron will be removed by magnetic separator 27-S104.

Coal directed to the load out area will be weighed for dead storage inventory on belt scale 27-WS104 and then be conveyed on belt conveyor 27-CR110 to a load out dump where scrapers will build the 90 day dead storage pile.

In the event that coal from dead storage is to be used it will be drawn from 2 reclaim hoppers (27-TK107 and 27-TK108) located at the dead storage site. Vibrating pan feeders 27-FD108 and 27-FD109 located under the hoppers will each feed reclaim collecting conveyor 27-CR116 which conveys the material to the gasifier and steam generator feed conveyors 27-CR117A/B.

The gasifier and steam generator feed conveyors will direct the material to either the pulverizer bunker fill conveyors 27-CR118A/B which will fill four 1430 tons storage bunkers (27-TK109 thru 27-TK112 each having a 4 hour storage capacity) or to the steam generator transfer conveyors 27-CR119A/B which convey the material onto the steam generator bunker fill conveyors 27-CR120A/B.

All equipment from the gasifier and steam generator feed conveyors to the storage bunkers are provided with one operating and one spare train.

Limestone Storage

Limestone will be delivered to the plant site by barge, then loaded into trucks. The trucks will be equipped with pneumatic unloaders for unloading into the 980 ton limestone storage silo. Limestone will be removed from the silo using vibrating bin bottom 27-BV101 and will be fed into a pneumatic transport line by 2 rotary feeders 27-FD110A/B, leading the material to the steam generator limestone storage bunkers. The pneumatic transport line will be equipped with silencers before and after pneumatic transport blowers 27-B101A/B for noise suppression.

TVA Coal Gasification Study
B&W Gasifier

Barge Unloading System

A power winch system for barge pulling has been contemplated and included in Item UD-101, of the equipment list for Section 100, Coal Preparation. The barge puller is designed to move a line of coal laden barges, already moved, and eventually, a single barge only during the actual coal unloading operation of that barge.

Considering the scale of the Key Plot Plan, 1 in. = 400 ft., the barge puller is not shown. It does not appear on the Process Flow Diagrams of Section 100, either, as it is an ancillary device which does not serve to clarify the movement and treatment of the product, coal, the principal purpose of the Process Flow Diagrams.

The cost of the barge puller is included as part of the hardware costs of equipment Item UD-101, for each of the coal gasification plants.

The foregoing comments apply as well to the barge cleanout system which consists of a small front end loader and a single bucket crane which loads the residual coal into a barge dedicated to the plant site for cleanout service. When it becomes full, the dedicated barge is moved into the unloading line and is then replaced by another of the empty barges.

Movement of single barges, other than those operated by the power winch, is effected by means of a 750 hp switch boat for which pricing provisions have been made in our estimate of plant costs.

FOSTER WHEELER ENERGY CORPORATION
CUSTOMER: TVA
LOCATION: Murphy Hill, Alabama

SECTION NAME: B/W COAL PREPARATION
REF. DWG.: 54099-27-1-50-1
CONTRACT NO. 11-27-5099 REV.: 0

SECTION NO.: 100
PAGE NO.: 1 of 4
DATE: 6/30/80

EQUIPMENT SUMMARY

ITEM	DESCRIPTION	DEFINITION	DESIGN * TEMP. (°F)	DESIGN * PRESS. (PSIG)	CONSTRUCTION MATERIAL *
27-B101A/B	Pneumatic Transport Supply Blrs.				
27-BV101	Vibrating Discharger	25 TPH			
27-CR101	Unloader Transfer Conveyor	84" Belt 5,600 TPH			
27-CR102	Surge Bin Feed Conveyor	84" Belt 5,600 TPH			
27-CR103	Sampling Station Feed Conveyor	48" Belt 1,700 TPH			
27-CR104	Sampling Station Feed Conveyor	48" Belt 1,700 TPH			
27-CR105	Truck Receiving Transfer Conveyor	30" Belt 125 TPH			
27-CR106	Breaker Refuse Conveyor	24" Belt			
27-CR107	Breaker Refuse Conveyor	24" Belt			
27-CR108	Breaker Collecting Conveyor	48" Belt 1,762 TPH			
27-CR109	Breaker Collecting Conveyor	48" Belt 1,762 TPH			
27-CR110	Dead Storage Load Out Conveyor	66" Belt 3,525 TPH			
27-CR111	Silo Fill Conveyor	66" Belt 3,525 TPH			
27-CR112	Silo Fill Conveyor	66" Belt 3,525 TPH			
27-CR113	Silo Fill Conveyor	66" Belt 3,525 TPH			
27-CR114	Silo Feed Conveyor	66" Belt 3,525 TPH			
27-CR115	Silo Discharge Collecting Conveyor	48" Belt 1,300 TPH			
27-CR116	Reclaim Collecting Conveyor	48" Belt 1,300 TPH			
27-CR117A/B	Gasifier & Stm. Gen. Feed Conveyor	48" Belt 1,300 TPH			
27-CR118A/B	Pulverizer Bunker Fill Conveyor	48" Belt 1,300 TPH			
27-CR119A/B	Steam Gen. Transfer Conveyor	48" Belt 1,300 TPH			
27-CR120A/B	Steam Gen. Fill Conveyors	48" Belt 1,300 TPH			
27-DC101	Dust Collection System	Includes F-101 thru F-109			
27-DP101	Dust Suppression System				

* SHELL/TUBE WHERE APPLICABLE

FOSTER WHEELER ENERGY CORPORATION
CUSTOMER: TVA
LOCATION: Murphy Hill, Alabama

SECTION NAME: B/W COAL PREPARATION
REF. DWG.: 54099-27-1-50-1
CONTRACT NO. 11-27-54099 REV.: 0

SECTION NO.: 100

DATE: 6/30/80

EQUIPMENT SUMMARY

ITEM	DESCRIPTION	DEFINITION	DESIGN * TEMP. (°F)	DESIGN * PRESS. (PSIG)	CONSTRUCTION MATERIAL *
27-F101	Silo Bag House	Part of 27-DC101			
27-F102	Silo Bag House	Part of 27-DC101			
27-F103	Silo Bag House	Part of 27-DC101			
27-F104	Silo Bag House	Part of 27-DC101			
27-F105	Pulverizer Storage Bunker Filter	Part of 27-DC101			
27-F106	Pulverizer Storage Bunker Filter	Part of 27-DC101			
27-F107	Pulverizer Storage Bunker Filter	Part of 27-DC101			
27-F108	Pulverizer Storage Bunker Filter	Part of 27-DC101			
27-F109	Limestone Silo Filter - Separator	Part of 27-DC101			
27-FD101	Unloader Surge Bin Vib. Feeder	1,700 TPH			
27-FD102	Unloader Surge Bin Vib. Feeder	1,700 TPH			
27-FD103	Truck Receiving Vib. Feeder	125 TPH			
27-FD104A-G	Silo Discharge Feeder	4 @ 325 & 3 @ 433 TPH			
27-FD105A-G	Silo Discharge Feeder	4 @ 325 & 3 @ 433 TPH			
27-FD106A-G	Silo Discharge Feeder	4 @ 325 & 3 @ 433 TPH			
27-FD107A-G	Silo Discharge Feeder	4 @ 325 & 3 @ 433 TPH			
27-FD108	Reclaim Hopper Discharge Feeder	650 TPH			
27-FD109	Reclaim Hopper Discharge Feeder	650 TPH			
27-FD110A/B	Rotary Feeders	25 TPH			
27-SL101	Silencer				
27-SL102	Silencer				
27-S101	Unloader Mag. Separator	84", (Suspended Elec. Mag.)			
27-S102	Truck Receiving Mag. Separator	30", (Suspended Elec. Mag.)			
27-S103	Dead Storage Reclaim Mag. Sep.	48", (Suspended Elec. Mag.)			
27-S104	Silo Discharge Mag. Separator	48", (Suspended Elec. Mag.)			

* SHELL/TUBE WHERE APPLICABLE

FOSTER WHEELER ENERGY CORPORATION
CUSTOMER: TVA
LOCATION: Murphy Hill, Alabama

SECTION NAME: B/W COAL PREPARATION
REF. DWG.: 54099-27-1-50-1
CONTRACT NO. 11-27-54099 REV.: 0

SECTION NO.: 100
PAGE NO.: 3 of 4
DATE: 6/30/80

EQUIPMENT SUMMARY

ITEM	DESCRIPTION	DEFINITION	DESIGN * TEMP. (°F)	DESIGN * PRESS. (PSIG)	CONSTRUCTION MATERIAL *
27-SR101	Breaker	882 TPH			
27-SR102	Breaker	882 TPH			
27-SR103	Breaker	882 TPH			
27-SR104	Breaker	882 TPH			
27-SS101	Sampling Station	Two Stage			
27-SS102	Sampling Station	Two Stage			
27-TK101	Unloader Surge Bin	600 Tons			
27-TK102	Truck Receiving Hopper	25 Tons			
27-TK103	Storage Silo	14,500 Tons			
27-TK104	Storage Silo	14,500 Tons			
27-TK105	Storage Silo	14,500 Tons			
27-TK106	Storage Silo	14,500 Tons			
27-TK107	Dead Storage Reclaim Hopper	25 Tons			
27-TK108	Dead Storage Reclaim Hopper	25 Tons			
27-TK109	Pulverizer Storage Bunker	1,430 Tons			
27-TK110	Pulverizer Storage Bunker	1,430 Tons			
27-TK111	Pulverizer Storage Bunker	1,430 Tons			
27-TK112	Pulverizer Storage Bunker	1,430 Tons			
27-TK113	Limestone Silo	980 Tons			
27-UD101	Barge Unloader	5,600 TPH			
27-WS101	Sampling Sta. Feed Weigh Scale	1,700 TPH			
27-WS102	Sampling Sta. Feed Weigh Scale	1,700 TPH			
27-WS103	Truck Weigh Scale	10' x 60'			
27-WS104	Load Out Weigh Scale	3,525 TPH			
27-WS105	Silo Feed Weigh Scale	3,525 TPH			

* SHELL/TUBE WHERE APPLICABLE

FOSTER WHEELER ENERGY CORPORATION
CUSTOMER: TVA
LOCATION: Murphy Hill, Alabama

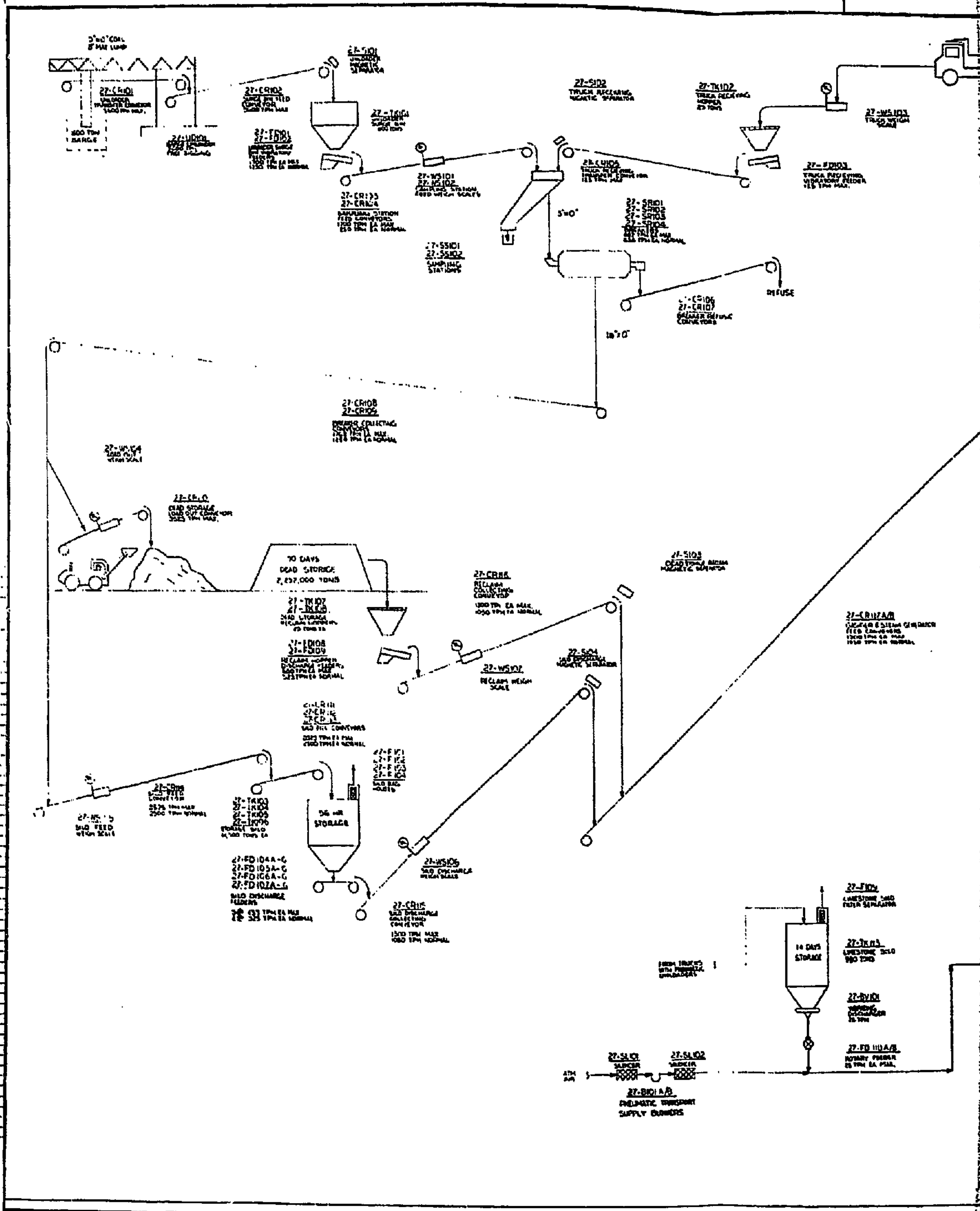
SECTION NAME: B/W COAL PREPARATION
REF. DWG.: 54099-27-1-50-1
CONTRACT NO. 11-27-54099 REV.: 0

SECTION NO.: 100
PAGE NO.: 4 of 4
DATE: 6/30/80

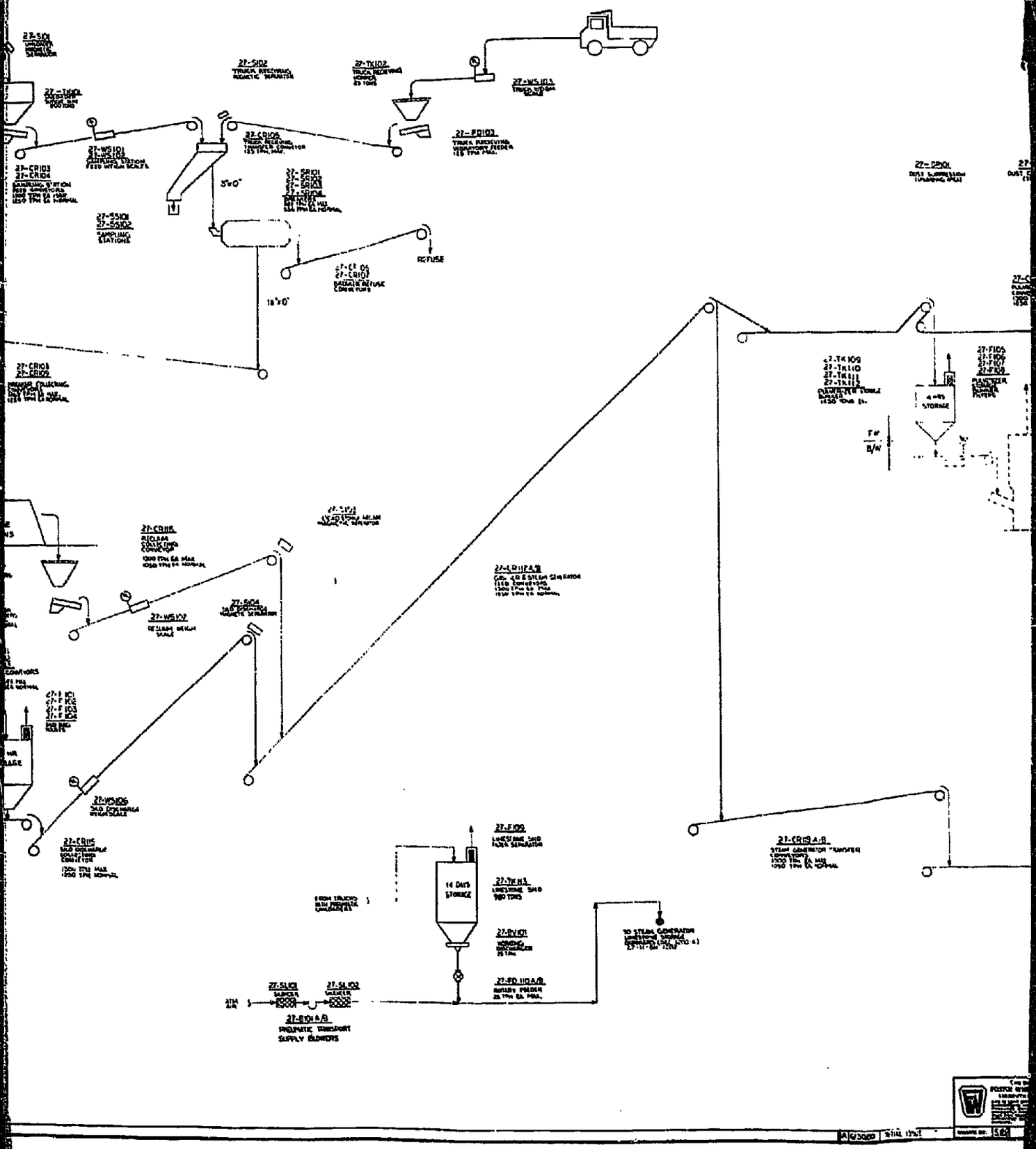
EQUIPMENT SUMMARY

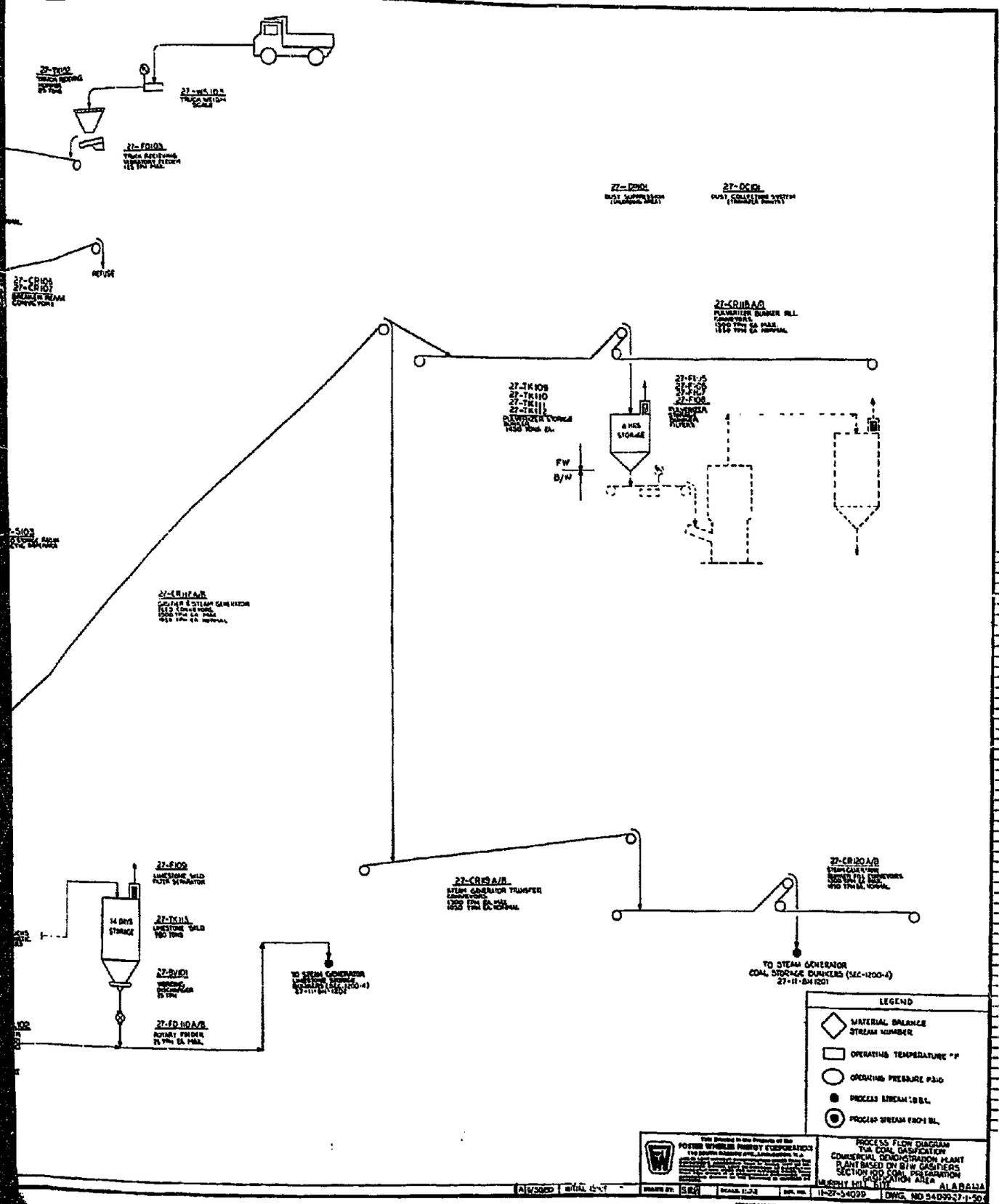
ITEM	DESCRIPTION	DEFINITION	DESIGN * TEMP. (°F)	DESIGN * PRESS. (PSIG)	CONSTRUCTION MATERIAL *
27-WS106	Silo Discharge Weigh Scale	1,300 TPH			
27-WS107	Reclaim Weigh Scale	1,300 TPH			

