TVA/OGM/CG--81/12

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TVA COAL-GASIFICATION
COMMERCIAL DEMONSTRATION PLANT PROJECT

VOLUME 5

PLANT BASED ON
KOPPERS-TOTZEK GASIFIER

FINAL REPORT

November 1, 1980

Foster Wheeler Energy Corporation

110 South Orange Avenue, Livingston, New Jersey

PROCESS PLANTS DIVISION

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SECTION 1.0

INTRODUCTION

TVA Coal Gasification
Koppers-Totzek Gasifier

Introduction

This volume presents a technical description of a coal gasification plant, based on Koppers-Totzek gasifiers, producing a medium BTU fuel gas product. Foster Wheeler carried out a conceptual design and cost estimate of a nominal 20,000 TPSD plant based on TVA design criteria and information supplied by Krupp-Koppers concerning the Koppers-Totzek coal gasification process. Technical description of the design is given in this volume.

SECTION 2.0

PROCESS SELECTION

2.1 Discussion of Choice of Processing Sequence

Selection of the processing sequence for the coal gasification plant is determined largely by the characteristics of the Koppers-Totzek (K-T) process and the results of the several specific studies carried out in Task 1 (Volume 2) including:

- acid gas removal
- oxygen purity
- coal washing
- sulfur recovery

The K-T process is an atmospheric pressure entrained flow oxygen blown coal gasifier operating at high temperatures - about 3000°F. Pulverized coal is blown into an opposed burner gasifier together with oxygen and steam. Coal is gasified rapidly at the high temperature existing in the gasifier to form a gas rich in hydrogen and carbon monoxide. Hot gas is cooled in a waste heat boiler and scrubbed with water to remove fly ash. Oil and tar are absent from the raw gas because of the high temperature of gasification. As a result, further processing of the gas consists essentially of compression and removal of sulfur compounds.

Studies carried out in Task 1 included consideration of acid gas removal processes, oxygen purity, coal washing, and sulfur recovery. As described, in Volume 2, consideration of the characteristics of the raw K-T gas, the requirement of delivering the fuel gas product at elevated pressure and the parameters of various acid gas removal processes led to a selection of the Selexol process to remove sulfur compounds from the gas. The question of oxygen purity was studied and it was concluded that 98% oxygen was the preferred purity. Washing of the coal feed prior to gasification to lower ash content did not appear to be economically justified and resulted in production of a waste stream containing appreciable coal content which would require disposal. Consequently, unwashed coal was used for gasification and as fuel for boilers. Recovery of sulfur as elemental sulfur or as sulfuric acid was considered. It was concluded that the prospects for marketing elemental sulfur were better than for sulfuric acid and this form of sulfur was selected even though acid production appeared to be less costly. TVA decided that elemental sulfur should be produced as prills rather than as molten sulfur.

Pulverized coal is conveyed pneumatically to K-T gasifiers where it is mixed with oxygen and steam and injected into the gasifiers operating at essentially atmospheric pressure. Gasification of coal occurs rapidly at temperatures of about 3000°F. Gas from the gasification zone flows through a vertical waste heat boiler where high pressure saturated steam is produced and then through a cooler/washer where the gas is cooled to ambient temperatures and coal ash dust is removed from the gas. Approximately 75% of the coal ash is carried overhead with the gas while approximately 25% of the coal ash is removed from the bottom of the gasifier as slag. The cooled gas flows through a disintegrator to remove additional dust and then to blower which delivers gas to the next processing section at a pressure of about 0.5 psig.

Section 400 Acid Gas Removal

The first part of the Acid Gas Removal section consists of gas compression. Raw gas first flows through electrostatic precipitators to remove ash dust sufficiently to permit compression of the gas. Gas is then compressed from atmospheric pressure to about 25 psia and passed through catalytic reactors which convert traces of nitrogen oxides and oxygen to nitrogen and water vapor. This treatment avoids the formation of elemental sulfur in compressors and acid gas removal systems. Koppers Totzek gasification plants have previously experienced difficulty in blockage of compressors and scrubbing towers by traces of elemental sulfur apparently formed by reaction of hydrogen sulfide and traces of oxygen, catalyzed by traces of nitrogen oxides. Catalytic conversion of nitrogen oxides in raw gas is provided to avoid these difficulties.

The gas is then compressed to a pressure of about 300 psig and passed through hydrolysis reactors to effect conversion of carbonyl sulfide to hydrogen sulfide. Compression to a pressure of about 300 psia prior to hydrolysis and acid gas removal was selected as the preferred balance between removing acid gases at low pressure and compressing clean gas to 600 psig delivery pressure and compressing raw gas to the final pressure of 600 psig and then removing acid gas. Hydrolysis was included because removal of carbonyl sulfide from raw gas without excessive removal of carbon dioxide is significantly more difficult than removal of hydrogen sulfide.

Acid gas, principally hydrogen sulfide, is removed from the hydrolyzed gas in a Selexol scrubbing process unit. This process uses a high boiling oxygenated compound to selectively absorb hydrogen sulfide from the gas together with an equal amount of carbon dioxide. Treated gas, containing about 200 ppmv of sulfur, flows to the Treated Gas Compression section. Drying of the gas is not required since sufficient water is removed from the gas in the Selexol unit to meet the moisture specification of 7 lb/MMSCF.

Section 500 Treated Gas Compression

Purified gas from the Selexol unit is compressed to a pressure of about 600 psig. The gas is then cooled and delivered to the battery limits of the plant.

Section 600 Sulfur Recovery

In accordance with the Task I recommendations, sulfur compounds in the acid gas stream are converted to elemental sulfur using a Claus process unit followed by a Beavon tail gas treating unit. The hydrogen sulfide concentration in the acid gas stream from the Selexol unit is about 50%. Accordingly, a conventional Claus plant without supplemental fuel is used to obtain about 95% conversion to elemental sulfur.

In order to limit sulfur emissions from the Sulfur Recovery Section, the Beavon Sulfur Removal process is used to treat the tail gas. Overall sulfur recovery is increased to about 99.9% which meets sulfur recovery unit emission standards of 200 ppm or less of sulfur compounds in treated tail gas.

Molten elemental sulfur produced in the Claus and Beavon units is converted to solid prills in a Chemsource sulfur prilling process. In this operation, molten sulfur is sprayed into a circulating stream of water. Solid prills of uniform size are produced and then separated from the water stream. Dewatered prills are sent to storage for eventual shipment from the site.

Section 700 Sour Water Stripping

Water condensed during compression of raw gas from K-T gasifiers is contaminated with small amounts of hydrogen sulfide, ammonia, hydrogen cyanide, thiocyanates, sulfites and chlorides. The first step in treatment of this water is carried out in the sour water stripping section. The sour water is stripped of acid components in a sour water stripping tower. Acid gases flow to the Claus plant in the Sulfur Recovery Section. Stripped water is used as cooling tower makeup.

Section 800 Ash and Slag Handling

In the K-T gasifier, approximately 75% of the coal ash is entrained with the raw gas and flows through the gasifier waste heat boiler to the washer/cooler. Most of the entrained ash is separated from the gas in the washer and flows to the Ash and Slag Handling Section. The remainder of the coal ash flows as liquid from the bottom of the gasification zone to a water bath located at the bottom of the gasifier. The bottom ash is removed from the water bath as a granulated slag containing about 6% water.

Slurry from the cooler washers in the Gasification Section flows to a gravity settler where a thickened sludge of about 15-20 percent solids content is obtained. Sludge from the settler flows to a belt filter press where a filter cake containing about 50% solids is produced. The filter cake and the bottom slag from the gasifier are transported by conveyor to the Long Term Solid Waste Storage Area.

Section 1200 Utility Area

The Utility Area includes:

- o Raw water storage and treatment
- o Potable water treatment
- o BFW and condensate treatment
- o Steam generation
- o Plant and instrument air and inert gas

Raw water is taken from the river and filtered and softened. This water is used for cooling tower makeup and for process water makeup as well as for feed for boiler feed water treatment. A portion of the softened water is further treated by chlorination to provide potable water.

Softened water is treated by ion exchange to provide water of satisfactory quality for use as boiler feed water in high pressure steam systems. Recovered condensate is treated in an ion exchange system to "polish" the water reused in steam generation.

Steam for the plant based on K-T gasifiers will be generated in Foster Wheeler coal fired fluidized bed boilers. These boilers superheat the saturated steam made in the K-T gasifier waste heat boilers as well as generate superheated steam from boiler feed water. Emissions of sulfur dioxide is controlled in Foster Wheeler fluidized bed boilers by the addition of limestone which captures sulfur dioxide made during combustion. Spent limestone is sent to Long Term Solid Waste storage.

Plant and instrument air systems are based on the use of nitrogen produced as byproduct in the air separation section.

Section 1300 Cooling Water System

Cooling water used in process heat exchangers and exhaust steam condensing systems is cooled in mechanical draft cooling towers. Blowdown from the cooling tower is treated for recovery of chromates and then sent to Waste Water Treatment.

Section 1400 Flare and Incinerator

Flares are provided to handle startup and emergency disposal of gas. An incinerator is provided to handle disposal of any combustible wastes or gas which cannot be flared.

Section 1500 Wastewater Treatment

Wastewater collected in the plant based on K-T gasifiers is comprised of cooling tower blowdown, water treatment and steam generation blowdowns, and sanitary treatment effluent. In addition, water runoff from coal storage piles and long term solid waste storage piles and long term solid waste storage piles and long term solid waste storage is added to the waste water.

The treatment system provided for wastewater includes API separator, air floatation, surge basin and activated sludge biological oxidation systems and final holding ponds. Water from these final ponds is discharged to the river.

Section 2000 General Facilities

General facilities for the coal gasification plant include:

Long term solid waste storage
By products and chemicals storage
Power, lighting, and communications
Roads and fences
Firewater system
Sewage plant
Interconnecting piping

Storage of solid wastes accumulated over a 20 year period is provided. The major byproduct storage for the plant other than waste solids is elemental sulfur prills. Chemicals storage include water chemicals, solvents and limestone.

Section 2100 Buildings

Buildings are provided as required in TVA's Design Criteria, Section 1, Paragraph 1.3.

Section 2200 Dock Facilities

Dock facilities are provided to receive and handle barges delivering coal and barges handling sulfur shipments.

2.2 General Description of Flow

Section 100 Coal Receipt and Handling

Coal is delivered by barge to the plant as essentially 3"X0 material. Coal is unloaded from the barges, broken to remove oversize pieces, and transferred to live storage or dead storage as required. Provision is made for receipt of about 5% of the coal by truck. During normal operation of the plant, coal is reclaimed from live storage and delivered to the gasification section.

Section 200 Air Separation Plant

Oxygen required for gasification in the K-T gasifier is produced as 98 volume% oxygen from an air separation plant. The K-T gasification process requires approximately 4400 TPD of oxygen to gasify 5000 TPD of Kentucky #9 coal per module.

Principal components of the air separation plant are:

- Air compression to a pressure of 85 psig
- Low temperature air fractionation
- Oxygen compression to about 7 psig for K-T gasifiers

Liquid oxygen storage (24 hours consumption in one module) and high pressure gaseous oxygen storage (13 minutes consumption in one module) are provided as back-up supply of oxygen during outage of the air separation plants. In addition, atmospheric pressure oxygen gas holders (350,000 SCF each) are provided as required by the K-T gasification process.

The air separation plant produces nitrogen for use as a conveying medium for pulverized coal and as inert gas for blanketing and instrument service. Liquid nitrogen storage of 250 tons is provided as back-up nitrogen supply. In addition, atmospheric pressure nitrogen gas holders are provided as required by the K-T gasification process.

Section 300 Coal Gasification

The K-T process for gasification of coal requires pulverized coal dried to essentailly zero surface moisture content. The coal pulverization area consists of surge hoppers, gravimetric feeders, Foster Wheeler MB mills, pulverized coal storage hoppers equipped with bag filters, and hot flue gas blowers. The Foster Wheeler MB mills are vertical ring and roller mills. Hot flue gas from Foster Wheeler fluidized bed boilers sweep pulverized coal through the mills and classifiers and transfer coal to storage hoppers. Sensible heat of the flue gas is used to dry the coal to low moisture content which is required to obtain proper flow characteristics of coal in bins and feeders.

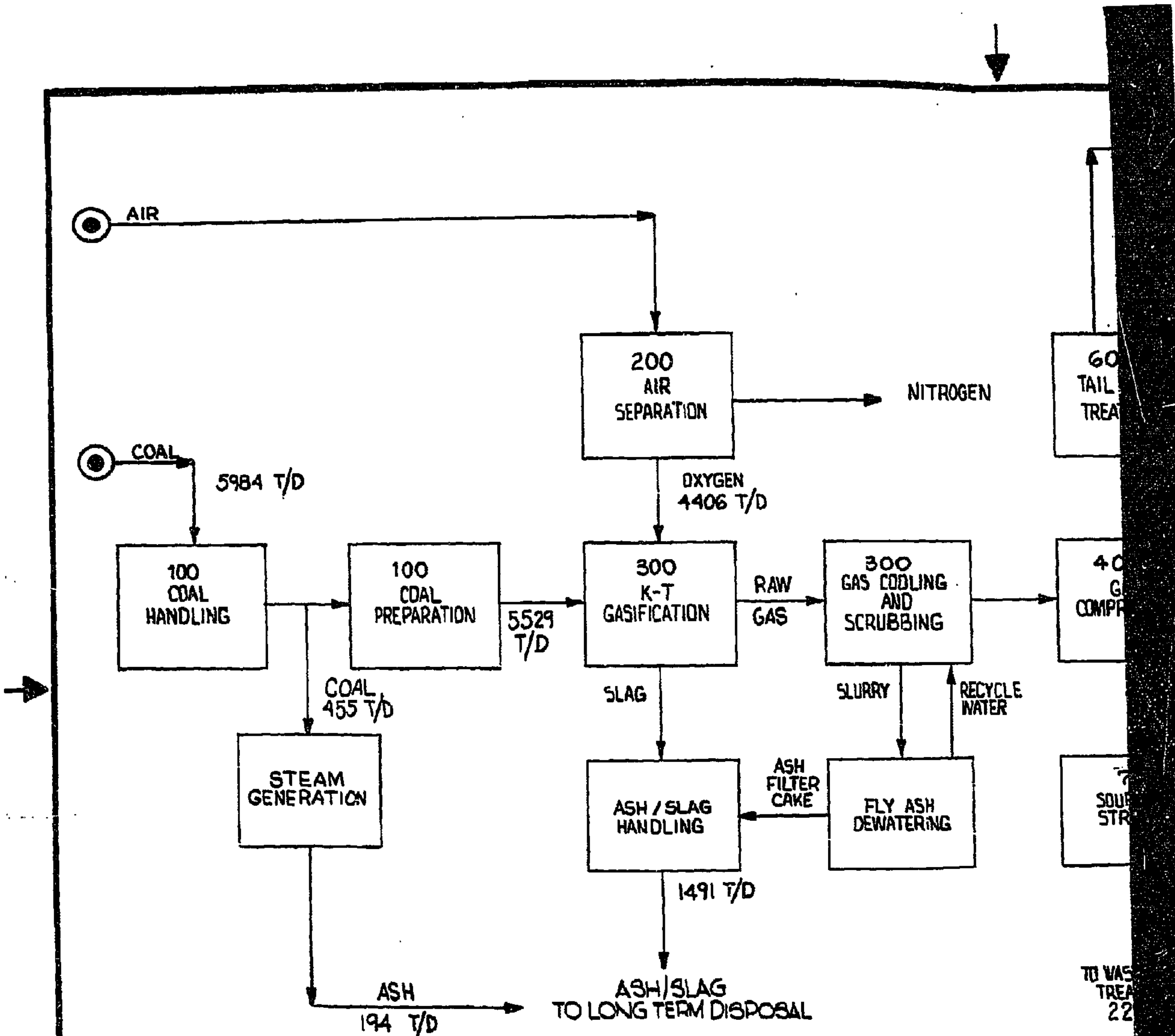
2.3 NOMINAL PLANT CAPACITIES

2.3 Nominal Plant Capacities

Nominal capacities of the processing sections of the plant are as follows:

Section	Description	Nominal Design Capacity	
100	Coal Handling	6100	TPH Coal
200	Air Separation	17,624	TPD O_2
300	Coal Gasification	22,116	TPD Coal (as received)
400	Acid Gas Removal	1280	MMSCFD Raw Gas
500	Treated Gas Compression	1140	MMSCFD Clean Gas
600	Sulfur Recovery	740	LTPD Sulfur
700	Sour Water Stripping	1120	GPM Sour Water
800	Ash/Slag Handling	4900	TPD D.B. Ash/Slag

2.4 Block Flow Diagram



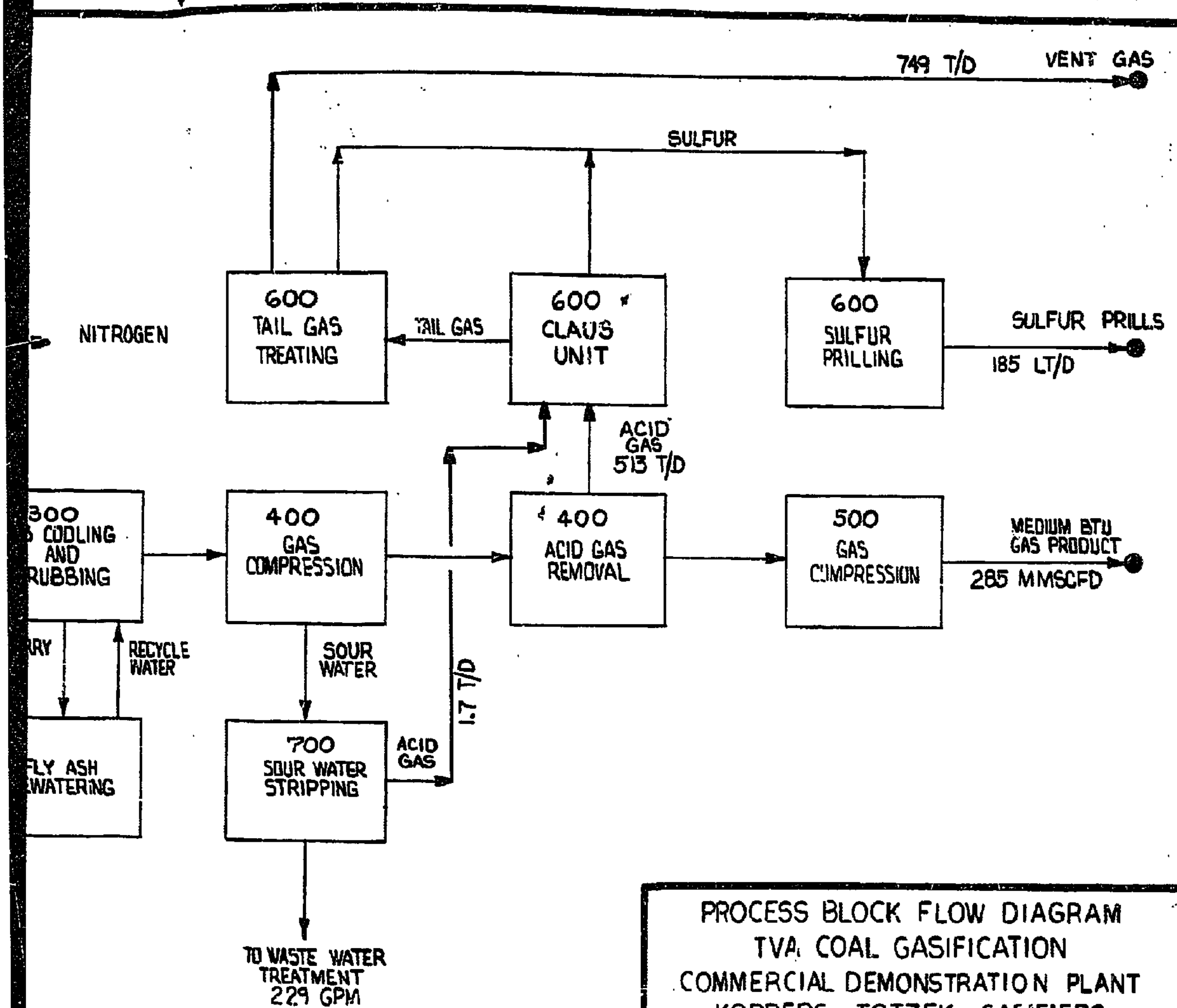
NOTE:

FLOW RATES CORRESPOND TO ONE OF FOUR PLANT MODULES.

SUPPORT FACILITIES

ASH/SLAG DISPOSAL	WASTE WATER TREATING
COOLING TOWER	FLARE / INCINERATION
UTILITIES AREA	GENERAL FACILITIES

REVISION



FACILITIES

WASTE WATER TREATING

FLARE / INCINERATION

GENERAL FACILITIES

PROCESS BLOCK FLOW DIAGRAM
TVA COAL GASIFICATION
COMMERCIAL DEMONSTRATION PLANT
KOPPERS-TOTZEK GASIFIERS

DRAWN BY:	O.T.M	3-20-80	SCALE:	=1'-0"
CHECKED BY:			54099-32-4-50-0	
APPROVED BY:				

ORDER NO. 11-54099

FORM NO. 285-63M

SECTION 3.0

BASELINE DESIGN

TVA Coal Gasification Study
Koppers - Totzek

SECTION DESCRIPTION

3.1 SECTION 100-COAL PREPARATION

A. Reference Material:

- Process Flowsheet — FWEC Dwg. No. 54099-32-1-50-1
- Elevation Drawing — FWEC Dwg. No. 54099-32-1-01-1
- Equipment List

B. Description of Flow

The unit is designed to receive, store, prepare and transport coal 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 5300 TPH free digging barge unloader (32-UD101). The barge unloader will feed belt conveyor 32-CR102 which will convey the coal to a 600 ton surge bin (32-TK101). Prior to entering the surge bin, tramp iron will be removed by magnetic separator 32-S101. Vibrating feeders 32-FD101 and 32-FD102 located under the surge bin will feed belt conveyors 32-CR103 and 32-CR104 conveying the material to sampling stations 32-SS101 and 32-SS102. Prior to entering the sampling stations an inventory of the material will be made by belt weigh scales 32-WS101 and 32-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 32-WS103 located at the unloading site. The trucks will dump the material into a 25 ton receiving hopper 32-TK102. The material will then be removed from the hopper using vibrating feeder 32-FD103 and will be conveyed to the sampling tower. Prior to sampling, tramp iron will be removed using magnetic separator 32-S102.

After sampling, the material will be fed to 4 coal breakers (32-SR101 thru 32-SR104) where the coal will be reduced to 1-1/4" x 0" lumps and then fed to 2 collecting conveyors (32-CR108 and 32-CR109) transporting the coal to a transfer tower. Refuse material discharged by the coal breakers will be collected by refuse conveyors 32-CR106 and 32-CR107 which will convey the refuse out of the breaker tower and discharge to grade.

At the transfer tower the material will either be directed to four 14,500 ton storage silos (32-TK103 thru 32-TK106) or to the load out area. Coal discharged to the silos will be weighed for silo inventory by belt scale 32-WS105 and then conveyed by belt conveyor 32-CR111 to a cascaded conveyor system 32-CR112, 32-CR113 and 32-CR114 on top of the silos.

Coal will then be removed from the silos using either 3 or 4 belt feeders per silo (32-FD104A-G thru 32-FD107A-G). They will be feeding belt conveyor 32-CR115 discharging the material to the pulverizer storage bunker feed conveyors 32-CR117A/B. Prior to this the material will be weighed on belt scale 32-WS106 and tramp iron will be removed by magnetic separator 32-S104.

Coal directed to the load out area will be weighed for dead storage inventory on belt scale 32-WS104 and then be conveyed on belt conveyor 32-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 used it will be drawn from 2 reclaim hoppers (32-TK107 and 32-TK108) located at the dead storage site. Vibrating pan feeders 32-FD108 and 32-FD109 located under the hoppers will each feed reclaim collecting conveyor 32-CR116 which conveys the material to the pulverizer storage bunker feed conveyors 32-CR117A/B. Prior to this the material will be weighed on belt scale 32-WS107 and tramp iron will be removed by magnetic separator 32-S103.

The pulverizer storage bunker feed conveyors will feed the material to the pulverizer bunker fill conveyors 32-CR118A/B which will fill four 1430 ton storage bunkers (32-TK109 thru 32-TK112 each having a 4 hour storage capacity) or to the steam generator bunker fill conveyors 32-CR119A/B which conveys the material to steam generation, Section 1200.

The material from the pulverizer storage bunkers will be removed from the bunkers on a weight controlled basis by using 10 weigh belt feeders (32-1-FD110A-J thru 32-4-FD 113A-J) per module. The material will then be led to the pulverizer feed, section 300.

All equipment from the pulverizer storage bunker feed conveyors to the storage bunkers are provided with one operating and one spare train.

Limestone

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 3400 ton limestone storage silo. Limestone will be removed from the silo using vibrating bin bottom 32-BV101 and will be fed into a pneumatic transport line by 2 rotary feeders 32-FD114A/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 32-B101A/B for noise suppression.

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: Koppers-Totzek Coal Prep.
REF. DWG.: 54099-32-1-50-1
CONTRACT NO.: 11-32-54099 REV.: 0

SECTION NO.: 100
PAGE NO.: 1 OF 3
DATE: 6/30/80

EQUIPMENT SUMMARY

ITEM	DESCRIPTION	DEFINITION	DESIGN * TEMP. (°F)	DESIGN * PRESS. (PSIG)	CONSTRUCTION MATERIAL *
32-B101A/B	Pneumatic Transport Supply Blowers				
32-BV101	Vibrating Discharger	15 TPH			
32-CR101	Unloader Transfer Conveyor	Part of 32-UD101			
32-CR102	Surge Bin Feed Conveyor	84" Belt 5,300 TPH			
32-CR103	Sampling Station Feed Conveyor	48" Belt 1,600 TPH			
32-CR104	Sampling Station Feed Conveyor	48" Belt 1,600 TPH			
32-CR105	Truck Receiving Transfer Conveyor	30" Belt 125 TPH			
32-CR106	Breaker Refuse Conveyor	24" Belt			
32-CR107	Breaker Refuse Conveyor	24" Belt			
32-CR108	Breaker Collecting Conveyor	48" Belt 1,650 TPH			
32-CR109	Breaker Collecting Conveyor	48" Belt 1,650 TPH			
32-CR110	Dead Storage Load Out Conveyor	66" Belt 3,264 TPH			
32-CR111	Silo Feed Conveyor	66" Belt 3,264 TPH			
32-CR112	Silo Fill Conveyor	66" Belt 3,264 TPH			
32-CR113	Silo Fill Conveyor	66" Belt 3,264 TPH			
32-CR114	Silo Fill Conveyor	66" Belt 3,264 TPH			
32-CR115	Silo Discharge Collecting Conveyor	48" Belt 1,300 TPH			
32-CR116	Reclaim Collecting Conveyor	48" Belt 1,300 TPH			
32-CR117A/B	Pulverizer Stor. Bunker Feed Con.	48" Belt 1,300 TPH EA.			
32-CR118A/B	Pulverizer Bunker Fill Conveyor	48" Belt 1,300 TPH EA.			
32-CR119A/B	Steam Gen. Bunker Fill Conveyor	48" Belt 1,300 TPH EA.			
32-DC101	Dust Collection System	Includes F-101 thru F-108			
32-DP101	Dust Suppression System				
32-F101	Silo Bag House	Part of 32-DC101			
32-F102	Silo Bag House	Part of 32-DC101			
32-F103	Silo Bag House	Part of 32-DC101			
32-F104	Silo Bag House	Part of 32-DC101			
32-F105	Pulverizer Storage Bunker Filter	Part of 32-DC101			

* SHELL/TUBE WHERE APPLICABLE

FOSTER WHEELER ENERGY CORPORATION
CUSTOMER: TVA
LOCATION: MURPHY HILL, ALABAMA

SECTION NAME: KOPPERS-TOTZEK COAL PREP.
REF. DWG.: 54099-32-1-50-1
CONTRACT NO.: 11-32-54099 REV.: 0

SECTION NO.: 100
PAGE NO.: 2 OF 3
DATE: 6/30/80

EQUIPMENT SUMMARY

ITEM	DESCRIPTION	DEFINITION	DESIGN * TEMP. (°F)	DESIGN * PRESS. (PSIG)	CONSTRUCTION MATERIAL *
32-F106	Pulverizer Storage Bunker Filter	Part of 32-DC101			
32-F107	Pulverizer Storage Bunker Filter	Part of 32-DC101			
32-F108	Pulverizer Storage Bunker Filter	Part of 32-DC101			
32-F109	Limestone Silo Filter Separator				
32-FD101	Unloader Surge Bin Vib. Feeder	84" x 120" 1,600 TPH			
32-FD102	Unloader Surge Bin Vib. Feeder	84" x 120" 1,600 TPH			
32-FD103	Truck Receiving Vib. Feeder	24" x 42" 125 TPH			
32-FD104A-G	Silo Discharge Feeders	36" Belt 3 @ 433 & 4 @ 325 TPH EA.			
32-FD105A-G	Silo Discharge Feeders	36" Belt 3 @ 433 & 4 @ 325 TPH EA.			
32-FD106A-G	Silo Discharge Feeders	36" Belt 3 @ 433 & 4 @ 325 TPH EA.			
32-FD107A-G	Silo Discharge Feeders	36" Belt 3 @ 433 & 4 @ 325 TPH EA.			
32-FD108	Reclaim Hopper Discharge Feeder	48" x 72" 650 TPH			
32-FD109	Reclaim Hopper Discharge Feeder	48" x 72" 650 TPH			
32-1-FD110A-J	Pulverizer Feeders	24" Belt 30 TPH EA.			
32-2-FD-111A-J	Pulverizer Feeders	24" Belt 30 TPH EA.			
32-3-FD112A-J	Pulverizer Feeders	24" Belt 30 TPH EA.			
32-4-FD113A-J	Pulverizer Feeders	24" Belt 30 TPH EA.			
32-FD114A/B	Rotary Feeders	15 TPH EA.			
32-S101	Unloader Mag. Separator	Electromagnetic Type			
32-S102	Truck Receiving Mag. Separator	Electromagnetic Type			
32-S103	Dead Storage Reclaim Mag. Sep.	Electromagnetic Type			
32-S104	Live Storage Reclaim Mag. Sep.	Electromagnetic Type			
32-SL101	Silencer				
32-SL102	Silencer				

