3.9 UTILITY SUPPORT SYSTEMS

The proper and efficient operation of the GKT gasification plant requires the following utility and offsite support systems in addition to the process units described in Sections 3.2 through 3.7.

Utilities

- Plant and Potable Water System (Unit 84)
- Cooling Water System (Unit 81)
- Steam, Condensate, and Boiler Feedwater System (Unit 82)
- Firewater System (Unit 83)
- Plant and Instrument Air (Unit 85)
- Sewer and Sanitary Drain (Unit 86)
- Auxillary Steam Generation (Unit 87)

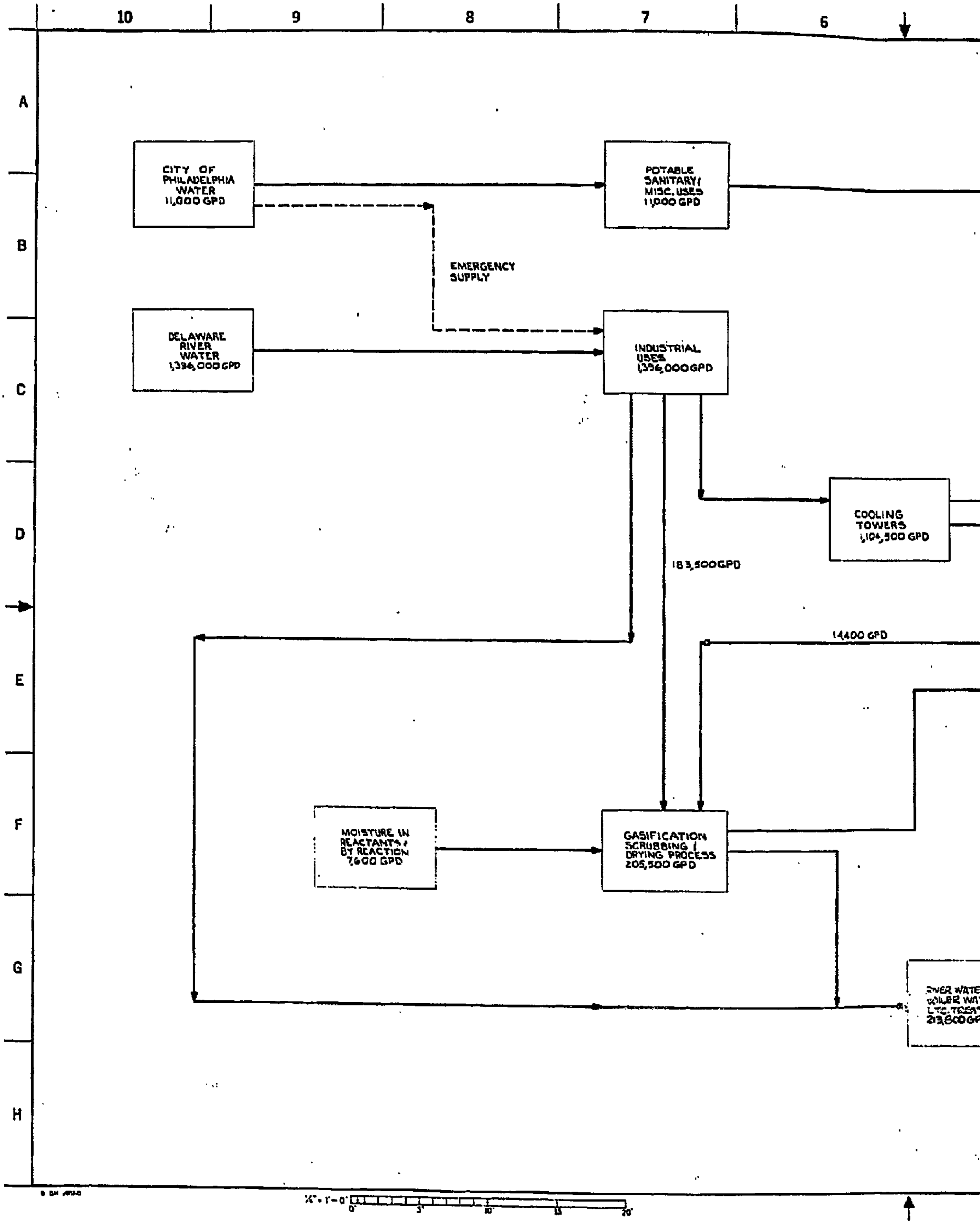
Offsites

- Main Process Flare and Relief (Unit 91)
- Fly Ash Removal and Storage (Unit 92)
- Slag Removal and Storage (Unit 94)

This section will describe the utility and offsite support systems essential to the operation of the plant.

3.9.1 Plant and Potable Water System

The block flow diagram shown in Figure 3-11 schematically represents the distribution of the average daily water use for the plant. Potable water is required for drinking water supply and sanitary services including showers. City of Philadelphia - Water Department supply is the exclusive source of potable water. All plant water requirements are supplied from the on-site, Delaware River water treatment system.


CITY OF PHILADELPHIA WATER 11,000 GPD
POTABLE SANITARY / MISC. USES 11,000 GPD
EMERGENCY SUPPLY
DELAWARE RIVER WATER 1,396,000 GPD
INDUSTRIAL USES 1,396,000 GPD
COOLING TOWERS 1,104,500 GPD
183,500 GPD
14400 GPD
MOISTURE IN REACTANTS & BY REACTION 7,600 GPD
GASIFICATION SCRUBBING & DRYING PROCESS 205,500 GPD