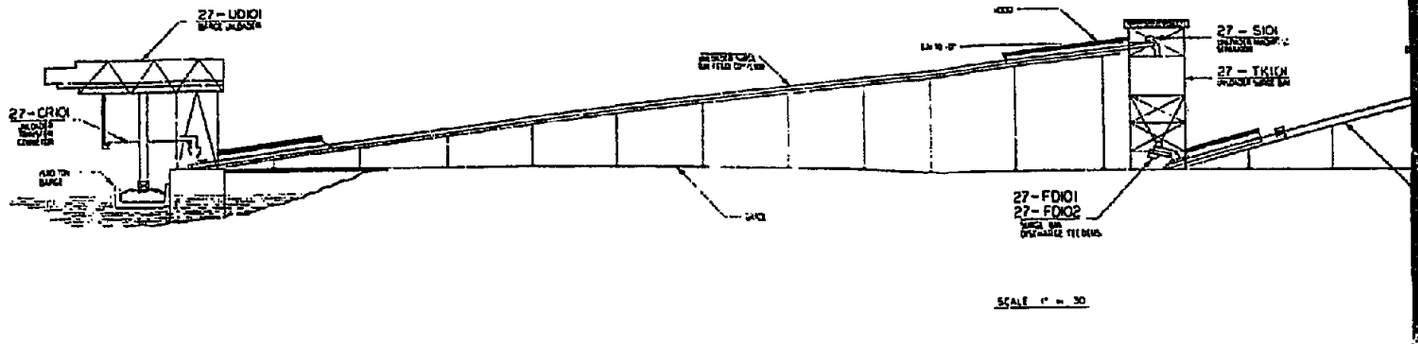
* SHELL/TUBE WHERE APPLICABLE



27-CR101
600 TON BARGE
27-UD101
27-CR102
27-TK101
27-FD101
27-CR103
27-WS101
27-SI02
27-TK102
TRUCK RECEIVING HOPPER
27-WS103
TRUCK WEIGH SCALE
27-FD103
TRUCK RECEIVING VIBRATORY FEEDER
27-SR101
27-SR102
27-SR103
27-SR104
27-SS101
27-SS102
SAMPLING STATIONS
REFUSE
27-CR106
27-CR107
BREAKER REFUSE CONVEYORS
27-CR108
27-CR109
BREAKER COLLECTING CONVEYORS
DEAD STORAGE LOAD OUT CONVEYOR
70 DAYS
DEAD STORAGE
2,257,000 TONS
27-TK107
27-FD108
27-FD109
RECLAIM HOPPER DISCHARGE FEEDERS
27-CR116
RECLAIM COLLECTING CONVEYOR
27-WS107
RECLAIM WEIGH SCALE
27-SI03
27-SI04
SILO FILL CONVEYORS
27-F101
27-F102
27-F103
27-F104
27-TK103
27-TK104
27-TK105
27-TK106
56 HR
STORAGE
SILO FEED WEIGH SCALE
27-FD104A-G
27-FD105A-G
27-FD106A-G
SILO DISCHARGE FEEDERS
27-WS106
SILO DISCHARGE WEIGH SCALE
27-CR115
SILO DISCHARGE COLLECTING CONVEYOR
1500 TPH MAX
1080 TPH NORMAL
27-CR117A/B
14 DAYS
STORAGE
LIMESTONE SILO
27-SL101
27-SL102
27-BL101A/B
PNEUMATIC TRANSPORT
SUPPLY BLOWERS


27-SI01
27-SI02
TRUCK RECEIVING MAGNETIC SEPARATOR
27-TK102
TRUCK RECEIVING HOPPER
27-WS103
TRUCK WEIGH SCALE
27-CR103
27-CR104
27-CR106
TRUCK RECEIVING TRANSFER CONVEYOR
27-FD103
TRUCK RECEIVING VIBRATORY FEEDER
27-WS101
27-WS102
27-CR101
27-CR102
27-CR104
27-SS101
27-SS102
REFUSE
27-CR105
27-CR107
27-CR108
27-CR109
27-TK109
27-TK110
27-TK111
27-TK112
27-FI05
27-FI06
27-FI07
27-FI08
4 HRS STORAGE
27-CR116
27-SI04
27-WS104
27-CR117A/B
27-WS105
27-CR115
27-FI09
LIMESTONE SAND FLASH SEPARATOR
14 DAYS STORAGE
27-TK113
LIMESTONE SAND 980 TONS
27-EV101
27-FD 110A/B
ROTARY FEEDER
27-CR15A-B
27-SL101
27-SL102
27-B101A/B
PNEUMATIC TRANSPORT SUPPLY BLOWERS


27-TK108
27-TK110
27-TK111
27-TK112
6 HRS STORAGE
FW
B/W
27-CR118A/B
27-CR119A/B
27-CR120A/B
27-FD103
27-DC106
REFUSE
27-CR104
27-CR107
27-CR118A/B
27-CR119A/B
27-CR120A/B
27-CR114A/B
27-FD109
14 DAYS STORAGE
27-TK113
27-BV101
27-FD110A/B
TO STEAM GENERATOR
COAL STORAGE BUNKERS (SEC-1200-4)
27-11-BM 1201
LEGEND
MATERIAL BALANCE STREAM NUMBER
OPERATING TEMPERATURE °F
OPERATING PRESSURE PSIG
PROCESS STREAM LIQUID
PROCESS STREAM FROM BL
POSTER WHEELER ENERGY CORPORATION
PROCESS FLOW DIAGRAM
TVA COAL GASIFICATION
COMMERCIAL DEMONSTRATION PLANT
PLANT BASED ON B/W GASIFIERS
SECTION 100 COAL PREPARATION
GASIFICATION AREA
MURPHY HILL SITE ALABAMA
DWG. NO 54099-27-1-501



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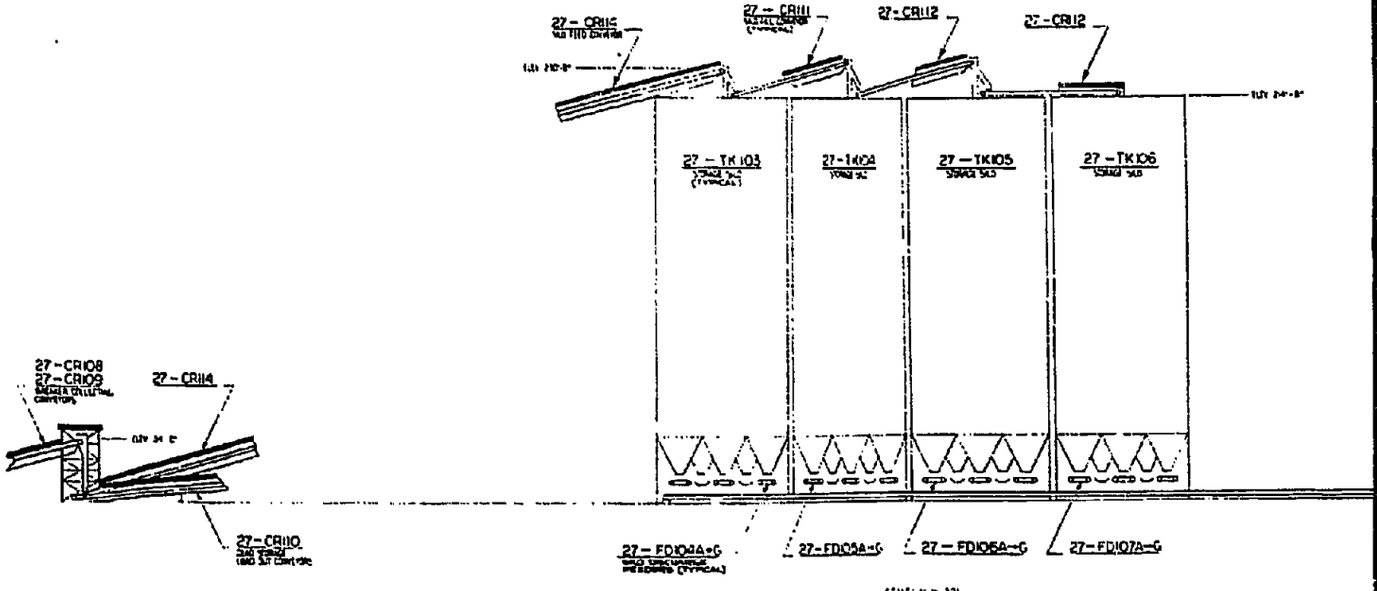

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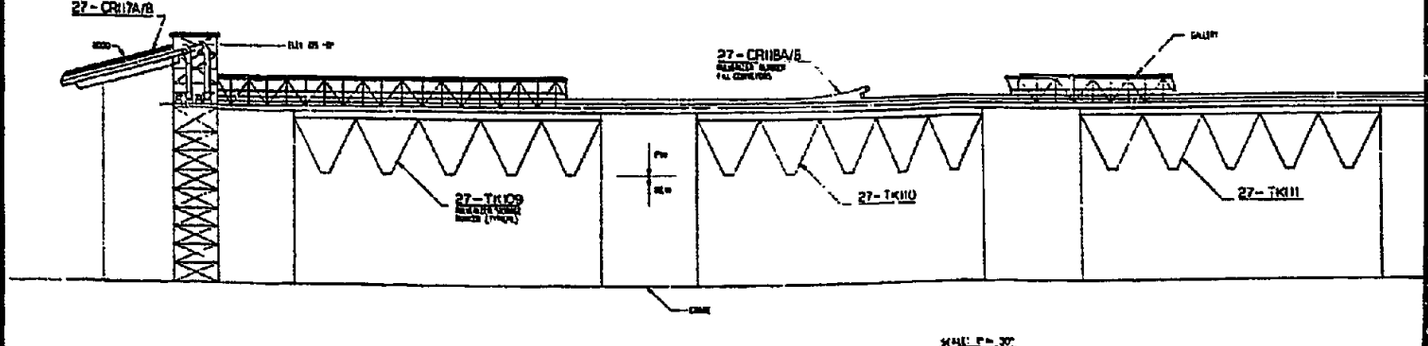

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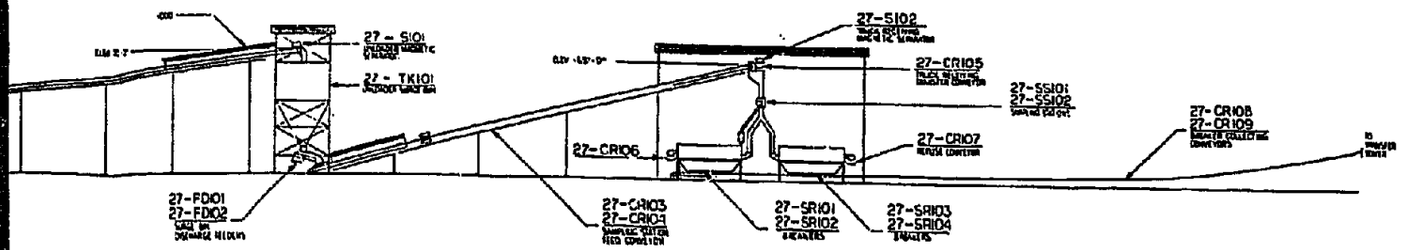

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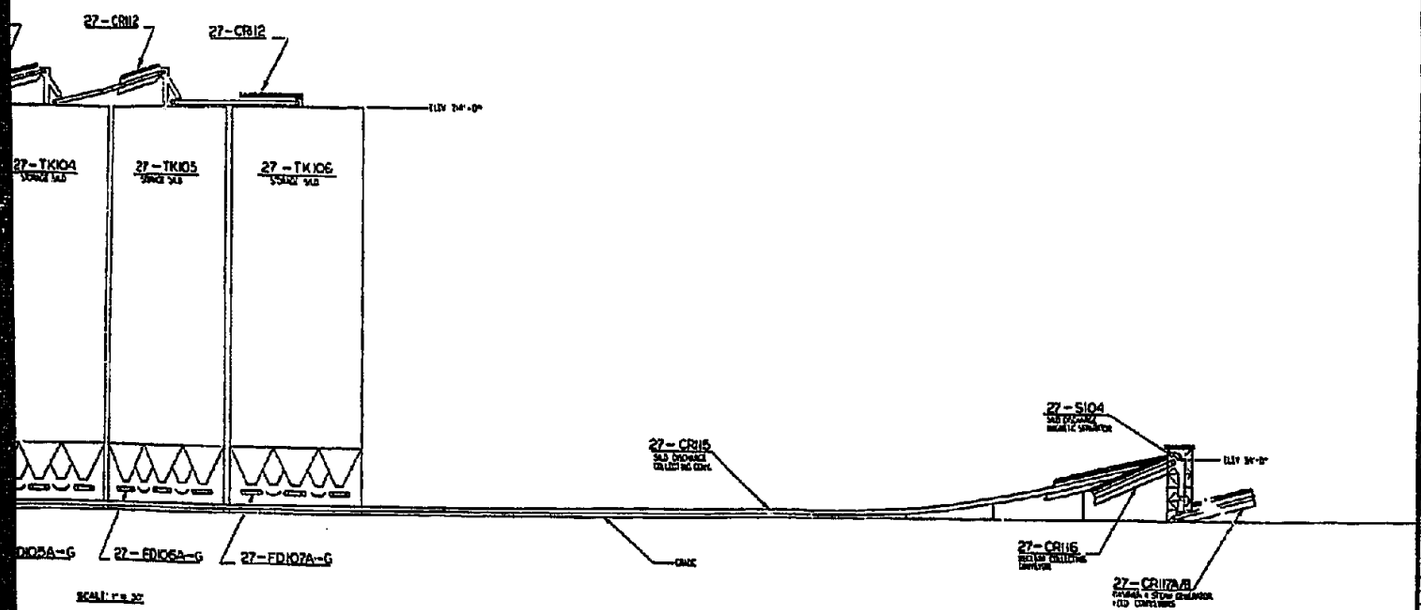
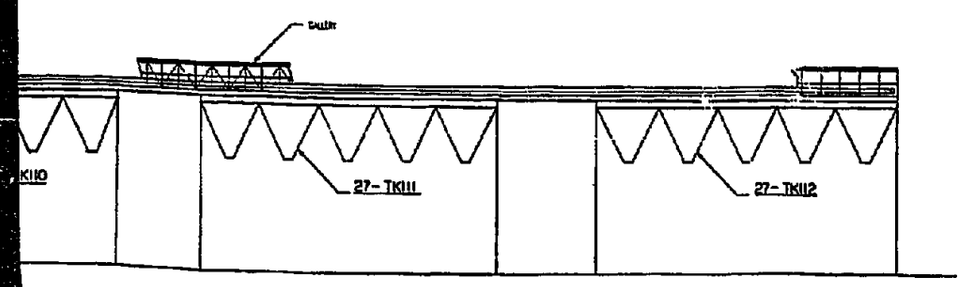


SCALE: 1" = 32'



SCALE: 1" = 32'

A	1/29/80	INITIAL ISSUE			

POSTER WHEELER ENERGY CORPORATION

ELEVATION
TVA COAL GASIFICATION
COMMERCIAL DEMONSTRATION PLANT
PLANT BASED ON B/W DESIGNERS
SECTION 100 COAL PREPARATION
GASIFICATION AREA
MUSCLE SHOALS, ALABAMA

DRAWN [illegible] | CLEAN [illegible] | DATE 11-27-54099 | DWG.NO. 54099-27-1-01-1

TVA Coal Gasification Study
B&W Gasifier

SECTION DESCRIPTION

3.2 SECTION 200 - AIR SEPARATION PLANT

A. Reference Material:

- Process Flowsheet — FWEC Dwg. No. 54099-27-1-50-2
- Equipment List
- Material Balance

B. Description of Flow

Filtered air is compressed to approximately 90 PSIG in three stage Air Compressors (27-12-C-201A/B), half turbine/half motor driven. Intercoolers, an aftercooler, and K.O. Drums are provided. Condensate leaving the K.O. Drums flows to the cooling tower.

Some compressed air is fed to the gasifier during startup. Normally compressed air is fed only to the Cold Box Package (27-12-PG-201).

The Cold Box Package produces nitrogen containing about 10 ppmv O_2 and oxygen of about 98 vol % O_2 purity. Waste nitrogen is vented through the Waste Nitrogen Silencer (27-12-SL-201) to atmosphere. Oxygen gas leaving the cold box package is compressed in three stage machines (half turbine driven) to a pressure of about 275 PSIG by the Oxygen Compressor (27-12-C-202). Intercoolers and K.O. drums will be provided by the compressor manufacturer. A portion of the compressed oxygen is recirculated through the Oxygen Comp. Recirc. Cooler (27-12-E-207), to the suction side of the Oxygen Compressor for controllability. A fraction of the compressed oxygen is sent to the Gasifier (27-14-R-301) in Section 300. A smaller fraction is boosted to about 3,000 PSIG by the O_2 Storage Feed Compressor and flows to the Gaseous Oxygen Storage Tanks (27-12-TK-202A/B/C/D). Stored oxygen is required for the Gasifiers in Section 300, approximately ten minutes every two hours, due to a reversal in Cold Box Package operation.

The liquid oxygen product leaving the Cold Box Package (27-12-PG-201) enters the Liquid Oxygen Storage Tank (27-12-TK-201). When required, liquid oxygen is vaporized in the Liquid Oxygen Vaporation Package (27-12-PG-205), then combined with oxygen from the O_2 Storage Feed Compressors in both air plants (two air plants per module). The combined gaseous oxygen stream enters the Gaseous Oxygen Storage Tanks.