* SHELL/TUBE WHERE APPLICABLE

FOSTER WHEELER ENERGY CORPORATION
CUSTOMER: TVA
LOCATION: MURPHY HILL, ALABAMA

SECTION NAME: KOPPERS-TOTZEK COAL PREP.
REF. DWG.: 54099-32-1-50-1
CONTRACT NO. 11-32-54099 REV.: 0

DATE: 6/30/80

EQUIPMENT SUMMARY

ITEM	DESCRIPTION	DEFINITION	DESIGN TEMP. (°F) *	DESIGN PRESS. (PSIG) *	CONSTRUCTION MATERIAL *
32-SR101	Breaker	816 TPH			
32-SR102	Breaker	816 TPH			
32-SR103	Breaker	816 TPH			
32-SR104	Breaker	816 TPH			
32-SS101	Sampling Station	Two Stage			
32-SS102	Sampling Station	Two Stage			
32-TK101	Unloader Surge Bin	600 Tons			
32-TK102	Truck Receiving Hopper	25 Tons			
32-TK103	Storage Silo	14,500 Tons			
32-TK104	Storage Silo	14,500 Tons			
32-TK105	Storage Silo	14,500 Tons			
32-TK106	Storage Silo	14,500 Tons			
32-TK107	Dead Storage Reclaim Hopper	25 Tons			
32-TK108	Dead Storage Reclaim Hopper	25 Tons			
32-TK109	Pulverizer Storage Bunker	1,430 Tons			
32-TK110	Pulverizer Storage Bunker	1,430 Tons			
32-TK111	Pulverizer Storage Bunker	1,430 Tons			
32-TK112	Pulverizer Storage Bunker	1,430 Tons			
32-TK113	Limestone Silo	3,400 Tons			
32-UD101	Barge Unloader	5,300 TPH			
32-WS101	Sampling Sta. Feed Weigh Scale	1,600 TPH 48'			
32-WS102	Sampling Sta. Feed Weigh Scale	1,600 TPH 48'			
32-WS103	Truck Weigh Scale	10'-0" x 60'-0"			
32-WS104	Load Out Weigh Scale	3,264 TPH 66'			
32-WS105	Silo Feed Weigh Scale	3,264 TPH 66'			
32-WS106	Silo Discharge Weigh Scale	1,300 TPH 48'			
32-WS107	Reclaim Weigh Scale	1,300 TPH 48'			

* SHELL/TUBE WHERE APPLICABLE

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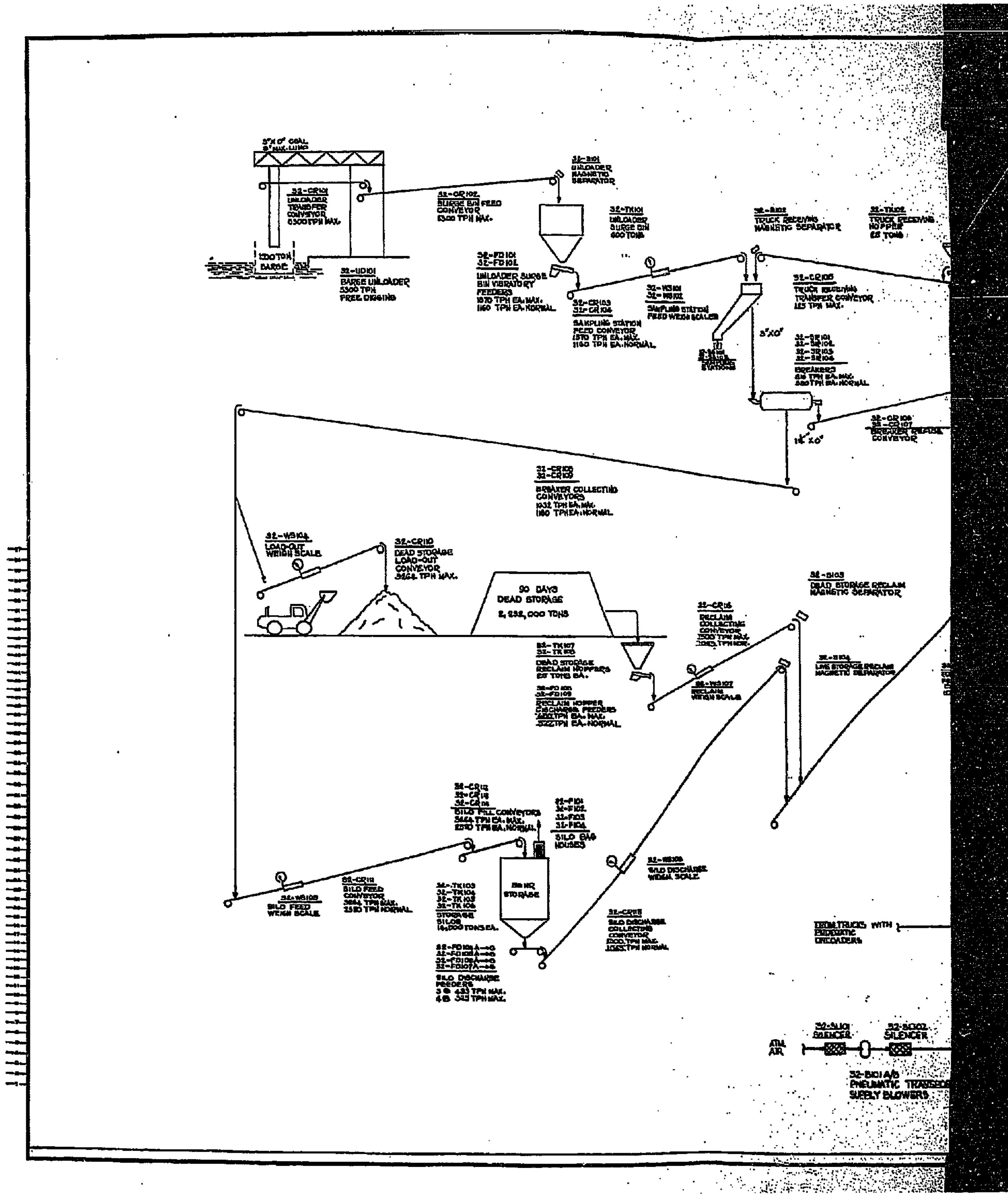
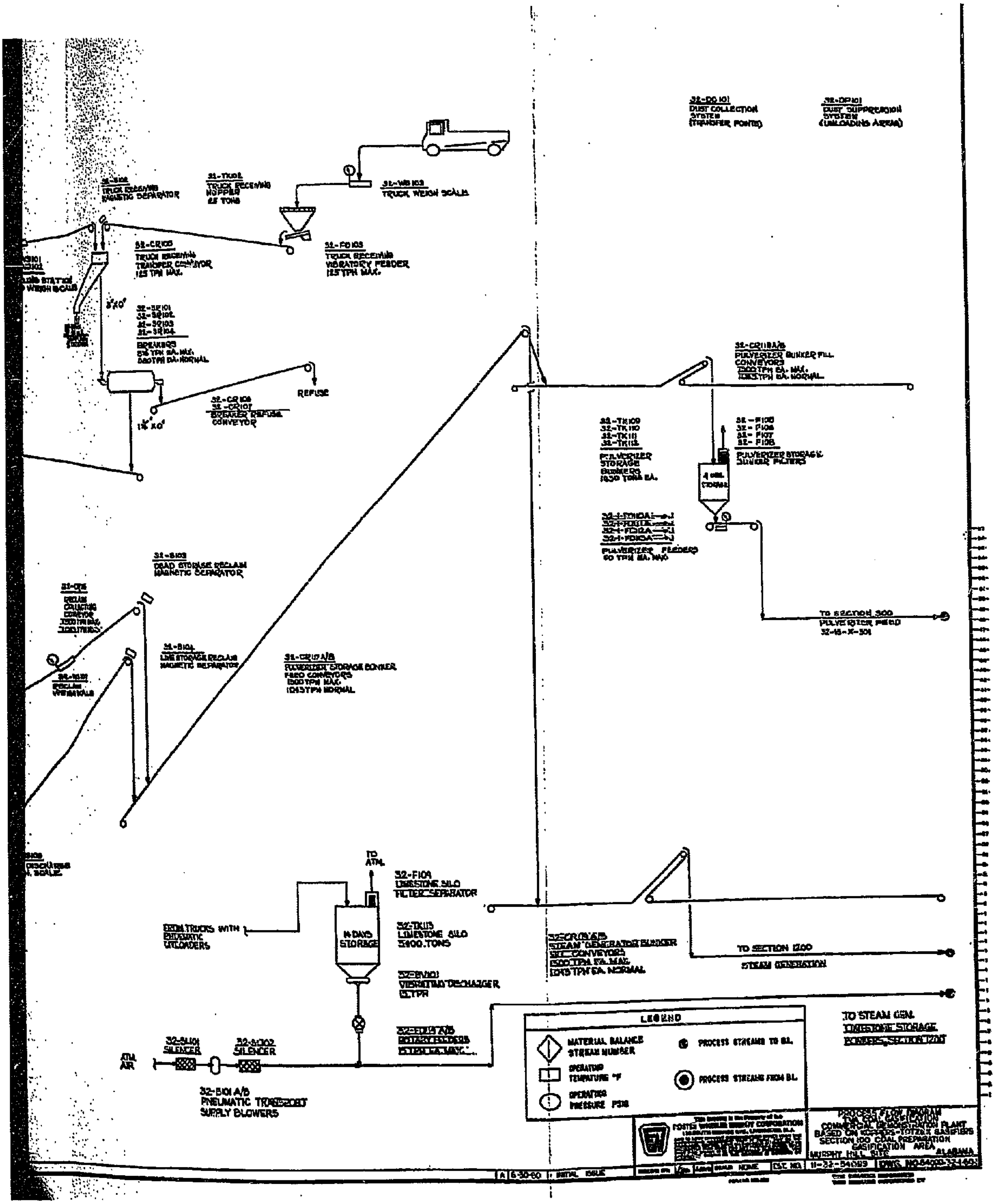
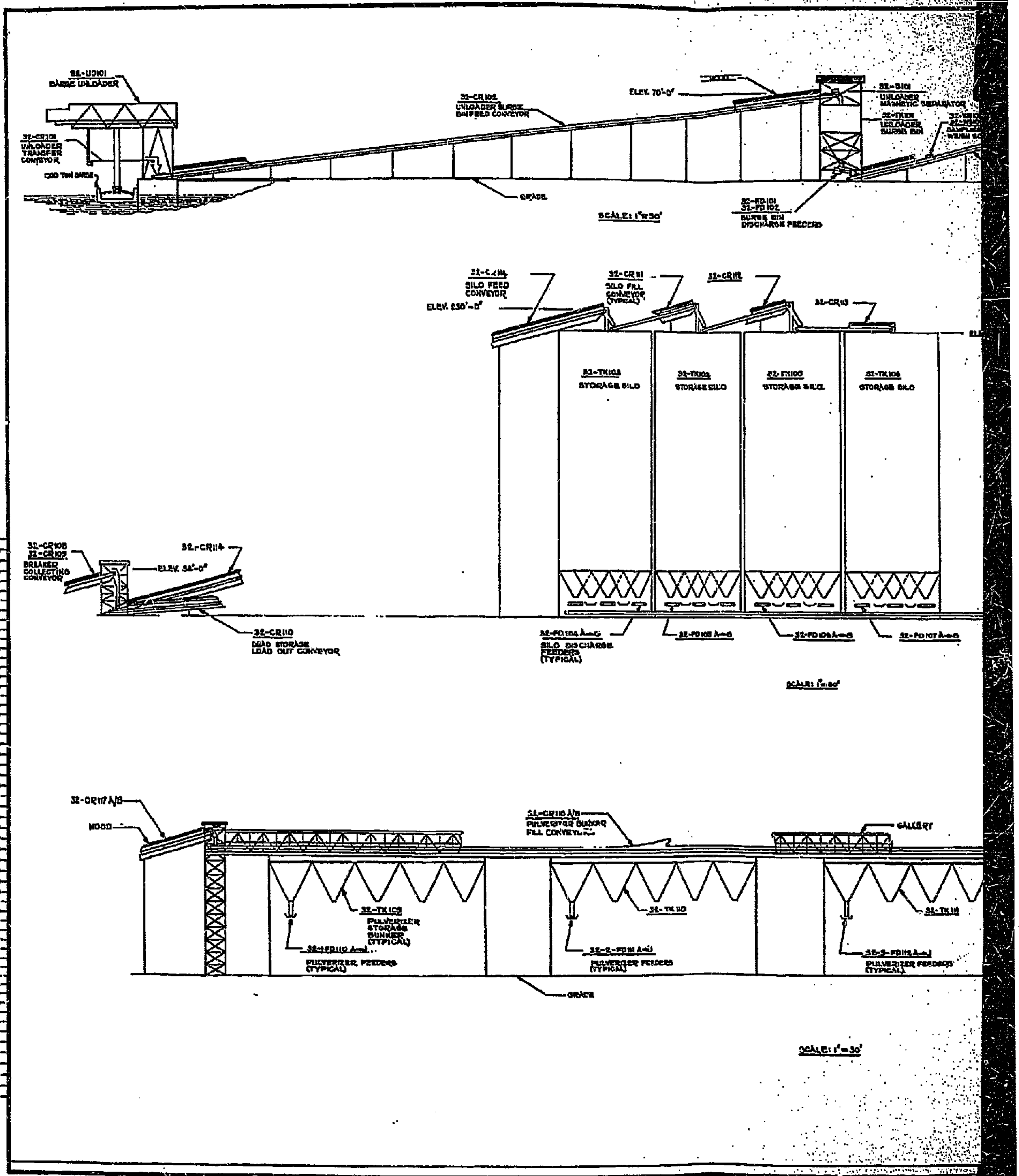
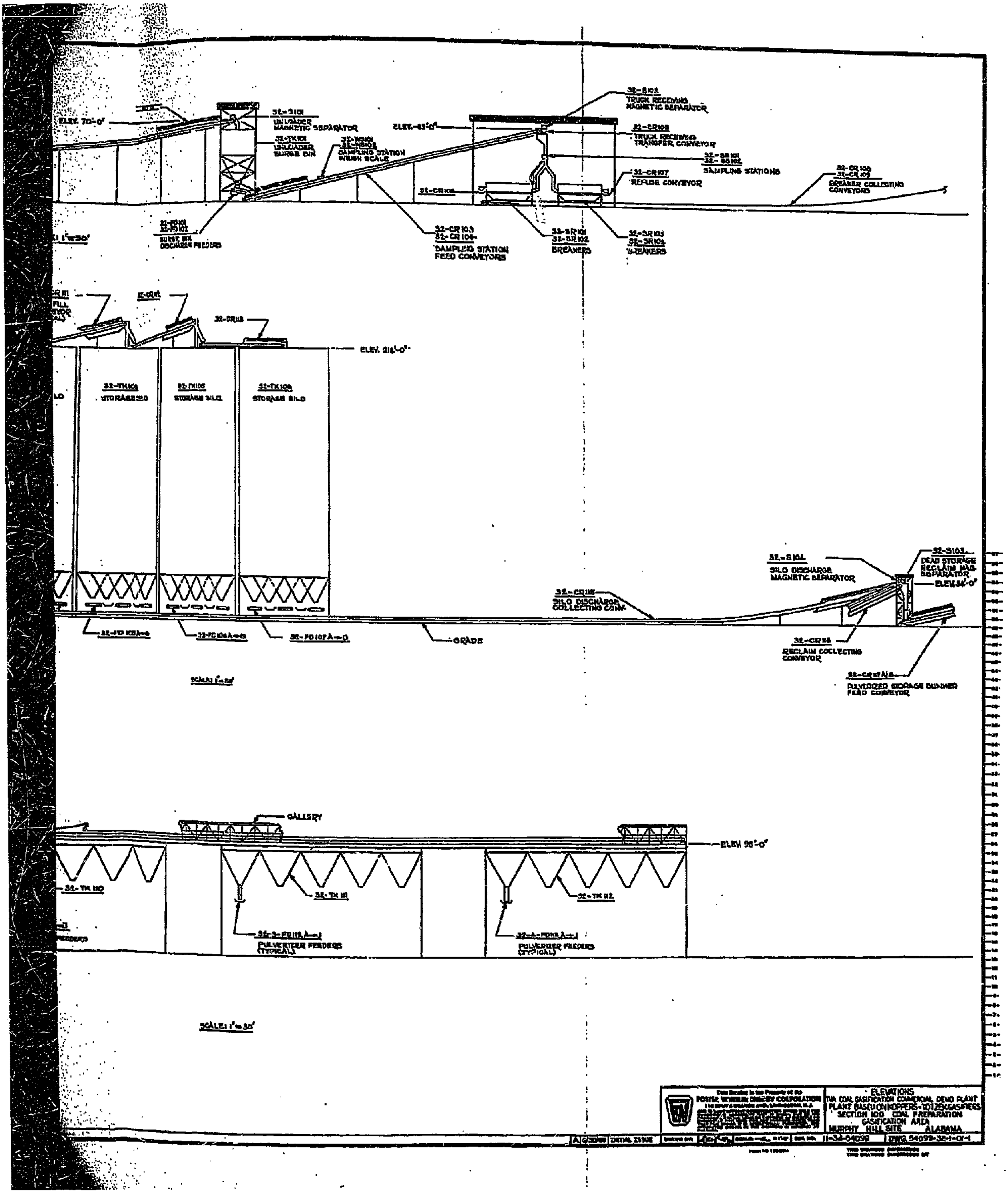

32-CR101
UNLOADER TRANSFER CONVEYOR
32-UD101
BARGE UNLOADER
5300 TPH
FREE DIGGING
SURGE BIN FEED CONVEYOR
32-TK101
UNLOADER SURGE BIN
32-FD101
32-FD102
UNLOADER SURGE BIN VIBRATORY FEEDERS
SAMPLING STATION FEED CONVEYOR
SAMPLING STATION FEED WEIGH SCALES
TRUCK RECEIVING MAGNETIC SEPARATOR
TRUCK RECEIVING HOPPER
TRUCK RECEIVING TRANSFER CONVEYOR
BREAKERS
BREAKER COLLECTING CONVEYORS
32-WS104
LOAD-OUT WEIGH SCALE
32-CR110
DEAD STORAGE LOAD-OUT CONVEYOR
90 DAYS
DEAD STORAGE
DEAD STORAGE RECLAIM HOPPERS
RECLAIM HOPPER DISCHARGE FEEDERS
RECLAIM COLLECTING CONVEYOR
RECLAIM WEIGH SCALE
DEAD STORAGE RECLAIM MAGNETIC SEPARATOR
LIVE STORAGE RECLAIM MAGNETIC SEPARATOR
SILO FILL CONVEYORS
SILO BAG HOUSES
SILO FEED WEIGH SCALE
SILO FEED CONVEYOR
STORAGE SILOS
SILO DISCHARGE FEEDERS
SILO DISCHARGE WEIGH SCALE
SILO DISCHARGE COLLECTING CONVEYOR
FROM TRUCKS WITH PNEUMATIC UNLOADERS
ATM. AIR
SILENCER
SILENCER
SUPPLY BLOWERS



TRUCK WEIGH SCALE
TRUCK RECEIVING VIBRATORY FEEDER 125 TPH MAX.
TRUCK RECEIVING TRANSFER CONVEYOR 125 TPH MAX.
BREAKERS
REFUSE
BREAKER REFUSE CONVEYOR
DEAD STORAGE RECLAIM MAGNETIC SEPARATOR
PULVERIZER STORAGE BUNKER FEED CONVEYORS
PULVERIZER BUNKER FILL CONVEYORS
PULVERIZER STORAGE BUNKERS
PULVERIZER STORAGE BUNKER FILTERS
PULVERIZER FEEDERS
TO SECTION 300
PULVERIZER FEED
TO ATM.
32-F104
LIMESTONE SILO FILTER SEPARATOR
FROM TRUCKS WITH PNEUMATIC UNLOADERS
14 DAYS STORAGE
32-TK113
LIMESTONE SILO
5400 TONS
STEAM GENERATOR BUNKER FILL CONVEYORS
TO SECTION 1200
STEAM GENERATION
TO STEAM GEN.
LIMESTONE STORAGE
BUNKERS, SECTION 1200
ATM. AIR
32-S101
SILENCER
32-S102
SILENCER
32-B101 A/B
PNEUMATIC TRANSPORT SUPPLY BLOWERS
LEGEND
MATERIAL BALANCE STREAM NUMBER
OPERATING TEMPERATURE °F
OPERATING PRESSURE PSIG
PROCESS STREAMS TO B.L.
PROCESS STREAMS FROM B.L.
FOSTER WHEELER ENERGY CORPORATION
PROCESS FLOW DIAGRAM
TVA COAL GASIFICATION
COMMERCIAL DEMONSTRATION PLANT
BASED ON KOPPERS-TOTZEK GASIFIERS
SECTION 100 COAL PREPARATION
GASIFICATION AREA
MURPHY HILL SITE
ALABAMA
SCALE NONE
INITIAL ISSUE



32-UD101
BARGE UNLOADER
32-CR101
UNLOADER TRANSFER CONVEYOR
1500 TON BARGE
32-CR102
UNLOADER SURGE BIN FEED CONVEYOR
ELEV. 70'-0"
HOOD
32-SI01
UNLOADER MAGNETIC SEPARATOR
UNLOADER SURGE BIN
GRADE
SCALE: 1"=30'
32-FD101
32-FD102
SURGE BIN DISCHARGE FEEDERS
32-CR114
SILO FEED CONVEYOR
ELEV. 230'-0"
32-CR111
SILO FILL CONVEYOR (TYPICAL)
32-CR112
32-CR113
32-TK103
STORAGE SILO
32-TK104
STORAGE SILO
32-TK105
STORAGE SILO
32-TK106
STORAGE SILO
32-CR108
32-CR109
BREAKER COLLECTING CONVEYOR
ELEV. 32'-0"
32-CR110
DEAD STORAGE LOAD OUT CONVEYOR
SILO DISCHARGE FEEDERS (TYPICAL)
SCALE: 1"=30'
32-CR117 A/B
HOOD
32-CR118 A/B
PULVERIZER BUNKER FILL CONVEYOR
GALLERY
32-TK109
PULVERIZER STORAGE BUNKER (TYPICAL)
PULVERIZER FEEDERS (TYPICAL)
32-TK110
PULVERIZER FEEDERS (TYPICAL)
32-TK111
PULVERIZER FEEDERS (TYPICAL)
GRADE
SCALE: 1"=30'



FOSTER WHEELER ENERGY CORPORATION

ELEVATIONS
TVA COAL GASIFICATION COMMERCIAL DEMO PLANT
PLANT BASED ON KOPPERS-TOTZEK GASIFIERS
SECTION 100 COAL PREPARATION
GASIFICATION AREA
MURPHY HILL SITE ALABAMA

11-34-04099 DWG. 54099-32-1-01-1

SECTION DESCRIPTION

3.2 SECTION 200 - AIR SEPARATION

A. Reference Material

- Process Flowsheet FWEC Dwg. No. 54099-32-1-50-2

B. Description of Flow

Section 200 of the Coal Gasification plant includes two air separation units each rated at 2313 tons per day of 98% oxygen. This capacity is about 5% higher than the normal oxygen consumption of the K-T gasifiers and is provided to account for the expected variability in coal in accordance with Foster Wheeler's supplemental design criteria.

Although the final design of the air separation unit has not been made in the conceptual design, a typical plant includes the process steps of air compression to about 85 psig, water and CO_2 removal, air cooling, gas expansion to produce refrigeration, separation of air by distillation, product heating by heat exchange with incoming air, and compression of air to the required pressure. A simplified flow diagram for an air separation plant using reversing heat exchangers is shown in Drawing 54099-32-1-50-2.

Air is compressed and the heat of compression is removed in a water wash which also removes a part of the moisture and carbon dioxide contained in the incoming air. The compressed air then flows through reversing heat exchangers where it is cooled against product streams. Residual amounts of carbon dioxide and water freeze out in the exchangers. These deposits are periodically removed by a reverse flow of nitrogen which results in an impure nitrogen stream. Cold air flows to the distillation column where it is separated into oxygen and nitrogen components.

A part of the separated nitrogen vapor is used to remove deposits from the reversing heat exchangers. The remainder is expanded to produce low temperature refrigeration and then used to cool incoming air. Separated oxygen from the column exchanges heat with incoming air and flows to the oxygen compressor. Since the K-T gasifiers operate at essentially atmospheric pressure, oxygen is compressed only to about 7 psig.

In addition to the air separation units, Section 200 contains the following systems:

a) liquid oxygen storage, equivalent to 24 hours consumption of oxygen for one module in the gasification plant.

b) high pressure gaseous oxygen storage equivalent to 15 minutes consumption of oxygen for the one module. The system is provided so that a rapid supply of oxygen is available in the event of air separation unit upset until the liquid oxygen storage system can be brought into operation.

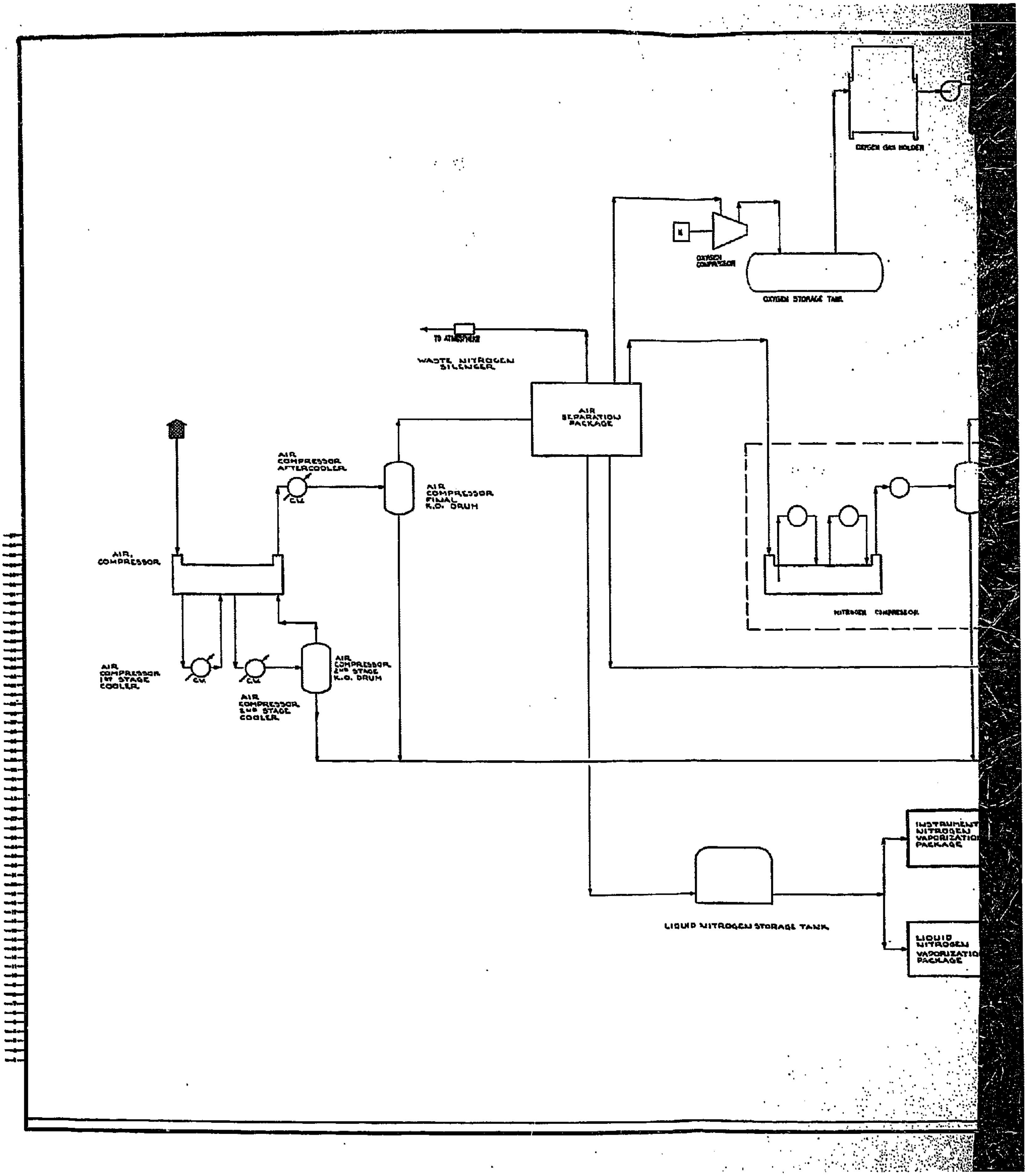
c) liquid nitrogen storage having a capacity of 250 tons. This system is provided as a limited backup supply of nitrogen for coal conveying, inerting, etc.

d) gaseous oxygen gas holder which provides a means of leveling out fluctuations in oxygen purity which may occur during periodic switching or reversing heat exchangers.