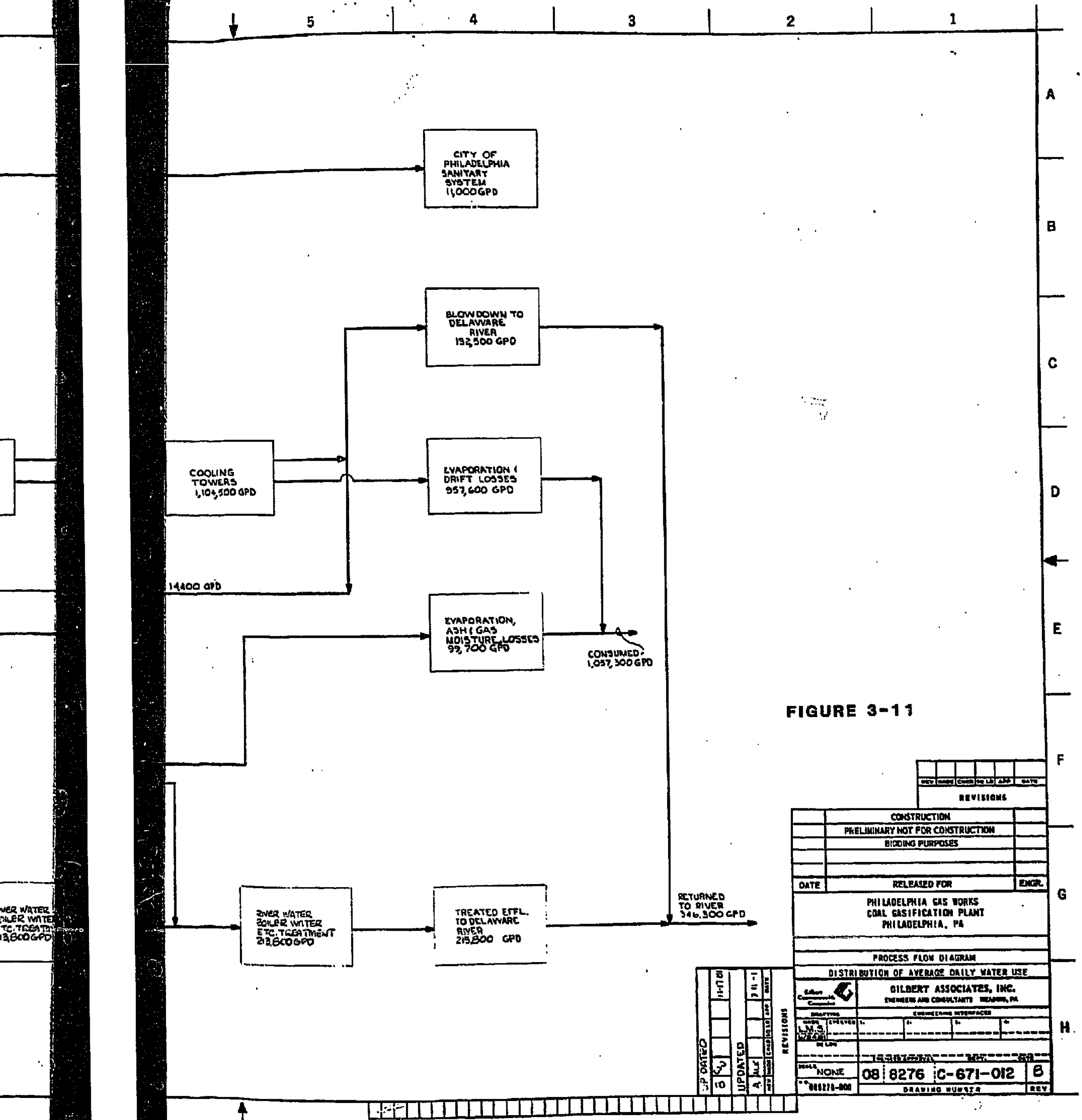
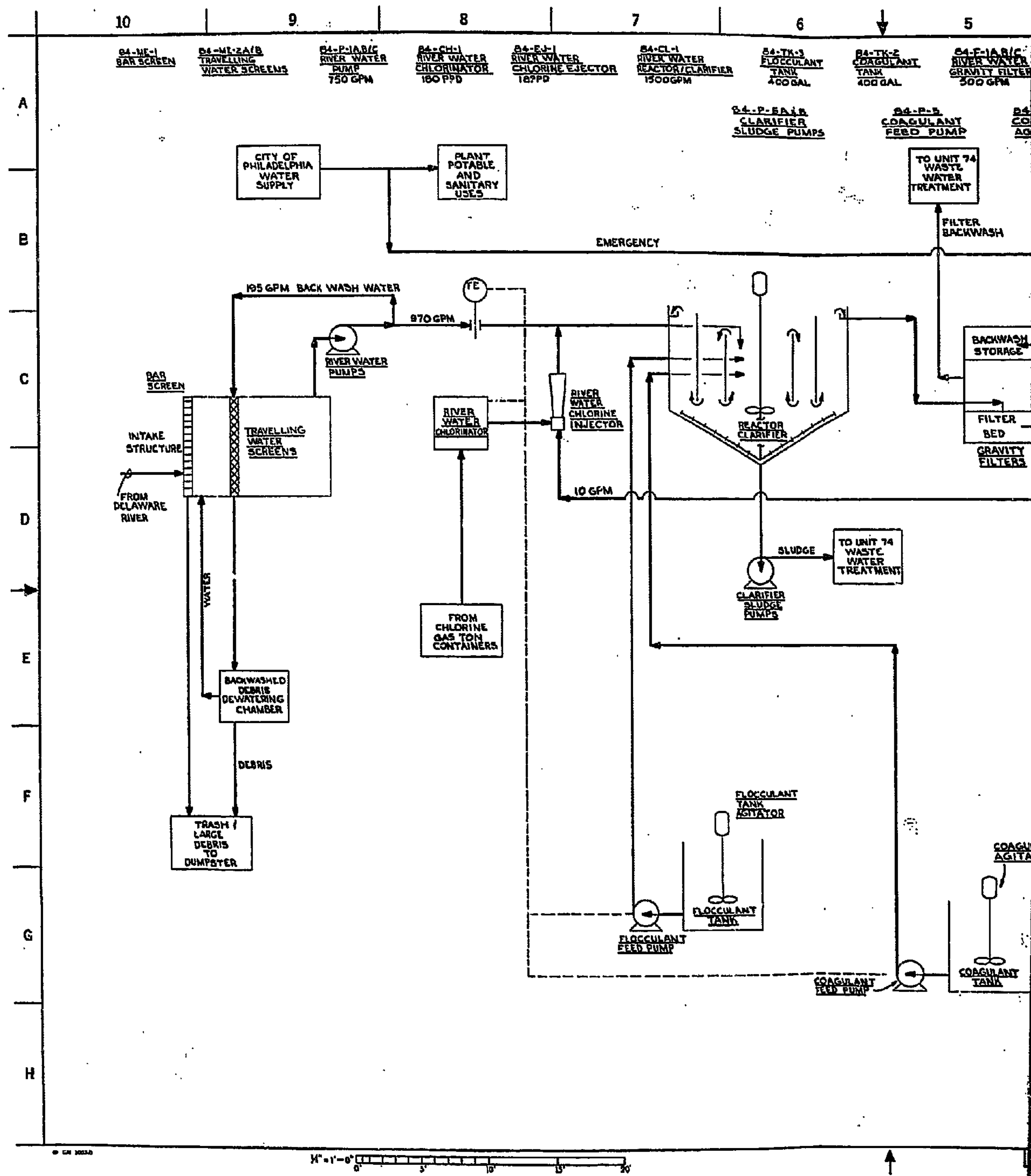