Liquid nitrogen leaves the Cold Box Package and enters the Liquid Nitrogen Storage Tank (27-12-TK-203). When required, liquid nitrogen is vaporized in the Nitrogen Vaporization Packages (27-12-PG-204A/B). Vaporized nitrogen from Nitrogen Package PG-204A is sent to the Gasifier in Section 300, while vaporized nitrogen from Nitrogen Vaporization Package PG-204B is used for Plant Instruments.

Gaseous nitrogen from the Cold Box Package, PG-201, enters the Plant Nitrogen Compressor (27-12-C-203A/B), motor driven, with intercoolers, an aftercooler and knockout drums. Compressed nitrogen leaving the Knockout Drum at a pressure of about 585 PSIG is distributed to process users. A fraction of the compressed nitrogen is utilized by plant instruments, the remainder used for purging, blanketing, coal system shutdown, coal treatment and the coal feed system.

FOSTER WHEELER ENERGY CORPORATION
CUSTOMER: TVA
LOCATION: ALABAMA
PLANT TYPE: B. & W. COAL GASIFICATION

SECTION NAME: AIR SEPARATION PLANT
REF. DWG.: 54099-27-1-50-2
CONTRACT NO.: 11-27-54099 REV.:

SECTION NO.: 300
PAGE NO.: 1 of 1
DATE: 4-18-80

STREAM NUMBER		27 201		27 206	27 305	27 311	
STREAM DESCRIPTION		AIR INTAKE		CONDENSATE	N_{2v} to Gasifier	O_{2v} to Gasifier	
COMPONENTS	(MW)	MOL/HR	MOL/HR	MOL/HR	MOL/HR	MOL/HR	MOL/HR
HYDROGEN	2.016						
CARBON MONOXIDE	28.011						
CARBON DIOXIDE	44.011						
METHANE	16.043						
NITROGEN	28.014	39,896			1,934	1	
OXYGEN	32.000	10,663				10,663	
HYDROGEN SULFIDE	34.080						
CARBONYL SULFIDE	60.075						
AMMONIA	17.031						
HYDROGEN CYANIDE	27.026						
CHLORIDES	35.453						
SULFUR	32.066						
CARBON DISULFIDE	76.143						
SULFUR DIOXIDE	64.066						
ARGON	39.944	217				217	
MERCAPTANS							
TOTAL DRY GAS					1,934	10,881	
WATER	18.016	944			0	0	
TOTAL WET GAS		51,720			1,934	10,881	
		LBS/HR	LBS/HR	LBS/HR	LBS/HR	LBS/HR	LBS/HR
TOTAL STREAM LBS/HR		1,484,538		17,000	54,179	349,905	
SOLIDS LBS/HR							
COAL							
ASH							
CARBON							
TOTAL SOLIDS							
WATER LIQUID				17,000			
TOTAL STREAM							
TEMPERATURE, °F		80			100	77	
MMSCFD DRY GAS							
DRY GAS GHV (BTU/SCF)							

TWO 50% AIR PLANTS (BOTH OPERATING) PER MODULE. FOUR MODULES TOTAL. B & W GASIFIERS

FORM NO 135-904

FOSTER WHEELER ENERGY CORP.
PROCESS PLANTS DIVISION

CONTRACT: 11-27-54099
SECTION: 200

EQUIPMENT LIST

NAME OF UNIT: AIR SEPARATION PLANT

PAGE 1 OF 2

CLIENT: TVA (COAL GASIFICATION STUDY)

LOCATION: ALABAMA

REVISION	1	2	3	4	5
DATE					
ORIGINAL					

CLASS	ITEM NO.	DESCRIPTION	No./Module	REV.
COMPRESSOPS	PerPlant			
27-12-	C-201A/B	AIR COMPRESSOR	4-25%	
-	C-202	OXYGEN COMPRESSOR	2-50%	
-	C-203A/B	PLANT NITROGEN COMPRESSOR	4-25%	
-	C-204	O_2 STORAGE FEED COMPRESSOR	2-50%	
DRUMS				
27-12-	D-201A/B	1st AIR COMPRESSOR K.O. DRUM	4-25%	
-	D-202A/B	2nd AIR COMPRESSOR K.O. DRUM	4-25%	
-	D-203A/B	3rd AIR COMPRESSOR K.O. DRUM (AIR COMPRESSOR AFTER DRUM	4-25%	
EXCHANGERS				
27-12-	E-201A/B	1st STG AIR COMP. INTERCONDENSER	4-25%	
-	E-202A/B	2nd STG AIR COMP. INTERCONDENSER	4-25%	
-	E-203A/B	AIR COMPRESSOR AFTERCONDENSER	4-25%	
-	E-204	O_2 COMP 1st STG INTERCOOLER	2-50%	
-	E-205	O_2 TEMP. 2nd STG INTERCOOLER	2-50%	
-	E-207	OXYGEN COMP RECIRC COOLER	2-50%	

TWO 50% AIR PLANTS (BOTH OPERATING) PER MODULE. FOUR MODULES TOTAL B & W GASIFIERS

FORM NO. 135-904

FOSTER WHEELER ENERGY CORP.
PROCESS PLANTS DIVISION

CONTRACT 11-27-54099
SECTION: 200

EQUIPMENT LIST

NAME OF UNIT: AIR SEPARATION PLANT

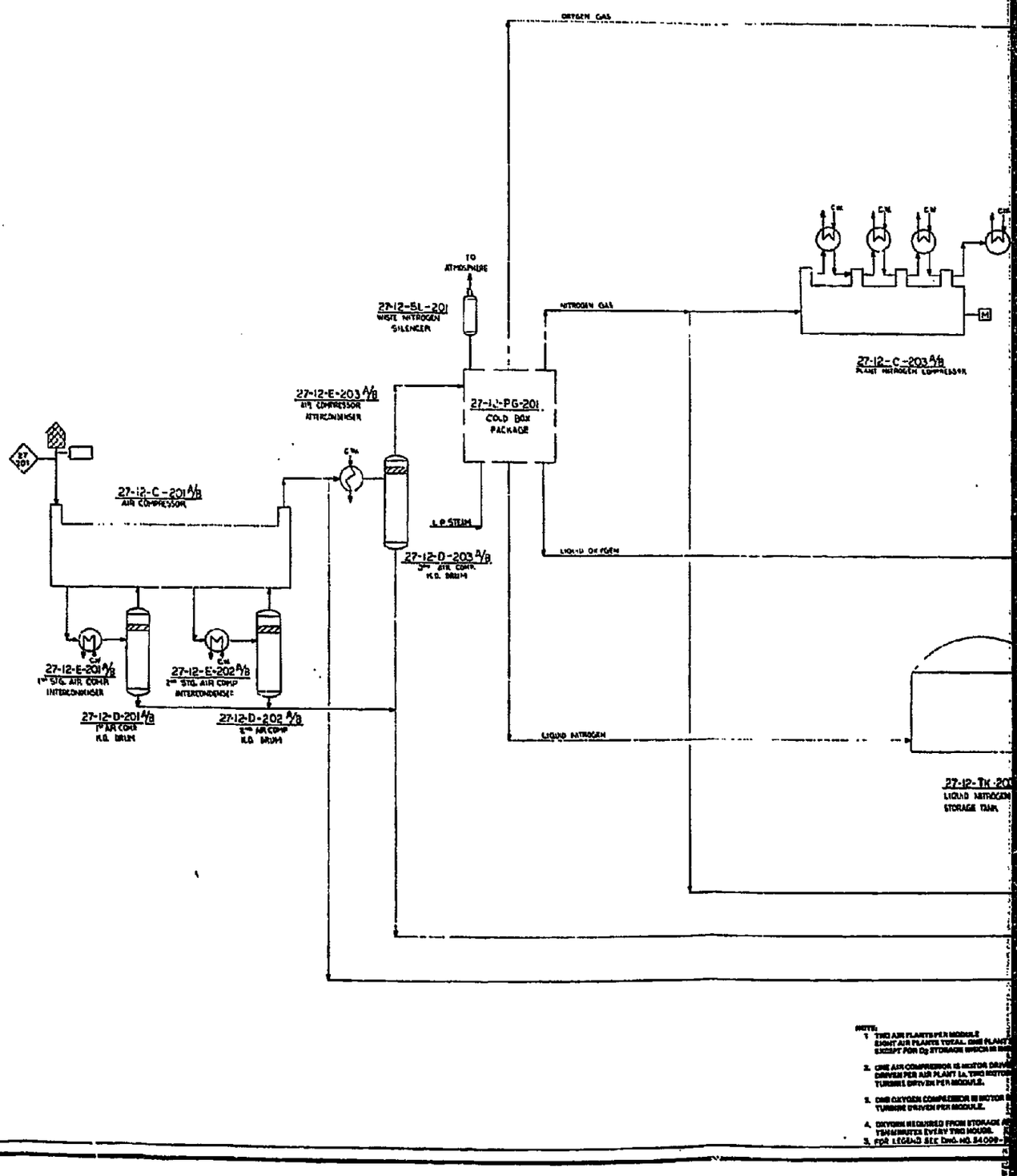
PAGE 2 OF 2

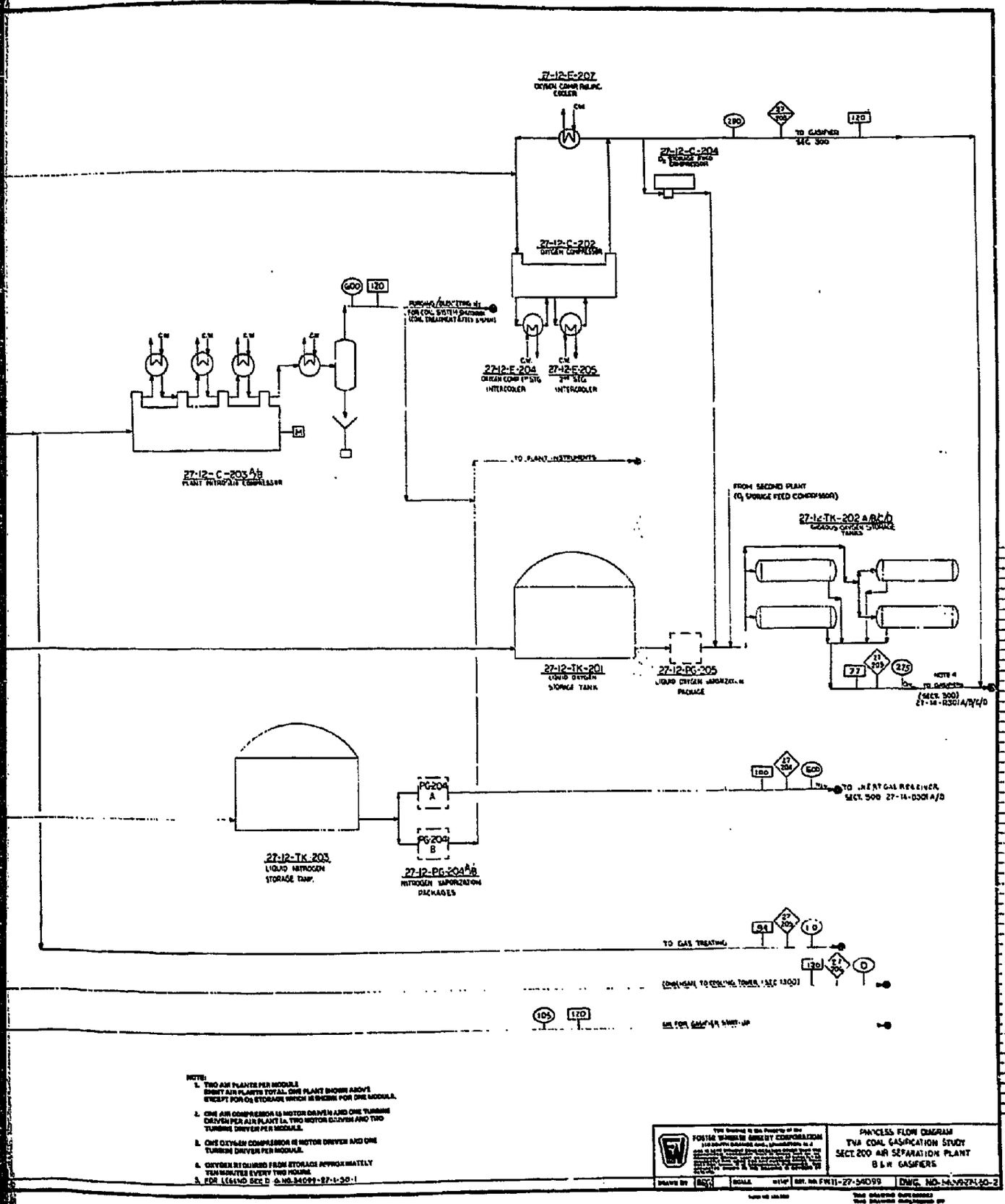
CLIENT: TVA (COAL GASIFICATION STUDY)

LOCATION: ALABAMA

REVISION	ORIGINAL	1	2	3	4	5
DATE						

CLASS	ITEM NO.	DESCRIPTION	EFD	No./Module	REV.
PACKAGE ITEMS	Per Plant				
27-12-	PG-201	COLD BOX PACKAGE		2-50%	
-	PG-204A/B	NITROGEN VAPORIZATION PKGS		2-100 Tons/Day Each	
-	PG-205	LIQUID OXYGEN VAPORIZATION PKG.		1-185 Tons/Hr	
TANKS 27-12-	TK-201	LIQUID OXYGEN STORAGE TANK		1-4,500 Tons	
-	TK-202A/B	GASEOUS OXYGEN STORAGE TANKS		4-50%	
-	TK-203	LIQUID NITROGEN STORAGE TANK		1-250 Tons	
SILENCER 27-12-	SL-201	WASTE NITROGEN SILENCER		2-50%	


OXYGEN GAS
TO ATMOSPHERE
27-12-SL-201
WASTE NITROGEN SILENCER
NITROGEN GAS
27-12-C-203 A/B
PLANT NITROGEN COMPRESSOR
27-12-E-203 A/B
AIR COMPRESSOR AFTERCOOLER
27-12-PG-201
COLD BOX PACKAGE
27-12-C-201 A/B
AIR COMPRESSOR
L.P. STEAM
27-12-D-203 A/B
3rd AIR COMP. K.O. DRUM
LIQUID OXYGEN
27-12-E-201 A/B
1st STG. AIR COMP. INTERCOOLER
27-12-E-202 A/B
2nd STG. AIR COMP INTERCOOLER
27-12-D-201 A/B
1st AIR COMP K.O. DRUM
27-12-D-202 A/B
2nd AIR COMP K.O. DRUM
LIQUID NITROGEN
27-12-TK-201
LIQUID NITROGEN STORAGE TANK
NOTE:
1. TWO AIR PLANTS PER MODULE-2 EIGHT AIR PLANTS TOTAL. ONE PLANT EXCEPT FOR O2 STORAGE
2. ONE AIR COMPRESSOR IS MOTOR DRIVEN PER AIR PLANT 1A, TWO MOTOR TURBINE DRIVEN PER MODULE.
3. ONE OXYGEN COMPRESSOR IS MOTOR TURBINE DRIVEN PER MODULE.
4. OXYGEN REQUIRED FROM STORAGE TRANSMITTER EVERY TWO HOURS.
5. FOR LEGEND SEE Dwg. NO. 84009-



NOTES:

1. TWO AIR PLANTS PER MODULE EIGHT AIR PLANTS TOTAL. ONE PLANT SHOWN ABOVE EXCEPT FOR O_2 STORAGE WHICH IS SHOWN FOR ONE MODULE.
2. ONE AIR COMPRESSOR IS MOTOR DRIVEN AND ONE TURBINE DRIVEN PER AIR PLANT I.E. TWO MOTOR DRIVEN AND TWO TURBINE DRIVEN PER MODULE.
3. ONE OXYGEN COMPRESSOR IS MOTOR DRIVEN AND ONE TURBINE DRIVEN PER MODULE.
4. OXYGEN RETURNED FROM STORAGE APPROXIMATELY TEN MINUTES EVERY TWO HOURS.
5. FOR LEGEND SEE D. G. NO. 84099-27-1-30-1

FOSTER WHEELER ENERGY CORPORATION
110 SOUTH ORANGE AVE., LIVINGSTON, N.J.

PROCESS FLOW DIAGRAM
TVA COAL GASIFICATION STUDY
SECT 200 AIR SEPARATION PLANT
B & W GASIFIERS

DRAWN BY: BCS | SCALE: NTS | EST. NO. FW11-27-34099 | DWG. NO. M-W27M60-2

TVA Coal Gasification Study
B&W Gasifier

SECTION DESCRIPTION

3.3 SECTION 300A- B&W GASIFICATION SYSTEM

A. Reference Material:

. Process Flow Diagram FWEC Dwg. No. 54099-27-1-50-3

. Equipment List

. Material Balance

B. Description of Flow

Crushed coal from Coal Preparation (Section 100) is surged in the Crushed Coal Bunker (27-14-BN-301), then flows to the Raw Coal Feeder (27-14-FD-301 A thru J) which conveys the coal (dried basis) at an average rate of 5000 T/D per module into the Coal Pulverizers (27-14-GR-301 A thru J). Coal is pulverized so as to pass through 200 mesh and dried in the Pulverizers with flue gases from the Steam Generators (27-11-SG-1201 A/B). The pulverized coal and flue gas enter the Pulv. Coal Cyclone (27-14-S-301 A-H) where the two are separated, coal flowing through the Coal Cyclone Discharge Feeder (27-14-TK-301 A,B,C,D) to the Pulv. Coal Reservoir Tank (27-14-TK-301 A,B,C,D). The Pulv. Coal Cyclone is vented through the Primary Pulv. Coal Baghouses (27-14-FD-301 A thru H) which removes particulates to a low level before venting the gas to the atmosphere. Coal fines recovered are discharged through the Primary Baghouse Discharge Feeder, D-303 A,B,C,D to the Pulv. Coal Reservoir Tank.

Pulverized coal from the Pulv. Coal Reservoir Tank enters the Pulv. Coal Lock Hoppers (27-14-BN-302 A thru H) where it is pneumatically transported to the Pulv. Coal Feed Tank (27-14-TK-302 A,B,C,D). High pressure nitrogen from the Inert Gas Receiver is fed to the Lock Hoppers and the Feed Tank to pneumatically transport the pulverized coal to the Gasifiers (27-14-R-302 A,B,C,D). Vented gas from the Feed Tank and Lock Hoppers is sent through the Sec. Pulv. Coal Baghouse (27-14-F-302 A,B,C,D), then released to atmosphere. Coal particles are returned to the Pulv. Coal Reservoir Tank by the Sec. Baghouse Discharge Feeder (27-14-FD-304 A,B,C,D). The lock hopper/feed tank arrangement permits continuous feeding of the Gasifiers.

Gaseous oxygen from the Air Plant is injected directly into the gasification zone where it is mixed and combusted with the pulverized coal. The ash in the coal forms a molten slag which drops into the Slag Tank (27-14-TK-303 A,B,C,D) and quenched with sluice water. The slag is transported to the Slag Lock Hopper (27-14-BN-303 A,B,C,D) intermittently and conveyed by the Slag Eductor (27-14-J-301 A,B,C,D) to the slag disposal pond.

Hot gases leaving the gasification zone contain ungasified suspended char particles. Much of the char is removed in the Primary Char Cyclone (27-14-S-302 A,B,C,D) where it is cooled and discharged through the Prim. Char Cyclone Discharge Feeder (27-14-FD-305 A,B,C,D) and combined with char recovered from the Secondary Char Cyclone Discharge Feeder (27-14-FD-306 A,B,C,D). The combined stream is returned to the Gasifier by the Char Eductor (27-14-J-302 A,B,C,D).