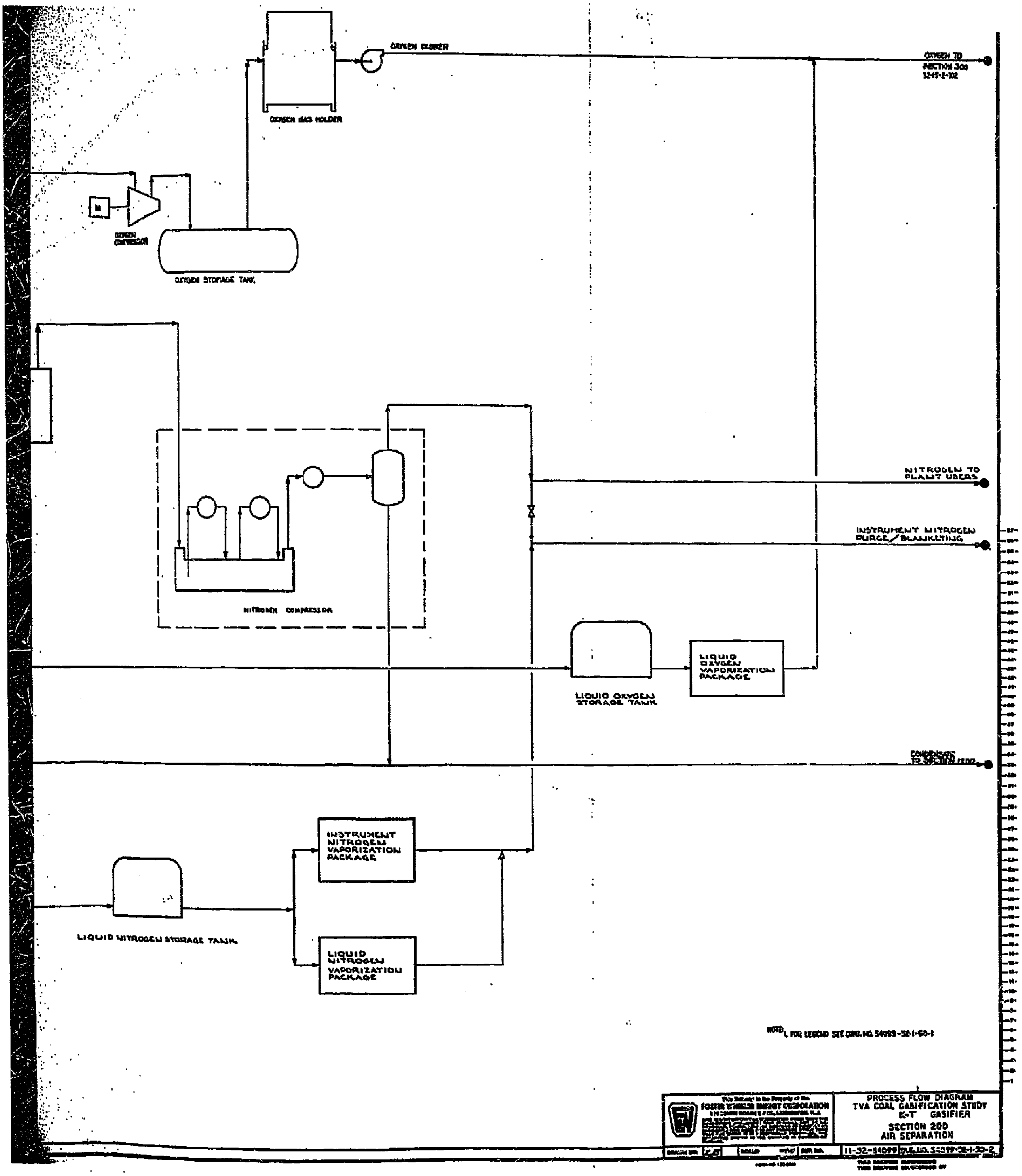
e) gaseous nitrogen gas holder which provides additional backup supply of nitrogen for coal conveying and inerting.

Compressed oxygen flows to the gasification area of Section 300. A part of the nitrogen product is used for coal conveying and inerting; the remainder is vented to the atmosphere. Any water condensed out in the air separation units is sent to the water treatment system in Section 1200.

p



OXYGEN GAS HOLDER
OXYGEN COMPRESSOR
OXYGEN STORAGE TANK
TO ATMOSPHERE
WASTE NITROGEN SILENCER
AIR SEPARATION PACKAGE
AIR COMPRESSOR AFTERCOOLER
C.W.
AIR COMPRESSOR FINAL K.O. DRUM
AIR COMPRESSOR
NITROGEN COMPRESSOR
AIR COMPRESSOR 1ST STAGE COOLER
C.W.
C.W.
AIR COMPRESSOR 2ND STAGE K.O. DRUM
AIR COMPRESSOR 2ND STAGE COOLER
INSTRUMEN NITROGEN VAPORIZATIO PACKAGE
LIQUID NITROGEN STORAGE TANK
LIQUID NITROGEN VAPORIZATIO PACKAGE


OXYGEN BLOWER
OXYGEN GAS HOLDER
OXYGEN TO
SECTION 300
OXYGEN COMPRESSOR
OXYGEN STORAGE TANK
NITROGEN COMPRESSOR
NITROGEN TO
PLANT USERS
INSTRUMENT NITROGEN
PURGE/BLANKETING
LIQUID OXYGEN STORAGE TANK
LIQUID OXYGEN VAPORIZATION PACKAGE
INSTRUMENT NITROGEN VAPORIZATION PACKAGE
LIQUID NITROGEN STORAGE TANK
LIQUID NITROGEN VAPORIZATION PACKAGE
PROCESS FLOW DIAGRAM
TVA COAL GASIFICATION STUDY
K-T GASIFIER
SECTION 200
AIR SEPARATION
FOSTER WHEELER ENERGY CORPORATION
11-32-54099

SECTION DESCRIPTION

3.3 SECTION 300 - GASIFICATION SYSTEM

A. Reference Material FWEC Dwg. No. 54099-32-1-50-3
54099-32-1-50-4

- Process Flowhseet
- Major Stream Flows
- Equipment List

B. Description of Flow

Section 300 of the coal gasification plant consists of two major areas, coal pulverization/drying and coal gasification. Each of these areas is described below.

Coal Pulverization/Drying Area

A flow diagram for this area of Section 300 is shown in Drawing 54099-32-1-50-3. Crushed coal is conveyed from Section 100 - Coal Handling to the hoppers of the coal pulverizers. For the purposes of this conceptual design, Foster Wheeler MB mills were selected for this service.

The raw coal is fed through the center of the pulverizer and is centrifugally force fed radially outward between rollers and grinding segments where it is pulverized. Pulverized coal travels outward from the grinding segments where it is entrained by a stream of high velocity hot flue gas directed upward through the airport ring. The coal is entrained and dried by the flue gas and carried to the classifier section. Coal which has not been pulverized to proper fineness in the grinding section is redeposited on the grinding table for further pulverization. The coal which remains suspended in the flue gas stream is carried to the pulverizer discharge section and then to the pulverized coal hopper. The flue gas passes through a bag filter system to remove residual coal particles before the gas is released to the atmosphere.

Coal Gasification Area

A flow diagram for this area of Section 300 is shown in Drawing 54099-32-1-50-4. Koppers-Totzek oxygen-blown, entrained flow gasifiers are used to gasify coal at elevated temperatures to produce raw fuel gas.

Pulverized coal (approximately 90% through 200 mesh) is conveyed from hoppers in the coal pulverization/drying area to the bunker system of the K-T gasifiers. Coal is withdrawn from the bunkers by means of screw conveyers and fed to each gasifier mixed with the necessary oxygen and steam. In this design, four-head gasifiers are used, each burner located in opposing position around the periphery of each gasifier. A high temperature (about 3000°F) zone is maintained in the K-T gasifier and the injected coal undergoes preheating, gasification, and partial combustion within a time of about one second. The gas formed consists primarily of carbon monoxide, hydrogen, and carbon dioxide. Formation of methane is very limited because of the high temperature gasification. No oil, tar, or other low temperature pyrolysis product is formed since these materials are completely reacted in the high temperature zone of the gasifier.

Hot gas from the gasifier is tempered with water quench and flows through a waste heat boiler positioned immediately above the gasifier. The sensible heat of the hot gas is recovered as saturated steam. In this design, saturated steam at a pressure of 950 psig is generated in the waste heat boiler. Low pressure steam (42 psia) is generated in cooling jackets around the gasifier.

Approximately 25% of the ash contained in the coal leaves the bottom of the gasifier as a molten slag. The slag is solidified in a water quench chamber located immediately below the gasfifier and is removed as a frit containing about 6% water by a conveyor. The remainder of the ash is carried with the gas into the waste heat boiler. This fly ash either settles into the bottom of the waste heat boiler where it is removed as a dilute water slurry or is carried over to the cooler/washer tower.

Gas from the waste heat boiler carrying entrained fly ash is washed and cooled with a circulating stream of water. Most of the fly ash is separated from the gas in the washer and is removed as a dilute water slurry. Additional fly ash is removed in a disintegrator/separator Slurry from this unit is combined with slurry from the cooler/washer tower. The scrubbed gas then flows to a blower which provides sufficient head to transfer the gas to Section 400, Acid Gas Removal. Flyash-water slurry is pumped to Section 800, Ash/Slag Handling.

The flowsheet shown in Drawing 54099-32-1-50-4 depicts one K-T gasification train. There are 10 identical trains in this design for each module, 8 trains specified by Krupp-Koppers as required for the normal capacity and two spare trains. Foster Wheeler's analysis indicated that at least two spare gasification trains are required to achieve TVA's requirement of 90% on stream factor for each module of the 4 module gasification plant .

Major Stream Flows

A listing of the major input and output flows of the gasification area is given in the attached table of major streams. The flowrates given are for one of the total 4 module gasification plant.

Equipment List

A summary of equipment for the gasification area as provided by Krupp-Koppers is given in the following Equipment List. The number of each equipment item required for one module is shown.

FOSTER WHEELER ENERGY CORPORATION

TVA COAL GASIFICATION DEMONSTRATION PLANT

PLANT BASED ON KOPPER-TOTZEK GASIFIERS

MAJOR STREAM FLOWS

SECTION 300-GASIFICATION

ONE MODULE

STREAM NUMBER	DESCRIPTION	FLOW, LB/HR
32-301	Crushed Coal	460,750
32-302	Hot Flue Gas	460,750
32-303	Conveying Nitrogen	57,000
32-304	Oxygen	367,170
32-305	Wash Water	3,257,145
32-306	Flue Gas To Atmosphere	464,060
32-308	Ash-Water Slurry	3,218,430
32-309	Slag	21,130

KOPPERS-TOTZEK

FORM NO. 135-904

FOSTER WHEELER ENERGY CORP. PROCESS PLANTS DIVISION | CONTRACT: 54099-32 | SECTION: 300

EQUIPMENT LIST

NAME OF UNIT: GASIFICATION

PAGE 1 OF 6

CLIENT: TVA

LOCATION:

REVISION	ORIGINAL	1	2	3	4	5
DATE		-				

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.	NO/MODULE	REV.
BLOWERS							
32-15	B-301	Hot Flue Gas Blower					
32-12	B-302	Nitrogen Blower					
32-110	B-303	Raw Gas Blower					
BINS/ HOPPERS							
32-15	BN-301	Pulv. Coal Storage Bin					
32-15	BN-302	Pulv. Coal Transfer Hopper					
32-110	BN-303 A/B/C/D	Service Bin					
32-110	BN-304 A/B/C/D	Feed Bin					

KOPPERS–TOTZEK

FORM NO. 135-904

FOSTER WHEELER ENERGY CORP.
PROCESS PLANTS DIVISION

CONTRACT: 54099–32
SECTION: 300

EQUIPMENT LIST

NAME OF UNIT: GASIFICATION

CLIENT: TVA
LOCATION:

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P.O. NO.	NO/MODULE		REV.
CONVEYORS/ FEEDERS								
32–110	CR–301 A/B/C/D	Pulverized Coal Feeder						
32–110	CR–302 A/B/C/D	Pneumatic Coal Pump						
32–110	CR–303 A/B/C/D	Coal Feeder						
32–110	CR–304 A/B/C/D	Double Coal Screw Feeder						
32–110	CR–305	Slag Belt Conveyor						

REVISION	ORIGINAL	1	2	3	4	5
DATE						

KOPPERS-TOTZEK

FORM NO. 135-904

FOSTER WHEELER ENERGY CORP.
PROCESS PLANTS DIVISION

CONTRACT: 54099-32
SECTION: 300

EQUIPMENT LIST

NAME OF UNIT: GASIFICATION

CLIENT: TVA

LOCATION:

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.	NO/MODULE	REV.
DRUMS							
32-12	D-301	Nitrogen Surge Drum					
32-110	D-302	Gasifier Nitrogen Drum					
32-15	D-303	Blow Down Drum					
32-110	D-304	LP Steam Drum					
32-110	D-305	HP Steam Drum					
32-110	D-306	Fly Dust Discharge Drum					
32-110	D-307	N_2 Seal Pot For Whrs					
32-110	D-309	N_2 Seal Pot For Cooling/Washer					
32-110	D-310	Flare Seal Pot					
32-110	D-311	H_2 Seal Pot For Flare					
32-110	D-312	Quick Gas Seal					
32-110	D-313	H_2 Seal Pot For Raw Gas Blw					

KOPPERS-TOZEK

FORM NO. 135-904

FOSTER WHEELER ENERGY CORP. PROCESS PLANTS DIVISION

CONTRACT: 54099-32
SECTION: 300

EQUIPMENT LIST

NAME OF UNIT: GASIFICATION

CLIENT: TVA

LOCATION:

REVISION: ORIGINAL, 1, 2, 3, 4, 5

DATE:

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.	NO/MODULE	REV.
HEAT EXCHANGERS							
32-110	E-301	Waste Heat Recovery System					
32-15	E-302	Oxygen Heater					
32-12	E-303	Nitrogen Aftercooler					
32-12	E-304	Nitrogen Recycle Aftercooler					
FILTERS							
32-15	F-301	Bag Filter					
32-110	F-302	Fly Dust Classifier					
32-110	F-303	Disintegrator					
MIXERS							
32-110	M-301 A/B	Steam-Oxygen Mixer					

KOPPERS-TOTZEK

FORM NO. 135-904

FOSTER WHEELER ENERGY CORP. PROCESS PLANTS DIVISION | CONTRACT: 54099-32 | SECTION: 300

EQUIPMENT LIST

NAME OF UNIT: GASIFICATION

CLIENT: TVA

LOCATION:

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.	NO/MODULE		REV.
PUMPS								
32-12	P-301 A/B	Quench Water Pump						
32-110	P-302	Water Wash Pump						
REACTORS								
32-110	R-301	K-T Gasifier				10		
SEPARATORS								
32-15	S-301	Cyclone Separator						
32-110	S-302	Steam-Condensate Separator						
32-110	S-303	Slag Extractor						
32-110	S-304	Drop Separator						
32-110	S-305	Separator						

REVISION	ORIGINAL	1	2	3	4	5
DATE						

KOPPERS-TOTZEK

FORM NO. 135-904

FOSTER WHEELER ENERGY CORP. PROCESS PLANTS DIVISION | CONTRACT 54099-32 | SECTION: 300

EQUIPMENT LIST

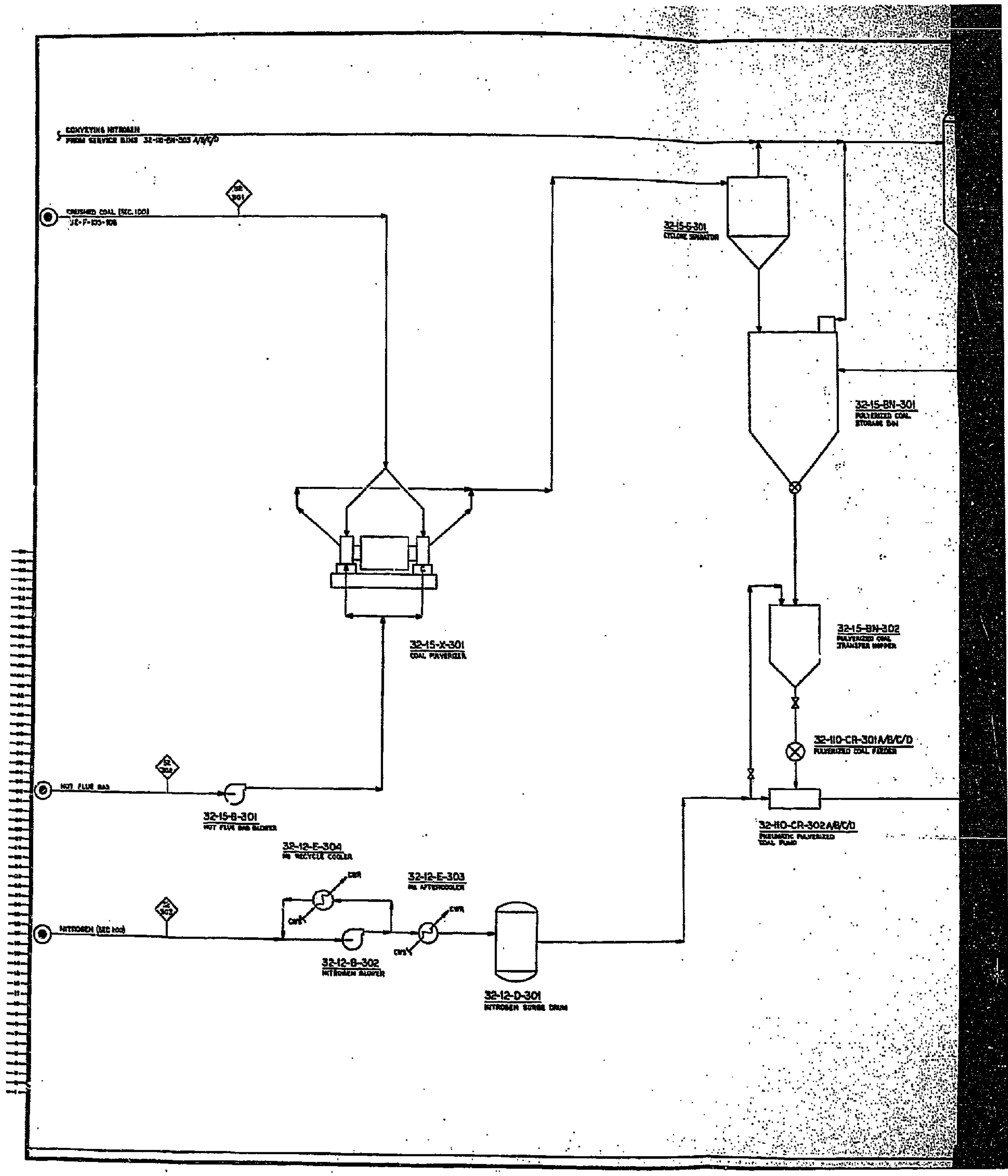
NAME OF UNIT: GASIFICATION

CLIENT: TVA

LOCATION:

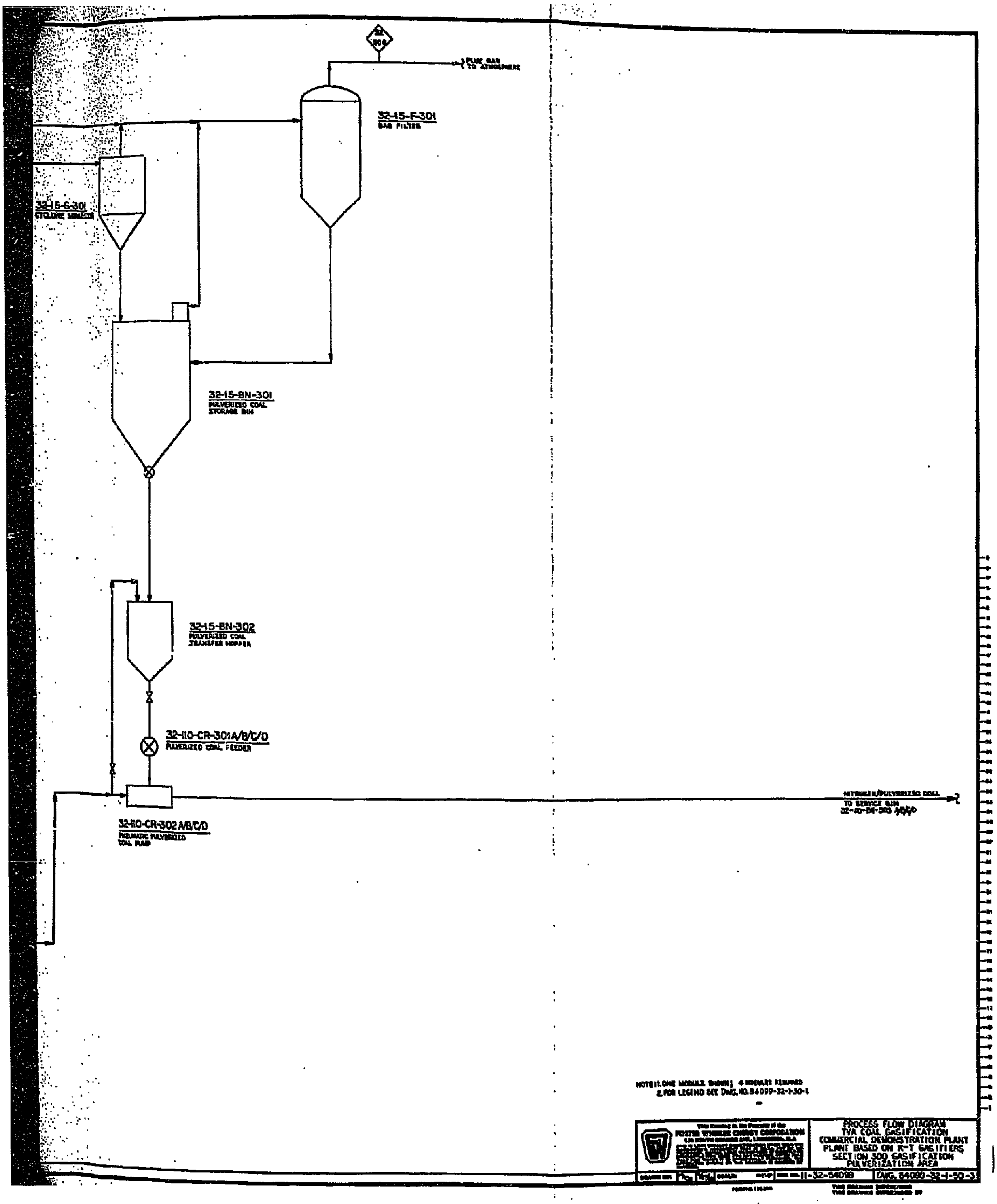
REVISION	ORIGINAL	1	2	3	4	5
DATE						

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.	NO/MODULE		REV.
TOWERS 32-110	T-301	Cooling Washer Tower						
PULVERIZERS 32-15	X-301	Coal Pulverizer						



CONVEYING NITROGEN
FROM SERVICE BINS 32-10-BN-303 A/B/C/D
CRUSHED COAL (SEC. 100)
32-15-G-301
CYCLONE SEPARATOR
32-15-BN-301
PULVERIZED COAL
STORAGE BIN
32-15-X-301
COAL PULVERIZER
32-15-BN-302
PULVERIZED COAL
TRANSFER HOPPER
32-110-CR-301A/B/C/D
PULVERIZED COAL FEEDER
HOT FLUE GAS
32-15-B-301
HOT FLUE GAS BLOWER
32-110-CR-302A/B/C/D
PNEUMATIC PULVERIZED
COAL PUMP
32-12-E-304
N2 RECYCLE COOLER
32-12-E-303
N2 AFTERCOOLER
CWR
CWS
NITROGEN (SEC 100)
32-12-B-302
NITROGEN BLOWER
32-12-D-301
NITROGEN SURGE DRUM

p



FLUE GAS TO ATMOSPHERE
32-15-F-301
BAG FILTER
32-15-G-301
32-15-BN-301
PULVERIZED COAL STORAGE BIN
32-15-BN-302
PULVERIZED COAL TRANSFER HOPPER
32-110-CR-301 A/B/C/D
PULVERIZED COAL FEEDER
32-110-CR-302 A/B/C/D
NITROGEN/PULVERIZED COAL TO SERVICE BIN
PROCESS FLOW DIAGRAM
TVA COAL GASIFICATION
COMMERCIAL DEMONSTRATION PLANT
PLANT BASED ON K-T GASIFIERS
SECTION 300 GASIFICATION
PULVERIZATION AREA
11-32-54098
DWG. 54090-32-1-50-3

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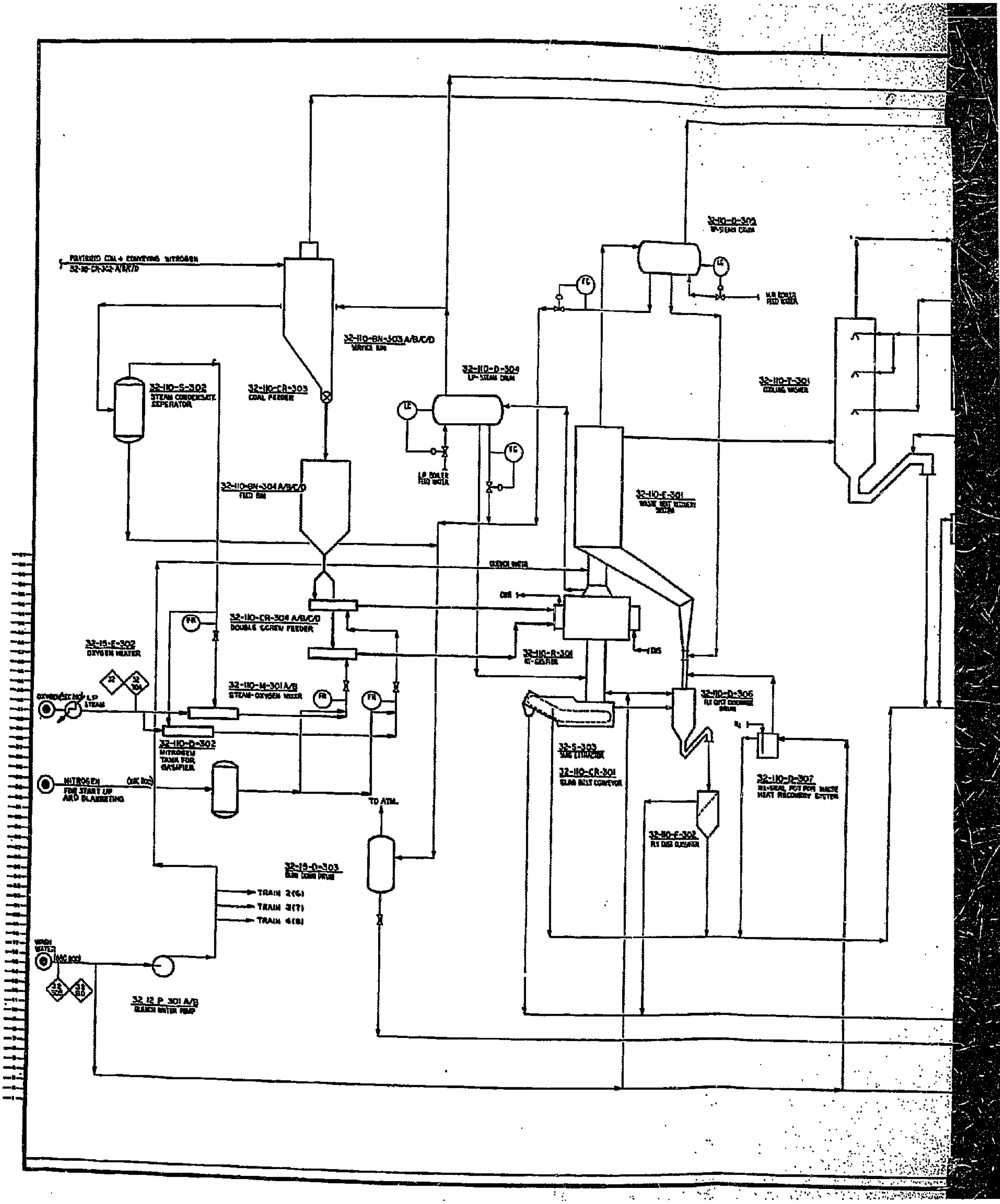
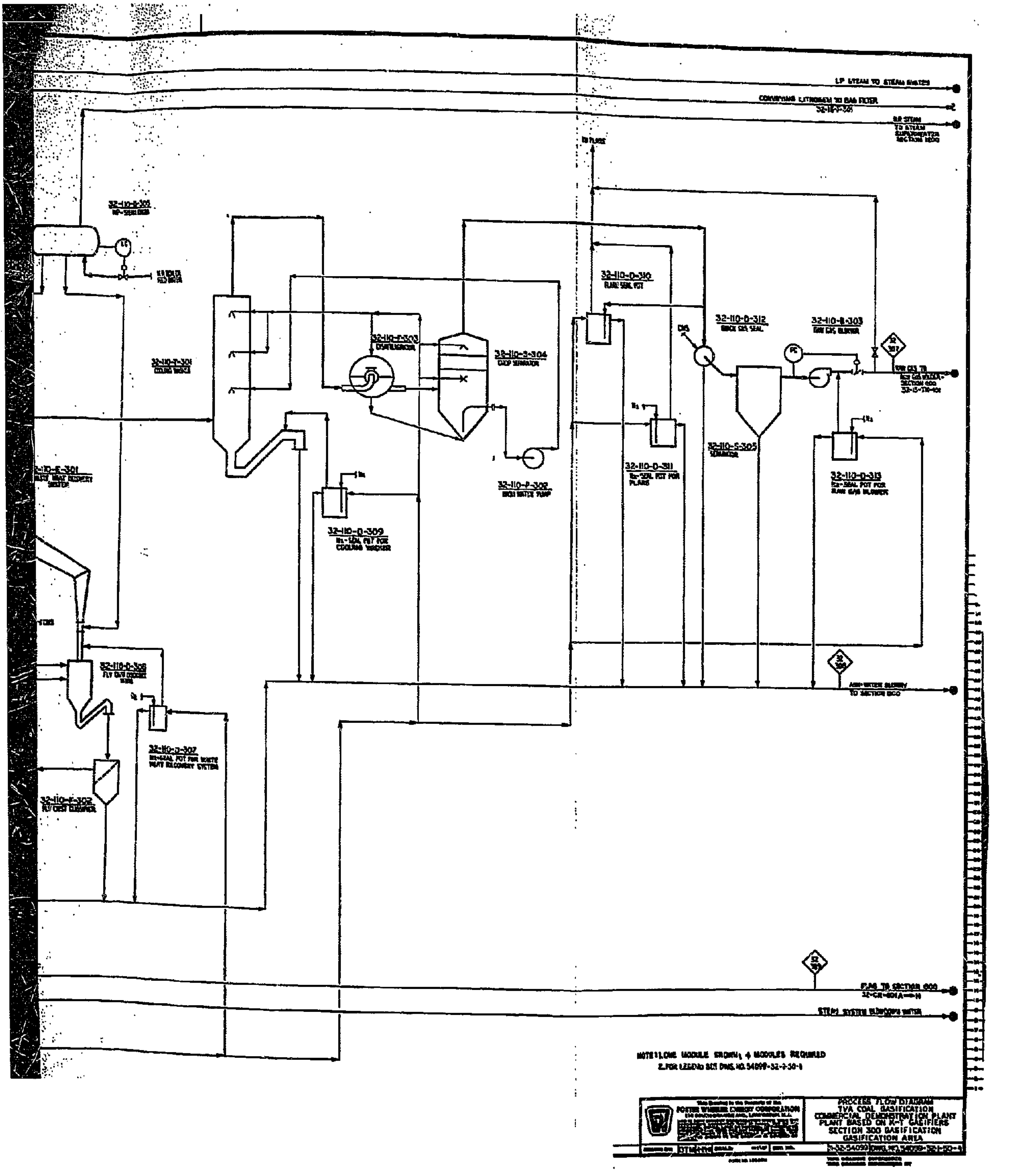