CITY OF PHILADELPHIA SANITARY SYSTEM 11,000 GPD
BLOWDOWN TO DELAWARE RIVER 192,500 GPD
COOLING TOWERS 1,104,500 GPD
EVAPORATION & DRIFT LOSSES 957,600 GPD
14400 GPD
EVAPORATION, ASH & GAS MOISTURE LOSSES 99,700 GPD
CONSUMED 1,057,300 GPD
RIVER WATER BOILER WATER ETC. TREATMENT 213,600 GPD
TREATED EFFL. TO DELAWARE RIVER 215,800 GPD
RETURNED TO RIVER 346,300 GPD
REVISIONS
CONSTRUCTION
PRELIMINARY NOT FOR CONSTRUCTION
BIDDING PURPOSES
DATE
RELEASED FOR
ENGR.
PHILADELPHIA GAS WORKS
COAL GASIFICATION PLANT
PHILADELPHIA, PA
PROCESS FLOW DIAGRAM
DISTRIBUTION OF AVERAGE DAILY WATER USE
GILBERT ASSOCIATES, INC.
NONE
08 8276 C-671-012 B
DRAWING NUMBER
REV
UPDATED
UP DATED

FIGURE 3-11

The process flow diagram shown in Figure 3-12 schematically represents the plant makeup water treatment system (Unit 84). All flow rates shown are based on normal two gasifier operation at 100 percent design capacity. Plant water is drawn from the Delaware River. An intake structure is provided with a bar screen to remove sticks, leaves and other large debris from the water. This debris is collected in a dumpster and removed as trash. Travelling water screens are provided to remove smaller particles down to approximately 3/8 inch size, and are provided with an automatic screen backwash system. Backwashed debris is directed to a dewatering chamber - the water being drained back to the intake structure. River water pumps convey water to the reactor/clarifier. Three 50 percent design capacity pumps are provided, two operating and one spare.

Chlorine solution is injected into the common river water pump discharge header. River water enters the center well of the reactor/clarifier where it is mixed with recirculated sludge and coagulant. Water proceeds through a flocculation zone where a flocculant (or coagulant aid) is added. The water rises up through the sludge blanket for clarification. The clarifier overflow feeds the gravity filters for removal of any fine material. The filters are provided with an integral backwash system. A filtered water storage tank is provided to hold approximately 30 minutes supply at design flow. Three 50 percent design capacity filtered water pumps supply the process plant.

Filtered water directly from the filters is fed by gravity to the process cooling water system. All other plant services are supplied by the filtered water pumps. Filtered water is provided to the air separation plant cooling water system, to the GKT gasifier quench system, to the GKT wash water system, to the boiler feedwater makeup demineralizer system, to the Stretford plant, to the river water chlorine ejector and to the various in-plant users such as the water and wastewater treatment makeup chemical tanks.



10
9
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6
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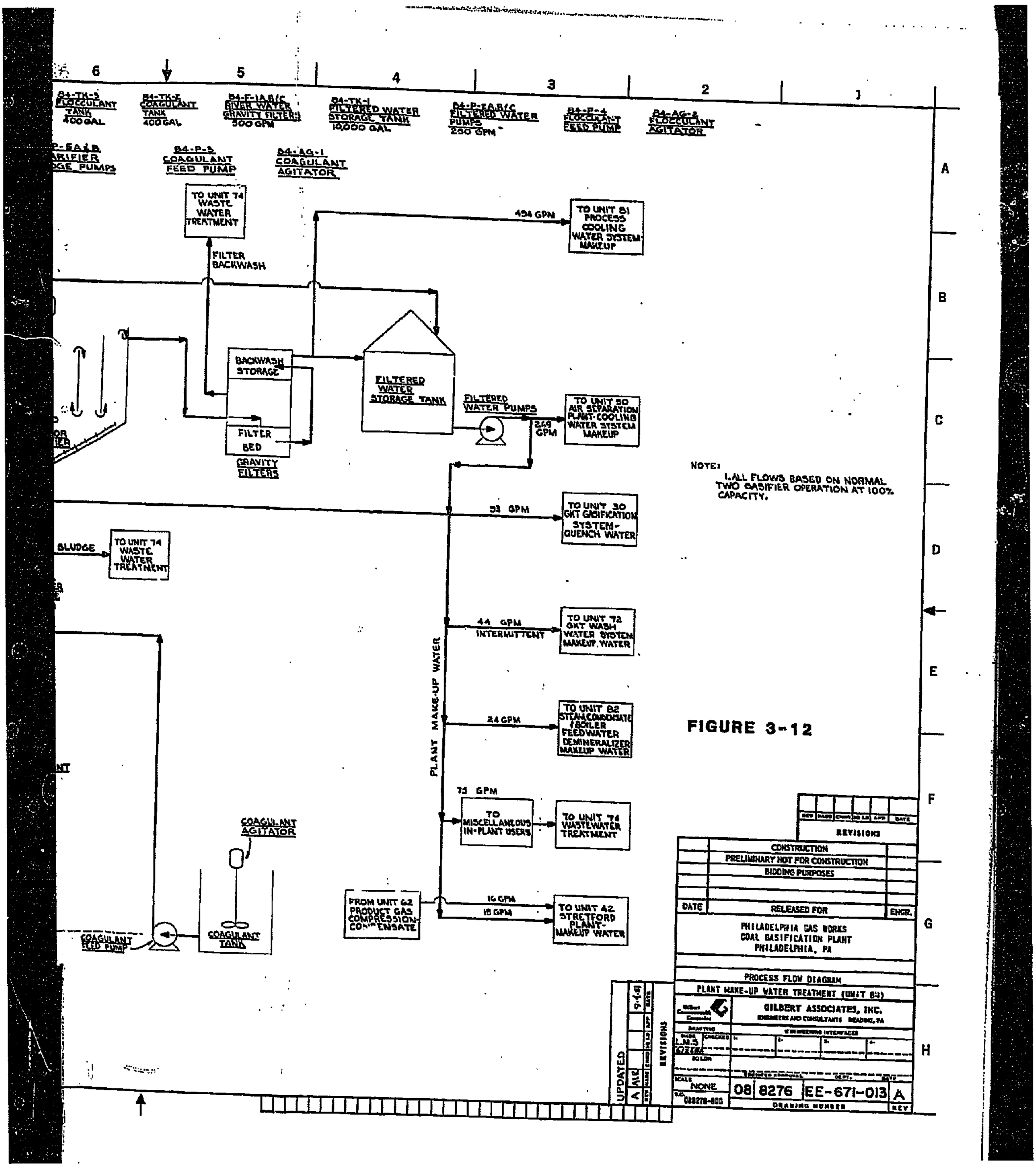
84-ME-1 BAR SCREEN
84-ME-2A/B TRAVELLING WATER SCREENS
84-P-1A,B/C RIVER WATER PUMP 750 GPM
84-CH-1 RIVER WATER CHLORINATOR 180 PPD
84-EJ-1 RIVER WATER CHLORINE EJECTOR 187PD
84-CL-1 RIVER WATER REACTOR/CLARIFIER 1500GPM
84-TK-3 FLOCCULANT TANK 400 GAL
84-TK-2 COAGULANT TANK 400 GAL
84-F-1A,B/C RIVER WATER GRAVITY FILTER 500 GPM
84-P-6A & B CLARIFIER SLUDGE PUMPS
84-P-5 COAGULANT FEED PUMP
A
B
C
D
E
F
G
H
CITY OF PHILADELPHIA WATER SUPPLY
PLANT POTABLE AND SANITARY USES
TO UNIT 74 WASTE WATER TREATMENT
FILTER BACKWASH
EMERGENCY
195 GPM BACK WASH WATER
FE
970 GPM
RIVER WATER PUMPS
BAR SCREEN
INTAKE STRUCTURE
TRAVELLING WATER SCREENS
FROM DELAWARE RIVER
RIVER WATER CHLORINATOR
RIVER WATER CHLORINE INJECTOR
REACTOR CLARIFIER
BACKWASH STORAGE
FILTER BED
GRAVITY FILTERS
10 GPM
SLUDGE
TO UNIT 74 WASTE WATER TREATMENT
CLARIFIER SLUDGE PUMPS
WATER
FROM CHLORINE GAS TON CONTAINERS
BACKWASHED DEBRIS DEWATERING CHAMBER
DEBRIS
TRASH / LARGE DEBRIS TO DUMPSTER
FLOCCULANT TANK AGITATOR
FLOCCULANT TANK
FLOCCULANT FEED PUMP
COAGULANT FEED PUMP
COAGULANT TANK
¼" = 1'-0"
0'
5'
10'
15'
20'