Heat is recovered from raw gas indirectly in the upper portion of the Gasifier, producing H.P. Steam in the waterwall. The H.P. steam-condensate mixture flows to the H.P. Steam Drum (27-14-D-303 A,B,C,D). Separated steam flows to the Heat Recovery Boiler (27-14-E-301 A,B,C,D), is superheated, then flows to the H.P. steam header.

Heat is recovered from the hot raw gas leaving the Primary Char Cyclone in the Heat Recovery Boiler, E-301 A,B,C,D, thereby producing additional H.P. superheated steam. The cooled gases at about 450°F flow through the Secondary Char Cyclone to aqueous Gas Scrubbing also in Section 300.

Four gasifiers are provided in each module (sixteen gasifiers in the entire plant), two operating, two on standby, to gasify the normal throughput of 5.000 T/D of coal per module.

FOSTER WHEELER ENERGY CORPORATION
CUSTOMER: TVA COAL GASIFICATION
LOCATION: ALABAMA
PLANT TYPE: B.&.W. GASIFIERS

SECTION NAME: B.&.W. GASIFICATION SYSTEM SECTION NO.: 300
REF. DWG.: 54099-27-1-50-3 PAGE NO.: 1
CONTRACT NO. 11-27-54099 REV.: DATE:

STREAM NUMBER		27 301			27 306	27 307	27 309
STREAM DESCRIPTION		Raw Crushed Coal			Gas Separated From Pulv Coal	Inert Gas Supply	Vented Gas From 2nd Bghs.
COMPONENTS	(MW)	MOL/HR	MOL/HR	MOL/HR	MOL/HR	MOL/HR	MOL/HR
NO, AS NO_2	46.008				1.55		
HYDROGEN	2.016						
CARBON MONOXIDE	28.011						
CARBON DIOXIDE	44.011				939.86		
METHANE	16.043						
NITROGEN	28.014				23,517.38	1,934	1,258
OXYGEN	32.000				5,123.10		
HYDROGEN SULFIDE	34.080						
CARBONYL SULFIDE	60.075						
AMMONIA	17.031						
HYDROGEN CYANIDE	27.026						
CHLORIDES (Cl_2)	35.463				(0.31)		
SULFUR	32.066						
CARBON DISULFIDE	76.143						
SULFUR DIOXIDE	~~64.065~~				1.90		
ARGON	39.944						
MERCAPTANS							
TOTAL DRY GAS					29,584.11	1,934	1,258
WATER	18.016				2,427.47		
TOTAL WET GAS					32,011.58	1,934	1,258
		LBS/HR	LBS/HR	LBS/HR	LBS/HR	LBS/HR	LBS/HR
TOTAL STREAM LBS/HR		451,517			908,074	54,179	35,242
SOLIDS LBS/HR							
COAL		416,667					
ASH							
CARBON							
TOTAL SOLIDS		416,667					
WATER LIQUID		34,850					
TOTAL STREAM							
TEMPERATURE, °F		77			150	100	100
MMSCFD DRY GAS							
DRY GAS GHV (BTU/SCF)							

FOSTER WHEELER ENERGY CORPORATION
CUSTOMER: TVA COAL GASIFICATION
LOCATION: ALABAMA
PLANT TYPE: B & W GASIFIERS

SECTION NAME: B & W GASIFICATION
REF. DWG.: 54099-27-1-50-3
CONTRACT NO.: 11-27-54099 REV.: .....

SECTION NO.: 300
PAGE NO.: 2
DATE: .....

STREAM NUMBER		27 311	27 317	27 315	27 318	27 319	
STREAM DESCRIPTION		Oxidant Into Gasifier	Sluice Water	Steam For Char Recycle	Slag To Ash Pond	Gas to Particulate Cleanup	
COMPONENTS	(MW)	MOL/HR	MOL/HR	MOL/HR	MOL/HR	MOL/HR	MOL/HR
HYDROGEN	2.016					10,039	
CARBON MONOXIDE	28.011					20,707	
CARBON DIOXIDE	44.011					1,557	
METHANE	16.043						
NITROGEN	28.014	1				900	
OXYGEN	32.000	10,663				0	
HYDROGEN SULFIDE	34.080					489	
CARBONYL SULFIDE	60.075					33	
AMMONIA	17.031					1	
HYDROGEN CYANIDE	27.026						
CHLORIDES	35.453					HCL 15	
SULFUR	32.066						
CARBON DISULFIDE	76.143						
SULFUR DIOXIDE	64.066						
ARGON	39.944	217				217	
MERCAPTANS						TRACE	
TOTAL DRY GAS		10,881				33,956	
WATER	18.016			1,966		1,522	
TOTAL WET GAS		10,881				35,480	
		LBS/HR	LBS/HR	LBS/HR	LBS/HR	LBS/HR	LBS/HR
TOTAL STREAM LBS/HR		349,905	360,000	35,417	413,810	767,131	
SOLIDS LBS/HR							
COAL					52,436	12,272	
ASH					1,374	5,599	
CARBON							
TOTAL SOLIDS					53,810	17,871	
WATER LIQUID			360,000		360,000		
TOTAL STREAM							
TEMPERATURE, °F		77	77	406	90	450	

MMSCFD DRY GAS
[illegible] AS G TONS

FOUR GASIFIERS PER MODULE — B & W GASIFIERS

FORM NO 135-904

FOSTER WHEELER ENERGY CORP. — PROCESS PLANTS DIVISION | CONTRACT 11-27-54099 | SECTION 300 | **EQUIPMENT LIST** | NAME OF UNIT: B & W GASIFICATION | PAGE 1 OF 3

CLIENT. TVA (COAL GASIFICATION STUDY) | REVISION | ORIGINAL | 1 | 2 | 3 | 4 | 5

LOCATION. ALABAMA | DATE

CLASS	ITEM NO	DESCRIPTION	EFD	No./Module	REV.
BINS					
27-14	BN-301	CRUSHED COAL BIN			
-	BN-302A-H	PULV COAL LOCK HOPPERS		8-25%	
-	BN-303 A-D	SLAG LOCK HOPPERS		4-50%	
DRUMS					
-	D-301 A,B	INERT GAS RECEIVER		4-50%	
-	D-302 A-D	M. P. STEAM DRUM		4- 50%	
-	D-303 A-D	H.P. STEAM DRUM		4-50%	
FEEDERS					
27-14	FD-301 A thru J	RAW COAL FEEDER		10-25%	
-	FD-302 A-D	COAL CYCLONE DISCHARGE FEEDER		4-50%	
-	FD-303 A-D	PRIMARY BAGHOUSE DISCHARGE FEEDER		4-50%	
-	FD-304 A-D	SECOND BAGHOUSE DISCHARGE FEEDER		4-50%	
-	FD-305 A-D	PRIM. CHAR CYCLONE DISCHARGE FEEDER		4-50%	
-	FD-306 A-D	SEC. CHAR CYCLONE DISCHARGE FEEDER		4-50%	

FOUR GASIFIERS PER MODULE B & W GASIFIERS

FORM NO. 135-904

FOSTER WHEELER ENERGY CORP.
PROCESS PLANTS DIVISION

CONTRACT 11-27-54099
SECTION: 300

EQUIPMENT LIST

NAME OF UNIT: B & W GASIFICATION

PAGE 2 OF 3

CLIENT: TVA (COAL GASIFICATION STUDY)

LOCATION: ALABAMA

REVISION	ORIGINAL	1	2	3	4	5
DATE						

CLASS	ITEM NO	DESCRIPTION	EFD	No./Module	REV.
FILTERS					
27-14-	F-301 A-H	PRIMARY PULV. COAL BAGHOUSE		8-25%	
-	F-302A-D	SEC. PULV. COAL BAGHOUSE		4-50%	
EXCHANGER					
27-14-	E-301 A-D	HEAT RECOVERY BOILER		4-50%	
GRINDER -	GR-301AJ	COAL PULVERIZER		8-25% +2spares	
EDUCTORS					
-	J-301 A-D	SLAG EDUCTOR		4-50%	
-	J-302 A-D	CHAR EDUCTOR		4-50%	
PUMPS					
27-14-	P-302 A-H	H.P. CIRCULATING PUMP (+DRIVE)		8-25%	
-	P-303 A-H	L. P. CIRCULATING PUMP (+DRIVE)		8-25%	

FOUR GASIFIERS PER MODULE

B & W GASIFIERS

FORM NO. 135-904

FOSTER WHEELER ENERGY CORP.
PROCESS PLANTS DIVISION

CONTRACT: 11-27-54099
SECTION: 300

EQUIPMENT LIST

NAME OF UNIT: B & W GASIFICATION

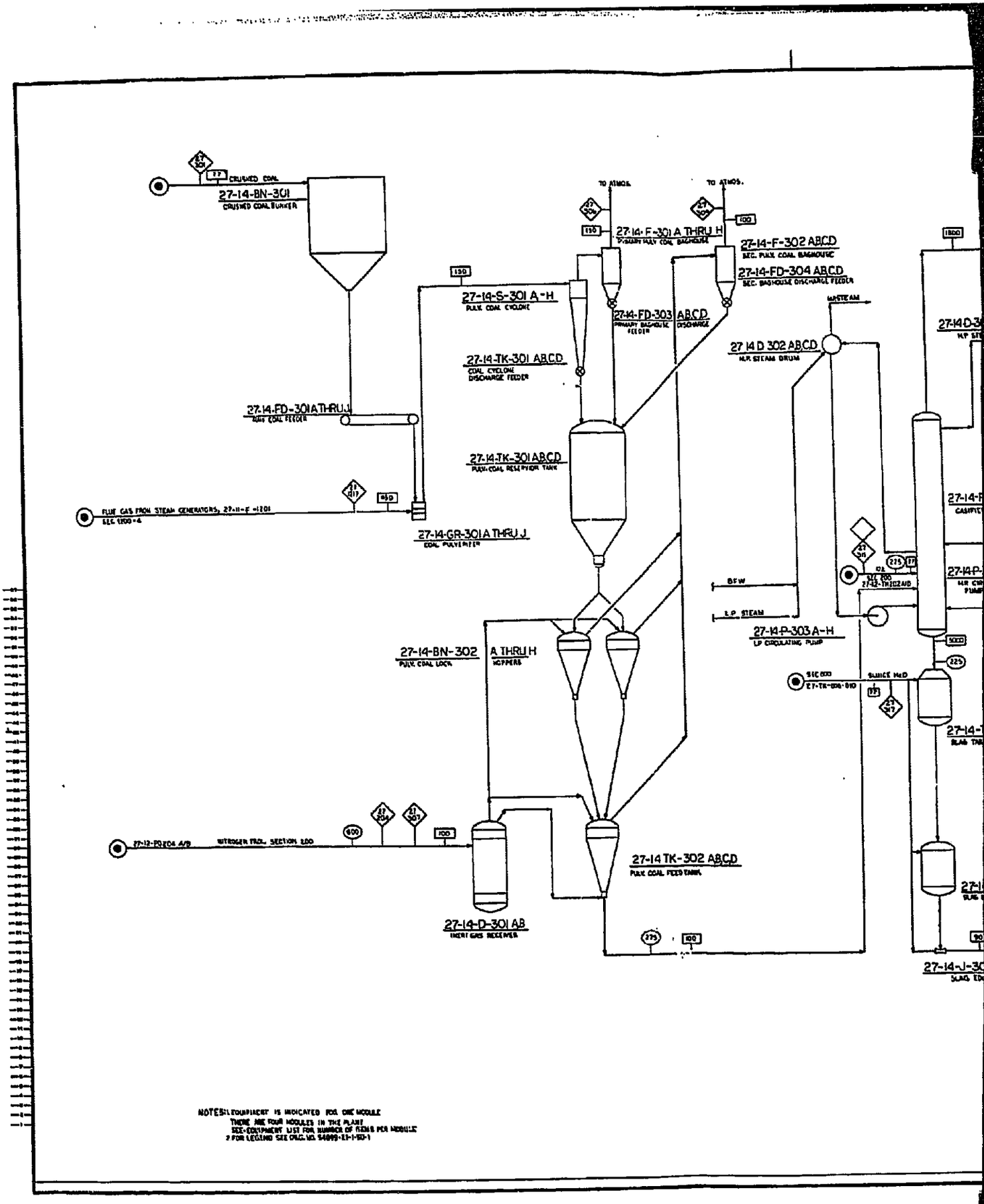
PAGE 3 OF 3

CLIENT: TVA (COAL GASIFICATION STUDY)

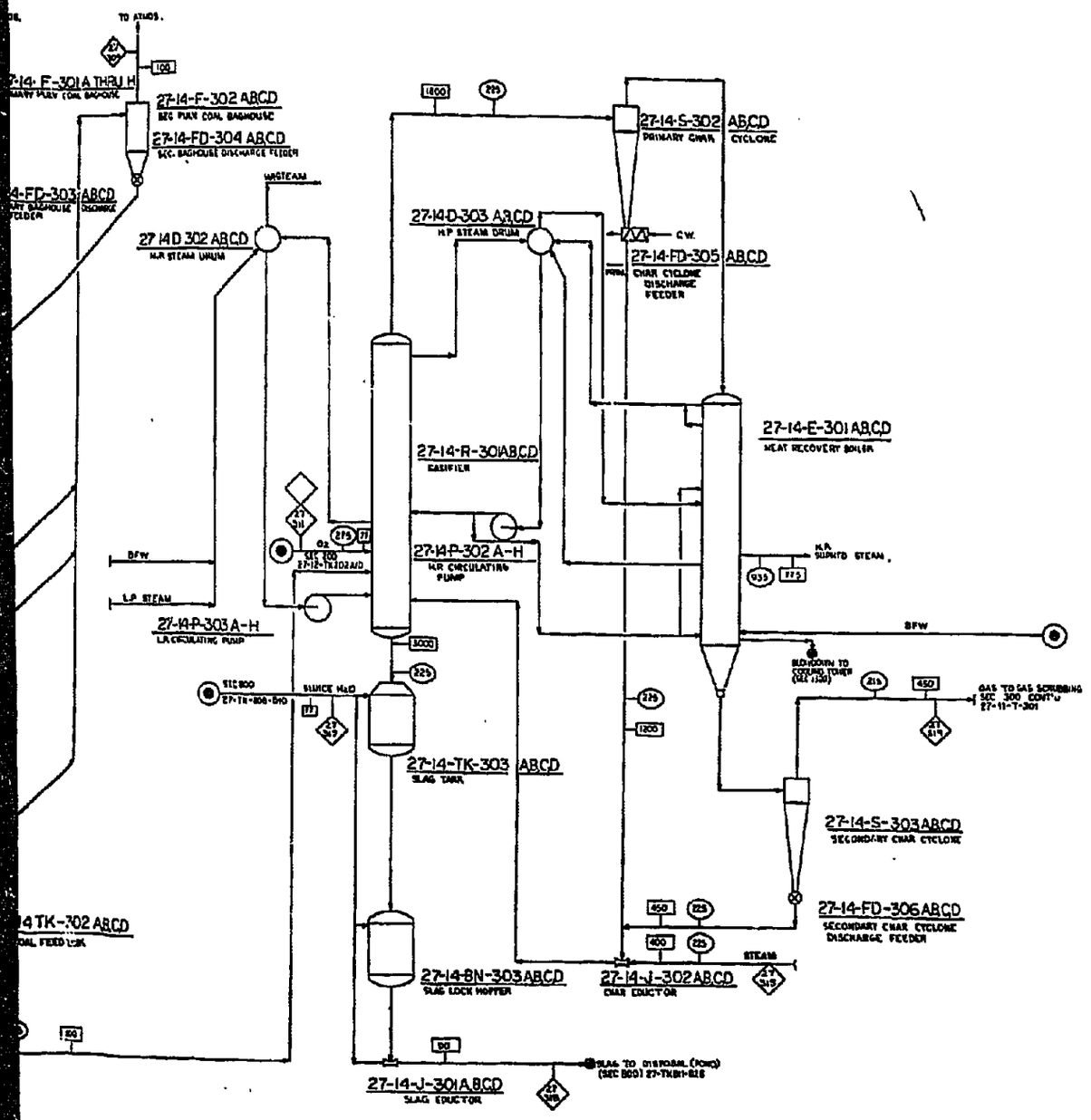
LOCATION: ALABAMA

REVISION	ORIGINAL	1	2	3	4	5
DATE						

CLASS	ITEM NO.	DESCRIPTION	EFD	No./Module	REV.
SEPARATORS					
27-14-	S-301 A-H	PULVERIZED COAL CYCLONE		4-50%	
-	S-302 A-D	PRIMARY CHAR CYCLONE		4-50%	
-	S-303 A-D	SECONDARY CHAR CYCLONE		4-50%	
TANKS					
27-14-	TK-301 A-D	PULVERIZED COAL RESERVOIR TANK		4-50%	
-	TK-302 A-D	PULVERIZED COAL FEED TANK		4-50%	
-	TK-303 A-D	SLAG TANK		4-50%	
REACTOR					
27-14-	R-301 A-D	GASIFIER		4-50%	



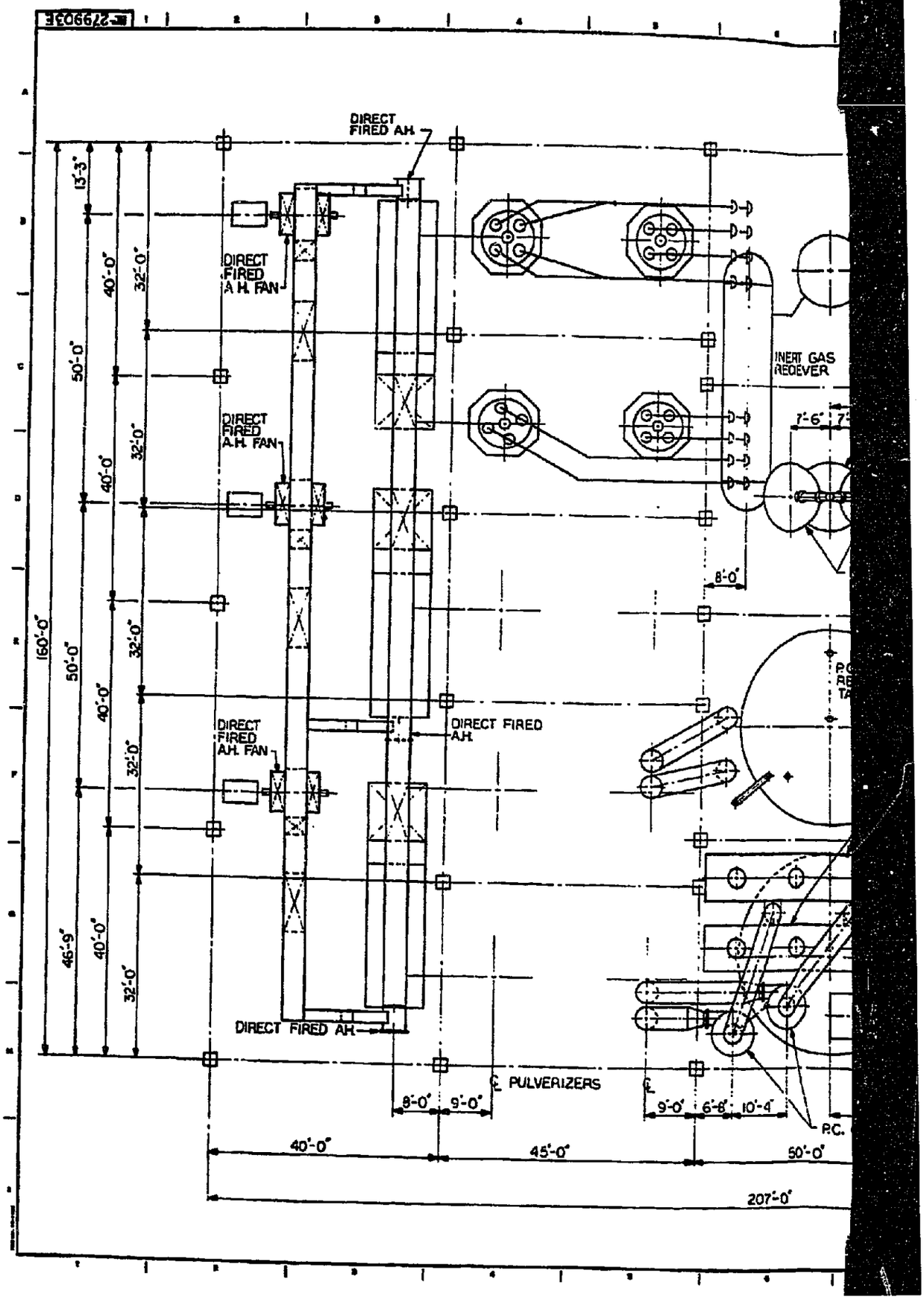
NOTES: 1. EQUIPMENT IS INDICATED FOR ONE MODULE
THERE ARE FOUR MODULES IN THE PLANT
SEE EQUIPMENT LIST FOR NUMBER OF ITEMS PER MODULE
2. FOR LEGEND SEE DWG. NO. 94099-11-1-101-1