32-110-BN-303 A/B/C/D
SERVICE BIN
32-110-S-302
STEAM CONDENSATE SEPERATOR
32-110-CR-303
COAL FEEDER
32-110-BN-304 A/B/C/D
FEED BIN
32-110-D-304
LP-STEAM DRUM
LP BOILER FEED WATER
32-110-D-305
32-110-T-301
COOLING WASHER
32-110-E-301
QUENCH WATER
32-110-CR-304 A/B/C/D
DOUBLE SCREW FEEDER
32-110-R-301
32-15-E-302
OXYGEN HEATER
32-110-M-301 A/B
STEAM-OXYGEN MIXER
L.P. STEAM
32-110-D-302
NITROGEN TANK FOR GASIFIER
NITROGEN
FOR START UP AND BLANKETING
TO ATM.
32-15-D-303
TRAIN 2(6)
TRAIN 3(7)
TRAIN 4(8)
WASH WATER
32 12 P 301 A/B
32-110-D-306
32-S-303
32-110-CR-301
SLAG BELT CONVEYOR
32-110-F-302
32-110-D-307

p


LP STEAM TO STEAM HEATER
CONVEYING NITROGEN TO GAS FILTER
HP STEAM TO STEAM SUPERHEATER SECTION 1000
TO FLARE
32-110-D-305
32-110-T-301
COOLING WASHER
32-110-E-303
32-110-S-304
32-110-D-310
FLARE SEAL POT
32-110-D-312
32-110-B-303
32-110-D-311
32-110-S-305
SEPARATOR
32-110-D-313
32-110-D-309
COOLING WASHER
32-110-P-302
32-110-D-306
32-110-D-307
32-110-F-302
32-110-E-301
TO SECTION 800
32-CR-801A
STEAM SYSTEM BLOWDOWN WATER
NOTE: 1. ONE MODULE SHOWN; 4 MODULES REQUIRED
2. FOR LEGEND SEE DWG. NO. 54099-32-2-30-1
FOSTER WHEELER ENERGY CORPORATION
PROCESS FLOW DIAGRAM
TVA COAL GASIFICATION
COMMERCIAL DEMONSTRATION PLANT
PLANT BASED ON K-T GASIFIERS
SECTION 300 GASIFICATION
GASIFICATION AREA

SECTION DESCRIPTION

3.4 SECTION 400 - ACID GAS REMOVAL

A. Reference Material

FWEC Dwg. No. 54099-32-1-50-5
54099-32-1-50-6

- Process Flowsheet
- Major Stream Flows
- Equipment List

B. Description of Flow

Section 400 of the coal gasification plant consists of two major areas, raw gas compression and acid gas removal. Each of these areas is described below.

Raw Gas Compression Area

The K-T gasifiers operate at essentially atmospheric pressure. As a result, it is necessary to compress the gas before or after acid gas removal in order to deliver fuel gas product at a pressure of 600 psig as specified by TVA. Foster Wheeler analysis of possible alternates for compression and acid gas removal indicated that two major considerations are involved. The first consideration is the necessity of removing trace amounts of nitrogen oxides which are present in the raw gas in order to avoid operating difficulties during compression and acid gas removal.

Nitrogen oxides are formed in small amounts in the K-T gasifier by reaction of nitrogen compounds (either molecular nitrogen present in the oxygen supplied to the gasifier or nitrogen compounds resulting from coal gasification) and oxygen at the high temperatures existing in the gasifier. Patridge /1/ described difficulties experienced in the AECI coal-based ammonia plant located near Johannesburg, South Africa arising from deposition of elemental sulfur in compressors and in a Rectisol unit. Elemental sulfur was apparently formed by oxidation of hydrogen sulfide by traces of oxygen in the gas, the reaction being catalyzed by traces of nitric oxides.

The difficulty is eliminated by passing the raw gas through a catalytic reactor where nitrogen oxides are reduced by hydrogen contained in the gas to molecular nitrogen and water. Trace amounts of oxygen

/1/ Partridge, L.J., "Production of Ammonia Synthesis Gas by Purification and Shift Conversion of Gas Produced from Coal," The Chemical Engineer, February 1980, page 88 - 91.

may also be reacted in this step. This catalytic treatment must be accomplished before any major compression of the gas is carried out.

The second consideration in the processing of raw gas is whether the raw gas should be compressed to a pressure slightly higher than 600 psig and then cleaned of sulfur compounds or compressed to an intermediate pressure, desulfurized, and then compressed to the final delivery pressure. The latter method, since it minimizes compression of wet sour gas in relatively more expensive compressors, was selected for this design.

Process Description

A flow diagram for the raw gas compression area is shown in Drawing 54099-32-1-50-5. Gas from the 8 operating gasification trains in a module flows to an atmospheric pressure gasholder. This holder provides surge capacity to even out minor fluctuations in raw gas flow so that compressors are providing a constant flow of gas. Gas from the holder is first compressed to a pressure of about 30 psia. Heat of compression heats the gas to a temperature of about 310^{o}F which is sufficient for the "DENOX" reaction. The gas flows through two parallel packed bed catalytic reactors where nitrogen oxides are reacted with hydrogen producing nitrogen and water.

Reactor effluent is cooled and condensed water is separated. The gas is then compressed to a pressure of about 330 psia and delivered to the Acid Gas Removal Area of Section 300. Intercoolers are provided in sufficient number to limit the gas temperature during compression to a maximum of about 390^{o}F.

The flow diagram mentioned above represents a single train of equipment provided for each module of the 4 module plant. Available information on compressor reliability indicates that a single train of compressors (two compressors in series) per module are sufficient to achieve the 90% on-stream factor for a module as required by TVA. Gas flow in the first compressor is sufficient to justify an axial compressor. The remaining compressor is centrifugal. The machines are rated for 5% over normal material balance to allow for variation in gas flow resulting from variation in coal properties.

Acid Gas Removal Area

A flow diagram for the Acid Gas Removal Area of Section 400 is shown in Drawing 54099-32-1-50-6. In accordance with the assessment of acid gas removal processes made by Foster Wheeler the Selexol Process was used to remove sulfur compounds from the K-T raw gas. Consideration was given, however, to the problem of carbonyl sulfide removal. This compound is difficult to separate from the gas without extensive removal of carbon dioxide at the same time. Since carbon dioxide removal is not required to meet product gas specification, it was decided to provide a conversion step wherein carbonyl sulfide is hydrolyzed to hydrogen sulfide. The Selexol process unit could then be designed essentially on the basis of hydrogen sulfide removal only. This would be of increased importance if the product gas sulfur specification were decreased substantially below 200 ppmv.

Hot gas from the final raw gas compressors is mixed with steam and then flows through fixed bed reactors containing activated alumina hydrolysis catalyst. Carbonyl sulfide reacts with steam to form hydrogen sulfide and carbon dioxide. For this design, a carbonyl sulfide conversion of 95% was selected.

Effluent from the hydrolysis reactors is cooled first against cooling water and then against cold clean gas from the Selexol absorber tower. Gas is separated from condensed water and flowsto the base of the Selexol tower. The gas is contacted countercurrently with Selexol solvent which removes hydrogen sulfide and some carbon dioxide from the gas.

The Selexol Solvent Process, developed and marketed by Allied Chemical Corporation, uses an oxygenated organic compound as solvent. This material has a high solubility for hydrogen sulfide and lesser solubility for carbon dioxide. Light gases such as hydrogen and carbon monoxide have low solubility.

Rich solvent flows from the bottom of the absorber to a flash tank. The flash gas is recompressed and recycled to the bottom of the absorber. The flashed solvent is preheated against hot stripped solvent and flows to the top of the stripper. Absorbed gases are stripped from the solvent and sent to Section 600, Sulfur Recovery. Lean solvent is cooled first by rich solvent and then by refrigerant. Cold lean solvent is introduced into the top of the absorber. The Selexol unit is designed to produce gas containing about 200 ppm total sulfur as required by TVA's criteria.

Water vapor has a high solubility in Selexol solvent. As a result, the clean gas is dehydrated sufficiently to meet TVA's water vapor specification.

TVA Coal Gasification Demonstration Plant Study

Plant Based on Koppers-Totzek Gasifier

MAJOR STREAM FLOWS

Section 400 - Acid Gas Removal

COS Hydrolysis - Selexol Area

One Module

Stream Number	Description	Flow Rate, Lbs/Hr
32-404	Compressed Raw Gas	706,625
32-407	Clean Gas	662,650
32-403	Process Condensate	114,475
32-408	Acid Gas	42,735

KOPPERS-TOTZEK

FORM NO. 135-904

FOSTER WHEELER ENERGY CORP. PROCESS PLANTS DIVISION | CONTRACT: 54099-5 | SECTION: 400

EQUIPMENT LIST

NAME OF UNIT: ACID GAS REMOVAL

CLIENT: TVA

LOCATION:

REVISION: 1 2 3 4 5 — ORIGINAL — DATE

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.	NO/MODULE	REV.
COMPRESSOR							
32-11	C-401	Stage 1 Raw Gas Compression				1	
32-11	C-402	Stage 2 Raw Gas Compression				1	
32-11	C-403	Stage 3 Raw Gas Compression				1	
32-11	C-404	Flash Gas Compressor				1	
DRUMS							
32-11	D-401	STG 1 Steam Turbine Cond. Drum				1	
32-11	D-402	STG 3 Steam Turbine Cond. Drum				1	
32-11	D-403	Process Condensate Drum				1	
32-11	D-404	Denox Eff. Separator Drum				1	
32-11	D-405	STG 2 Intercooler Sep. Drum				1	
32-11	D-406	STG 2 Aftercooler Sep. Drum				1	
32-11	D-407	Hydrolyzed Gas Sep. Drum				1	
32-11	D-408	Feed/Product Exch. Sep. Drum				1	
32-11	D-409	Flash Drum				1	
32-11	D-410 A/B	Stripper Overhead Sep. Drum				2	

KOPPERS–TOTZEK

FORM NO. 135-904

FOSTER WHEELER ENERGY CORP. PROCESS PLANTS DIVISION | CONTRACT 54099-32 | SECTION: 400

EQUIPMENT LIST

NAME OF UNIT: ACID GAS REMOVAL

CLIENT: TVA

LOCATION:

REVISION	1	2	3	4	5
DATE					

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.	NO/MODULE	REV.
EXCHANGERS							
32-11	E-401	STG. 1 Steam Turbine Condenser				1	
32-11	E-402	Denox Effluent Cooler				1	
32-11	E-403	STG. 2 Compressor Intercooler				1	
32-11	E-404	STG. 2 Compressor Aftercooler				1	
32-11	E-405	STG. 3 Steam Turbine Condenser				1	
32-11	E-406	Hydrolyzed Gas Cooler				1	
32-11	E-407	Feed/Product Exchanger				1	
32-11	E-408	Feed/Product Exch. Sep. Drum				1	
32-11	E-409	Flash Drum				1	
32-11	E-410	Stripper Overhead Condenser				1	
32-11	E-411	Stripper Reboiler				1	
FILTERS							
32-11	F-401 A/B	Lean Solution Filter				2	

KOPPERS-TOTZEK

FORM NO. 135-904

FOSTER WHEELER ENERGY CORP.
PROCESS PLANTS DIVISION

CONTRACT 54099-32
SECTION: 400

EQUIPMENT LIST

NAME OF UNIT: ACID GAS REMOVAL

CLIENT: TVA

LOCATION:

REVISION	ORIGINAL	1	2	3	4	5
DATE						

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.	NO/MODULE	REV.
PUMPS							
32-15	P-401 A/B	Fly Ash Slurry Pump				10	
32-11	P-402 A/B	STG 1 Steam Turbine Cond. Pump				2	
32-11	P-403	STG 3 Steam Turbine Cond. Pump				1	
32-11	P-404 A/B	Process Condensate Pump				2	
32-11	P-405 A/B	Process Condensate Pump				2	
32-11	P-406 A/B	Rich Solution Pump				2	
32-11	P-407 A/B	Lean Solution Pump				2	
32-11	P-408 A/B	Stripper Reflux Pump				2	
REACTORS							
32-12	R-401	Denox Reactor				2	
32-12	R-402	COS Hydrolysis Reactor				2	

KOPPERS-TOTZEK

FORM NO. 135-904

FOSTER WHEELER ENERGY CORP. PROCESS PLANTS DIVISION

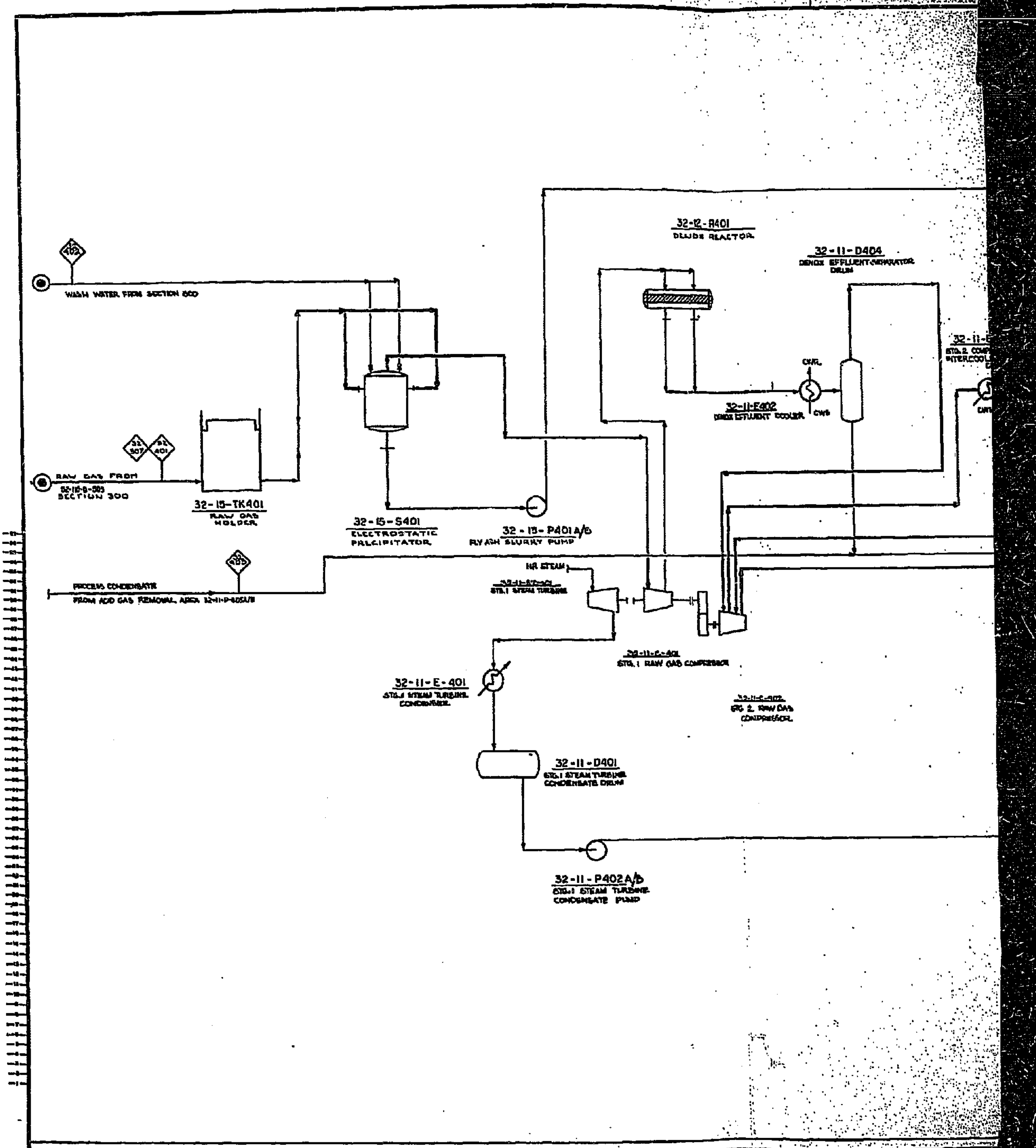
CONTRACT: 54099-32
SECTION: 400

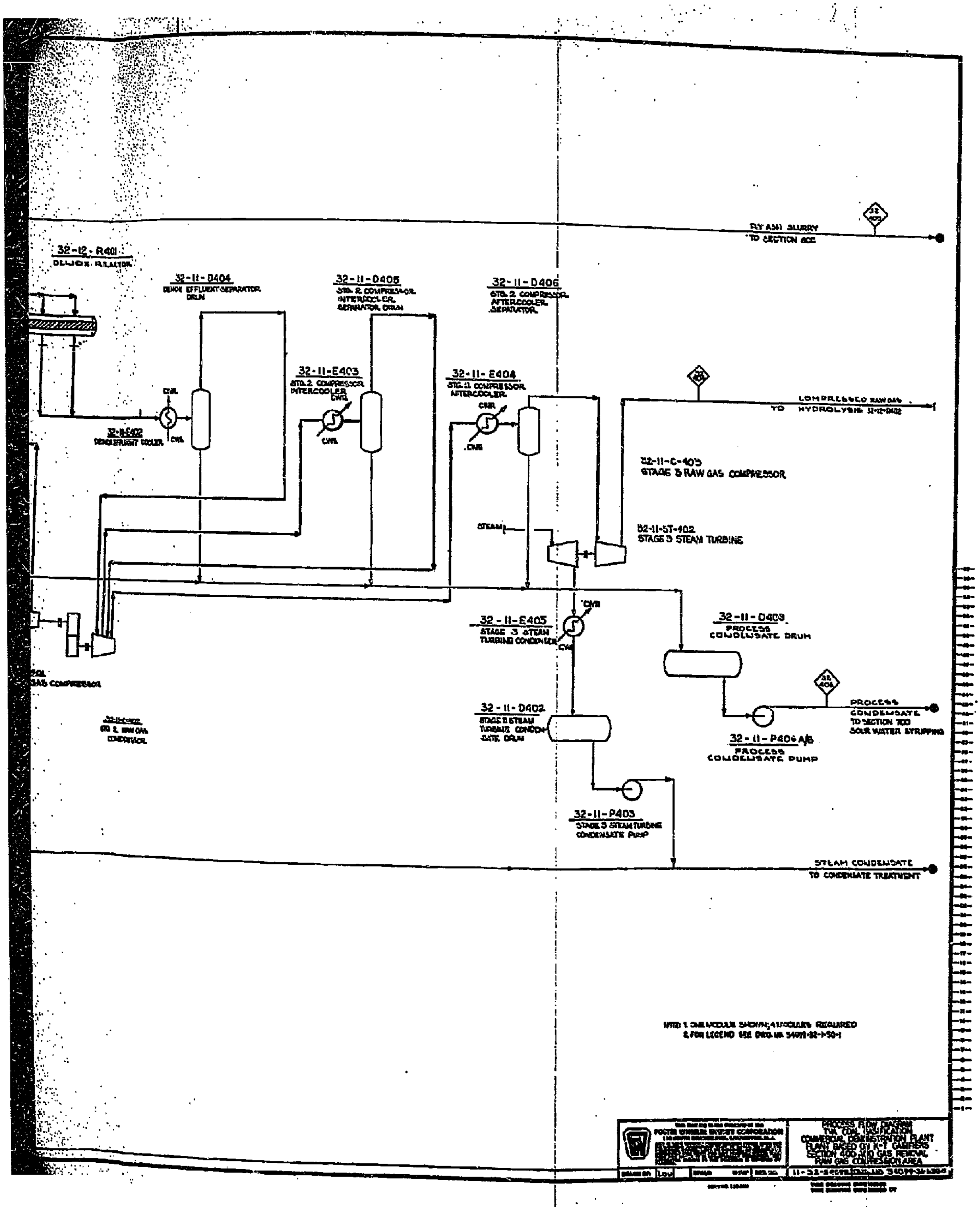
EQUIPMENT LIST

NAME OF UNIT: ACID GAS REMOVAL

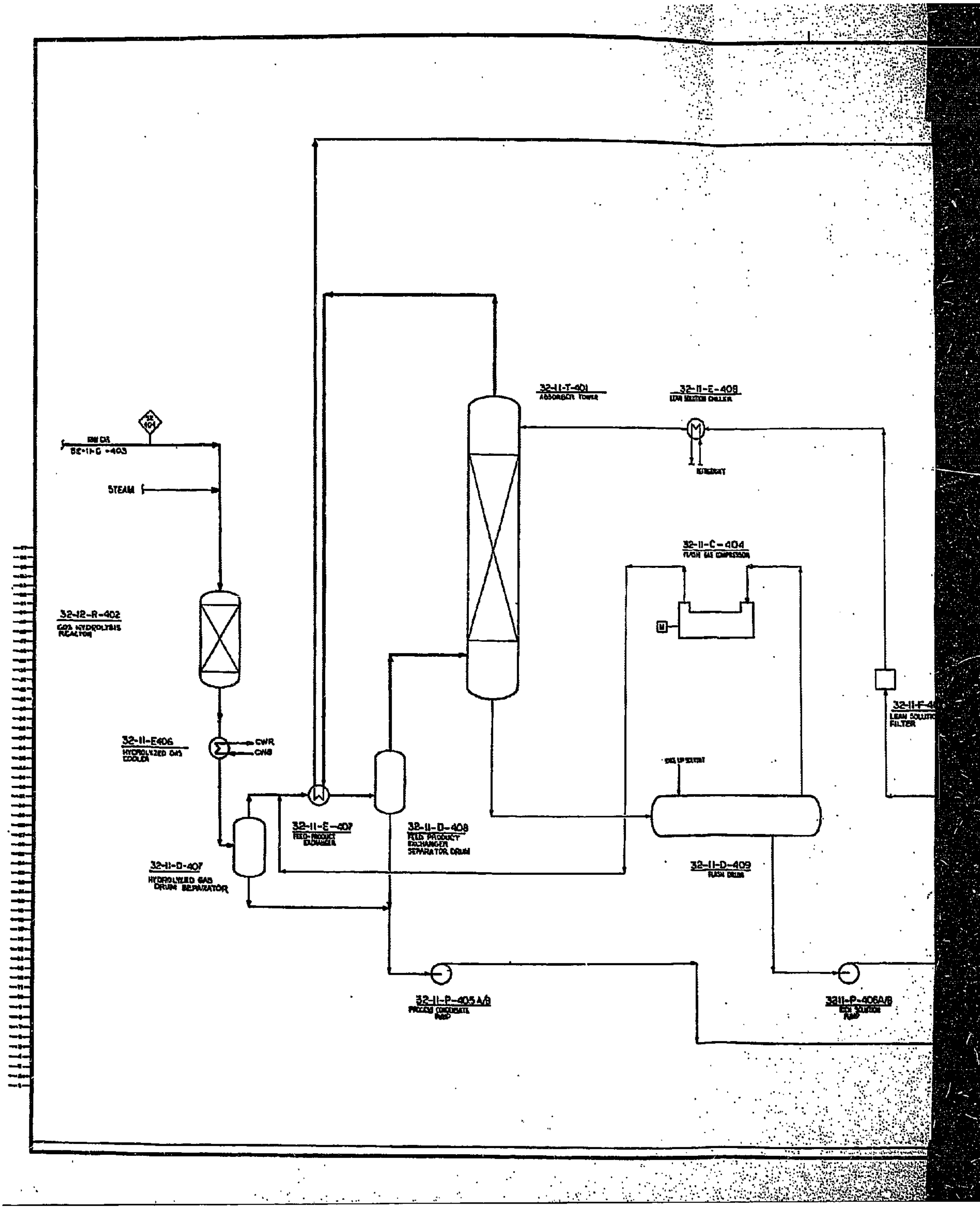
CLIENT: TVA
LOCATION:

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.	NO/MODULE	REV
SEPARATORS							
32-1	S-401	Electrostatic Precipitators					
STEAM TURBINES							
32-11	ST-401	STG. 1 Steam Turbine				1	
32-11	ST-402	STG. 3 Steam Turbine				1	
TOWERS							
32-11	T-401	Absorber Tower				1	
32-11	T-402	Stripper Tower				1	
TANKS							
32-15	TK-401	Raw Gas Holder				5	

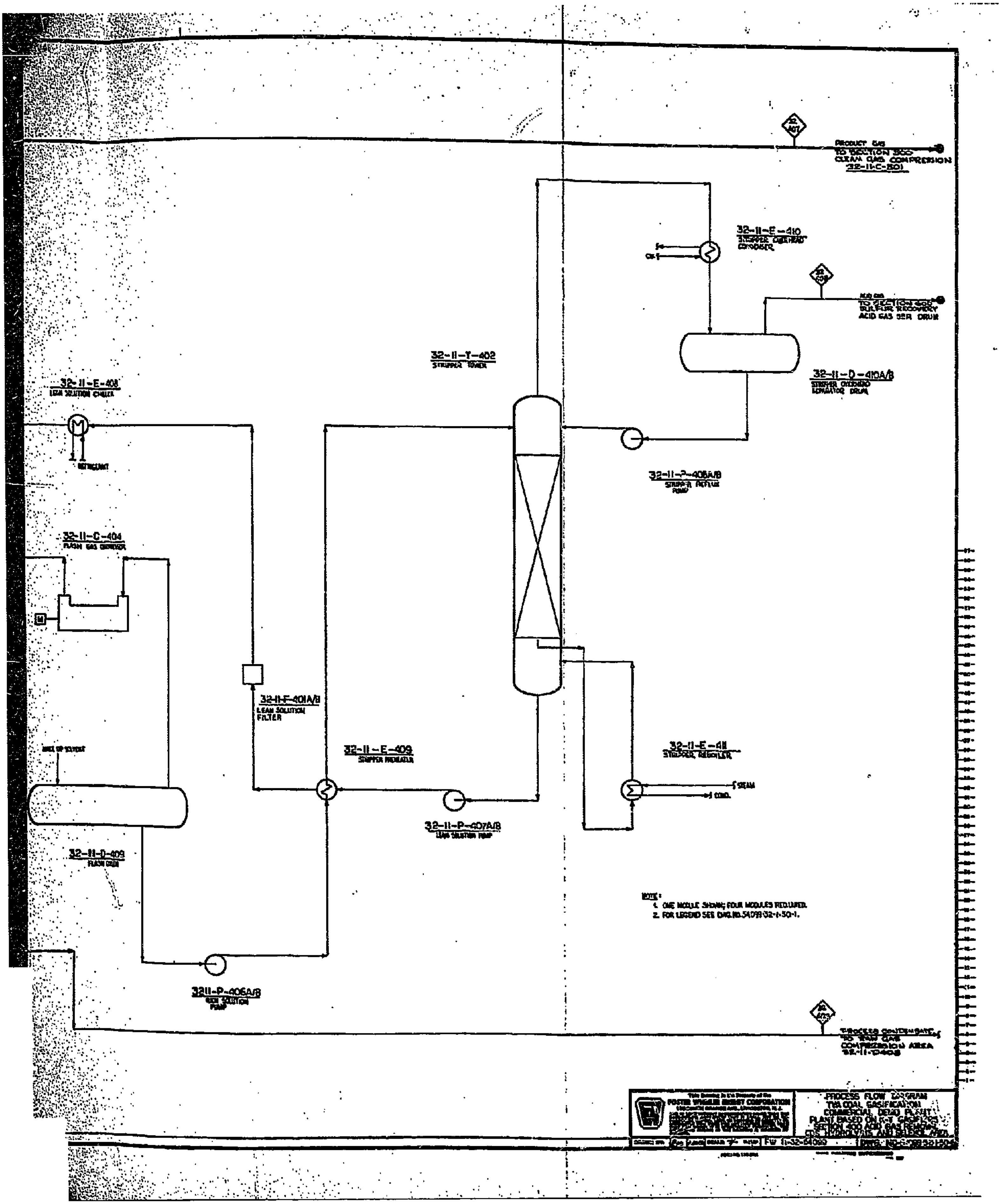

WASH WATER FROM SECTION 800
RAW GAS FROM
SECTION 300
32-15-TK401
RAW GAS HOLDER
32-15-S401
ELECTROSTATIC PRECIPITATOR
32-15-P401 A/B
FLY ASH SLURRY PUMP
PROCESS CONDENSATE
FROM ACID GAS REMOVAL
32-12-R401
32-11-D404
DENOX EFFLUENT SEPARATOR DRUM
CWR
CWS
32-11-E402
DENOX EFFLUENT COOLER
HP STEAM
STG. 1 STEAM TURBINE
STG. 1 RAW GAS COMPRESSOR
STG. 2 RAW GAS COMPRESSOR
32-11-E-401
STG. 1 STEAM TURBINE CONDENSER
32-11-D401
STG. 1 STEAM TURBINE CONDENSATE DRUM
32-11-P402 A/B
STG. 1 STEAM TURBINE CONDENSATE PUMP