6
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2
1
84-TK-3 FLOCCULANT TANK 400 GAL
84-TK-2 COAGULANT TANK 400 GAL
84-F-1A,B/C RIVER WATER GRAVITY FILTERS 500 GPM
84-TK-1 FILTERED WATER STORAGE TANK 10,000 GAL
84-P-2A,B/C FILTERED WATER PUMPS 250 GPM
84-P-4 FLOCCULANT FEED PUMP
84-AG-2 FLOCCULANT AGITATOR
84-P-3 COAGULANT FEED PUMP
84-AG-1 COAGULANT AGITATOR
A
B
C
D
E
F
G
H
TO UNIT 74 WASTE WATER TREATMENT
FILTER BACKWASH
494 GPM
TO UNIT 81 PROCESS COOLING WATER SYSTEM MAKEUP
BACKWASH STORAGE
FILTER BED
GRAVITY FILTERS
FILTERED WATER STORAGE TANK
FILTERED WATER PUMPS
249 GPM
TO UNIT 50 AIR SEPARATION PLANT-COOLING WATER SYSTEM MAKEUP
NOTE:
1. ALL FLOWS BASED ON NORMAL TWO GASIFIER OPERATION AT 100% CAPACITY.
25 GPM
TO UNIT 30 GKT GASIFICATION SYSTEM-QUENCH WATER
SLUDGE
TO UNIT 74 WASTE WATER TREATMENT
44 GPM INTERMITTENT
TO UNIT 72 GKT WASH WATER SYSTEM MAKEUP WATER
PLANT MAKE-UP WATER
24 GPM
TO UNIT 82 STEAM CONDENSATE / BOILER FEEDWATER DEMINERALIZER MAKEUP WATER
75 GPM
TO MISCELLANEOUS IN-PLANT USERS
TO UNIT 74 WASTEWATER TREATMENT
COAGULANT AGITATOR
COAGULANT TANK
COAGULANT FEED PUMP
FROM UNIT 62 PRODUCT GAS COMPRESSION CONDENSATE
16 GPM
15 GPM
TO UNIT 42 STRETFORD PLANT MAKEUP WATER
REVISIONS
CONSTRUCTION
PRELIMINARY NOT FOR CONSTRUCTION
BIDDING PURPOSES
DATE
RELEASED FOR
ENGR.
PHILADELPHIA GAS WORKS
COAL GASIFICATION PLANT
PHILADELPHIA, PA
PROCESS FLOW DIAGRAM
PLANT MAKE-UP WATER TREATMENT (UNIT 84)
GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS READING, PA
UPDATED
A
NONE
08 8276 EE-671-013 A
DRAWING NUMBER