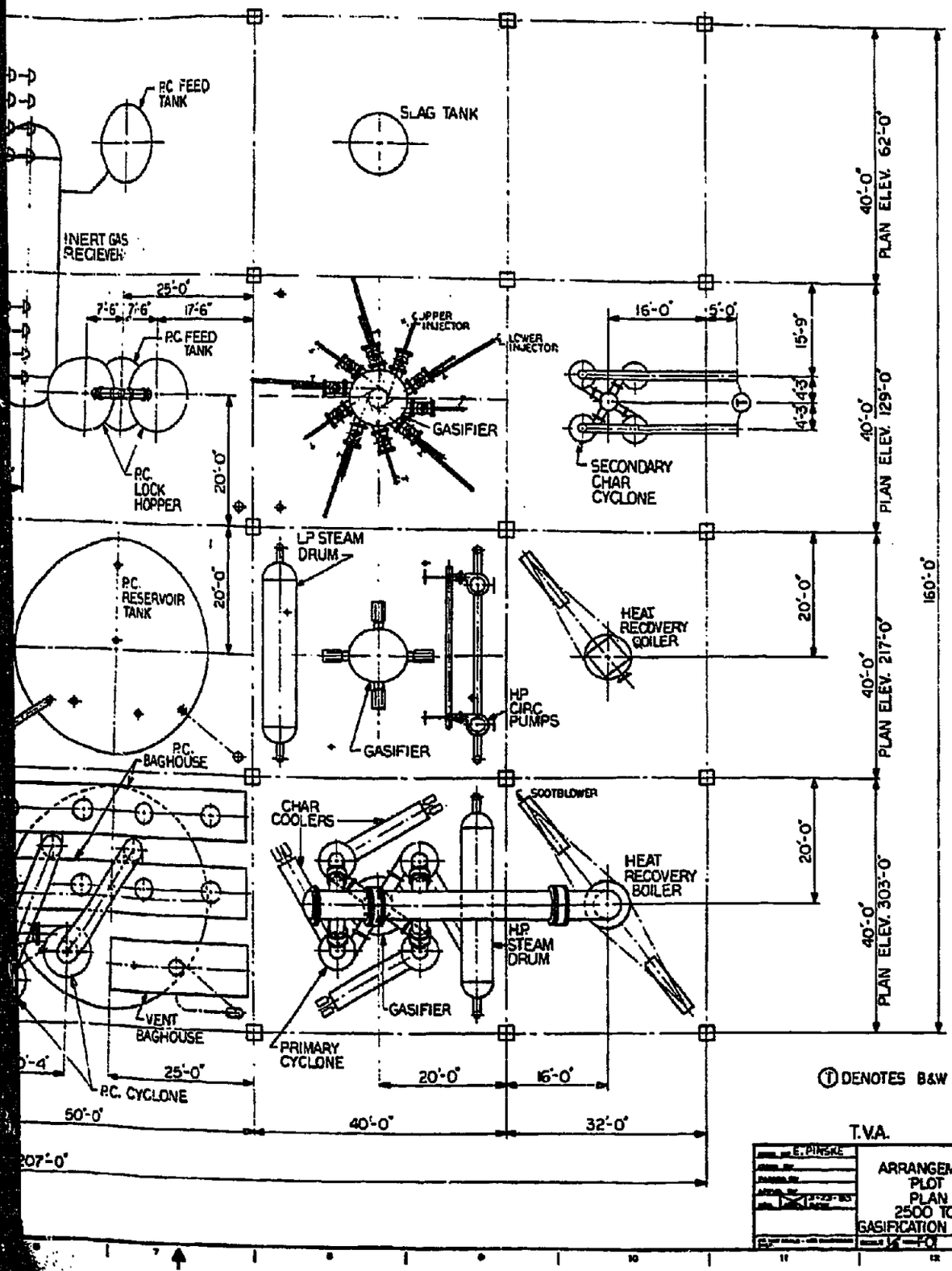


PROCESS FLOW DIAGRAM
TVA COAL GASIFICATION STUDY
SECTION 300 BEW GASIFICATION SYSTEM

FW N-274-4039 BEW GASIFIERS

DWG. NO. 24098-274-60-S


DIRECT FIRED A.H.
DIRECT FIRED A.H. FAN
DIRECT FIRED A.H. FAN
DIRECT FIRED A.H. FAN
DIRECT FIRED A.H.
DIRECT FIRED A.H.
INERT GAS REDEVER
13'-3"
40'-0"
32'-0"
50'-0"
160'-0"
46'-9"
7'-6"
8'-0"
℄ PULVERIZERS
8'-0"
9'-0"
9'-0"
6'-8"
10'-4"
40'-0"
45'-0"
50'-0"
207'-0"

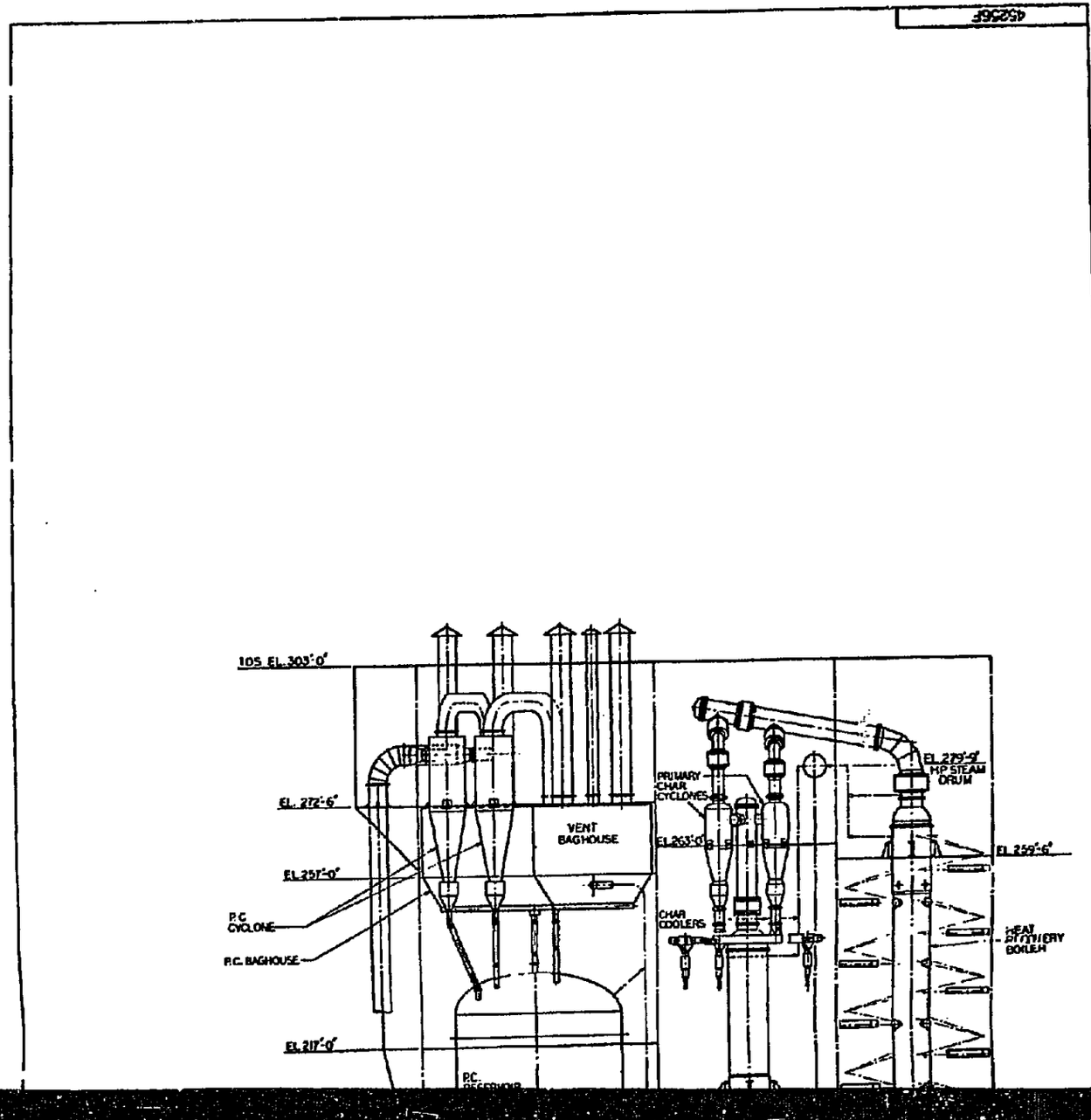


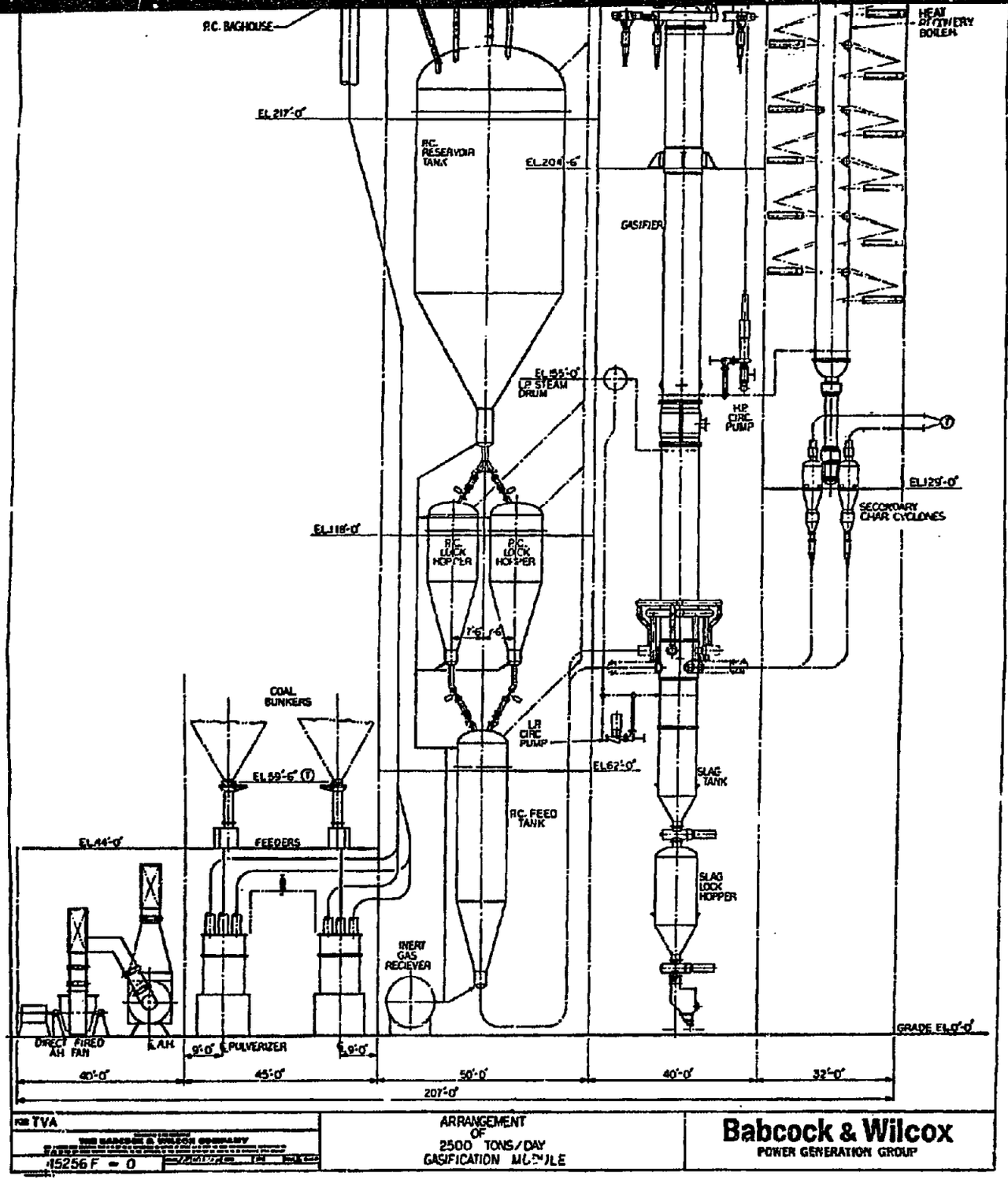
T.V.A.

E. PINSKE

ARRANGEMENT
PLOT
PLAN
2500 TONS/DAY
GASIFICATION SYSTEM

279903 E | 0


105 EL. 303'-0"
EL. 272'-6"
EL. 257'-0"
P.C. CYCLONE
P.C. BAGHOUSE
EL. 217'-0"
VENT BAGHOUSE
PRIMARY CHAR CYCLONES
EL. 263'-0"
CHAR COOLERS
EL. 279'-9" HP STEAM DRUM
EL. 259'-6"
HEAT RECOVERY BOILER


P.C. BAGHOUSE
EL 217'-0"
P.C. RESERVOIR TANK
EL 204'-6"
GASIFIER
HEAT EXCHANGER BOILER
EL 155'-0"
LP STEAM DRUM
HP CIRC PUMP
EL 129'-0"
SECONDARY CHAR CYCLONES
EL 118'-0"
P.C. LOCK HOPPER
P.C. LOCK HOPPER
COAL BUNKERS
LB CIRC PUMP
EL 62'-0"
SLAG TANK
EL 59'-6"
FEEDERS
EL 44'-0"
P.C. FEED TANK
SLAG LOCK HOPPER
INERT GAS RECIEVER
GRADE EL 0'-0"
DIRECT FIRED AH FAN
R.A.H.
9'-0" ϕ PULVERIZER
9'-0" ϕ
40'-0"
45'-0"
50'-0"
40'-0"
32'-0"
207'-0"
FOR TVA
15256 F - 0
ARRANGEMENT OF 2500 TONS/DAY GASIFICATION MODULE
Babcock & Wilcox
POWER GENERATION GROUP

TVA Coal Gasification Study
E&W Gasifier

Section Description

Section 300B - Gas Scrubbing

A. Reference Material

Process Flowsheet FWEC Drawing No. 54099-27-1-50-4

Equipment Summary List

Material Balance

B. Description of Flow

The raw gas is fed to the venturi section of the 1st Stage Scrubber (27-11-T-301) and contacted with a portion of the 1st Stage circulating water from P-307A/B. Purged water from the bottom of the 2nd Stage Scrubber (27-11-T-302) is added as makeup to the 1st Stage water circulation stream. Carbon, ash and small quantities of ammonia and hydrogen sulfide are scrubbed from the raw gas in the two Scrubbers in addition to cooling the raw gas. Recirculating 1st Stage scrubbing water in turn is cooled externally with cooling water in the 1st Stage Scrubber Water Cooler, E-302, before returning to the top of the 1st Stage Scrubber, T-301.

Scrubbing water is purged from the 1st Stage Scrubber at a rate of approximately 560 gpm. Purged water will be pumped to the Sour Water Stripping Unit (Section 700). Partially scrubbed raw gas leaving the 1st stage flows to the 2nd Stage Scrubber venturi where it is contacted in similar fashion to the 1st stage with recirculating water and makeup water from the Treated Water Storage Tank (27-11-TK-1201)(in Section 1200-3) in addition to sour condensate from Acid Gas Removal (Selexol-Section 400). Scrubbing water from the 2nd stage is purged to the 1st Stage Scrubber. The raw gas leaving the 2nd Stage Scrubber flows to Gas Treating (Section 400-Selexol) for further reduction of hydrogen sulfide and ammonia. The hydrogen sulfide concentration in scrubbed gas is about 13,700 ppmv but the ammonia level is relatively low (~ 23 ppmv).

FOSTER WHEELER ENERGY CORPORATION
CUSTOMER: TVA COAL GASIFICATION
LOCATION: ALABAMA
PLANT TYPE: B.& W GASIFIERS

SECTION NAME: GAS SCRUBBING
REF. DWG.: 54099-27-1-50-4
CONTRACT NO.: 11-27-54099 REV.:

SECTION NO.: 300
PAGE NO.: 1
DATE:

STREAM NUMBER		27 311	27 312	27 313	27 314	27 401	
STREAM DESCRIPTION		Raw Gas From B&W Gasifier	SourWater from 1st Stg scrubber	Scrubbed Gas ToGasTreat'g	MakeupTreated Water to 2d Stg	Sour Water FromAcidGasRemoval	
COMPONENTS	(MW)	MOL/HR	MOL/HR	MOL/HR	MOL/HR	MOL/HR	MOL/HR
						Liquid	
HYDROGEN	2.016	10,039		10,039		1.151	
CARBON MONOXIDE	28.011	20,707		20,707		4.437	
CARBON DIOXIDE	44.011	1,557		1,557		0.635	
METHANE	16.043						
NITROGEN	28.014	900		900			
OXYGEN	32.000	0					
HYDROGEN SULFIDE	34.080	489	0.64	490.784		2.424	
CARBONYL SULFIDE	60.075	33		33.		0	
AMMONIA	17.031	1	0.165	0.835			
HYDROGEN CYANIDE	27.026						
CHLORIDES	35.463	HCL 15		15.			
SULFUR	32.066						
CARBON DISULFIDE	76.143						
SULFUR DIOXIDE	64.066						
ARGON	39.944	217		217.			
MERCAPTANS		TRACE		TRACE			
						To	
TOTAL DRY GAS		33,958	0.805	33,959.6		Liquid 8.647	
WATER	18.016	1,522	15,541 Liq-	1,909.2	14,094	171.666	
TOTAL WET GAS		35,480	uid	35,868.8	Liquid	Liq- uid 180.313	
		LBS/HR	LBS/HR	LBS/HR	LBS/HR	LBS/HR	LBS/HR
TOTAL STREAM LBS/HR		767,131	297,883	756,291	253,918	3,330	
SOLIDS LBS/HR							
COAL							
ASH		12,272	12,272				
CARBON		5,599	5,599				
TOTAL SOLIDS		17,871	17,871				
WATER LIQUID			279,987		253,918	3,093	
TOTAL STREAM							
TEMPERATURE, °F		450	205	200	90	60	
MMSCFD DRY GAS							
DRY GAS GHV (BTU/SCF)							