32-12-R401
FLY ASH SLURRY TO SECTION 800
32-11-D404
32-11-D405
32-11-D406
STG. 2 COMPRESSOR AFTERCOOLER SEPARATOR
32-11-E403
STG. 2 COMPRESSOR INTERCOOLER
32-11-E404
STG. 2 COMPRESSOR AFTERCOOLER
CWR
CWS
TO HYDROLYSIS
32-11-C-405
STAGE 3 RAW GAS COMPRESSOR
STEAM
32-11-ST-402
STAGE 3 STEAM TURBINE
32-11-E405
STAGE 3 STEAM TURBINE CONDENSER
32-11-D403
PROCESS CONDENSATE DRUM
32-11-D402
STAGE 3 STEAM TURBINE CONDENSATE DRUM
PROCESS CONDENSATE TO SECTION 700 SOUR WATER STRIPPING
32-11-P404 A/B
PROCESS CONDENSATE PUMP
32-11-P403
STAGE 3 STEAM TURBINE CONDENSATE PUMP
STEAM CONDENSATE TO CONDENSATE TREATMENT
FOSTER WHEELER ENERGY CORPORATION
PROCESS FLOW DIAGRAM
TVA COAL GASIFICATION
COMMERCIAL DEMONSTRATION PLANT
PLANT BASED ON K-T GASIFIERS
SECTION 400 H2S GAS REMOVAL
RAW GAS COMPRESSION AREA


32-11-T-401
ABSORBER TOWER
32-11-E-408
STEAM
32-11-C-404
32-12-R-402
COS HYDROLYSIS REACTOR
32-11-E406
HYDROLYZED GAS COOLER
CWR
CWS
32-11-E-407
FEED-PRODUCT EXCHANGER
32-11-D-408
FEED PRODUCT EXCHANGER SEPARATOR DRUM
32-11-D-407
HYDROLYZED GAS DRUM SEPARATOR
32-11-D-409
FLASH DRUM
32-11-P-405 A/B
3211-P-406A/B

p


PRODUCT GAS TO SECTION 500 CLEAN GAS COMPRESSION 32-11-C-501
32-11-E-410
STRIPPER OVERHEAD CONDENSER
ACID GAS TO SECTION 600 SULFUR RECOVERY ACID GAS SEP. DRUM
32-11-T-402
STRIPPER TOWER
32-11-D-410A/B
STRIPPER OVERHEAD SEPARATOR DRUM
32-11-E-408
LEAN SOLUTION CHILLER
REFRIGERANT
32-11-P-408A/B
STRIPPER REFLUX PUMP
32-11-C-404
FLASH GAS COMPRESSOR
32-11-F-401A/B
LEAN SOLUTION FILTER
32-11-E-409
STRIPPER PREHEATER
32-11-E-411
STRIPPER REBOILER
STEAM
COND.
MAKE UP SOLVENT
32-11-P-407A/B
LEAN SOLUTION PUMP
32-11-D-409
FLASH DRUM
NOTE:
1. ONE MODULE SHOWN; FOUR MODULES REQUIRED.
2. FOR LEGEND SEE DWG.NO.54099 32-1-50-1.
3211-P-406A/B
RICH SOLUTION PUMP
PROCESS CONDENSATE TO RAW GAS COMPRESSION AREA 32-11-D408
FOSTER WHEELER ENERGY CORPORATION
PROCESS FLOW DIAGRAM
TVA COAL GASIFICATION
COMMERCIAL DEMO PLANT
PLANT BASED ON K-T GASIFIERS
SECTION 400 ACID GAS REMOVAL
FW 11-32-54090

SECTION DESCRIPTION

3.5 SECTION 500 - TREATED GAS COMPRESSION

A. Reference Material Dwg. No. 54099-32-1-50-7

- Process Flowsheet
- Major Stream Flows

B. Desription of Flow

A flow diagram for Section 500 of the plant is shown in Drawing 54099-32-50-1-7. Clean gas from Section 400 is compressed from a pressure of about 300 psig to the final pressure of 600 psig. A centrifugal compressor driven by electric motor is used for this service.

p

FOSTER WHEELER ENERGY CORPORATION

TVA Coal Gasification Demonstration Plant Study

Plant Based on Koppers-Totzek Gasifier

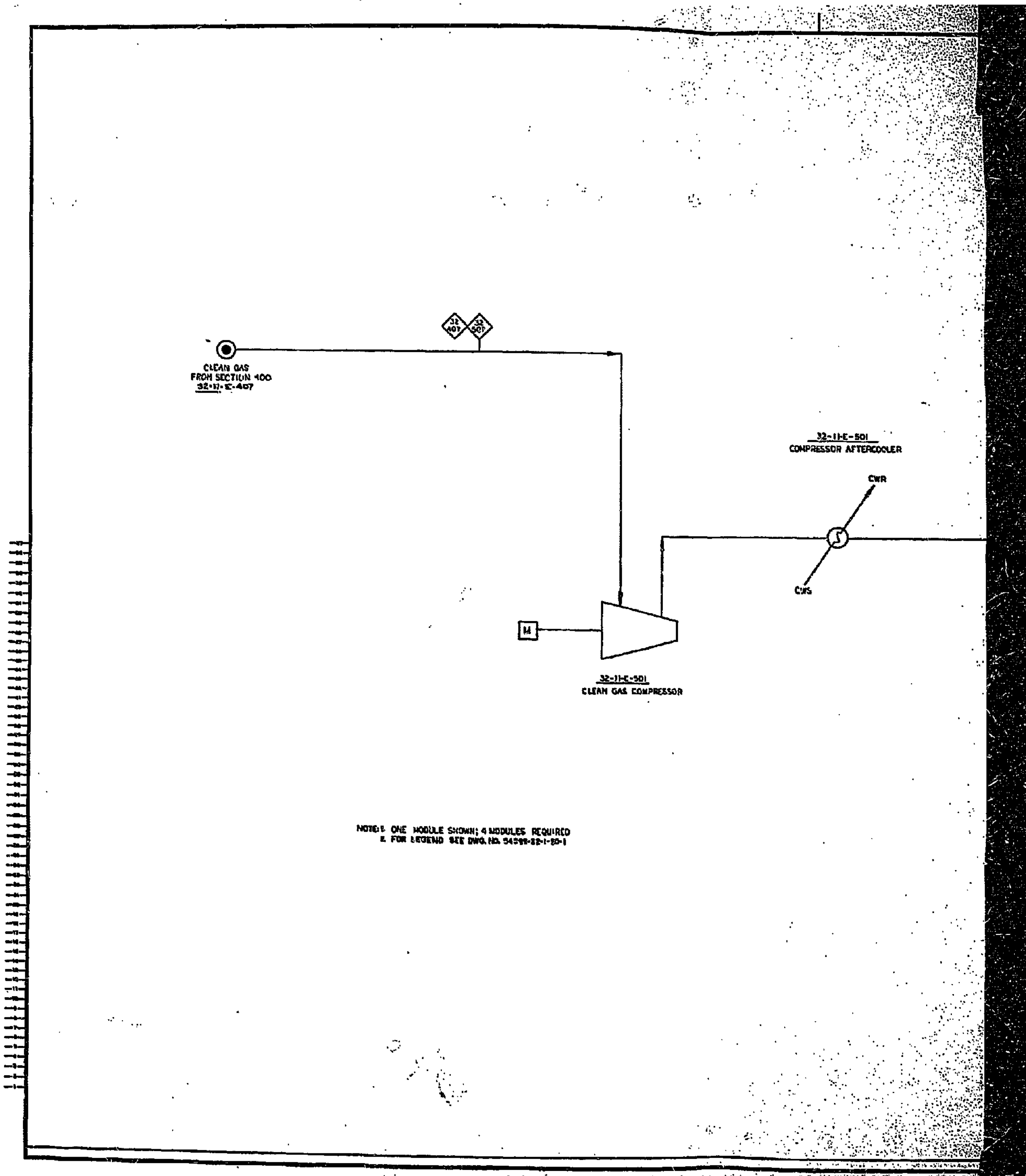
MAJOR STREAM FLOWS

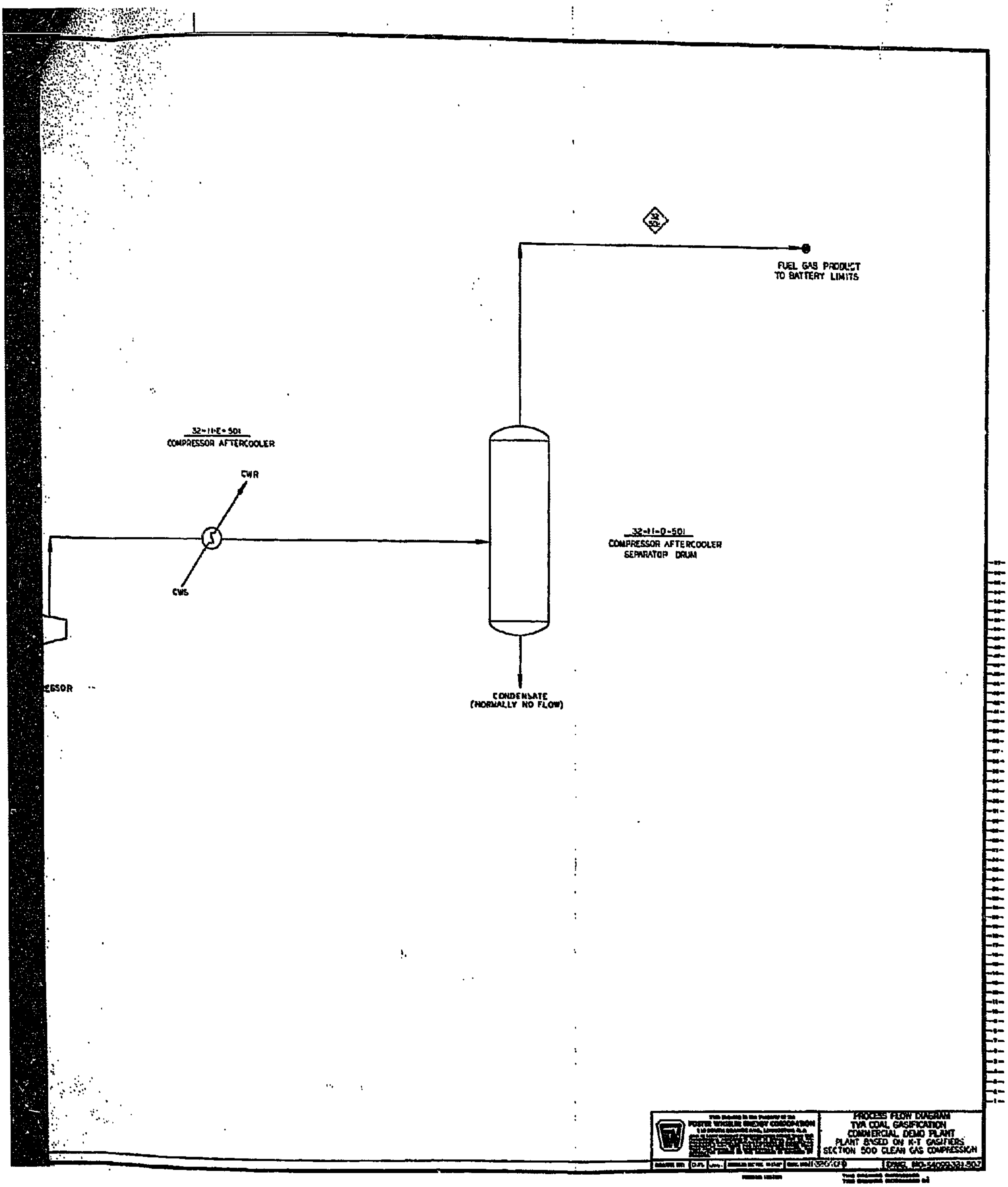
Section 500 - Treated Gas Compression

One Module

Stream Number	Description	Flow Rate Lbs/Hr
32-501	Clean Gas	662,650
32-502	Compressed Clean Gas	662,650

Form No. 130-171


CLEAN GAS
FROM SECTION 400
32-11-E-407
M
32-11-E-501
CLEAN GAS COMPRESSOR
32-11-E-501
COMPRESSOR AFTERCOOLER
CWR
CWS
NOTES: ONE MODULE SHOWN; 4 MODULES REQUIRED
FOR LEGEND SEE DWG. NO.



FUEL GAS PRODUCT
TO BATTERY LIMITS
32-11-E-501
COMPRESSOR AFTERCOOLER
CWR
CWS
32-11-D-501
COMPRESSOR AFTERCOOLER
SEPARATOR DRUM
CONDENSATE
(NORMALLY NO FLOW)
PROCESS FLOW DIAGRAM
TVA COAL GASIFICATION
COMMERCIAL DEMO PLANT
PLANT BASED ON K-T GASIFIERS
SECTION 500 CLEAN GAS COMPRESSION

SECTION DESCRIPTION

3.6 SECTION 600 - SULFUR RECOVERY

A. Reference Material

FWEC Dwg. No. 54099-32-1-50-8
54099-32-1-50-9
54099-32-1-50-10

- Process Flowsheet
- Major Stream Flows

B. Description of Flow

Acid gases from the Selexol unit in Section 400 and from the Sour Water Stripper in Section 700 are processed in the Sulfur Recovery Section. There are three major areas in this section - Claus unit, Beavon Tail Gas Treatment unit, and Chemsource sulfur prilling unit. These units are described below.

Claus Unit

A flow diagram of the Claus sulfur recovery unit is shown in Drawing 54099-32-1-50-8. The unit consists of a combustion furnace followed by three catalytic conversion stages. Acid gases from Sections 400 and 700 are combined and fed to the furnace where a portion of the contained hydrogen sulfide is burned with air to form sulfur dioxide. Hydrogen sulfide and sulfur dioxide react according to the Claus reaction:

$$2\ H_2S + SO_2 \rightleftarrows 3S + H_2O$$

Hot gases from the furnace flow through a waste heat boiler where steam is generated. The gas is then further cooled to a temperature of 300 - 350°F to condense elemental sulfur from the gas.

Acid gas recovered from raw gas produced from K-T coal gasifiers contains a relatively high concentration of hydrogen sulfide - about 45 volume %. Combustion of this acid gas in the Claus unit furnace provides sufficient heat to raise the temperature of the combustion gases to a temperature where the Claus reaction proceeds rapidly. As a result, supplemental fuel for the Claus furnace is not required as is the case for acid gases containing low hydrogen sulfide concentration.

The Claus reaction described above is a reversible reaction and the extent of reaction depends on the temperature and the concentration of reactants and products. Since the reaction to produce elemental sulfur is not completed in the Claus furnace, catalytic stages are provided to provide further conversion. Gas from the initial sulfur condenser is reheated to a temperature of about 500°F and passed through a fixed bed reactor containing Claus catalyst. Effluent from the reactor is cooled and additional elemental sulfur is condensed. The remaining gas is reheated and reacted in the same manner in the second and third catalytic stages.

Residual gas from the third catalytic stage flows to the Beavon Tail Gas unit since the concentration of sulfur compounds in the tail gas is too high to allow discharge of the gas directly to the atmosphere. Elemental sulfur from the condenser is collected in a sump and pumped as a liquid to the Chemsource sulfur prilling unit.

Beavon Tail Gas Unit

A flow diagram of the Beavon unit is shown in Drawing 54099-32-1-50-9. Tail gas from the Claus unit is mixed with a reducing gas (product fuel gas for TVA's coal gasification demonstration plant) and passed through a hydrogenation reactor. Sulfur compounds in the tail gas other than hydrogen sulfide - principally sulfur dioxide, but also carbonyl sulfide and mercaptans - are converted virtually completely to hydrogen sulfide. Effluent from the hydrogenation flow to a Stretford hydrogen sulfide conversion unit.

The gas is scrubbed with an aqueous solution containing sodium carbonate, sodium vanadate, anthraquinone disulfonic acid, and a a small amount of chelated iron compound. Hydrogen sulfide dissolves in the solution and is oxidized by the vanadium compound to elemental sulfur which disperses as solid particles in the solution.

The slurry of spent solution and sulfur particles flows to an oxidizer vessel where air is blown through the solution to reoxidize vanadium compounds. Sulfur particles are removed from the solution by froth flotation and transferred to a filtering and melting system to produce liquid sulfur. The material is sent to the molten sulfur tank in the Claus unit area.

Tail gas from the Stretford absorber is released to the atmosphere. This gas contains less than 10 ppm hydrogen sulfide and less than 200 ppm total sulfur compounds.

Form No. 130-171

Chemsource Sulfur Prilling Unit

A flow diagram of the Chemsource Sulfur Prilling unit is shown in Diagram 54099-32-1-50-10. Molten sulfur is pumped from the Claus plant sulfur storage tank to the sulfur storage pit in the prilling area. The sulfur is filtered to remove any solid impurities and then fed to the top of the prilling tower where it is distributed over a plate containing a number of nozzles.

Sulfur flows through the nozzles and falls through an air space where surface tension causes the streams of sulfur to form spheres. The spheres of molten sulfur fall into a pool of water where they are solidified and cooled. The slurry of sulfur prills and water flows from the bottom of the tower to a dewatering screen located below the tower. The screen separates the bulk of the water from the prills. Prills containing 3 - 4% water flow to a rotary screen where the water content of the solids are reduced to less than 2%.

Water from the dewatering screen and rotary screen flows to a two-compartment hotwell. The first compartment allows sulfur fines to settle out which are pumped back to the screens. The water overflows into a second compartment from which it is pumped to a cooling tower. Temperature of the water is controlled by operation of the cooling tower air fan. Cold water is returned to the prill tower.

Sulfur prills from the rotary screen are transferred to storage. The prills are hard surfaced spherical particles having an average size of about 1/8" diameter. Bulk density of the prills is about 73 lb/ft^3.