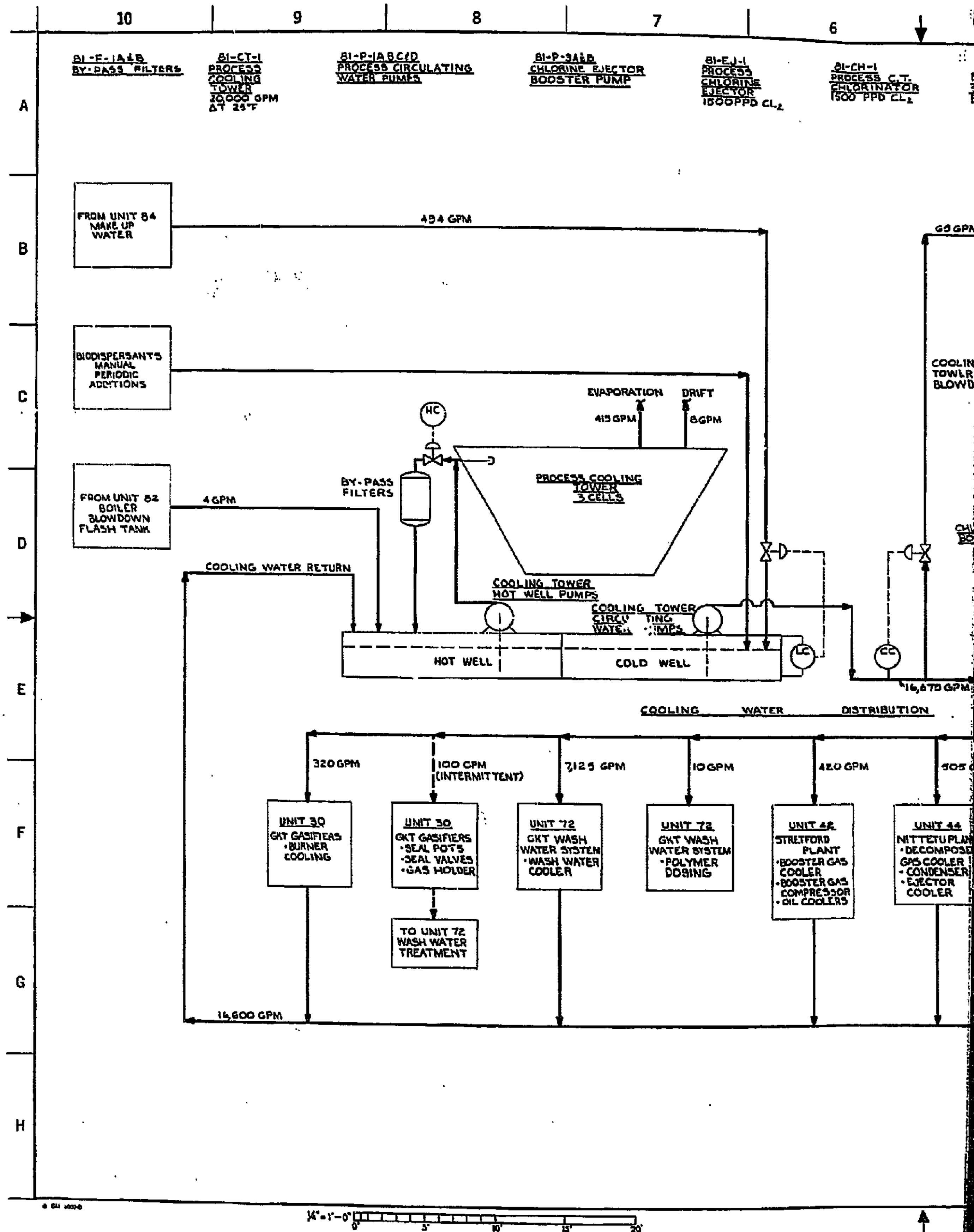
FIGURE 3-12

3.9.2 Cooling Water System - Process Plant

The process flow diagram shown in Figure 3-13 represents the cooling water system (Unit 81) for the process plant. A circulating water system is provided to supply cooling water users in Unit 30-GKT coal gasification plant, Unit 72-GKT wash water system, Unit 42-Stretford plant, Unit 44-Nittetu plant, Unit 62-product gas compression, plant air compressor and other smaller use service areas.

A three-cell mechanical draft cooling tower with integral cold-well and hot-well is provided to normally dissipate approximately 220 million Btu per hour. Hot water return (110°F summer temperature) is delivered from the hot well to the top of the cooling tower. Water is cooled by evaporation of approximately 2.5 percent of the circulating flow to yield 85°F water (summer conditions) at the cold well. Makeup water from Unit 84 (Plant and Potable Makeup Water System) is automatically added to the cold well by level control. Steam blowdown also serves as makeup water to the circulating system. Four process cold well pumps are provided, three operating and one spare, to supply cooling water to the individual users throughout the process plant. All cooling water is normally returned to the cooling tower with the exception of 10 gpm used for polymer dosing in Unit 72 and intermittent flows used for seal pots, quick seal valves and the gas holder seal in Unit 30.

Makeup water for the circulating water system is treated Delaware River water which has been screened, clarified and filtered. Cooling tower blowdown is regulated via a conductivity controller such that the normal operating cycles of concentration is 6.0. At 6.0 concentrations, the circulating water is generally balanced (i.e., does not exhibit corrosiveness or scale-forming tendencies), or has a slight scale-forming tendency. A scale inhibitor feed system is provided for maintaining a slight residual inhibitor concentration to prevent scale deposition on heat transfer surfaces.