B & W GASIFIERS

FORM NO. 135-904

FOSTER WHEELER ENERGY CORP.
PROCESS PLANTS DIVISION

CONTRACT 11-27-54099
SECTION: 300 cont'd

EQUIPMENT LIST

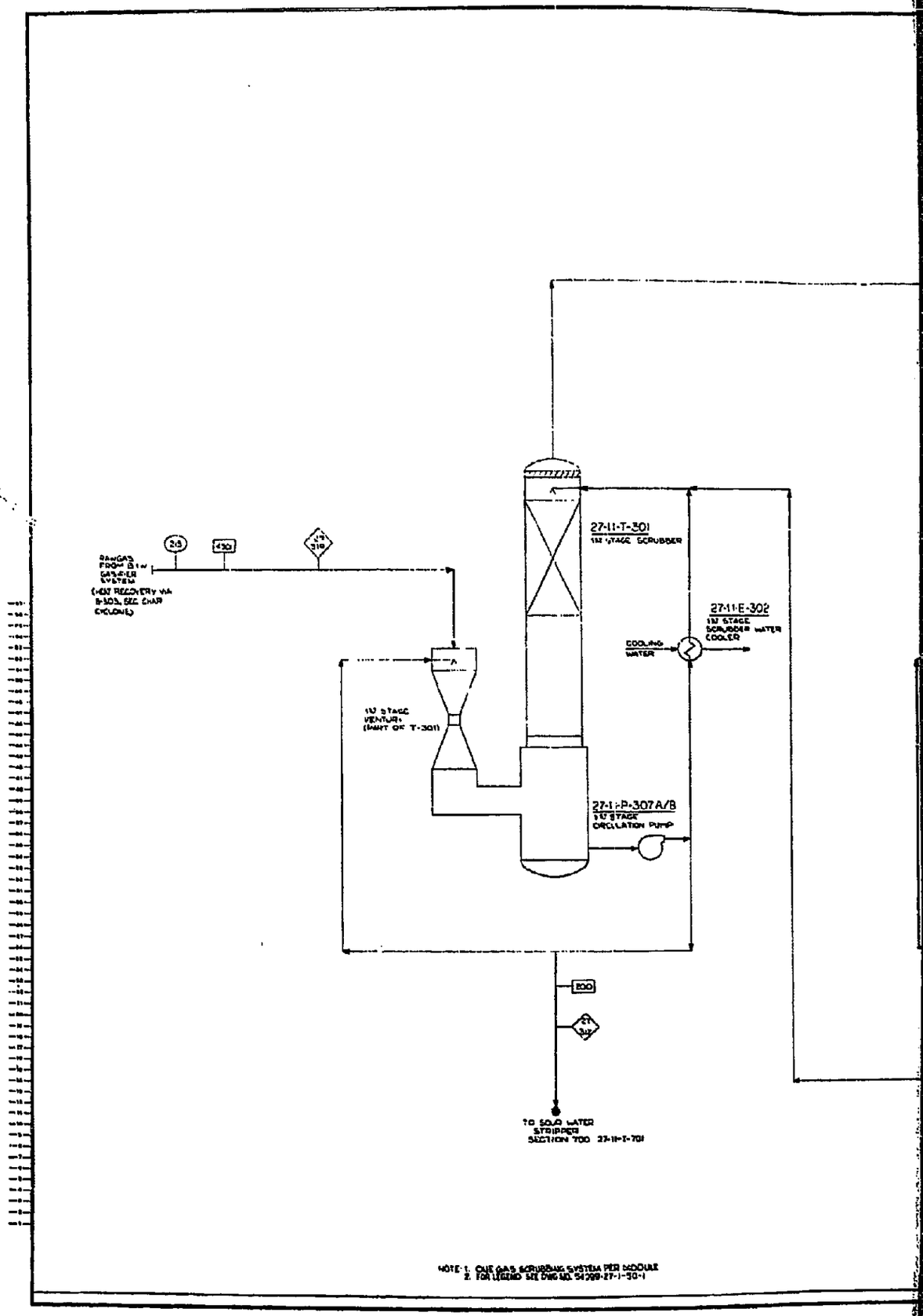
NAME OF UNIT: GAS SCRUBBING (Continuation of Gasification)

PAGE 1 OF 1

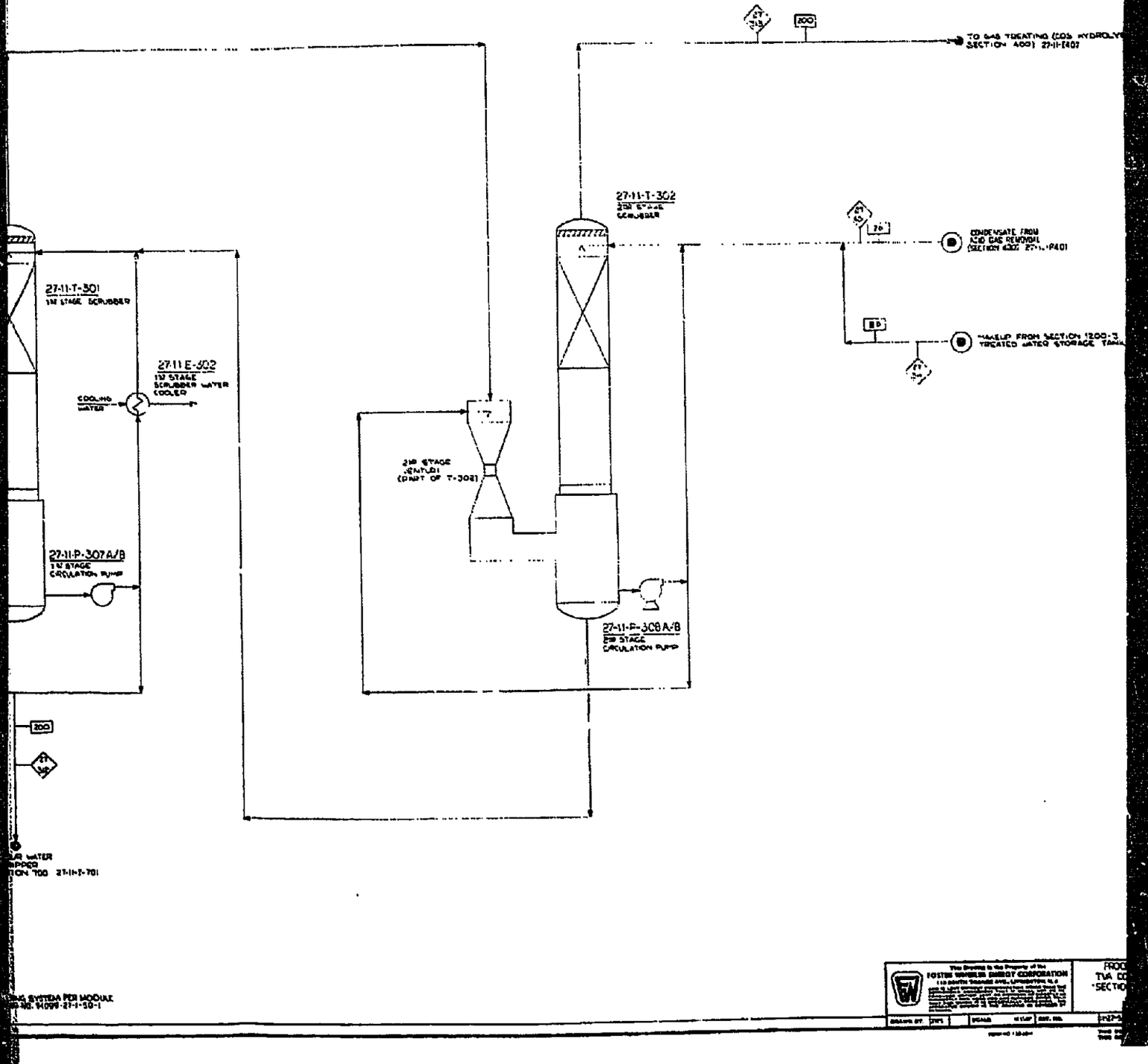
CLIENT: TVA (COAL GASIFICATION STUDY)
LOCATION: ALABAMA

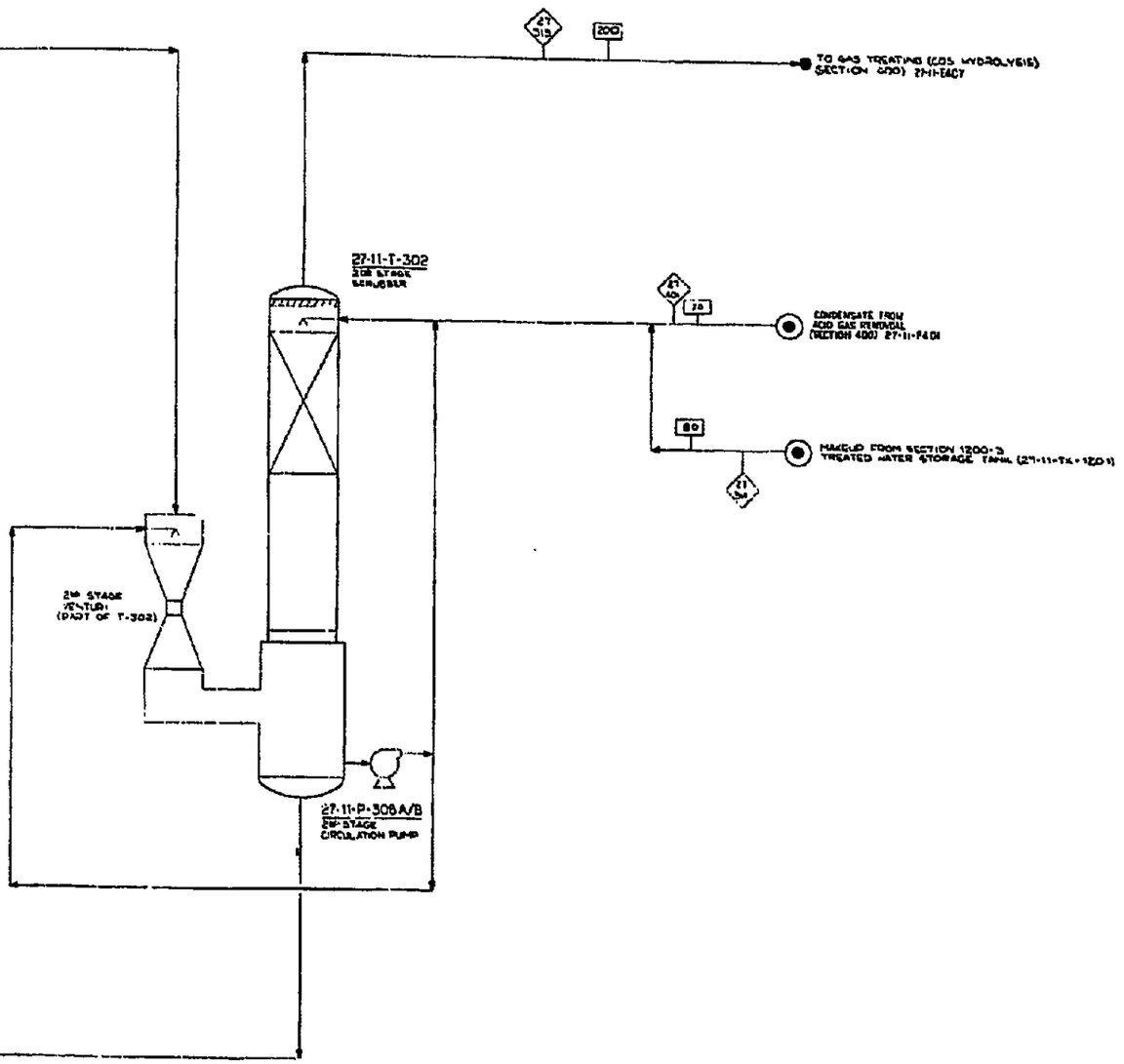
REVISION	ORIGINAL	1	2	3	4	5
DATE						

CLASS	ITEM NO.	DESCRIPTION	EFD	No./Module	REV.
EXCHANGERS					
27-11-	E-302	1st STG SCRUBBER WATER COOLER		1-100%	
PUMPS					
27-11-	P307A/B	1st STG CIRCULATION PUMP		2-100%	
-	P-308A/B	2nd STG CIRCULATION PUMP		2-100%	
TOWERS					
27-11-	T-301	1st STAGE VENTURI SCRUBBER		1-100%	
-	T-302	2nd STAGE VENTURI SCRUBBER		1-100%	



NOTE: 1. CWE GAS SCRUBBING SYSTEM PER McDOUGALL
2. FOR LEGEND SEE DWG NO. 94299-27-1-50-1





PROCESS FLOW DIAGRAM
TVA COAL GASIFICATION STUDY
SECTION 300 GAS SCRUBBING

DRAWING NO. 27P-54098 | DWG. MO-54098 27-11-50-4

SECTION DESCRIPTION

3.4 SECTION 400 - ACID GAS REMOVAL

A. Reference Material

Process Flow Diagram: FWEC Dwg. No. 54099-27-1-50-50-5
Equipment List
Material Balance

B. Description of Flow

The purpose of this section is to remove sulfur compounds from the raw gas. Raw gas from Gas Scrubbing (Section 300) flows to the Raw Gas Heater (27-11-E-407). The raw gas is heated to a temperature of 300°F by external heat exchange with 250 PSIG steam. The scrubbed raw gas then flows to the COS Hydrolysis Unit (27-11-PG-401).

The hydrolysis reactor converts the bulk of the COS in the raw gas to H_2S using the Haldor Topsoe CKA catalyst. The conversion of COS to H_2S in the Hydrolysis Unit decreases the utility requirements and size of the Selexol Unit. The raw gas leaving COS Hydrolysis flows to the Sour Gas Condenser, 27-11-E-408, where it is cooled with cooling water. Condensed water in the raw gas is removed in the Condenser K.O. Drum, 27-11-D-405, then combined with additional sour condensate from the H_2S Absorber K.O. Drum, 27-11-D-401, and pumped to Gas Scrubbing (Section 300). Raw gas from the Condenser K.O. Drum is combined with process recycle gas from the Recycle Gas Compressor, 27-11-C-401, and then cooled in the Feed-Product Gas Exchanger, 27-11-E-401, with the product gas. Additional water condensed from the raw gas is separated in the H_2S Absorber K.O. Drum, 27-11-D-401. Raw gas leaving the H_2S Absorber, 27-11-T-401, flows to the H_2S Absorber, 27-11-T-401, where cold lean Selexol solvent physically absorbs H_2S, residual COS and some CO_2. Product gas leaving the top of the H_2S Absorber is cooled in the Feed-Product Gas Exchanger. Most of the product gas flows to Section 500 (Compression) and the remainder to the Beavon Unit, Section 600, to be utilized as a reducing gas. The product gas contains less than 100 ppmv H_2S and less than 30 ppmv COS.

The Selexol solvent leaving the bottom of the H_2S Absorber flows directly to the H_2S Flash Drum, 27-11-D-402. Most of the absorbed CO_2 and sour gases are flashed, then compressed in the Recycle Gas Compressor, 27-11-C-401, and combined with the raw gas feed entering the Feed-Product Gas Exchanger. Make up solvent is added to the H_2S Flash Drum. Fresh solvent is stored in a Solvent Storage Tank, 27-11-TK-401.

Solvent leaving the bottom of the H_2S Flash Drum is pumped to the H_2S Stripper Preheater, 27-11-E-402. The Stripper Preheater is heated with hot lean solvent pumped from the bottom of the H_2S Stripper, 27-11-T-401. Preheated solvent enters the H_2S Stripper for removal of acid gases. Stripper bottoms are reboiled in the H_2S Stripper Reboiler, 27-11-E-404, heated with 60 PSIG steam. Vapors leaving the H_2S Stripper overhead are condensed in the H_2S Stripper Condenser, 27-11-E-405, then enter the Stripper Recycle Drum, D-403. Condensate is totally recycled back to the Stripper, while the Acid Gases flow to the Sulfur Recovery Claus Plant (Section 600). Hot lean solvent is pumped from the bottom of the H_2S Stripper and cooled in the H_2S Stripper Preheater as described earlier. The solvent is chilled in the Lean Solution Refrigerator, 27-11-E-403, then enters the top of the H_2S Absorber. The refrigerant required for E-403 will be provided from a package refrigeration system.

FOSTER WHEELER ENERGY CORPORATION
CUSTOMER: TVA COAL GASIFICATION
LOCATION: ALABAMA
PLANT TYPE: B & W GASIFIERS

SECTION NAME: ACID GAS REMOVAL (SELEXOL) SECTION NO.: 400
REF. DWG.: 54099-27-1-50-5 PAGE NO.: 1
CONTRACT NO.: 11-27-54099 REV.: ..... DATE: .....

STREAM NUMBER		27 313	27 401	27 402	27 403		
STREAM DESCRIPTION		Raw Gas From Sec 300 (Scrubbing)	Sour Water To Sec 300 (Gas Scrubbing)	Product Gas to Compression & Beaver Unit	Acid Gas To Claus Unit (See 600)		
COMPONENTS	(MW)	MOL/HR	MOL/HR	MOL/HR	MOL/HR	MOL/HR	MOL/HR
			LIQUID				
HYDROGEN	2.016	10,039	1.151	10,037.102	0.677		
CARBON MONOXIDE	28.011	20,707	4.437	20,696.258	6.153		
CARBON DIOXIDE	44.011	1,557	0.635	1,303.012	283.869		
METHANE	16.043						
NITROGEN	28.014	900		1,116.827	0.167		
OXYGEN	32.000						
HYDROGEN SULFIDE	34.080	490.784	2.424	3.243	513.029		
CARBONYL SULFIDE	60.075	33.		0.963	0.703		
AMMONIA	17.031	0.835	0	0.186	0.803		
HYDROGEN CYANIDE	27.026						
CHLORIDES	35.453	15					
SULFUR	32.066						
CARBON DISULFIDE	76.143						
SULFUR DIOXIDE	64.066						
ARGON	39.944	217					
MERCAPTANS		TRACE					
TOTAL DRY GAS		33,959.6	In Liquid 8.647	33,157.591	805.400		
WATER	18.016	1,909.2	In Liquid 171.666	6.244	38.860		
TOTAL WET GAS		35,868.8	180.313	33,163.835	844.260		
		LBS/HR	LBS/HR	LBS/HR	LBS/HR	LBS/HR	LBS/HR
TOTAL STREAM LBS/HR		756,291	3,300	688,855	30,911		
SOLIDS LBS/HR							
COAL							
ASH							
CARBON							
TOTAL SOLIDS							
WATER LIQUID			3,093				
TOTAL STREAM							
TEMPERATURE, °F		200	60	88.5	110		
MOLEC. WT. OF GAS		21.085		20.77	36.613		
MMSCFD DRY GAS							
DRY GAS GHV (BTU/SCF)							

1 SELEXOL UNIT PER MODULE

B & W GASIFIERS

FORM NO. 135-904

FOSTER WHEELER ENERGY CORP.
PROCESS PLANTS DIVISION

CONTRACT 11-27-54099
SECTION 400

EQUIPMENT LIST

NAME OF UNIT: ACID GAS REMOVAL (SELEXOL)

PAGE 1 OF 3

CLIENT: TVA (COAL GASIFICATION STUDY)

LOCATION: ALABAMA

REVISION	ORIGINAL	1	2	3	4	5
DATE						

CLASS	ITEM NO.	DESCRIPTION	EFD	No./Module	REV.
COMPRESSOR					
27-11-	C-401	RECYCLE GAS COMPRESSOR		1-100%	
DRUMS					
27-11-	D-401	H_2S ABSORBER K. O. DRUM		1-100%	
-	D-402	H_2S FLASH DRUM		1-100%	
-	D-403	STRIPPER RECYCLE DRUM		1-100%	
-	D-404	RECYCLE COMPRESSOR INTERSTAGE DRUM		1-100%	
	D-405	CONDENSER K.O. DRUM		1-100%	
EXCHANGERS					
27-11-	E-401	FEED-PRODUCT GAS EXCHANGER		1-100%	
-	E-402	H_2S STRIPPER PREHEATER		1-100%	
-	E-403	LEAN SOLUTION REFRIGERATOR		1-100%	
-	E-404	H_2S STRIPPER REBOILER		1-100%	
-	E-405	H_2S STRIPPER CONDENSER		1-100%	
-	E-406	RECYCLE COMPRESSOR INTERCOOLER		1-100%	