TVA Coal Gasification Commercial Demonstration Plant Study

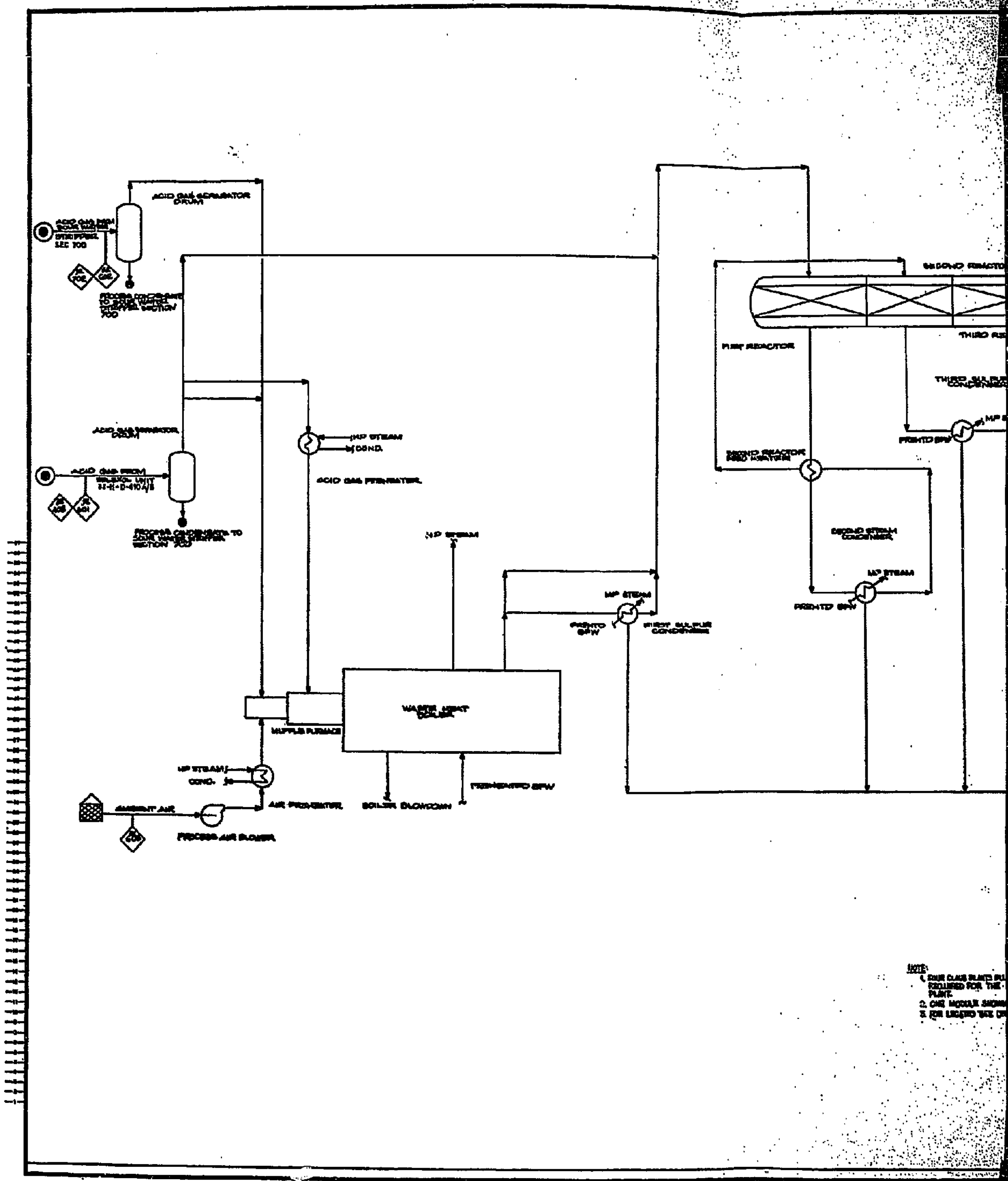
Plant Based on Koppers-Totzek Gasifiers

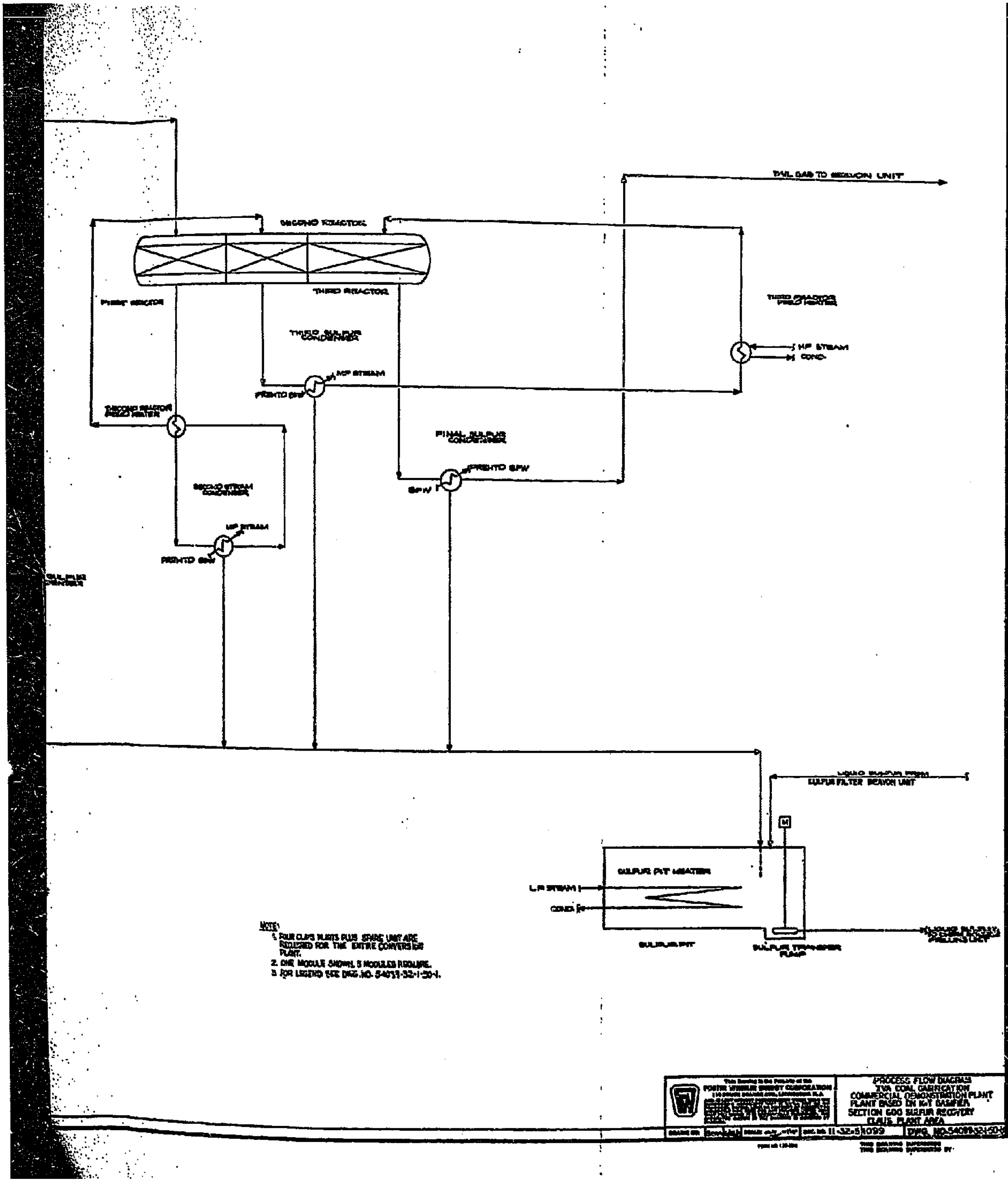
MAJOR STREAM FLOWS

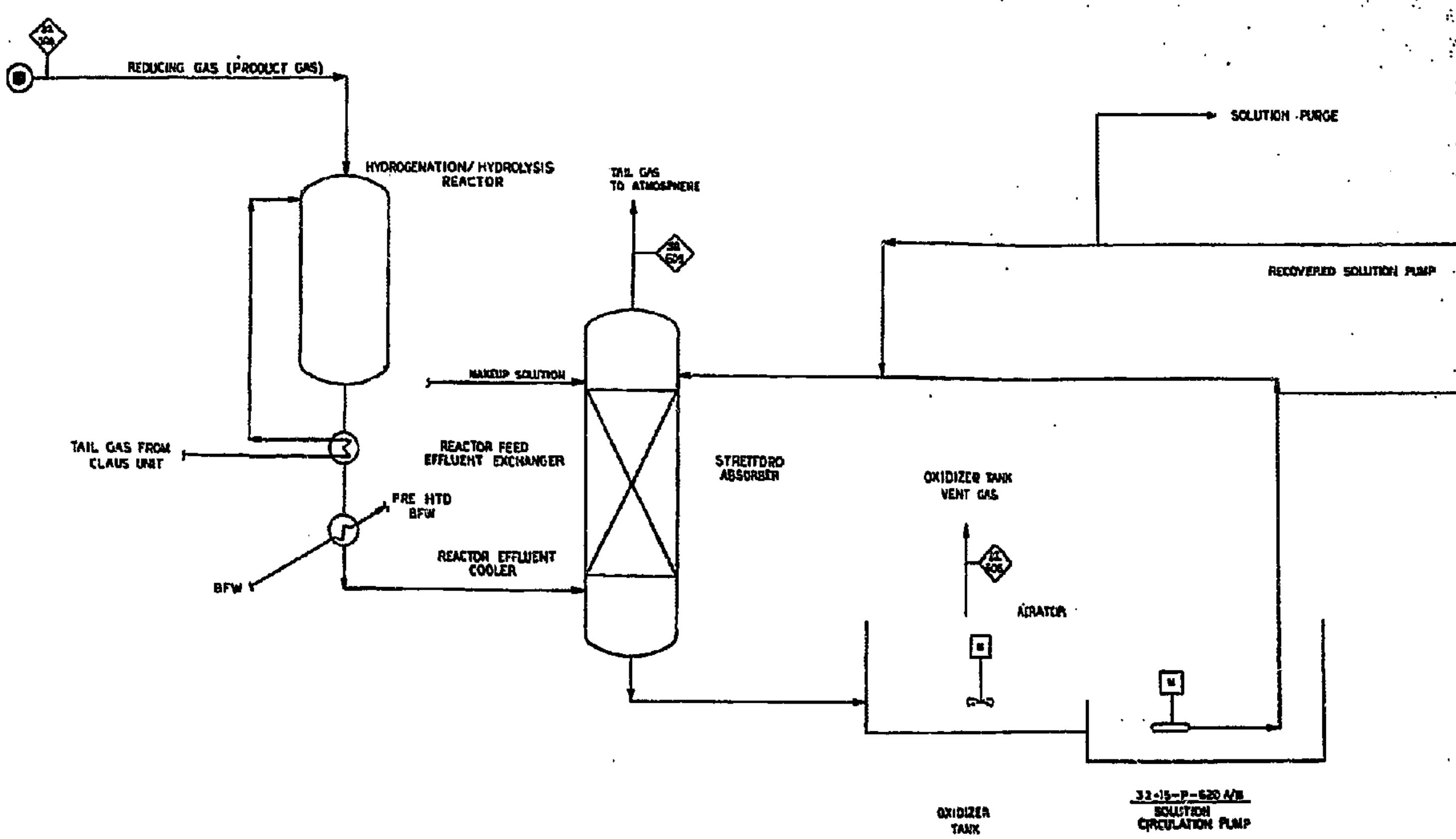
Section 600 - Sulfur Recovery

One Module

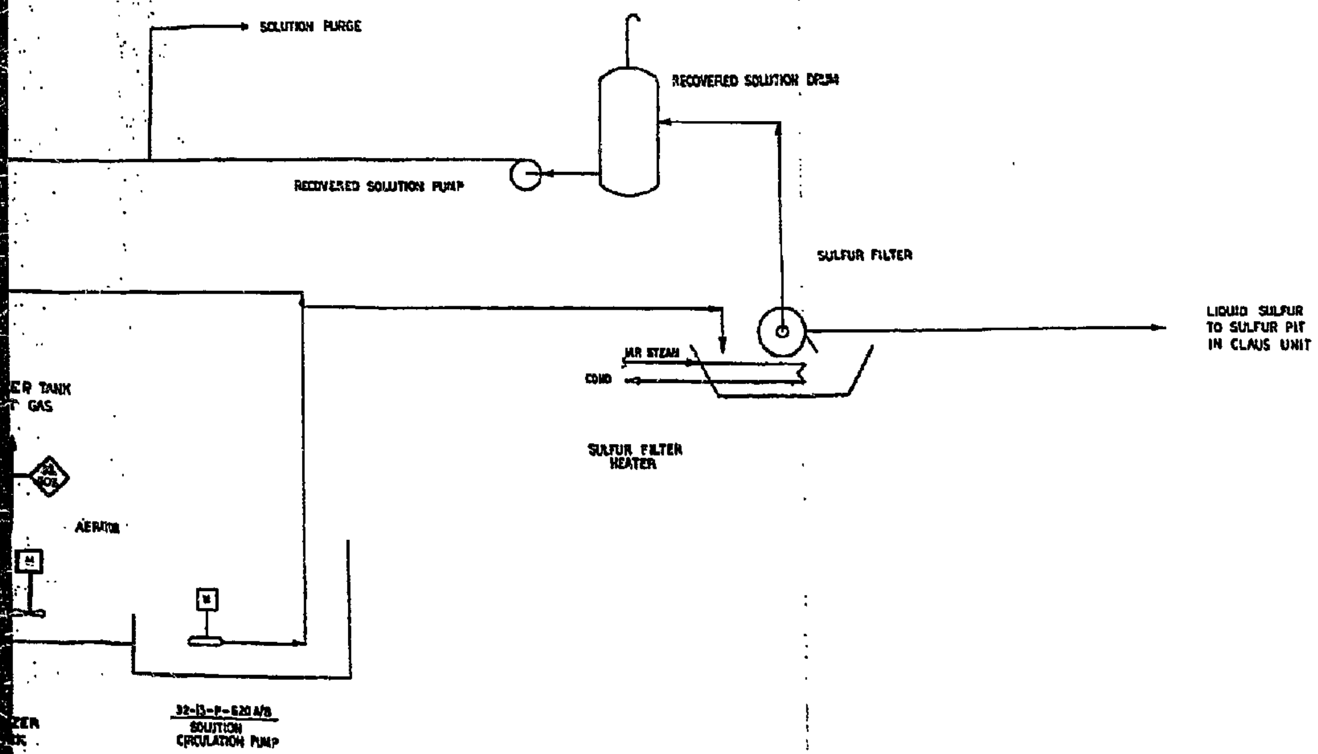
Stream Number	Description	Flow Rate (lbs/hr.)
32-601	Acid Gas from Selexol Unit	42,735
32-602	Acid Gas from SWS	140
32-603	Process Air	36,555
32-604	Reducing Gas	4,150
32-605	Beavon Unit Tail Gas	62,415
32-606	Oxidizer Tank Vent Gas	4,075
32-607	Cooling Tower Vapor	1,250
32-608	Prilled Sulfur Product	16,990


ACID GAS SEPARATOR DRUM
SEC 700
ACID GAS PREHEATER
HP STEAM
COND.
WASTE HEAT BOILER
MUFFLE FURNACE
AIR PREHEATER
BOILER BLOWDOWN
PROCESS AIR BLOWER
AMBIENT AIR
PREHEATED BFW
FIRST SULFUR CONDENSER
FIRST REACTOR
SECOND REACTOR
PREHTD BFW
NOTE:


TAIL GAS TO BEAVON UNIT
SECOND REACTOR
THIRD REACTOR
THIRD SULFUR CONDENSER
MP STEAM
PREHTD BFW
HP STEAM
COND.
FINAL SULFUR CONDENSER
PREHTD BFW
BFW
MP STEAM
PREHTD BFW
SULFUR FILTER BEAVON UNIT
M
SULFUR PIT HEATER
LP STEAM
COND.
SULFUR PIT
SULFUR TRANSFER PUMP
NOTE:
1. FOUR CLAUS PLANTS PLUS SPARE UNIT ARE REQUIRED FOR THE ENTIRE CONVERSION PLANT.
2. ONE MODULE SHOWN, 5 MODULES REQUIRE.
3. FOR LEGEND SEE DWG. NO. 54033-32-1-50-1.
FOSTER WHEELER ENERGY CORPORATION
PROCESS FLOW DIAGRAM
TVA COAL GASIFICATION
COMMERCIAL DEMONSTRATION PLANT
PLANT BASED ON K-T GASIFIER
SECTION 600 SULFUR RECOVERY
CLAUS PLANT AREA
1099


REDUCING GAS (PRODUCT GAS)
HYDROGENATION/ HYDROLYSIS REACTOR
TAIL GAS TO ATMOSPHERE
SOLUTION PURGE
RECOVERED SOLUTION PUMP
MAKEUP SOLUTION
TAIL GAS FROM CLAUS UNIT
REACTOR FEED EFFLUENT EXCHANGER
STRETFORD ABSORBER
OXIDIZER TANK VENT GAS
PRE HTD BFW
REACTOR EFFLUENT COOLER
BFW
AERATOR
OXIDIZER TANK
32-15-P-620 A/B
SOLUTION CIRCULATION PUMP

p



NOTE:
1. ONE MODULE SHOWN; 5 MODULES REQUIRED.
2. FOR LEGEND SEE DWG. NO. 8409-32-150-1.
3. ONLY THE FIRST OF FIVE TRAINS REQUIRED IS SHOWN ABOVE.

FOSTER WHEELER ENERGY CORPORATION

PROCESS FLOW DIAGRAM
TVA COAL GASIFICATION
COMMERCIAL DEMONSTRATION PLANT
PLANT BASED ON K-T GASIFIERS
SEC. 600 SULFUR RECOVERY

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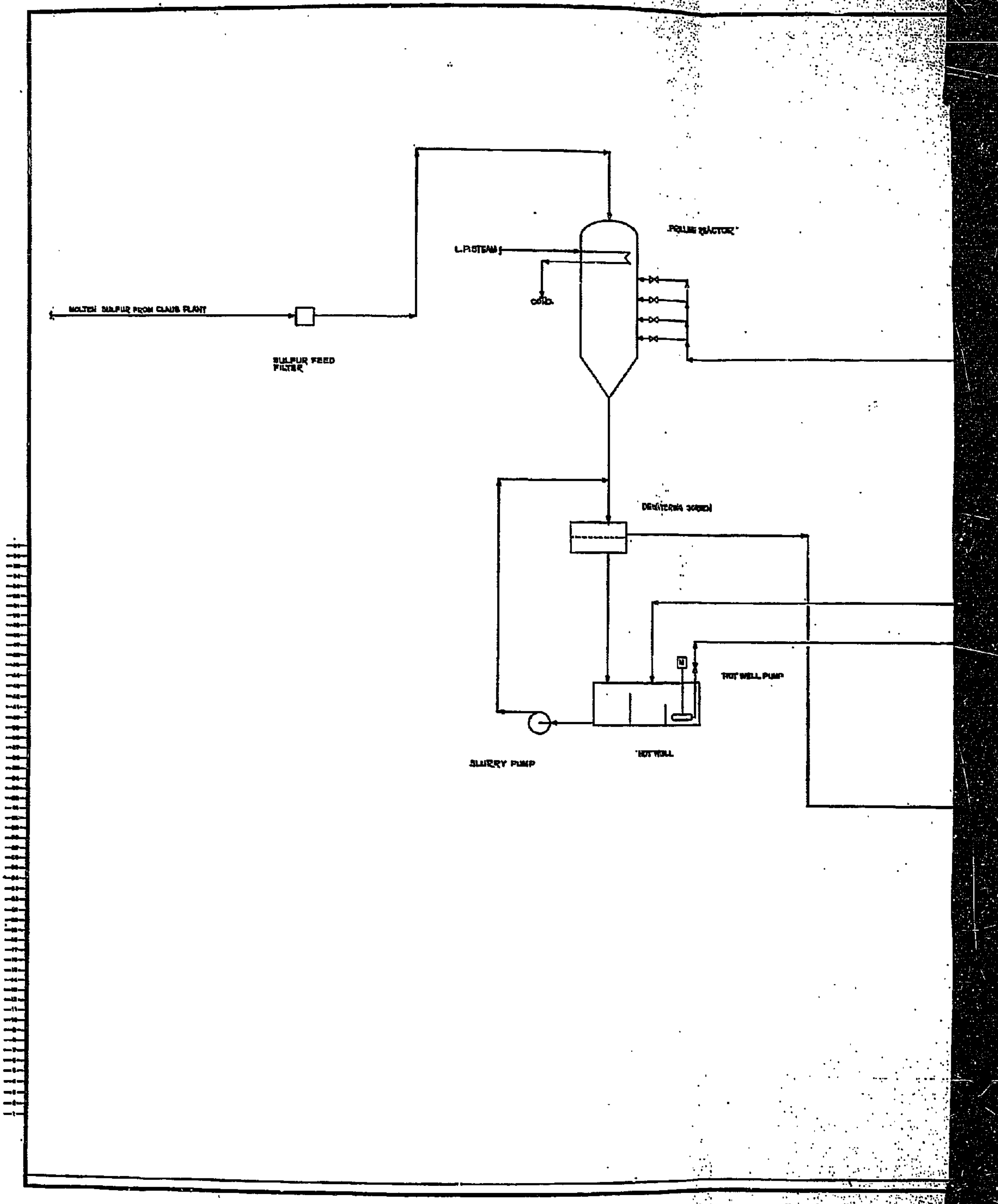
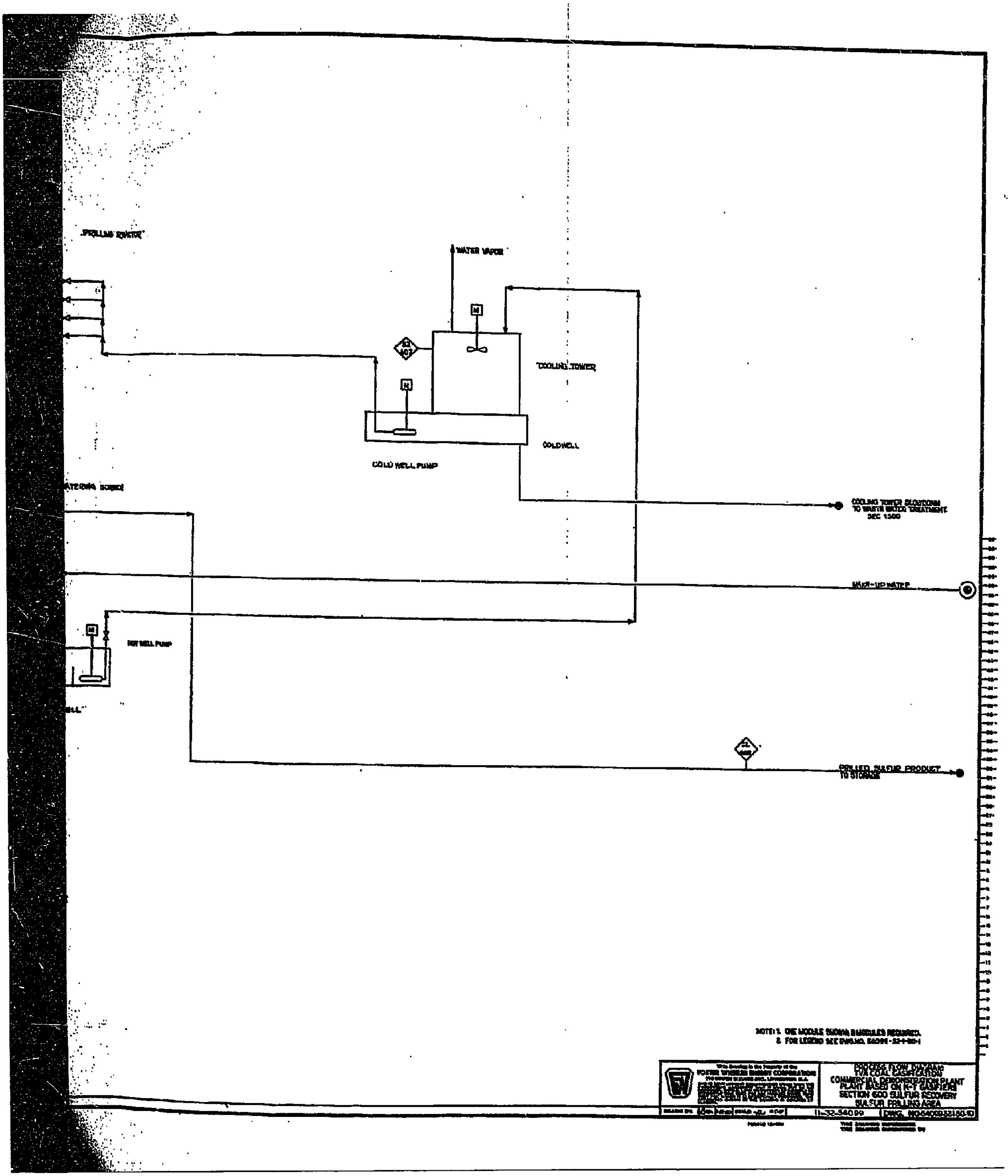

L.P. STEAM
COND.
MOLTEN SULFUR FROM CLAUS PLANT
SULFUR FEED FILTER
HOT WELL PUMP
SLURRY PUMP
HOT WELL


WATER VAPOR
COOLING TOWER
COLDWELL
COLD WELL PUMP
HOT WELL PUMP
COOLING TOWER BLOWDOWN TO WASTE WATER TREATMENT SEC 1500
MAKE-UP WATER
PRILLED SULFUR PRODUCT TO STORAGE
PROCESS FLOW DIAGRAM
TVA COAL GASIFICATION
COMMERCIAL DEMONSTRATION PLANT
PLANT BASED ON K-T GASIFIERS
SECTION 600 SULFUR RECOVERY
SULFUR PRILLING AREA
FOSTER WHEELER ENERGY CORPORATION
11-32-54099

TVA Coal Gasification Study
Koppers-Totzek Gasifier

SECTION DESCRIPTION

3.7 SECTION 700 - SOUR WATER STRIPPING

A. Reference Material FWEC Dwg. No. 54099-32-1-50-11

- Process Flowsheet
- Major Stream Flows

B. Description of Flow

Water condensed from raw gas during raw gas compression in Section 400 contaminated with acid gases such as hydrogen sulfide and carbon dioxide as well as traces of ammonia. The sour water is stripped with steam to remove volatile impurities prior to further treatment and reuse of the water.

A flow diagram of the Sour Water Stripping Section of the plant is shown in Drawing 54099-32-1-50-10. Sour water from Section 400 is preheated by heat exchange with stripping column bottoms and then charged to the top of the stripping column. The water flows downward through the column countercurrent to rising steam generated in the column reboiler. Low pressure (65 psia) steam is supplied to the reboiler at a rate of about 2.5 lb steam/gallon sour water to insure thorough stripping of the water.

Vapors from the top of the stripping column are cooled to condense steam. Acid gases flow to Section 600 - Sulfur Recovery. Condensed water is returned to the stripper column feed stream.

p

TVA Coal Gasification Commercial Demonstration Plant Study

Plant Based on Koppers-Totzek Gasifiers

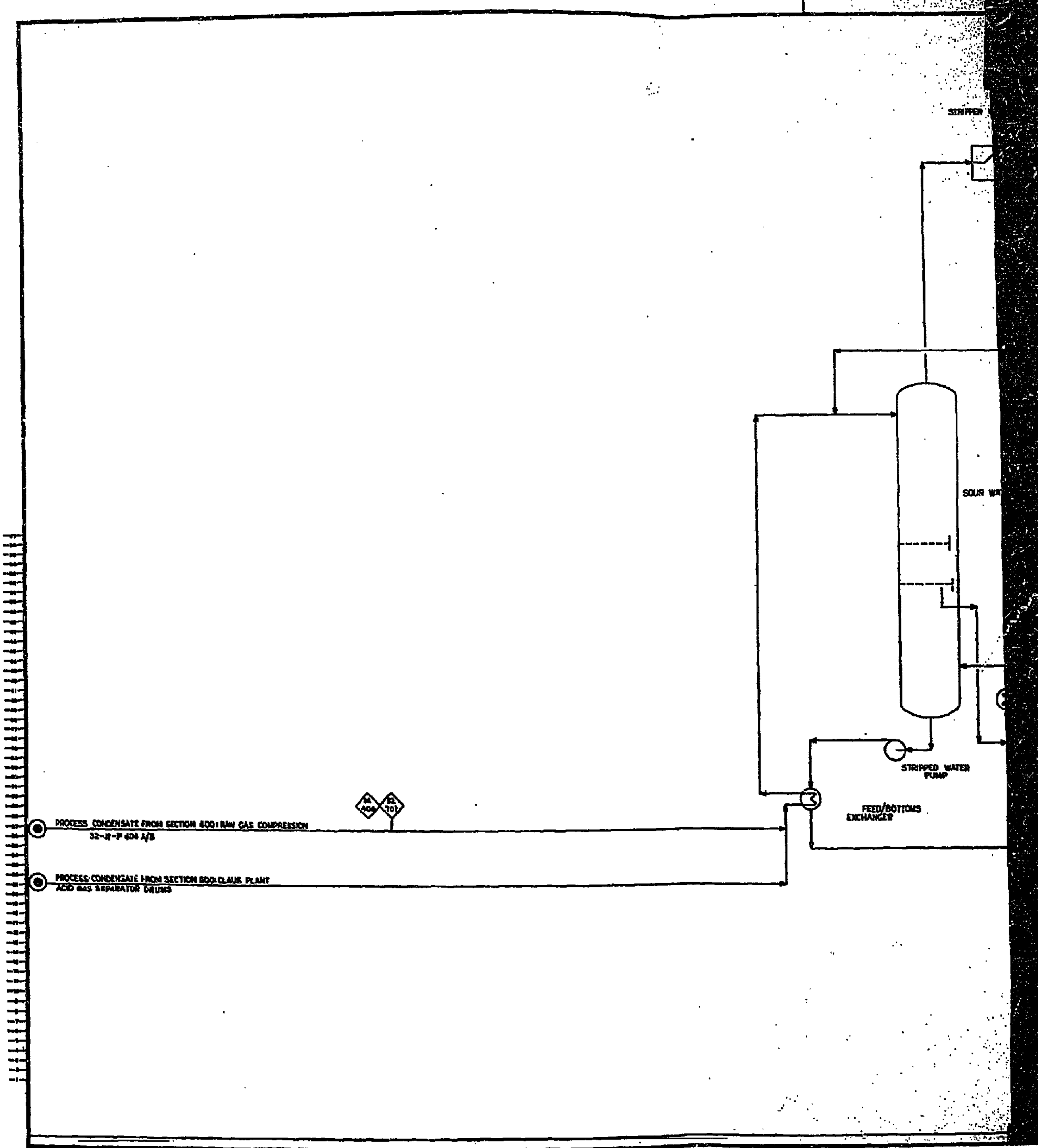
MAJOR STREAM FLOWS

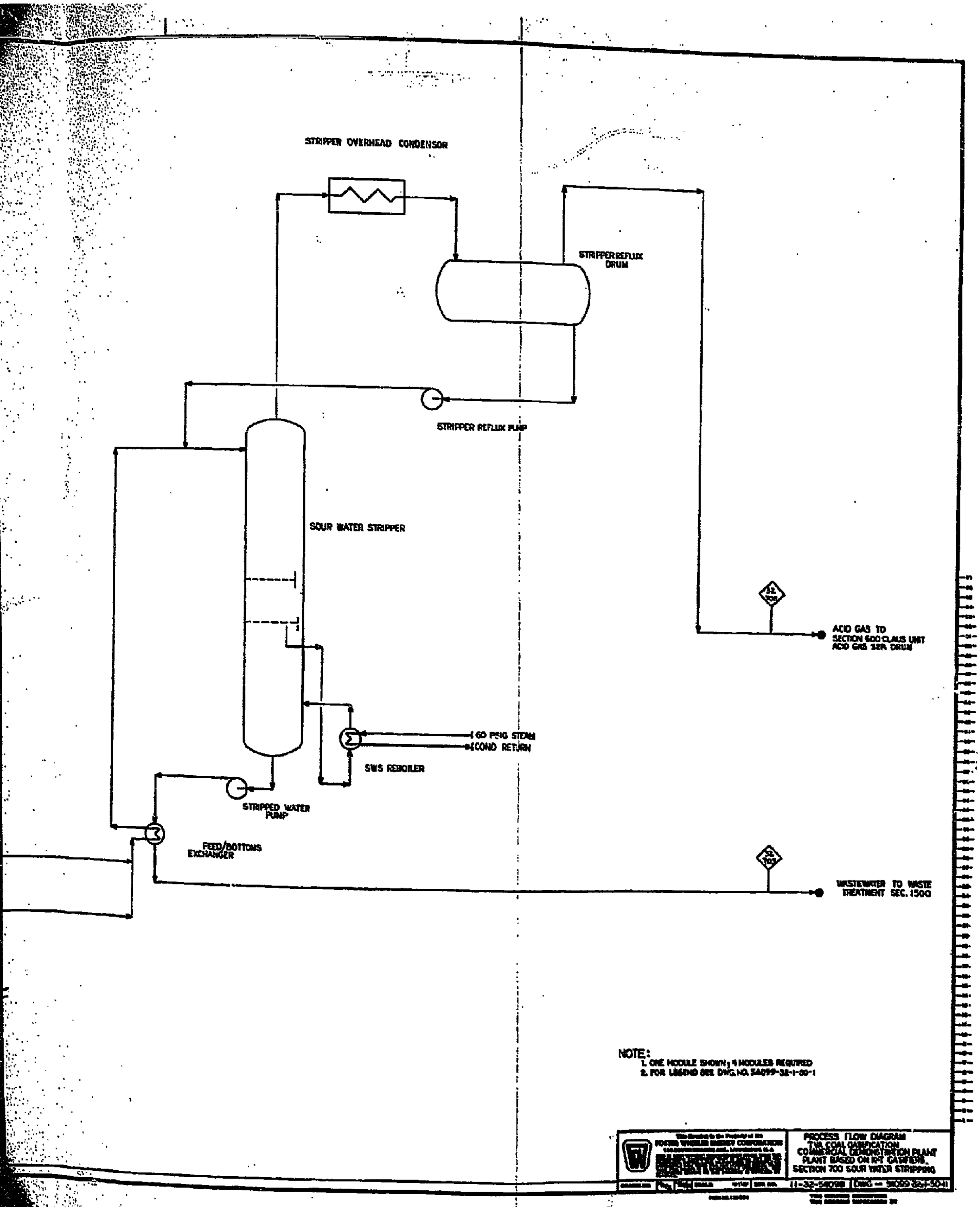
Section 700 - Sour Water Stripping

One Module

Stream Number	Description	Flow Rate (lbs./hr.)
32-701	Process Condensate	114,475
32-702	Acid Gas	140
32-703	Stripped Water	114,335

p


STRIPPER
STRIPPED WATER PUMP
FEED/BOTTOMS EXCHANGER
PROCESS CONDENSATE FROM SECTION 400: RAW GAS COMPRESSION
32-J-P 404 A/B
PROCESS CONDENSATE FROM SECTION 800: CLAUS PLANT
ACID GAS SEPARATOR DRUMS



STRIPPER OVERHEAD CONDENSOR
STRIPPER REFLUX DRUM
STRIPPER REFLUX PUMP
SOUR WATER STRIPPER
60 PSIG STEAM
COND RETURN
SWS REBOILER
STRIPPED WATER PUMP
FEED/BOTTOMS EXCHANGER
ACID GAS TO SECTION 600 CLAUS UNIT ACID GAS SEP. DRUM
WASTEWATER TO WASTE TREATMENT SEC. 1500
NOTE:
1. ONE MODULE SHOWN; 4 MODULES REQUIRED
2. FOR LEGEND SEE DWG. NO. 54099-32-1-50-1
PROCESS FLOW DIAGRAM
TVA COAL GASIFICATION
COMMERCIAL DEMONSTRATION PLANT
PLANT BASED ON K-T GASIFIERS.
SECTION 700 SOUR WATER STRIPPING

FOSTER WHEELER ENERGY CORPORATION

TVA Coal Gasification Study
Koppers - Totzek

SECTION DESCRIPTION

3.8 SECTION 800-SLAG HANDLING

A. Reference Material:

- Process Flowsheet — FWEC Dwg. No. 54099-32-[illegible]-12A, 54099-32-1-50-13
- Equipment List

B. Description of Flow

Slag

Slag discharged from dragchains will be collected by 8 collecting conveyors (32-CR801A-H) which will discharge the material to conveyor 32-CR802 transporting the material to the slag load out area. At the load out area there will be a 56 hour surge pile. Slag will be removed from the surge pile and brought to the slag pile via scrapers.

Spent Bed

Spent Bed from the spent bed coolers in section 1200 are fed into a pneumatic transport line by rotary feeders 32-FD801A-J. The material is then blown up to the filter separator 32-F801 by pneumatic transport blowers 32-B801A/B. The pneumatic transport line will be equipped with silencers before and after the pneumatic transport blowers 32-B801A/B for noise suppression.

The filter separator will remove the forced air from the material and discharge it into the atmosphere. The spent bed will then drop into the spent bed storage silo 32-TK801. The spent bed will be removed from the silo and discharge into the spent bed/flyash load-out conveyor (32-CR803) which will transport the material to a spent bed/flyash surge pile to be later removed by scrapers. Should the spent bed/flyash load-out conveyor fail the material will then be brought to the disposal site via trucks.

Flyash

Flyash from baghouses will be drawn into filter separator 32-F802 by flyash centrifugal blower 32-B802A/B. The air will be discharged to the atmosphere and the flyash will drop into the flyash storage silo 32-TK802. Flyash will be removed from the silo by flyash mixer conditioner 32-M801 which will also blend the flyash with water to create a uniform dust free mixture for clean disposal. The flyash/water mixture will be brought to the disposal site by spent bed/flyash load-out conveyor 32-CR803. Should the spent bed/flyash load-out conveyor fail the material will be brought to the disposal site via trucks.