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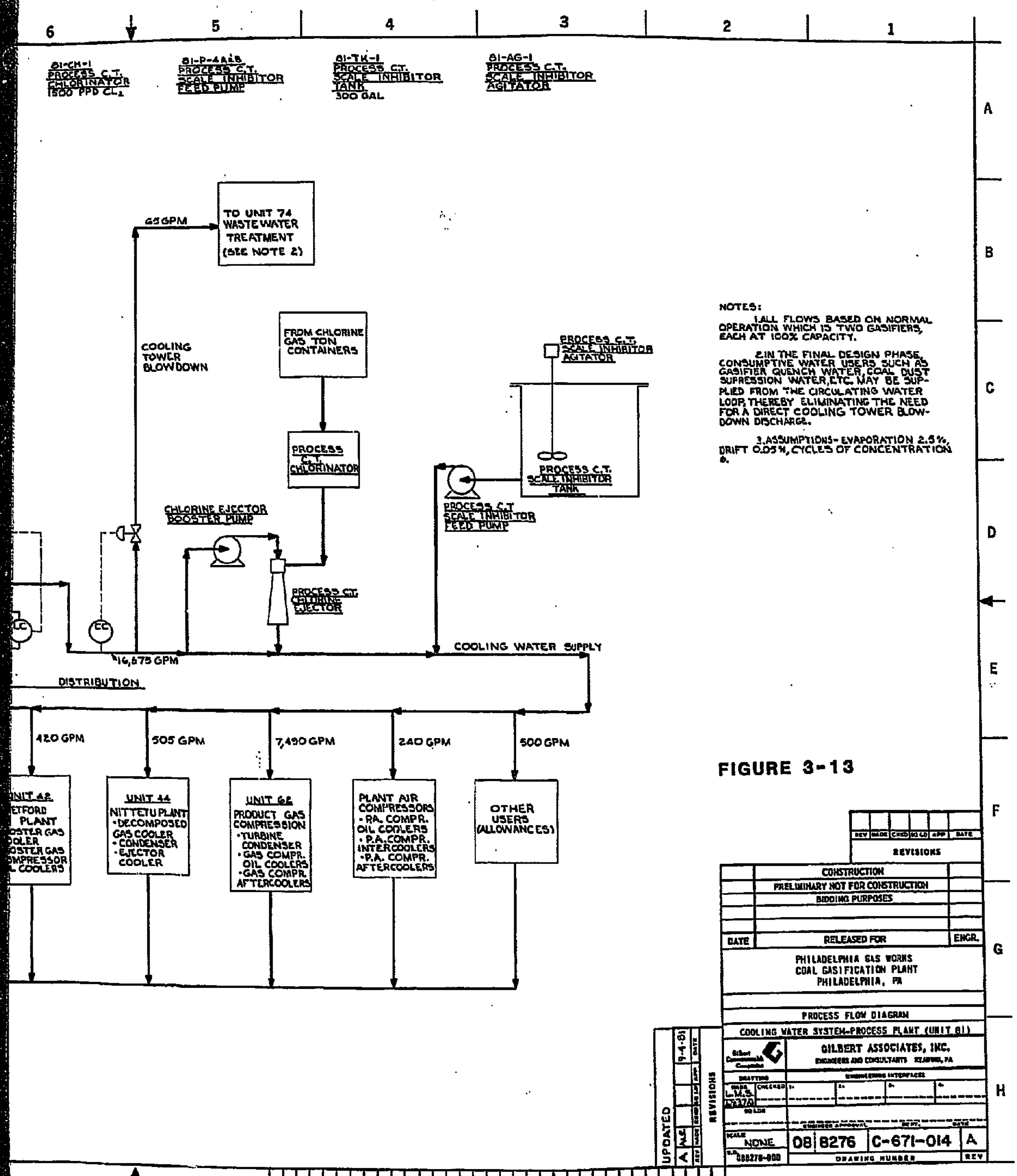
81-F-1A&B BY-PASS FILTERS
81-CT-1 PROCESS COOLING TOWER 20,000 GPM AT 25°F
81-P-1A B C&D PROCESS CIRCULATING WATER PUMPS
81-P-9A&B CHLORINE EJECTOR BOOSTER PUMP
81-EJ-1 PROCESS CHLORINE EJECTOR 1500PPD CL_2
81-CH-1 PROCESS C.T. CHLORINATOR 1500 PPD CL_2
FROM UNIT 84 MAKE UP WATER
494 GPM
65 GPM
BIODISPERSANTS MANUAL PERIODIC ADDITIONS
EVAPORATION
415 GPM
DRIFT
8 GPM
HC
BY-PASS FILTERS
PROCESS COOLING TOWER 3 CELLS
FROM UNIT 82 BOILER BLOWDOWN FLASH TANK
4 GPM
COOLING WATER RETURN
COOLING TOWER HOT WELL PUMPS
COOLING TOWER
HOT WELL
COLD WELL
LC
CC
16,670 GPM
COOLING WATER DISTRIBUTION
320 GPM
100 GPM (INTERMITTENT)
7125 GPM
10 GPM
420 GPM
UNIT 30 GKT GASIFIERS •BURNER COOLING
UNIT 30 GKT GASIFIERS •SEAL POTS •SEAL VALVES •GAS HOLDER
UNIT 72 GKT WASH WATER SYSTEM •WASH WATER COOLER
UNIT 72 GKT WASH WATER SYSTEM •POLYMER DOSING
UNIT 42 STRETFORD PLANT •BOOSTER GAS COOLER •BOOSTER GAS COMPRESSOR •OIL COOLERS
UNIT 44
TO UNIT 72 WASH WATER TREATMENT
14,600 GPM
1/4"=1'-0"
0' 5' 10' 15' 20'


6
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4
3
2
1
A
B
C
D
E
F
G
H
81-CH-1
PROCESS C.T. CHLORINATOR
1500 PPD CL2
81-P-4A&B
PROCESS C.T. SCALE INHIBITOR FEED PUMP
81-TK-1
PROCESS C.T. SCALE INHIBITOR TANK
300 GAL
81-AG-1
PROCESS C.T. SCALE INHIBITOR AGITATOR
65 GPM
TO UNIT 74 WASTE WATER TREATMENT (SEE NOTE 2)
COOLING TOWER BLOWDOWN
FROM CHLORINE GAS TON CONTAINERS
PROCESS C.T. CHLORINATOR
PROCESS C.T. SCALE INHIBITOR AGITATOR
PROCESS C.T. SCALE INHIBITOR TANK
PROCESS C.T. SCALE INHIBITOR FEED PUMP
CHLORINE EJECTOR BOOSTER PUMP
PROCESS C.T. CHLORINE EJECTOR
LC
CC
16,675 GPM
COOLING WATER SUPPLY
DISTRIBUTION
420 GPM
505 GPM
7,490 GPM
240 GPM
500 GPM
UNIT 42 PETFORD PLANT BOOSTER GAS COOLER BOOSTER GAS COMPRESSOR OIL COOLERS
UNIT 44 NITTETU PLANT •DECOMPOSED GAS COOLER •CONDENSER •EJECTOR COOLER
UNIT 62 PRODUCT GAS COMPRESSION •TURBINE CONDENSER •GAS COMPR. OIL COOLERS •GAS COMPR. AFTERCOOLERS
PLANT AIR COMPRESSORS •P.A. COMPR. OIL COOLERS •P.A. COMPR. INTERCOOLERS •P.A. COMPR. AFTERCOOLERS
OTHER USERS (ALLOWANCES)
NOTES:
1. ALL FLOWS BASED ON NORMAL OPERATION WHICH IS TWO GASIFIERS, EACH AT 100% CAPACITY.
2. IN THE FINAL DESIGN PHASE, CONSUMPTIVE WATER USERS SUCH AS GASIFIER QUENCH WATER, COAL DUST SUPRESSION WATER, ETC. MAY BE SUPPLIED FROM THE CIRCULATING WATER LOOP, THEREBY ELIMINATING THE NEED FOR A DIRECT COOLING TOWER BLOWDOWN DISCHARGE.
3. ASSUMPTIONS - EVAPORATION 2.5%, DRIFT 0.05%, CYCLES OF CONCENTRATION 6.
REV MADE CHKD SQ LD APP DATE
REVISIONS
CONSTRUCTION
PRELIMINARY NOT FOR CONSTRUCTION
BIDDING PURPOSES
DATE
RELEASED FOR
ENGR.
PHILADELPHIA GAS WORKS
COAL GASIFICATION PLANT
PHILADELPHIA, PA
PROCESS FLOW DIAGRAM
COOLING WATER SYSTEM-PROCESS PLANT (UNIT 81)
GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS READING, PA
UPDATED
A
9-4-81
REVISIONS
NONE
08
8276
C-671-014
A
DRAWING NUMBER
REV