1 SELEXOL UNIT PER MODULE

B & W GASIFIERS

FORM NO. 135-904

FOSTER WHEELER ENERGY CORP.
PROCESS PLANTS DIVISION

CONTRACT 11-27-54099
SECTION: 400

EQUIPMENT LIST

NAME OF UNIT: ACID GAS REMOVAL (SELEXOL)

PAGE 2 OF 3

CLIENT: TVA (COAL GASIFICATION STUDY)

LOCATION: ALABAMA

REVISION	ORIGINAL	1	2	3	4	5
DATE						

CLASS	ITEM NO.	DESCRIPTION	EFD	No./Module	REV.
27-11 -	E-407	RAW GAS HEATER			
	E-408	SOUR GAS CONDENSER			
PUMPS					
27-11-	P-401	SOUR CONDENSATE PUMP			
27-11-	P-402A/B	H_2S RICH SOLUTION PUMP		2-100%	
-	P-403A/B	CLEAN SOLUTION PUMP		2-100%	
-	P-404A/B	H_2S STRIPPER RECYCLE PUMP		2-100%	
-	P-405A/B	SOLVENT SUMP PUMP		2-100%	
TANK					
27-11-	TK-401	SOLVENT STORAGE TANK		1-100%	
FILTER					
27-11-	F-401	H_2S LEAN SOLUTION FILTER		1-100%	
PACKAGE ITEM					
27-11-	PG-401	COS HYDROLYSIS PACKAGE		1-100%	
-	PG-402	SELEXOL REFRIGERATION PACKAGE		1-100%	

1 SELEXOL UNIT PER MODULE

B & W GASIFIERS

FORM NO 135-904

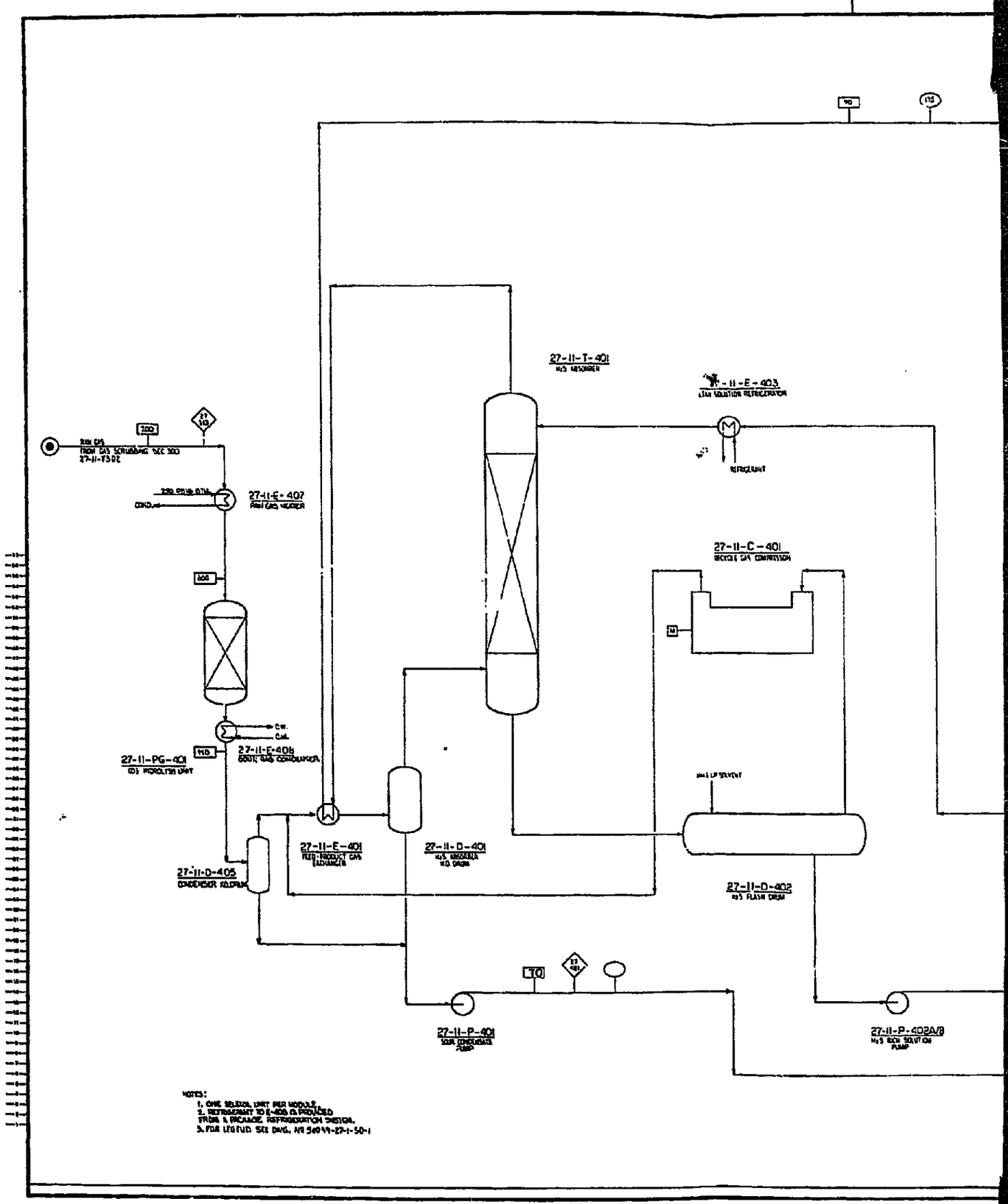
FOSTER WHEELER ENERGY CORP. PROCESS PLANTS DIVISION	CONTRACT 11-27-54099 SECTION 400	EQUIPMENT LIST	NAME OF UNIT: ACID GAS REMOVAL (SELEXOL)	PAGE 3 OF 3

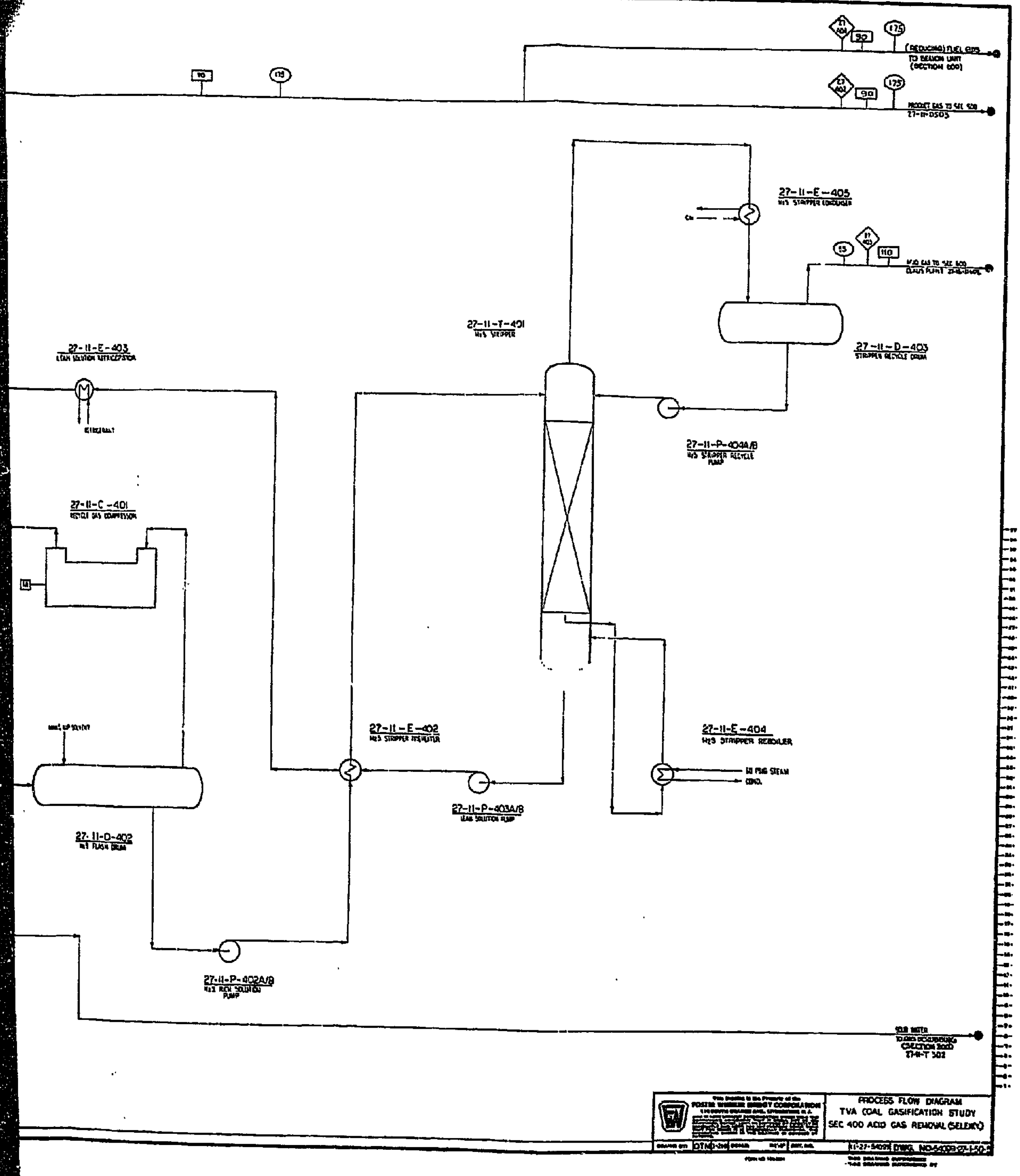
CLIENT: TVA (COAL GASIFICATION STUDY)

LOCATION: ALABAMA

REVISION	ORIGINAL	1	2	3	4	5
DATE						

CLASS	ITEM NO.	DESCRIPTION	EFD	No./Module		REV.
TOWERS 27-11-	T-401	H_2S ABSORBER			1-100%	
-	T-402	H_2S STRIPPER			1-100%	


27-11-T-401
27-11-E-403
27-11-C-401
27-11-E-407
27-11-PG-401
27-11-E-406
27-11-E-401
27-11-D-401
27-11-D-405
27-11-D-402
27-11-P-401
27-11-P-402A/B
TO



PRODUCT GAS TO SEC 500
27-11-E-405
27-11-T-401
27-11-E-403
27-11-D-403
27-11-P-404A/B
27-11-C-401
27-11-E-402
27-11-E-404
H2S STRIPPER REBOILER
27-11-P-403A/B
27-11-D-402
27-11-P-402A/B
PROCESS FLOW DIAGRAM
TVA COAL GASIFICATION STUDY
SEC 400 ACID GAS REMOVAL (SELEXOL)

TVA Coal Gasification Study
B&W Gasifier

SECTION DESCRIPTION

3.5 SECTION 500 - TREATED GAS COMPRESSION

A. Reference Material:

. Process Flow Diagram FWEC Dwg. No. 54099-27-1-50-6

. Equipment List

B. Description of Flow

This section compresses the product gas from a pressure of approximately 175 PSIG to about 610 PSIG for subsequent transfer to the distribution network. One product gas compressor is provided per module.

Product gas from Acid Gas Removal (Section 400) enters the PGC Suction K.O. Drum (27-11-D-503) for removal of entrained clean water. This water flows to the Clean Water Holding Basin (X-1506 on FS #18). Product gas leaving the top of the drum enters the turbine driven Product Gas Compressor (27-11-C-501). The turbine utilizes H.P. (935 PSIG superheated) steam and is an extraction type turbine, extracting a required amount of M.P. (250 PSIG) steam, the rest condensed. Extracted steam flows to the 250 PSIG steam header. Condensate from the turbine condenser flows to the Deaerator (27-11-DH-1201).

The compressed product gas enters the water cooled Prod. Gas Comp. Aftercooler (27-11-E-502) which cools the gas to about 120°F. Cooled product gas enters the PGC after K.O. Drum (27-11-D-502), then flows to the gas distribution network.

1 TRAIN PER MODULE

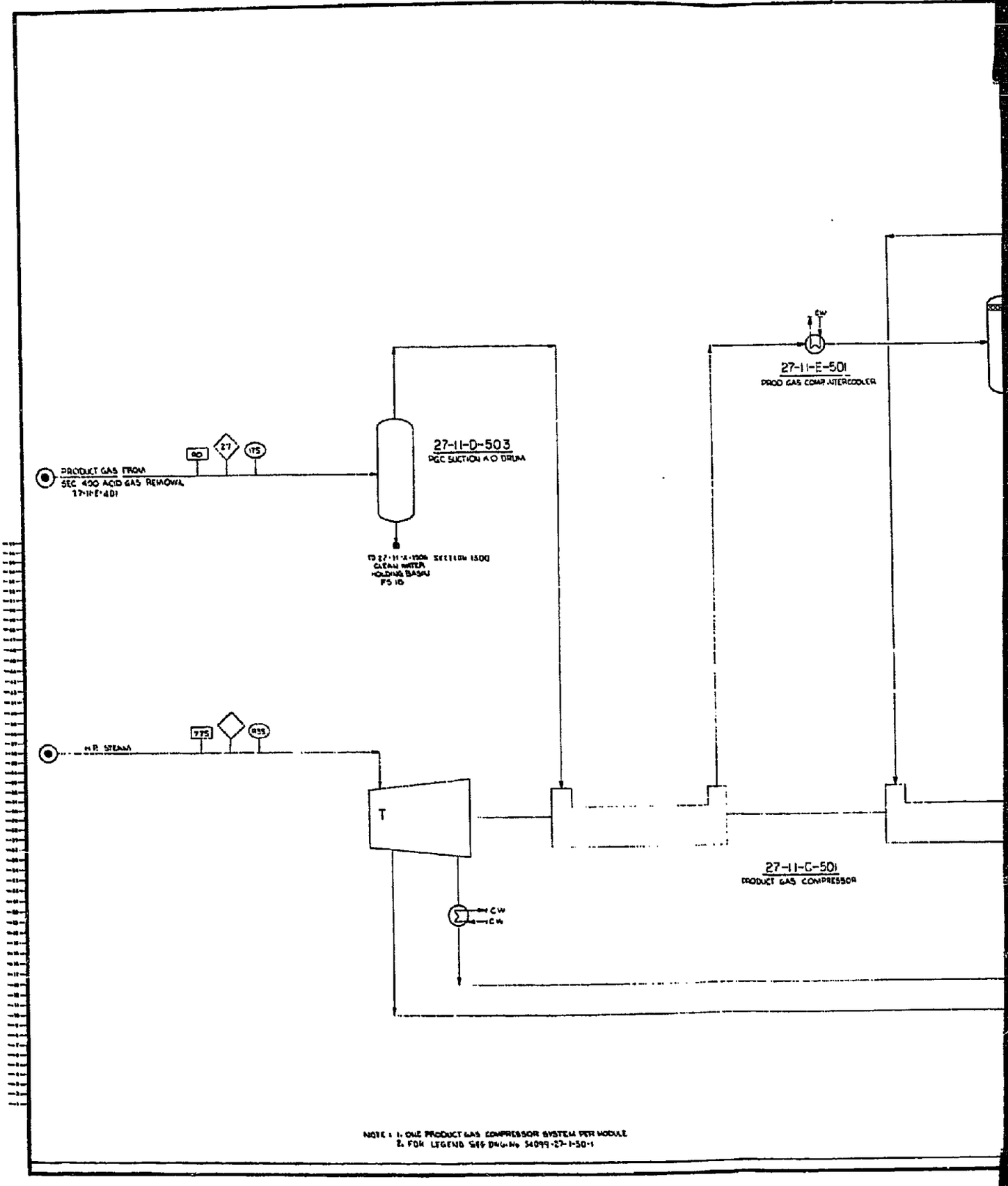
FORM NO. 135-904

FOSTER WHEELER ENERGY CORP. PROCESS PLANTS DIVISION	CONTRACT: 11-27-54099 SECTION: 500	EQUIPMENT LIST	NAME OF UNIT: PRODUCT GAS COMPRESSION	PAGE 1 OF 1

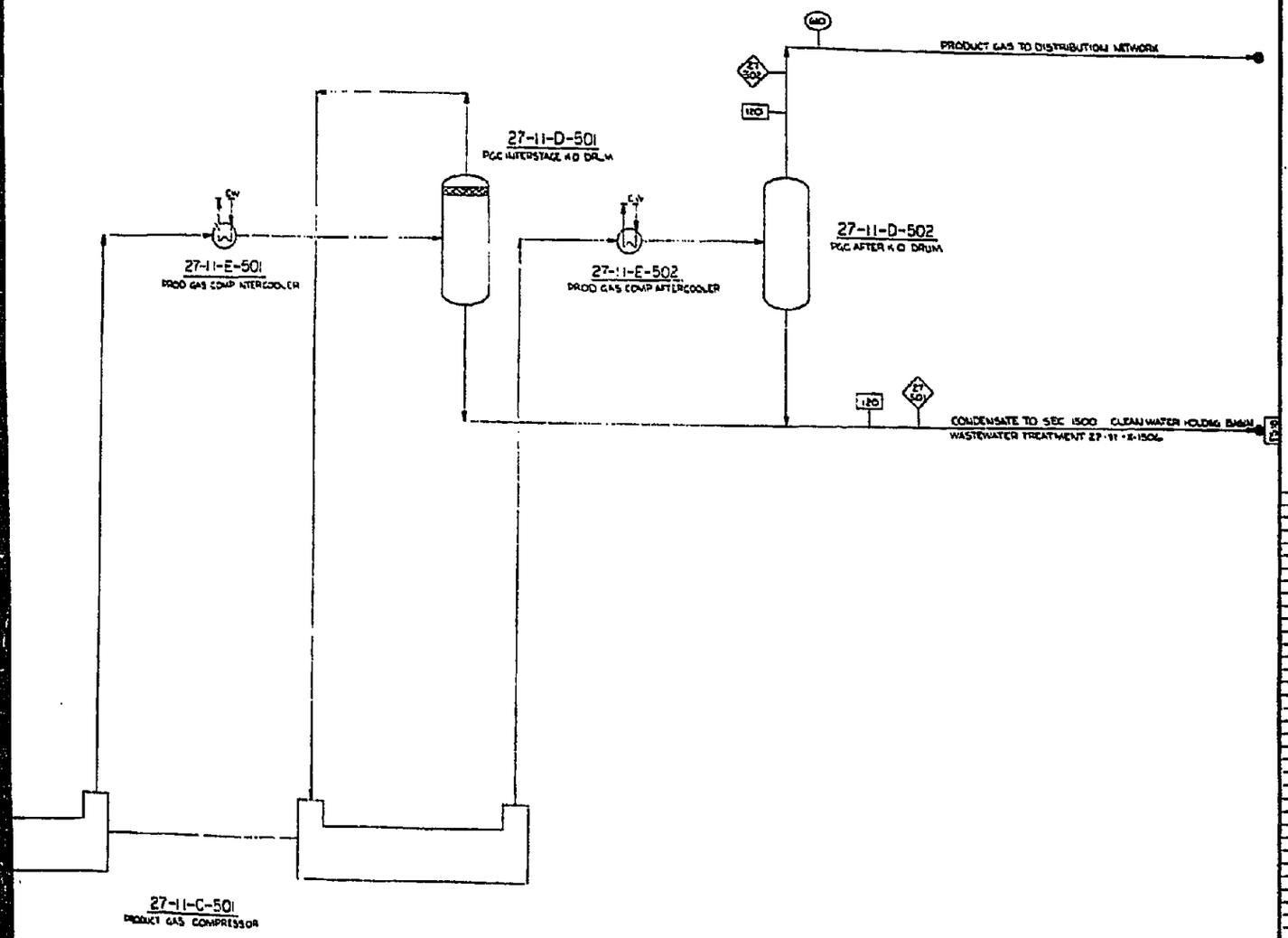
CLIENT: TVA (COAL GASIFICATION STUDY)
LOCATION: ALABAMA

REVISION	ORIGINAL	1	2	3	4	5
DATE						

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	No/Module		REV.
COMPRESSOR 27-11-	C-501	PRODUCT GAS COMPRESSOR			1-100%	Turbine Driven	
DRUMS 27-11-	D-501	PROD GAS COMP INTERSTAGE K.O. DRUM			1-100%		
-	D-502	PGC AFTER K. O. DRUM			1-100%		
-	D-503	PGC SUCTION K. O. DRUM			1-100%		
EXCHANGERS 27-11-	E-501	PRODUCT GAS COMP. INTERCOOLER			1-100%		
-	E-502	PROD. GAS COMP. AFTERCOOLER			1-100%		



NOTE : 1. ONE PRODUCT GAS COMPRESSOR SYSTEM PER MODULE
2. FOR LEGEND SEE DWG. No 54099-27-1-50-1



POSTER WHEELER ENERGY CORPORATION

PROCESS FLOW DIAGRAM
TVA COAL GASIFICATION STUDY
SEC 500-PRODUCT GAS COMPRESSION

DWG. NO. 540991-27-1-50-6

TVA Coal Gasification Study
B&W Gasifier

Section Description

3.6 SECTION 600 - SULFUR RECOVERY PLANT

CLAUS UNIT

A. Reference Material

Process Flowsheet — FWEC Drawing No. 54099-27-1-50-7

Equipment List

Material Balance

B. Description of Flow

Acid gas from the Selexol Unit Stripper Recycle Drum, D-403, and a smaller stream of acid gas from the Sour Water Stripper Reflux Drum, D-701, flow through respective K.O. drums and enter the Muffle Furnace, H-601, for destruction of ammonia. Hydrogen sulfide is partially (about one-third) oxidized to sulfur dioxide, utilizing air fed by the Process Air Blower, B-601. High pressure steam is generated in the Waste Heat Boiler, E-601, and is the major source of H.P. steam for process use (refer to 54099-27-1-50-151).