FOSTER WHEELER ENERGY CORPORATION — SECTION NAME: KOPPERS-TOTZEK SLAG HANDLING — SECTION NO.: 806

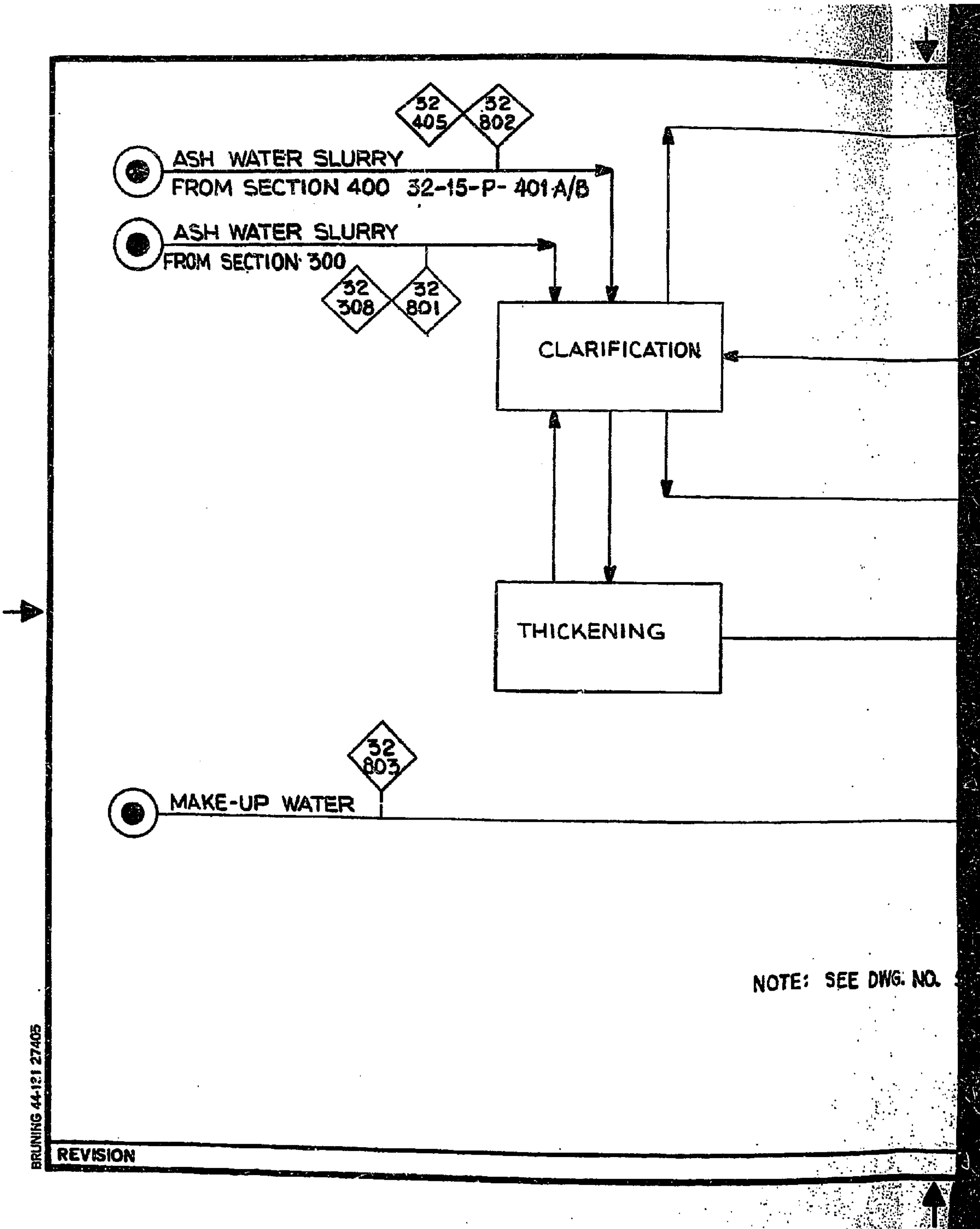
CUSTOMER: TVA — REF. DWG.: 54099-32-1-50-13 — PAGE NO.: 1 OF 1

LOCATION: MURPHY HILL, ALABAMA — CONTRACT NO.: 11-32-54099 REV.: 0 — DATE: 6/30/80

EQUIPMENT SUMMARY

ITEM	DESCRIPTION	DEFINITION	DESIGN * TEMP. (°F)	DESIGN * PRESS. (PSIG)	CONSTRUCTION MATERIAL*
32-B801A/B	Pneumatic Transport Supply Blowers				
32-B802A/B	Flyash Centrifugal Blower				
32-CR801A	Slag Collecting Conveyor	25 TPH			
32-CR801B	Slag Collecting Conveyor	25 TPH			
32-CR801C	Slag Collecting Conveyor	25 TPH			
32-CR801D	Slag Collecting Conveyor	25 TPH			
32-CR801E	Slag Collecting Conveyor	25 TPH			
32-CR801F	Slag Collecting Conveyor	25 TPH			
32-CR801G	Slag Collecting Conveyor	25 TPH			
32-CR801H	Slag Collecting Conveyor	25 TPH			
32-CR802	Slag Load-out Conveyor	200 TPH			
32-CR803	Spent Bed/Flyash Load-out Conveyor	200 TPH			
32-F801	Spent Bed Filter/Separator				
32-F802	Flyash Filter/Separator				
32-FD801A-J	Rotary Feeders	10 TPH			
32-M801	Flyash Mixer/Conditionur	100 TPH			
32-SL801	Silencer				
32-SL802	Silencer				
32-TK801	Spent Bed Storage Silo	410 Tons			
32-TK802	Flyash Storage Silo	820 Tons			

* SHELL/TUBE WHERE APPLICABLE



32
405
32
802
ASH WATER SLURRY
FROM SECTION 400 32-15-P- 401 A/B
ASH WATER SLURRY
FROM SECTION 300
32
308
32
801
CLARIFICATION
THICKENING
32
803
MAKE-UP WATER
NOTE: SEE DWG. NO.
BRUNING 44-121 27405
REVISION

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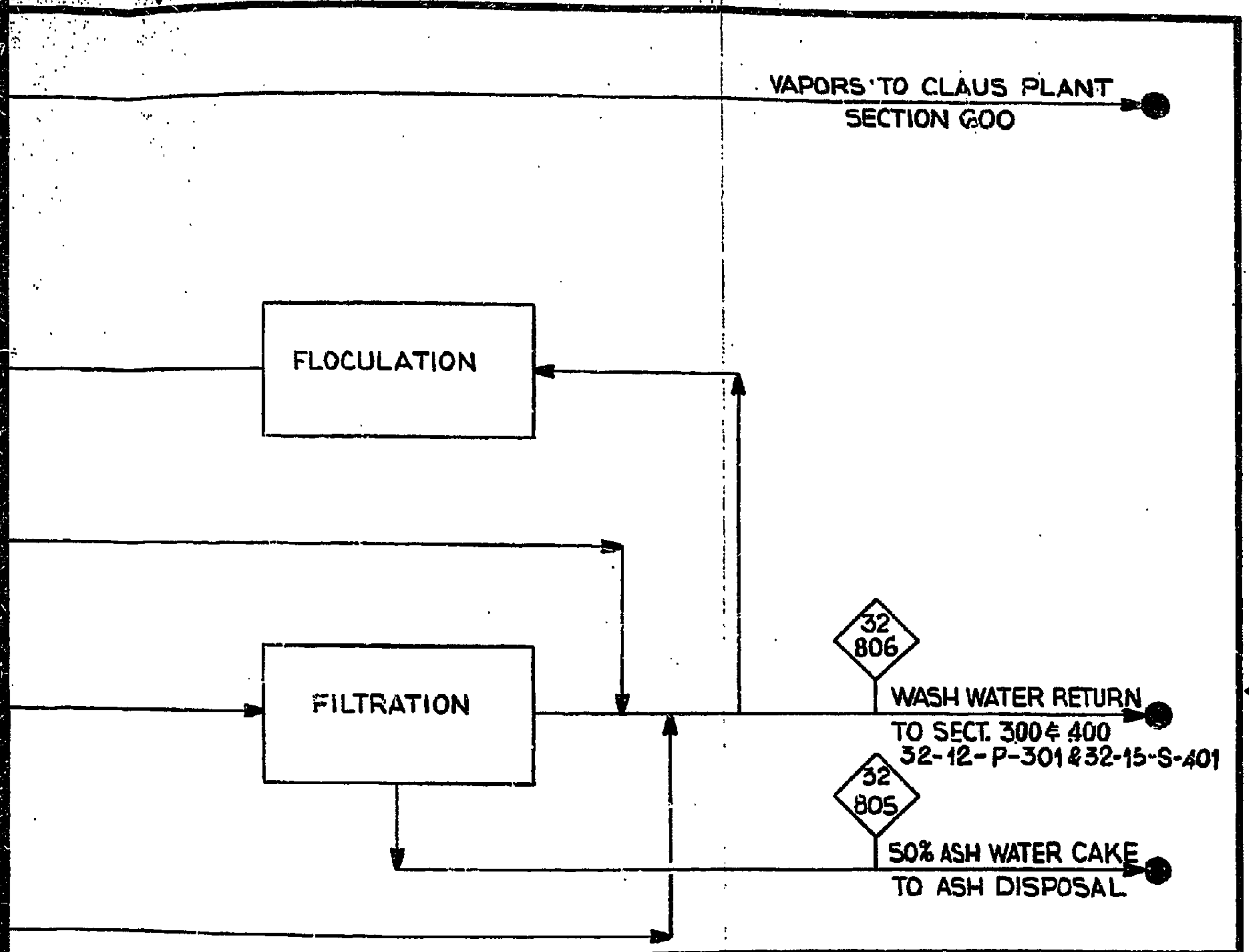


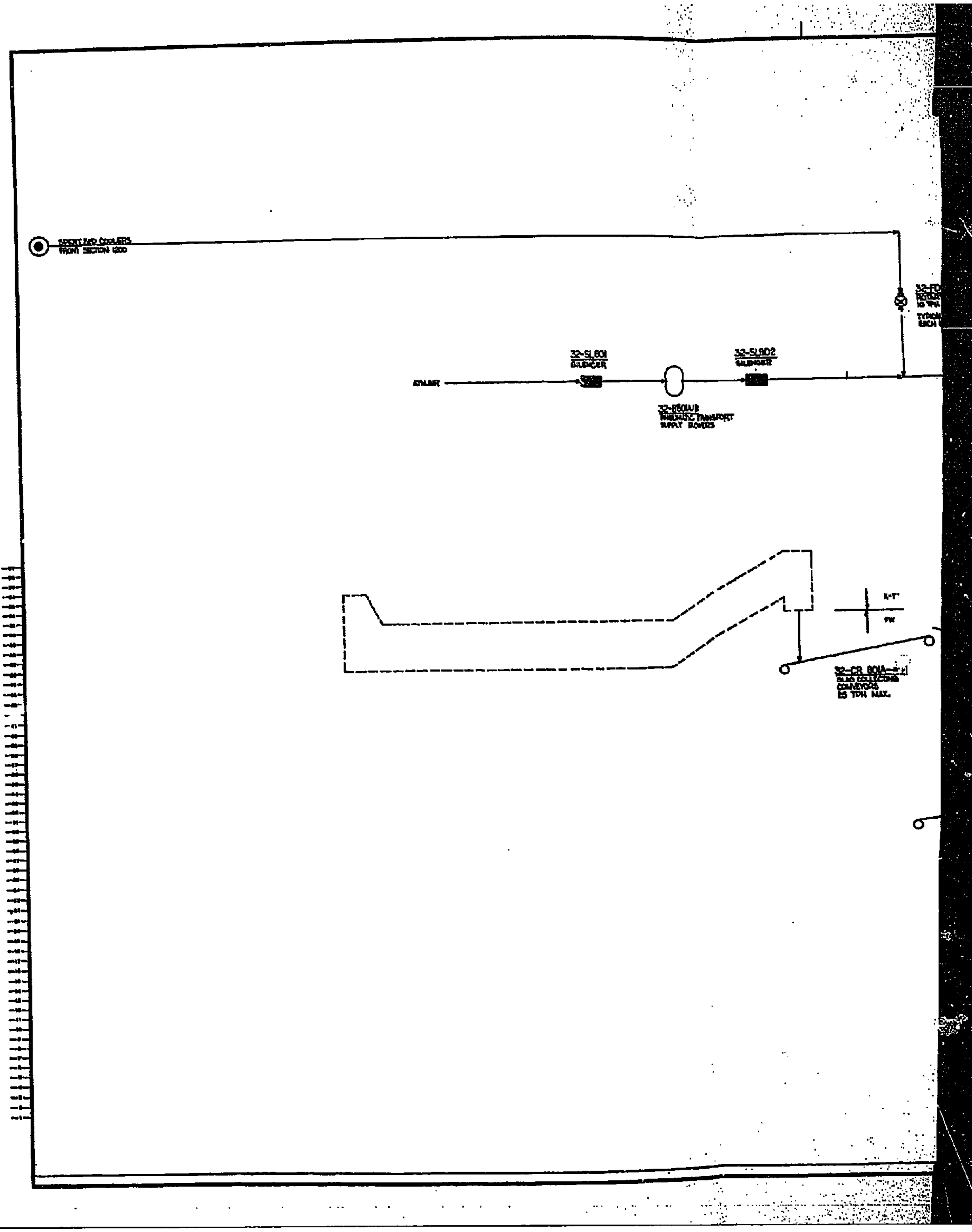
SEE DWG. NO. 54099-32-1-50-1 FOR LEGEND

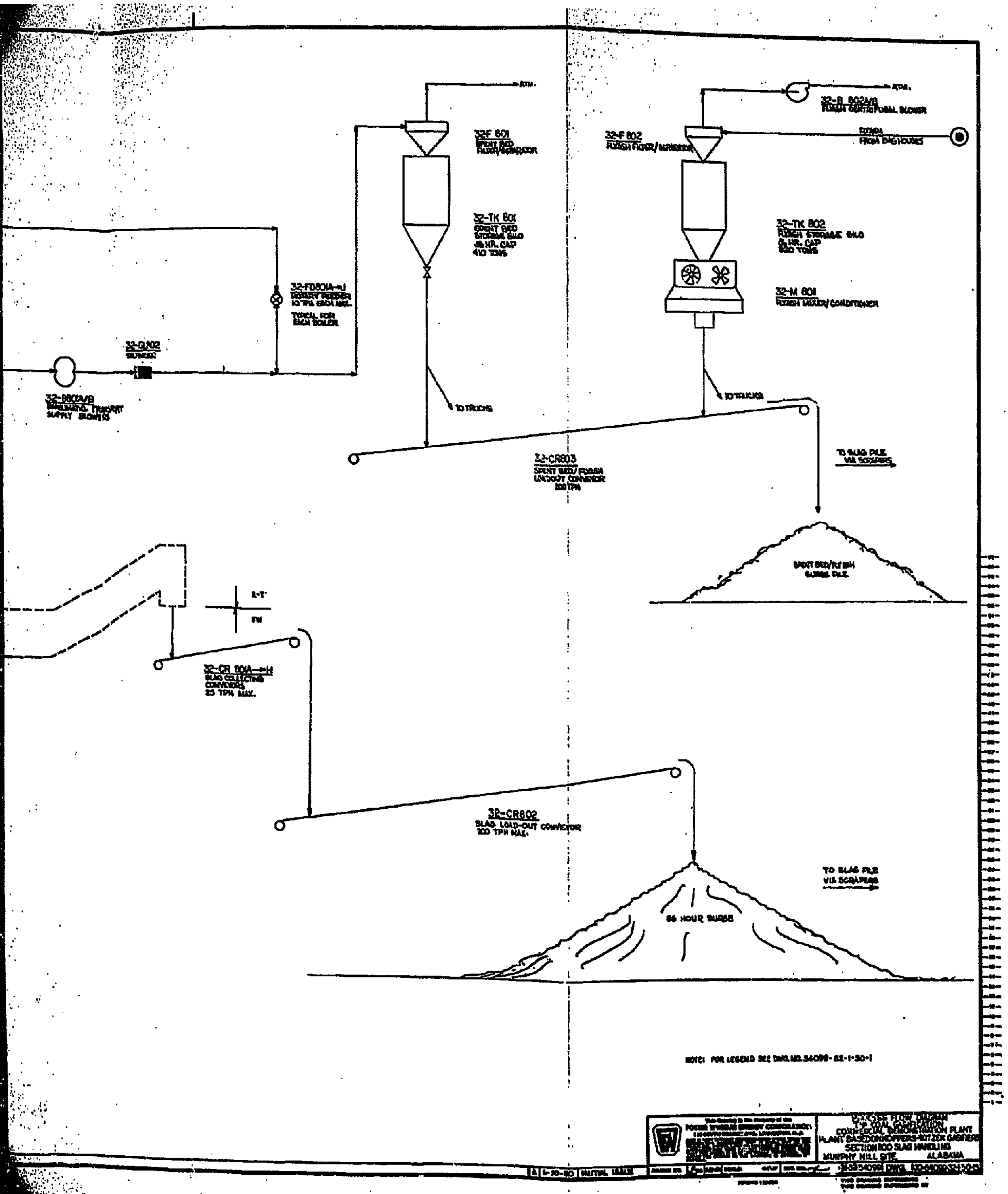
PROCESS FLOW DIAGRAM
TVA COAL GASIFICATION COMMERCIAL DEMO PLANT
PLANT BASED ON K-T GASIFIERS
SECTION 800 ASH / SLAG HANDLING
ASH DEWATERING AREA
MURPHY HILL SITE ALABAMA

DRAWN BY:	GJL	10-20-80	SCALE: =1'-0"
CHECKED BY:			DWG. NO.-54099-32-4-50-12A
APPROVED BY:			

ORDER NO. 11-32-54099

FORM NO. 285-63-M


32-SL801
32-SL802
PNEUMATIC TRANSPORT SUPPLY BLOWERS
25 TPH MAX.



ATM.
32F 801
SPENT BED FILTER/SEPARATOR
32-TK 801
SPENT BED STORAGE SILO
48 HR. CAP
410 TONS
32-FD801A-J
ROTARY FEEDER
10 TPH EACH MAX.
TYPICAL FOR EACH BOILER
32-GL802
SILENCER
32-B801A/B
PNEUMATIC TRANSPORT SUPPLY BLOWERS
TO TRUCKS
32-B 802A/B
FLUSH CENTRIFUGAL BLOWER
32-F 802
FLUSH FILTER/SEPARATOR
FLUSH
FROM BAGHOUSES
32-TK 802
FLUSH STORAGE SILO
48 HR. CAP
820 TONS
32-M 801
FLUSH MIXER/CONDITIONER
TO TRUCKS
32-CR803
SPENT BED/FLUSH LOADOUT CONVEYOR
100 TPH
TO SLAG PILE VIA SCRAPERS
SPENT BED/FLUSH SURGE PILE
32-CR 801A-H
SLAG COLLECTING CONVEYORS
25 TPH MAX.
32-CR802
SLAG LOAD-OUT CONVEYOR
200 TPH MAX.
TO SLAG PILE VIA SCRAPERS
56 HOUR SURGE
NOTE: FOR LEGEND SEE DWG. NO. 54099-82-1-30-1
FOSTER WHEELER ENERGY CORPORATION
PROCESS FLOW DIAGRAM
TVA COAL GASIFICATION
COMMERCIAL DEMONSTRATION PLANT
PLANT BASED ON KOPPERS-TOTZEK GASIFIERS
SECTION 800 SLAG HANDLING
MURPHY HILL SITE ALABAMA
INITIAL ISSUE

SECTION DESCRIPTION

3.9 SECTION 1200 - UTILITY AREA

A. Reference Material

- Process Flowsheet — Figure 32.1, Figure 32.2

B. Description of Flow

The utility area of the coal gasification plant includes raw water treatment and storage, potable water treatment, BFW and condensate treatment, and steam generation. These systems are discussed below.

Raw Water Treatment and Storage

Raw water treatment systems provided for the plant include the following:

raw water and firewater storage - 9.4 million gallons
softener/clarifier (alum, lime, polyelectrolyte)
clarifier chemicals storage and feed system
clarifier sludge dewatering system
sand filters
demineralizer package
potable water package and chlorinator
BFW deaerating heaters plus chemicals injection package
condensate polishing package
filtered water storage
condensate storage
demineralized water storage

A diagram of the sequence of water treatment operations is shown in Figure 32-1.

Steam Generation

K-T coal gasifiers produce a large quantity of high pressure saturated steam in waste heat boilers used to cool the hot gases from the high temperature gasification zone. It is important to utilize this steam efficiently since it represents a significant fraction of the heat energy of the feed coal. The most important application is for driving large compressors in the air separation and raw gas compression sections of the plant.

In order to provide driving power for the compressors, it is necessary to superheat the saturated steam made in the K-T gasifiers.

In addition, vaporization and superheating of some boiler feed water is required to achieve a practical situation where half of the large compressors are steam turbine driven and half are electric motor driven. The quantities involved for the total 4 module plant are as follows:

saturated steam from gasifiers	1,680,000 lb/hr
BFW vaporized and superheated	400,000 lb/hr
superheated steam made in boilers	2,080,000 lb/hr

Foster Wheeler selected fluidized bed boilers for this important service for the following reasons:

1) high efficiency of steam production
2) high heat transfer rate from fluidized bed to steam tubes
3) limestone added to fluidized bed captures sulfur dioxide formed during combustion
4) relatively low operating temperature resulting in reduced NO_x formation
5) less expensive that conventional boilers equipped with wet flue gas scrubbing systems
6) offered commercially by Foster Wheeler in capacities up to 600,000 lb/hr of steam production

Five fluidized bed boilers are provided, each capable of producing 600,000 lb/hr of 920 psig, 920 °F steam. One boiler services each module, the fifth boiler serves as a spare in the event one of the boilers is off-line. A schematic diagram of the fluidized boiler is shown in Figure 32-2.

FIGURE 32-1
RAW WATER TREATMENT DIAGRAM

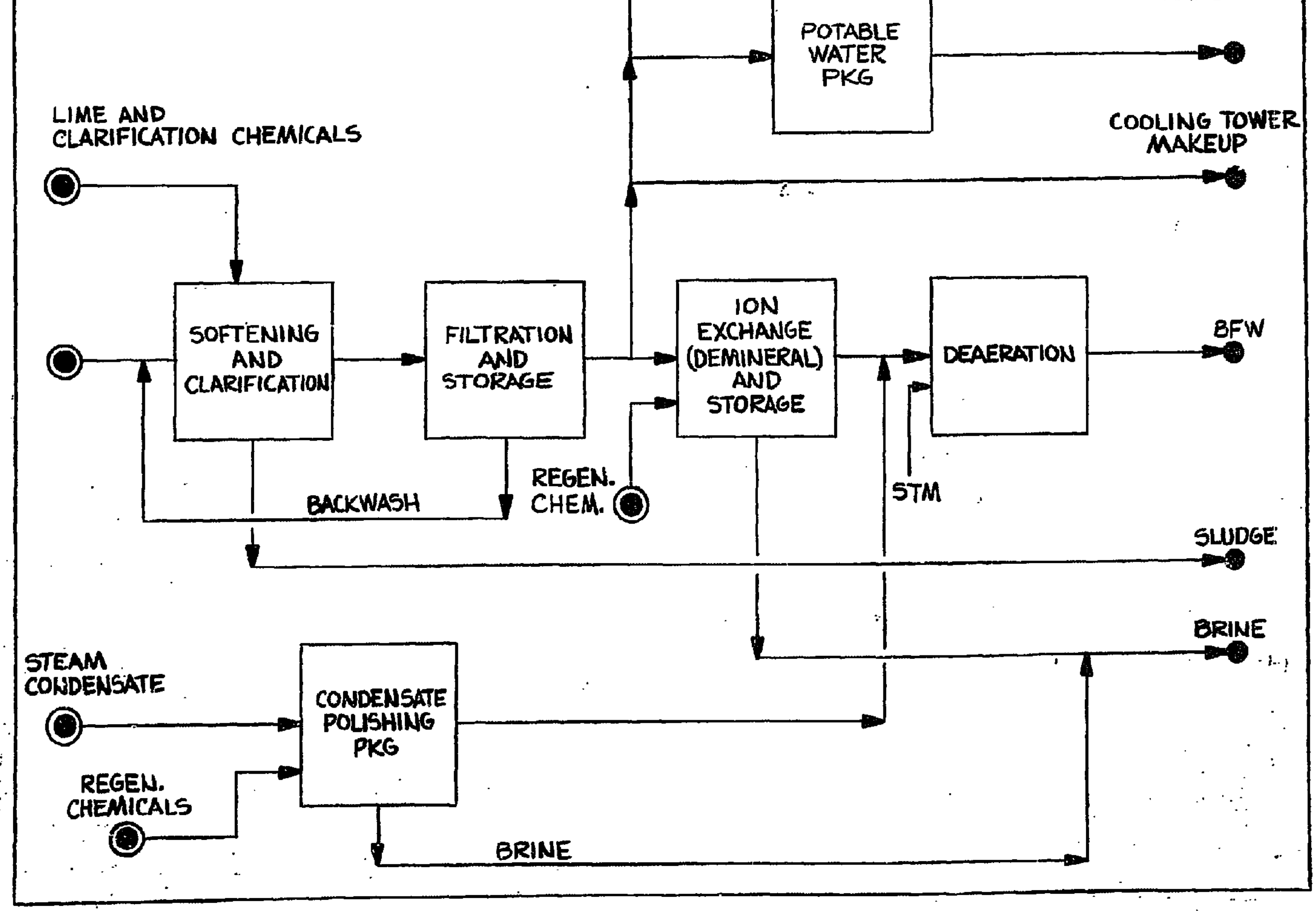
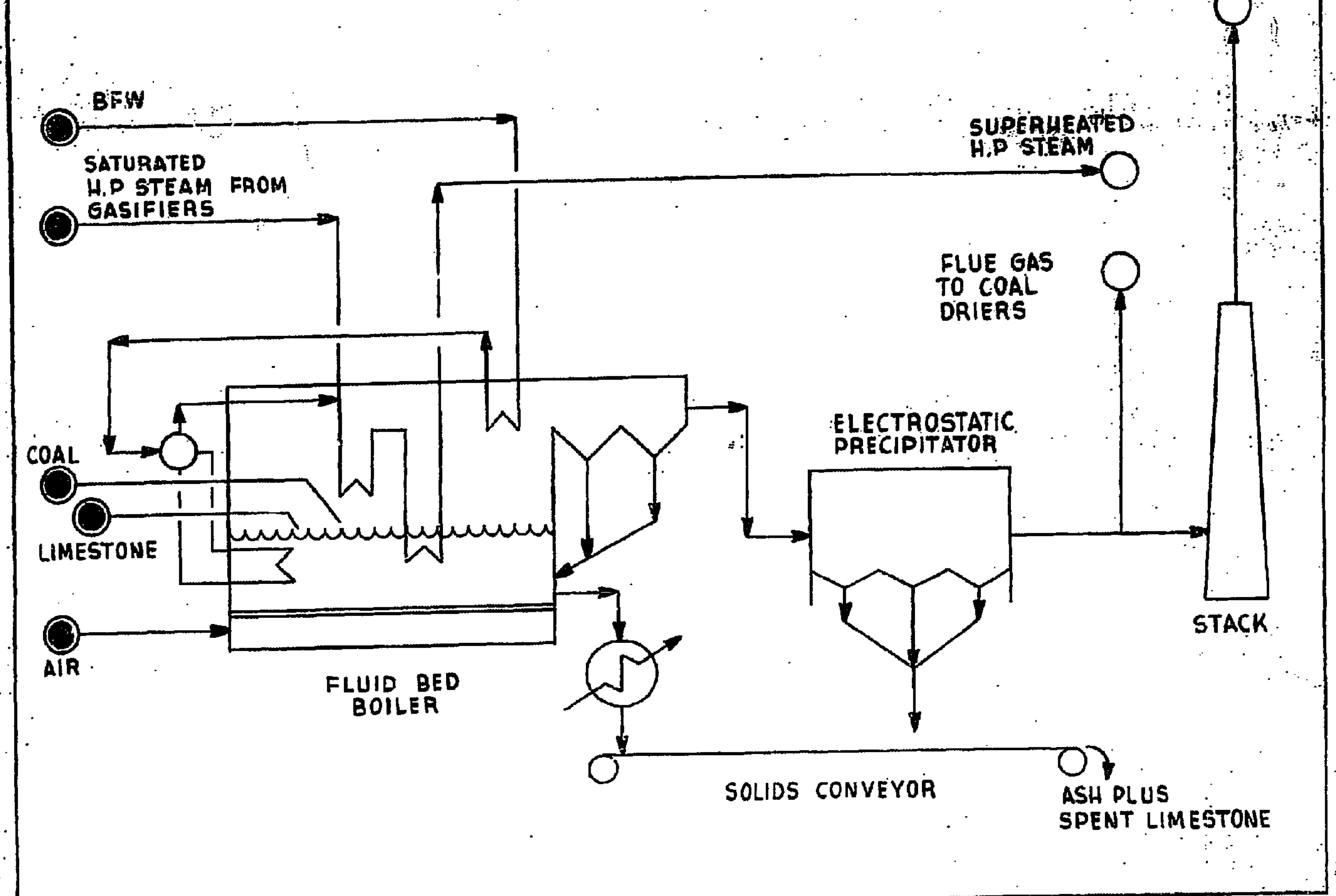


FIGURE 32-2
SCHEMATIC DIAGRAM OF FLUID BED BOILER SYSTEM



SECTION DESCRIPTION

3.10 SECTION 1300 - COOLING WATER SYSTEM

A. Reference Material FWEC Dwg. No. 54099-32-4-50-14

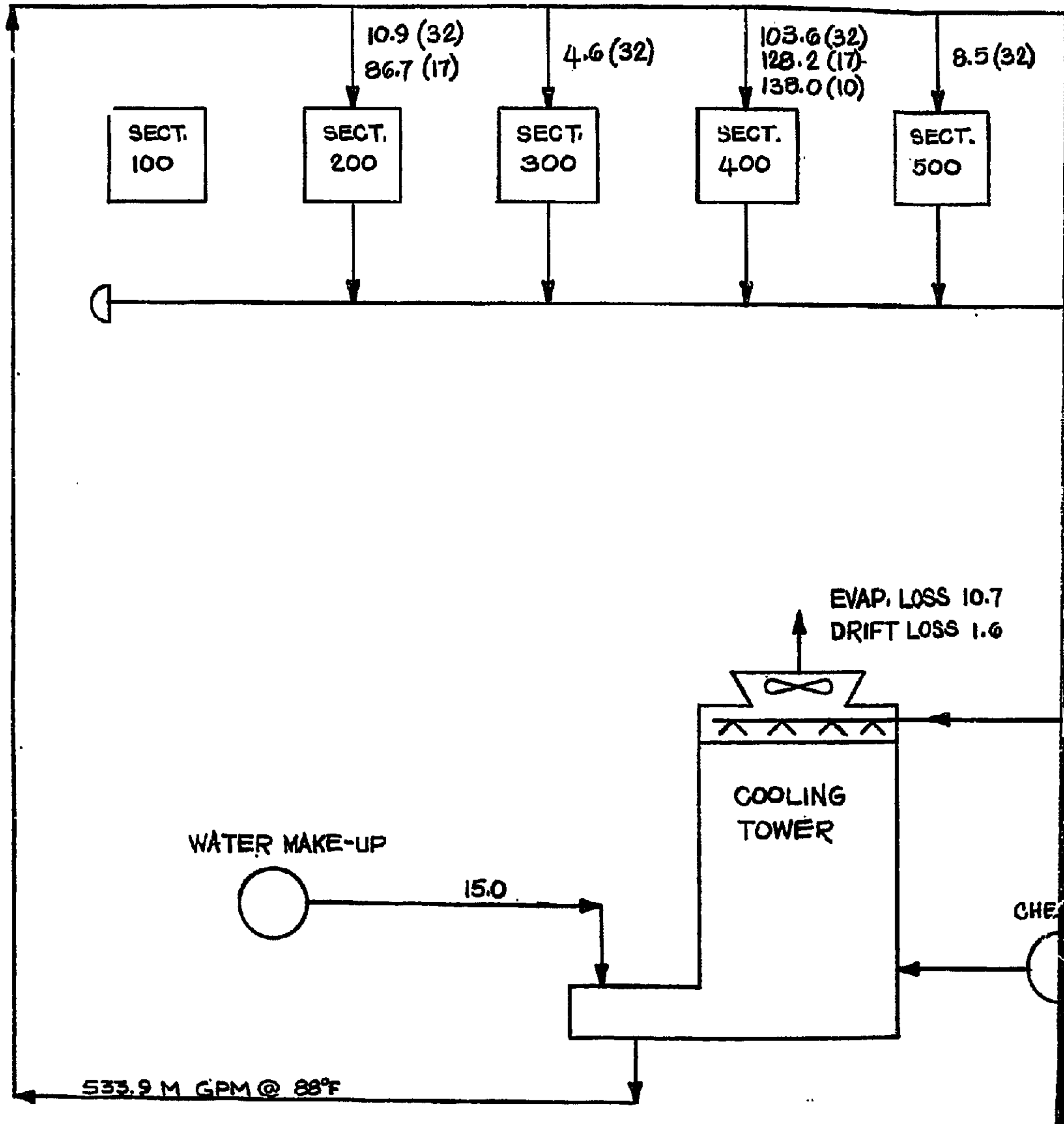
- Process Flowsheet

B. Description of FLow

Cooling water circulated through heat exchange equipment in the various sections of the plant is cooled in a wet cooling tower. A schematic diagram for the cooling water system is shown in Drawing 54099-32-4-50-14.