FIGURE 3-13

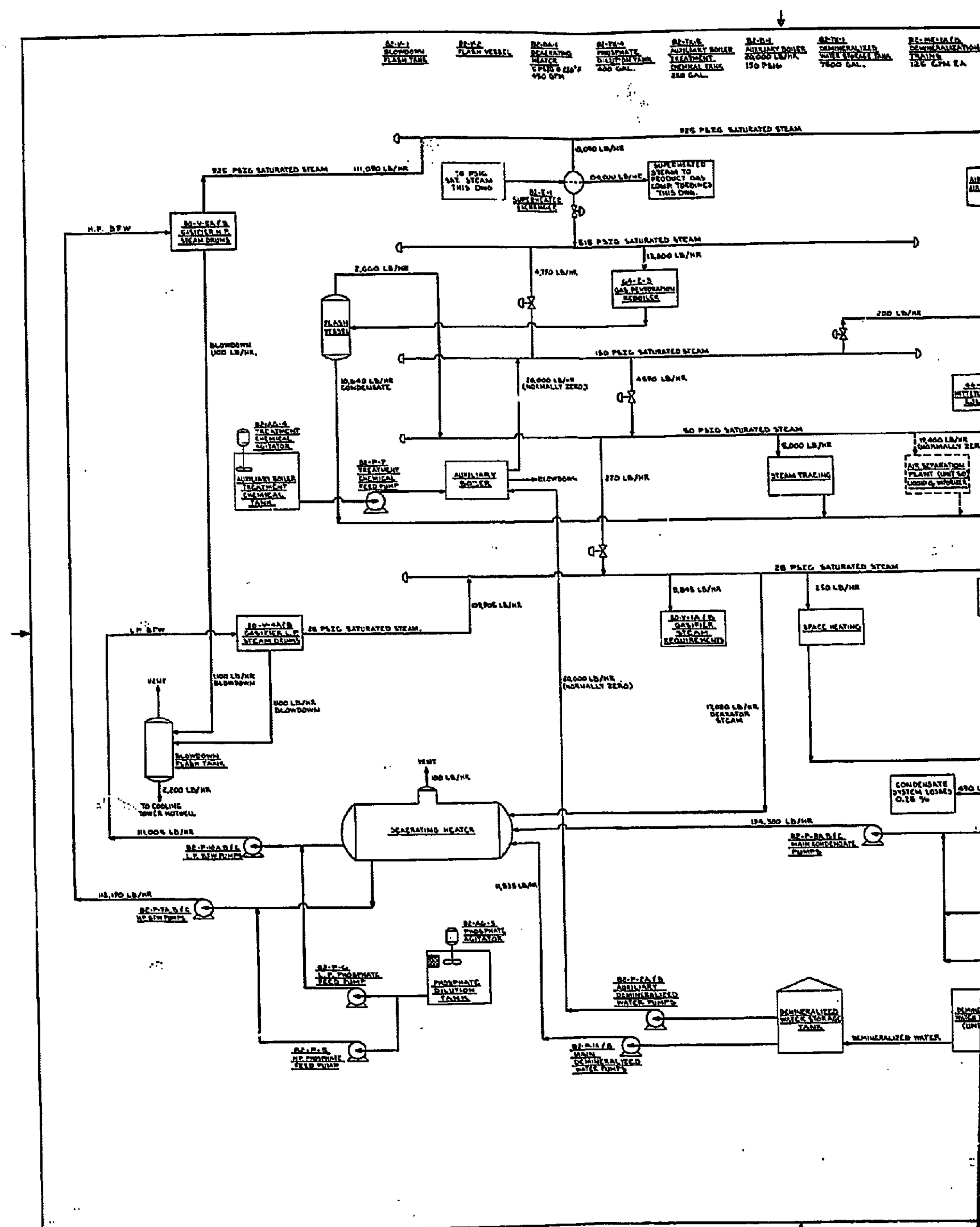
For microbiological contamination control, shock treatment using chlorine gas is provided. Chlorine gas is supplied from one-ton containers via a manifold to the process cooling tower chlorinator. A chlorine residual analyzer provides a signal to control chlorine gas flow to the chlorine ejector. Motive and dilution water is supplied to the ejector by a booster pump. A total chlorine residual of 0.14 mg per l for a contact period of two hours is to be practiced, repeated as necessary, one to several times per day. Manual, intermittent feed of biodispersant to loosen up slime deposits is practiced several times per year.

Cooling tower blowdown is discharged through a monitoring station in Unit 74 - wastewater treatment system and then directly to the Delaware River. In the final design phase, water consumers such as gasifier quench water, coal dust suppression water, etc. may be supplied from the circulating water loop, thereby eliminating the need for a direct cooling tower blowdown discharge.

3.9.3 Steam, Condensate, and Boiler Feedwater System

The process flow diagram shown in Figure 3-14 schematically represents the steam, condensate and boiler feedwater system (Unit 82). Under normal, full load, two-gasifier operation, sufficient steam is generated by the two gasifiers to support all process and plant users, approximately 65 percent of the power required for air separation plant air compression and 100 percent of the power required for product gas compression. An auxiliary boiler provides steam to supplement the normal gasifier steam supply as required for system startups, heating during gasifier shutdowns, and for equipment tracing.

The gasifier units generate two pressure levels of steam, 28 psig, saturated, low pressure (L.P.) steam from the gasifier jacket, and 925 psig, saturated, high pressure (H.P.) steam from the gasifier waste heat boiler. H.P. steam is used for air separation plant air



FLASH VESSEL
AUXILIARY BOILER
150 PSIG
7600 GAL.
925 PSIG SATURATED STEAM
111,090 LB/HR
H.P. BFW
SUPERHEATER
150 PSIG SATURATED STEAM
50 PSIG SATURATED STEAM
28 PSIG SATURATED STEAM
L.P. BFW
BLOWDOWN FLASH TANK
VENT
2,200 LB/HR
TO COOLING TOWER HOTWELL
DEAERATING HEATER
STEAM TRACING
SPACE HEATING
DEMINERALIZED WATER
CONDENSATE SYSTEM LOSSES 0.25 %