Gases leaving the Waste Heat Boiler flow to a three stage Claus reactor system, consisting of R-601, 602, and 603, where sulfur dioxide reacts catalytically with the remaining hydrogen sulfide, producing elemental sulfur and water. The Claus Unit is about 96% efficient in removal of sulfur compounds from acid gas. Treated tail gas leaving the Claus Unit flows to the Beavon Unit (in series with the Claus Unit) for further reduction of sulfur compounds from the gas and recovery as elemental sulfur. Total normal sulfur production from Claus and Beavon Units combined is about 198 T/D per module.

Gas leaving each Claus Reactor (stage) is cooled below about 300°F to condense sulfur before entering the next stage or flowing to the Beavon Unit. A third Reactor Preheater, E-606, is provided for optimum operation in the third stage.

Liquified (condensed) sulfur flows to a Sulfur Pit, X-601, and may be stored in the Liquid Sulfur Storage Tank, TK-601A/B, for sale as a liquid product or prilled in the Sulfur Prilling Unit, PG-601. At present, it has been decided to normally prill all of the sulfur recovered.

Medium pressure steam is generated during gas cooling to recover sulfur. Boiler blowdown streams will be used as cooling tower makeup as shown on 54099-27-1-50-151.

FOSTER WHEELER ENERGY CORPORATION
CUSTOMER: TVA COAL GASIFICATION
LOCATION: ALABAMA
PLANT TYPE: B & W GASIFIERS

SECTION NAME: SULPHUR RECOVERY-CLAUS PLANT
REF. DWG.: 54099-27-1-50-7
CONTRACT NO.: 11-27-54099 REV.:

SECTION NO.: 600
PAGE NO.: 1
DATE:

STREAM NUMBER		27 403	27 601	27 602	27 603	27 604	27 623
STREAM DESCRIPTION		Acid Gas from SELEXOL Sec. 400	Sour Water Stripper Gas	Air To Claus Plant	Claus Unit Tail Gas	Claus Unit Liquid Sulfur	Beavon Unit Liquid Sulfur
COMPONENTS	(MW)	MOL/HR	MOL/HR	MOL/HR	MOL/HR	MOL/HR	MOL/HR
HYDROGEN	2.016	0.677					
CARBON MONOXIDE	28.011	6.153			0.153		
CARBON DIOXIDE	44.011	283.869	0		289.269		
METHANE	16.043						
NITROGEN	28.014	0.167		975.2	975.62		
OXYGEN	32.000			259.2	0		
HYDROGEN SULFIDE	34.080	513.029	0.607		10.82		
CARBONYL SULFIDE	60.075	0.703			0.703		
AMMONIA	17.031	0.803	0.013		0		
HYDROGEN CYANIDE	27.026						
CHLORIDES	35.463						
SULFUR	32.066				2.81	Liquid493.4	Liquid 20.93
CARBON DISULFIDE	76.143				0.60		
SULFUR DIOXIDE	64.066				5.41		
ARGON	39.944						
MERCAPTANS							
TOTAL DRY GAS		805.400	0.620	1,234.4	1,285.385	Liquid493.4	Liquid 20.93
WATER	18.016	38.860	5.382		540.188		
TOTAL WET GAS		844.260	6.002	1,234.4	1,825.573	Liquid493.4	Liquid 20.93
		LBS/HR	LBS/HR	LBS/HR	LBS/HR	LBS/HR	LBS/HR
TOTAL STREAM LBS/HR		30,911.	97.0	35,614	50,865	15,822	671.
SOLIDS LBS/HR							
COAL							
ASH							
CARBON							
TOTAL SOLIDS							
WATER LIQUID							
TOTAL STREAM							
TEMPERATURE, °F		110		80	280	275	275
MMSCFD DRY GAS							
DRY GAS GHV (BTU/SCF)							

FOSTER WHEELER ENERGY CORPORATION
CUSTOMER: TVA COAL GASIFICATION
LOCATION: ALABAMA
PLANT TYPE: B & W GASIFIERS

SECTION NAME: SULFUR RECOVERY-CLAUS PLANT
REF. DWG.: 54099-27-1-50-7
CONTRACT NO.: 11-27-54099 REV.:

SECTION NO.: 600
PAGE NO.: 2
DATE:

STREAM NUMBER		27 605	27 606				
STREAM DESCRIPTION		Sulfur to Prilling Unit	Liquid Sulfur Product				
COMPONENTS	(MW)	MOL/HR	MOL/HR	MOL/HR	MOL/HR	MOL/HR	MOL/HR
HYDROGEN	2.016						
CARBON MONOXIDE	28.011						
CARBON DIOXIDE	44.011						
METHANE	16.043						
NITROGEN	28.014						
OXYGEN	32.000						
HYDROGEN SULFIDE	34.080						
CARBONYL SULFIDE	60.075						
AMMONIA	17.031						
HYDROGEN CYANIDE	27.026						
CHLORIDES	35.453						
SULFUR	32.066	514.33	0				
CARBON DISULFIDE	76.143						
SULFUR DIOXIDE	64.066						
ARGON	39.944						
MERCAPTANS							
TOTAL DRY GAS		514.33	0				
WATER	18.016						
TOTAL WET GAS		514.33	0				
		LBS/HR	LBS/HR	LBS/HR	LBS/HR	LBS/HR	LBS/HR
TOTAL STREAM LBS/HR		16,493	0				
SOLIDS LBS/HR							
COAL							
ASH							
CARBON							
TOTAL SOLIDS							
WATER LIQUID							
TOTAL STREAM							
TEMPERATURE, °F		275					
MMSCFD DRY GAS							
DRY GAS GHV (BTU/SCF)							

198 T/D S EACH PLANT 5 TRAINS TOTAL PER PLANT (4 MODULES)

FORM NO. 135-804

FOSTER WHEELER ENERGY CORP. PROCESS PLANTS DIVISION	CONTRACT: 11-27-54099 SECTION: 600	EQUIPMENT LIST	NAME OF UNIT: SULFUR RECOVERY-CLAUS PLANT	PAGE 1 OF 2

CLIENT: TVA (COAL GASIFICATION STUDY) LOCATION: ALABAMA

			REVISION		ORIGINAL	1	2	3	4	5	
			DATE								
CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	No/Module						REV.
DRUMS											
27-15-	D-601	SWS GAS K.O. DRUM			1-100%						
-	D-602	ACID GAS K.O. DRUM			1-100%						
-	D-603	BLOWDOWN DRUM			1-100%						
HEAT EXCHANGERS											
27-15-	E-601	WASTE HEAT BOILER			1-100%						
-	E-602	1ST SULFUR CONDENSER			1-100%						
-	E-603	SECOND REACTOR FEED HEATER			1-100%						
-	E-604	2ND SULFUR CONDENSER			1-100%						
-	E-605	3RD SULFUR CONDENSER			1-100%						
-	E-606	THIRD REACTOR FEED HEATER			1-100%						
-	E-607	FINAL SULFUR CONDENSER			1-100%						
-	E-608	SULFUR PIT HEATER			1-100%						
-	E-609	SULFUR TANK HEATER			1-100%						
-	E-610	AIR PREHEATER			1-100%						
-	E-611	ACID GAS PREHEATER			1-100%						
PACKAGE ITEM											
27-15-	PG-601	SULFUR PRILLING UNIT PACKAGE			1-100%						

198 T/D SEARCH PLANT FORM NO. 135-904 5 TRAINS TOTAL PER PLANT (4 MODULES)

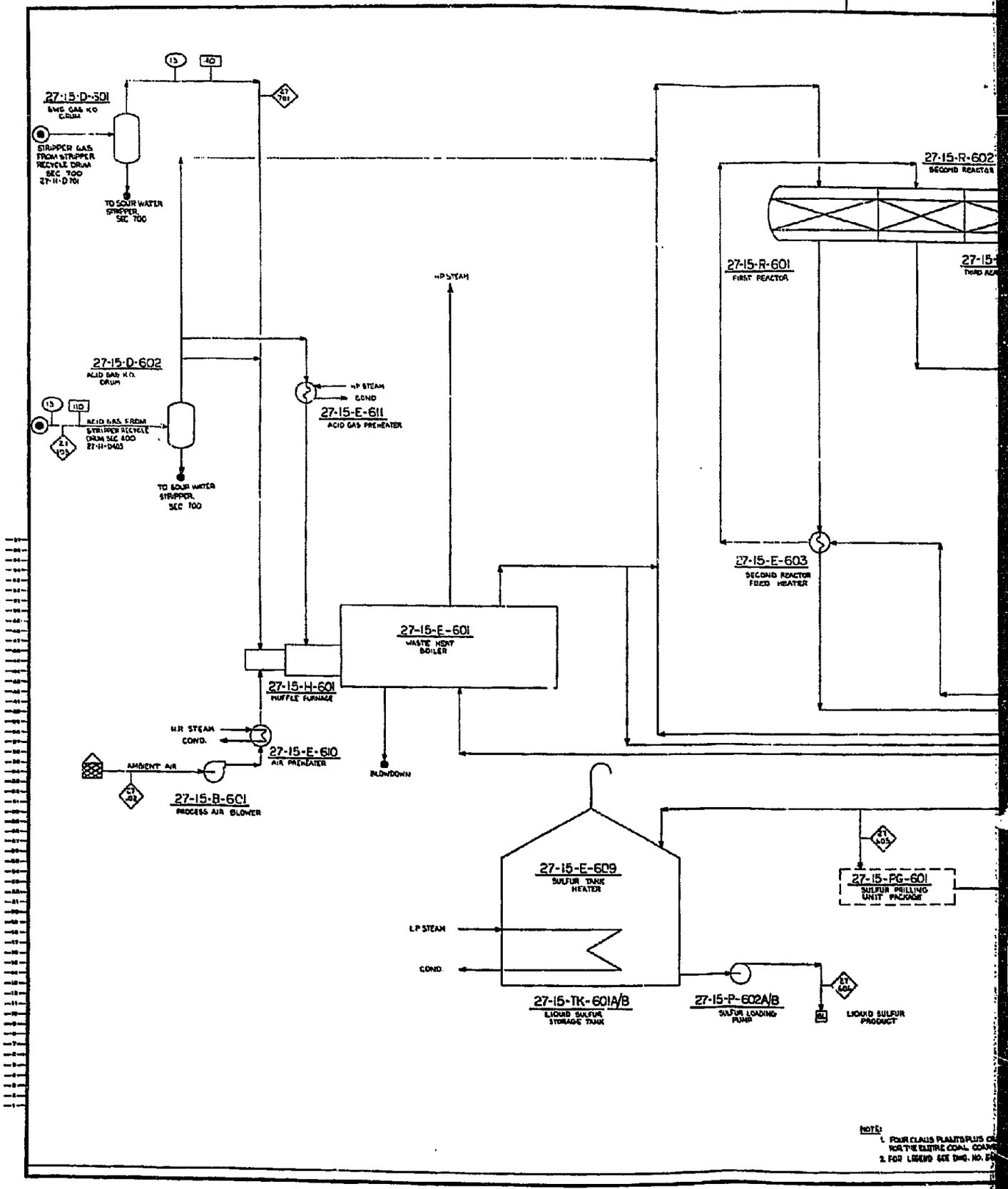
FOSTER WHEELER ENERGY CORP. PROCESS PLANTS DIVISION	CONTRACT: 11-27-54099 SECTION: 600	EQUIPMENT LIST	NAME OF UNIT: SULFUR RECOVERY-CLAUS PLANT	PAGE 2 OF 2

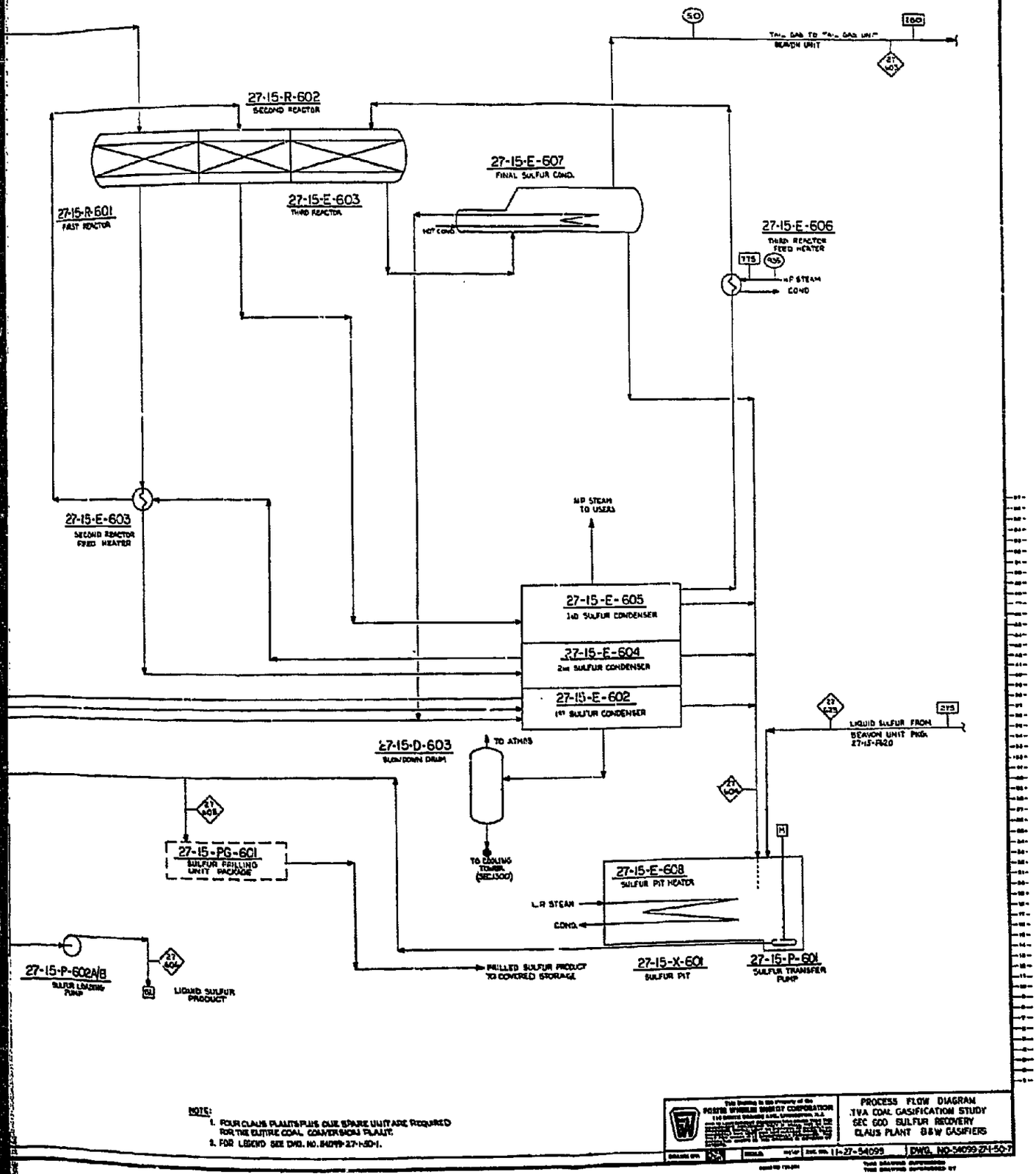
CLIENT: TVA (COAL GASIFICATION STUDY)

LOCATION: ALABAMA

REVISION	ORIGINAL	1	2	3	4	5
DATE						

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	No/Module	REV.
BLOWER 27-15-	B-601	PROCESS AIR BLOWER			1-100%	
FURNACE —	H-601	MUFFLE FURNACE			1-100%	
REACTORS —	R-601	FIRST REACTOR			1-100%	
—	R-602	SECOND REACTOR			1-100%	
—	R-603	THIRD REACTOR			1-100%	
PUMPS —	P-601	SULFUR TRANSFER PUMP			1-100%	
—	P-602A/B	SULFUR LOADING PUMP			2-50%	
TANKS —	TK-601A/B	LIQUID SULFUR STORAGE TANK			2-50%	
MISC. —	X-601	SULFUR PIT			1-100%	


27-15-D-501
SWS GAS K.O. DRUM
STRIPPER GAS FROM STRIPPER RECYCLE DRUM SEC 700 27-M-D701
TO SOUR WATER STRIPPER SEC 700
27-15-D-602
ACID GAS K.O. DRUM
ACID GAS FROM STRIPPER RECYCLE DRUM SEC 400 27-M-D403
TO SOUR WATER STRIPPER SEC 700
HP STEAM
COND
27-15-E-611
ACID GAS PREHEATER
27-15-R-601
FIRST REACTOR
27-15-R-602
SECOND REACTOR
27-15-E-603
SECOND REACTOR FEED HEATER
HP STEAM
27-15-E-601
WASTE HEAT BOILER
27-15-H-601
MUFFLE FURNACE
BLOWDOWN
HP STEAM
COND.
27-15-E-610
AIR PREHEATER
AMBIENT AIR
27-15-B-601
PROCESS AIR BLOWER
27-15-E-609
SULFUR TANK HEATER
LP STEAM
COND.
27-15-TK-601A/B
LIQUID SULFUR STORAGE TANK
27-15-P-602A/B
SULFUR LOADING PUMP
LIQUID SULFUR PRODUCT
27-15-PG-601
SULFUR PRILLING UNIT PACKAGE
NOTE:
1. FOUR CLAUS PLANTS PLUS
FOR THE ELKTRE COAL COMP
2. FOR LEGEND SEE DWG. NO.



NOTE:

1. FOUR CLAUS PLANTS PLUS ONE SPARE UNIT ARE REQUIRED FOR THE ENTIRE COAL CONVERSION PLANT.
2. FOR LEGEND SEE DWG. NO. 84099-27-15-D-1.

PROCESS FLOW DIAGRAM
TVA COAL GASIFICATION STUDY
SEC 600 SULFUR RECOVERY
CLAUS PLANT B&W GASIFIERS

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