Major Stream Flows

Estimated flow of cooling water to the various sections of the plant is shown in the cooling tower system diagram. Total flow for the 4 module plant is about 534,000 GPM. Capacity of the tower system provided is 640,000 GPM. Blowdown from the tower is treated in a chrome/zinc recovery package to remove and recycle the chemicals.



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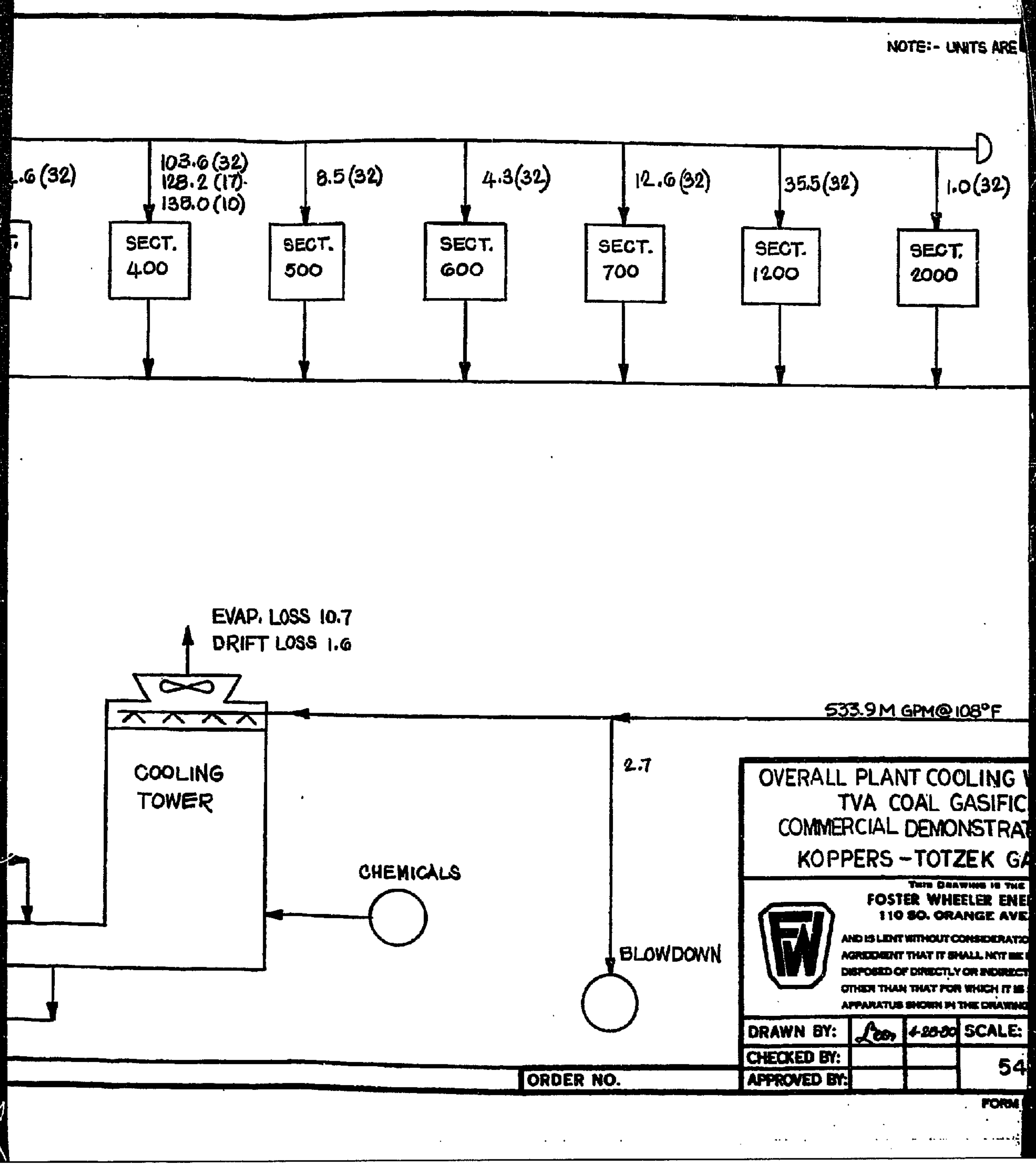

NOTE:- UNITS ARE
.6 (32)
103.6 (32)
128.2 (17)
138.0 (10)
8.5 (32)
4.3 (32)
12.6 (32)
35.5 (32)
1.0 (32)
SECT. 400
SECT. 500
SECT. 600
SECT. 700
SECT. 1200
SECT. 2000
EVAP. LOSS 10.7
DRIFT LOSS 1.6
533.9 M GPM @ 108°F
2.7
COOLING TOWER
CHEMICALS
BLOWDOWN
OVERALL PLANT COOLING
TVA COAL GASIFIC
COMMERCIAL DEMONSTRAT
KOPPERS - TOTZEK GA
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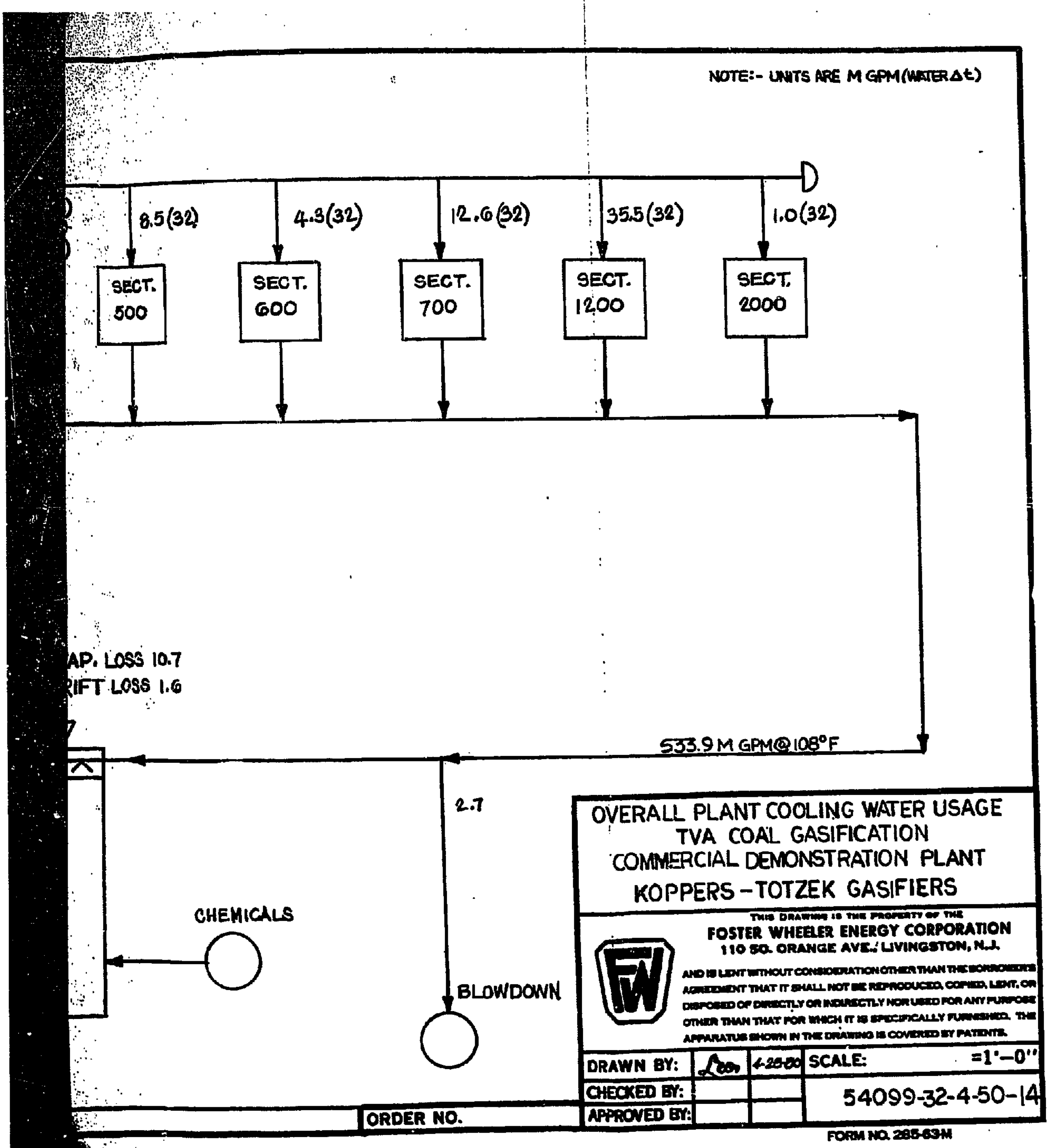
NOTE:- UNITS ARE M GPM (WATER Δt)
8.5(32)
4.3(32)
12.6(32)
35.5(32)
1.0(32)
SECT. 500
SECT. 600
SECT. 700
SECT. 1200
SECT. 2000
AP. LOSS 10.7
RIFT LOSS 1.6
533.9 M GPM @ 108°F
2.7
CHEMICALS
BLOWDOWN
OVERALL PLANT COOLING WATER USAGE
TVA COAL GASIFICATION
COMMERCIAL DEMONSTRATION PLANT
KOPPERS – TOTZEK GASIFIERS
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FORM NO. 285-63M

SECTION DESCRIPTION

3.11 SECTION 1400 - FLARE

Description of System

A flare system capable of handling 2125 MM BTU/hr is provided for each of the 4 modules of the plant. Two or more flares could be dedicated to a single module in the event additional flaring was required from a given module.

SECTION DESCRIPTION

3.12 SECTION 1500 - WASTE WATER TREATMENT

A. Reference Material FWEC Dwg. No. 54099-32-4-50-15

- Process Flowsheet

B. Description of Flow

A diagram showing the overall plant water usage, including waste water treatment is shown in Drawing 54099-32-4-50-15. Raw water is softened, clarified and filtered as described previously. A part of the filtered water is used to supply cooling tower make-up, gasification process water, sulfur prilling process water and sanitary water. The remainder of the filtered water is demineralized and deaerated for use in steam generation.

Stripped sour water, rain water and blowdown from steam condensate polishing are used as cooling tower makeup.

Blowdown from the cooling tower is treated for chrome/zinc recovery, used for seals and bearing cooling and then sent to waste water treatment. A portion of the cooling tower blowdown is used as make-up water in the gasification, primarily as make-up for the fly ash dewatering system. Blowdown from raw water treatment and steam generators are also sent to waste water treatment.

The waste water treatment system selected for this plant includes API separator and air floatation to remove entrained oil, and activated sludge biological oxidation to reduce COD, BOD, TOC, etc. of the water which is then dispersed into the river.

Blowdown from the raw gas cooler-washers in Section 300 leaves the system with the fly ash as a 60% solids filter cake. This material is placed in the ash/slag disposal area.

Major Stream Flows

Estimates of flow for the various water uses in the plant are shown in the water usage diagram. The major flows can be summarized as follows:

	GPM
Raw water intake	16,940
Cooling tower evaporization and drift	12,300
Cooling tower blowdown	2,700
Raw water and steam blowdowns	1,340
Effluent to river	3,900

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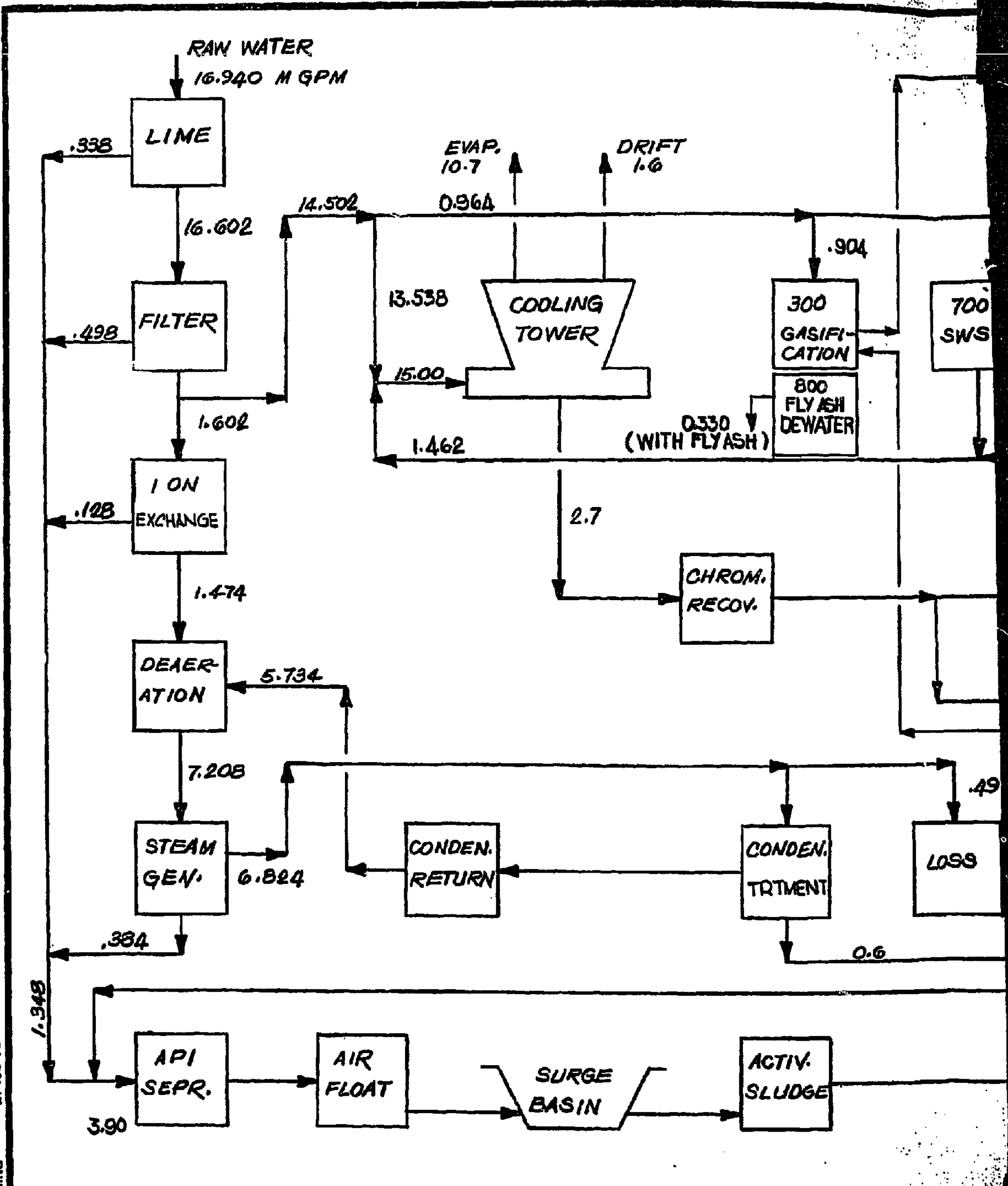

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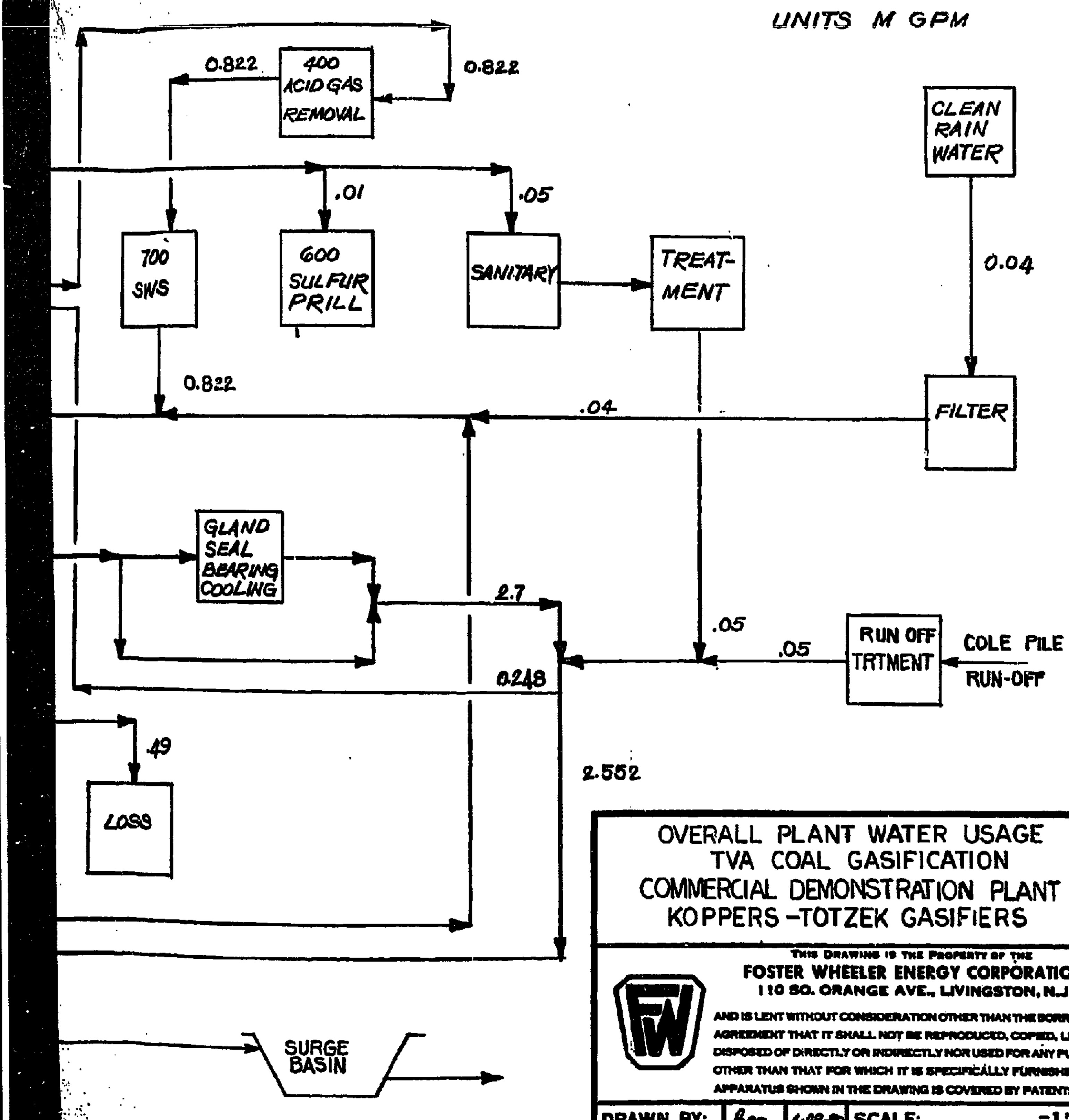

OVERALL PLANT WATER USAGE
TVA COAL GASIFICATION
COMMERCIAL DEMONSTRATION PLANT
KOPPERS -TOTZEK GASIFIERS

DRAWN BY:	Leo,	4-28-80	SCALE: =1'–0"
CHECKED BY:			54099-32-4-50-15
APPROVED BY:			

ORDER NO.

FORM NO. 285-63M

TVA Coal Gasification Study
Koppers - Totzek

SECTION DESCRIPTION

3.13 Section 2000 - General Facilities

This section describes long-term ash storage, by-products and chemicals storage, firewater system, sewage system. power. lighting and communications.

Ash Storage

An irregular area, generally N.E. of the operating plant facilities, is to be cleared and rough graded for deposition of ash and other spent solids related to the combustion processes. The perimeter of the ash pile is designed with a vertical to horizontal slope 1:3 to provide for a reasonable margin of design for stability. Should it be required, an additional margin of stability of the perimeter embankment can be provided by employing earth and rock fill material from the site.

Slag and flyash cakes from the Koppers-Totzek gasifiers and flyash and spent bed materials from the fluidized bed boilers, will be constituted with an overwhelming predominance of flyash. The constituents of the ash, given in Section 2.1.4 of the Design Criteria, indicate a high percentage of silicon and aluminum oxides. Such compounds, in the presence of moisture and an alkaline agent (limestone), would undergo pozzolanic activity to form, in many aspects, a more stable, cementitious compound.

The design Criteria (Section 4.3) of TVA, for base case design, stipulates no lining under ash, sludge, and water containment ponds. The present deisgn, which is dry storage, does not include any lining. The reader should be alerted to the possibility of leachate from the slag and ash pile finding its way into the Guntersville Reservoir. This possibility would become less likely if the ash undergoes pozzolanic activity, inasmuch as the permeability of the ash by moisture would be reduced. A further concern is the possibility of toxic materials which could leach into the ground and eventually into Guntersville Reservoir. The ash analysis, Section 2.1.4 of the Design Criteria, indicates compounds which are largely inert and non-toxic. It is known, however, that trace quantities of the heavy metals may be found in flyash. Leachate for the flyash, in particular, could be a source of unacceptable pollution of Guntersville Reservoir.

None of the foregoing comments are to be construed as definitive statements of fact and should, therefore, be verified by suitable testing immediately following startup of the plant, to verify the chemical and physical behavior of the mixture of slag, ash and spent bed materials. Additionally, the presence of toxic elements and the attenuating properties of the cementified pile and soil from the proposed plant site of Murphy Hill, should be determined.

By-products and Chemicals Storage

A 14-day supply of limestone for the fluidized bed steam superheaters is provided.

A variety of solvents, catalysts and other chemicals are stored either as a periodic replacement charge or as a continuing, spendable requirement. Such solvents, catalysts and chemicals are indicated in the succeeding Section 2, Plant Requirements.

Sulfur is converted into a solid form in a prilling operation at the sulfur recovery unit serving each module of the gasification plant. The solid prills are then transported to a storage bin of 30 days production capacity prior to removal from the plant site.

Firewater System

A 10-inch underground looped piping network will be provided to supply firewater to all areas of the plant. Hydrants are located at approximately 300-foot intervals. In the Porcess Area, 25 percent of the hydrants will be provided with monitor nozzles capable of directing water coverage on equipment in minimal response time.

The source of firewater is an allowance in the Raw Water Storage Tank. Three (3) 2000 gpm pumps -- one diesel-driven and two motor-driven -- supply water to the piping grid. A fourth 300 gpm capacity jockey pump provides pressurization of the system at all times. Should loss of pressure occure due to fire, the main pump(s) are sequentially started automatically. Pump discharge pressure is 150 psig. This assures firewater supply demands to remote hydrants at 80 to 100 psig.

Sewage System

Several sewer systems will be provided. These include a clean rain runoff system, an oily water system to handle rain runoff from areas of oily contamination, systems to handle rain runoff from coal pile and ash storage areas and sanitary sewer collecting wastes from all building sanitary facilities. All of these systems direct flow to the waste treatment facilities for treatment.

Power, Lighting and Communications

1. General

   The electrical facilities for the Coal Gasification Complex will be a complete installation, including power supply from a TVA power substation, lighting, communications, fire alarm and aircraft warning systems.

2. Standards, Codes and Regulations

The design, materials, equipment and installation of the electrical facilities will be in accordance with Foster Wheeler's Engineering Standard 70A1, the latest edition of the codes and regulations contained therein, and including the following:

- Section 1.4.3 Electrical Design Considerations (TVA Design Criteria)
- FAA Regulations
- FCC Regulations

3. Area Classification

All areas within limits are classified in accordance with the National Electrical Code, Article 500.

4. Power Distribution

A dual 138/13.8 KV intertie with the TVA power grid will be provided, including 2 transformers, each rated to supply the total plant load.

The overall design basis for the proposed electrical system is one of high reliability to minimize interruption of operation. Key features of the design are as follows:

- Dual feeders from the TVA system.
- Secondary-selective double-ended substation load centers are provided as required to supply medium and low voltage process loads.
- Double radial feeders are run to each load center.
- Outdoor/indoor bus duct is furnished from the outdoor transformers to the indoor 5 KV or 480 KV switchgears.
- All switchgear and motor control centers are indoors.
- Electric power is distributed to power consumers rated on the following basis:

  Motors 250 HP to 5,000 HP; 4,000 V, 3 phase, 3 wire

  Motors ½ to 200 HP; 460 V, 3 phase, 3 wire

  Motors below ½ HP; single phase, 2 wire, 115 V

  Lighting & instrument branch circuit; 120 V,single phase

5. Electrical Equipment

In general, electrical equipment and wiring materials are furnished as required by the National Electrical Code and Section 1.4.3 Electrical Design Considerations (TVA Design Criteria), and to conform to the following standards, where applicable:

- National Electrical Manufacturer's Association (NEMA)
- American National Standards Institute (ANSI)
- Underwriter Laboratories (UL)

6. Motor Control Equipment

The 4000 V motors up to 2000 HP are magnetic contactor-type control with current limiting fuses. Two high units are furnished. Motors greater than 2000 HP are controlled by switchgear type circuit breakers. The 460 V motors are controlled by a combination circuit breaker and magnetic contactor.

7. Wiring Method

Both 13.8 KV and 4,160 V distribution will be in underground conduits. Within process unit limits where overhead pipe racks or supports are available, wiring for 480 V and less will be in overhead conduit.

8. Lighting

Lighting for process areas is provided in accordance with FW Engineering Standard 70A1 and all applicable standards referred to in Section 1.4.3 Electrical Design Considerations (TVA Design Criteria).

Aviation obstruction lighting will be provided in accordance with the FAA requirements for the site.

Road and equipment lighting will be provided, using mercury vapor lighting fixtures mounted on poles.

9. Communications

Telephone Company system: An empty conduit system will be provided for the local telephone company to furnish and install telephone service to the plant.

Two-way Communication: A two-way FM radio communication system will be provided for plant operation.

10. Fire Alarm System

The fire alarm system design is based on utilization of the telephone system for fire alert throughout the plant. Telephone-type relays will be provided to actuate fire signal devices in areas required for personal safety.

TVA Coal Gasification
Koppers - Totzek

SECTION DESCRIPTION

3.14 Section 2100 - Buildings

Buildings for the Coal Gasification Complex will be provided in accordance with the building list tabulated below. This indicates the nominal building dimensions and designates the basic materials of construction. The buildings will be in accord with standard industry design. The envisioned scope of supply includes necessary foundations, structural framing, sheathing, roofing, insulation, plumbing, heating and ventilating, along with electrical power and lighting circuitry. All deisgn and construction will be completely in accordance with applicable local and state codes.

Allowance is provided for building furnishings. This includes office furnishings for the administration building and other office areas for personnel, tools and shop equipment to sufficiently outfit the various craft shops in the maintenance building to conduct normal maintenance of plant equipment, laboratory equipment for sampling and analyzing process streams, change house lockers and facilities for personnel convenience.

Service	Dimensions (ft)	Area (ft^2)	Construction Material
Administration		25,600	Masonry
Maintenance			
Shop	75 X 280	21,000	Pre-fac Metal
Offices	48 X 100	4,800	Masonry
Warehouse	200 X 240	48,000	Pre-fab Metal
Laboratory	50 X 100	5,000	Masonry
Firehouse/First Aid	50 X 90	4,500	Pre-fab Metal
Gate/Change House	80 X 125	10,000	Pre-fab Metal
Process Control	60 X 100	6,000	Masonry
Water Treatment	100 X 200	20,000	Pre-fab Metal
Electrical Substations (size varies-10 required)			Masonry