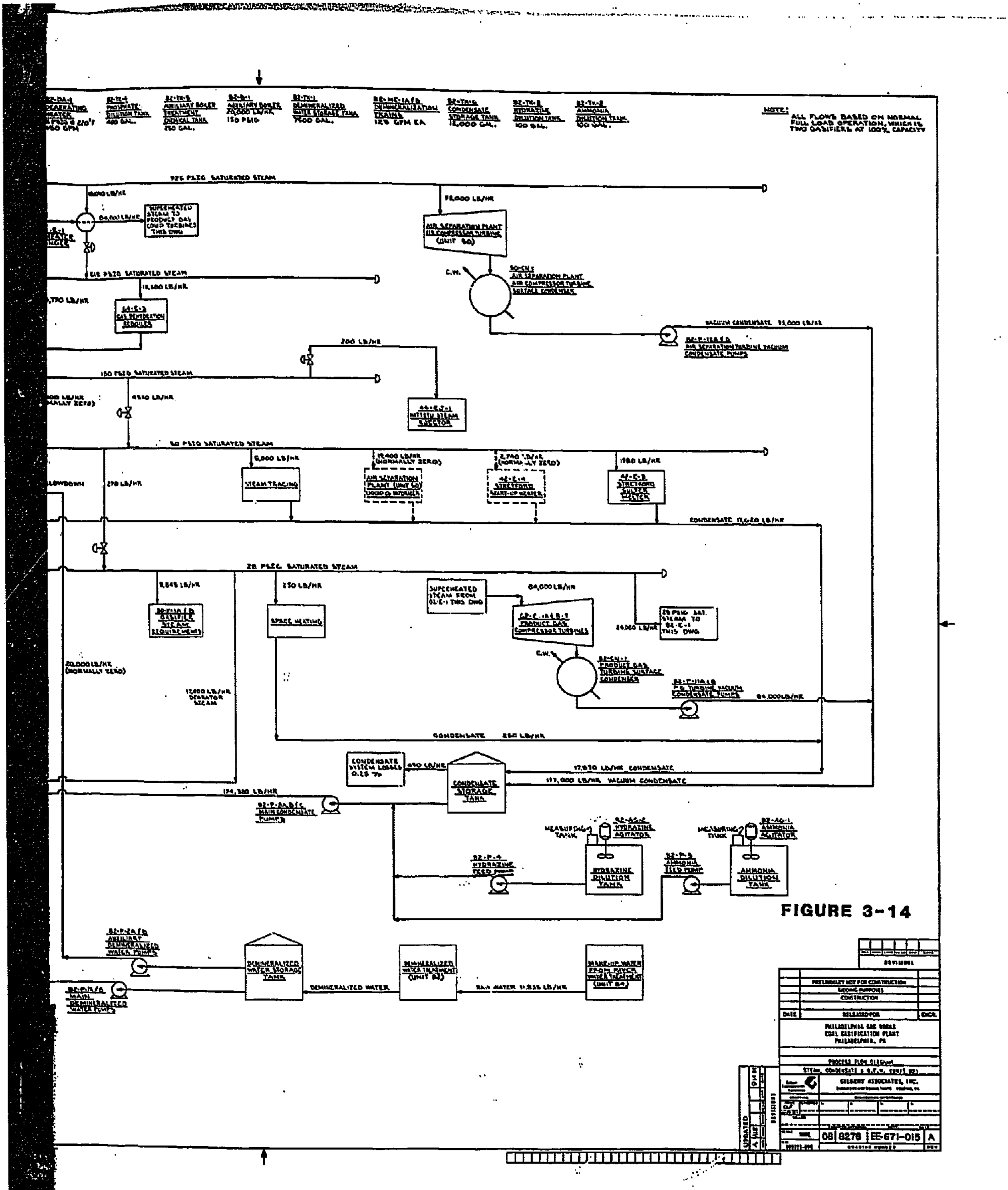

NOTE: ALL FLOWS BASED ON NORMAL FULL LOAD OPERATION, WHICH IS TWO GASIFIERS AT 100% CAPACITY
SATURATED STEAM
AIR SEPARATION PLANT AIR COMPRESSOR TURBINE (UNIT 50)
C.W.
150 PSIG SATURATED STEAM
50 PSIG SATURATED STEAM
STEAM TRACING
CONDENSATE
28 PSIG SATURATED STEAM
SPACE HEATING
SUPERHEATED STEAM FROM 82-E-1 THIS DWG
PRODUCT GAS COMPRESSOR TURBINES
CONDENSATE 250 LB/HR
CONDENSATE SYSTEM LOSSES 0.25 %
CONDENSATE STORAGE TANK
VACUUM CONDENSATE
MAIN CONDENSATE PUMPS
HYDRAZINE AGITATOR
MEASURING TANK
HYDRAZINE FEED PUMP
HYDRAZINE DILUTION TANK
AMMONIA AGITATOR
AMMONIA FEED PUMP
AMMONIA DILUTION TANK
AUXILIARY DEMINERALIZED WATER PUMPS
DEMINERALIZED WATER STORAGE TANK
DEMINERALIZED WATER
DEMINERALIZED WATER TREATMENT (UNIT 83)
RAW WATER
MAKE-UP WATER FROM RIVER WATER TREATMENT (UNIT 84)
MAIN DEMINERALIZED WATER PUMPS
PHILADELPHIA GAS WORKS COAL GASIFICATION PLANT PHILADELPHIA, PA
GILBERT ASSOCIATES, INC.
08 8276 EE-671-015 A

FIGURE 3-14

compression and let down to supply intermediate pressure steam at 515 psig, 100 psig, and 50 psig levels for process users. The auxiliary boiler, generating 150 psig steam, supplements lower steam levels as required.

H.P. saturated steam at 925 psig and 537°F is generated in the gasifier waste heat boiler. Over 80 percent of the H.P. steam is fed to the air separation plant air compressor turbine. The remaining H.P. steam is let down to intermediate pressure levels. The 515 psig steam is used in the product gas dehydration reboiler and the 100 psig steam is used in the Nittetu steam ejector. The 50 psig steam is used in the Stretford sulfur melter, for steam tracing, and intermittently for the Stretford start-up heater. Gas dehydration reboiler condensate is de-pressurized in a flash drum to recover approximately 20 percent of the condensate flow as steam, at the 50 psig level. Intermediate steam pressure levels of 100 psig and less are supplemented as necessary by steam generated in the auxiliary boiler.

Low pressure saturated steam at 28 psig and 272°F is generated in the gasifier jacket. About 8 percent of the L.P. steam is utilized as reactant steam in the gasification process and about 16 percent is utilized in the deaerating heater. A small portion of the L.P. steam is used for space heating; however, the majority of the L.P. steam, approximately 75 percent, is used to power the product gas compressor turbines. The 28 psig steam is superheated in a heat exchanger before being delivered to the gas compressor turbines (net of 25 psig to compressor turbines).

Under normal operating conditions, 85 percent or more of the total steam generated is returned as condensate for boiler feedwater. Condensate pumps are provided at the condensers for both the product gas compressor turbines and the air separation plant compressor turbines to convey condensate to the condensate storage tank. Three 50 percent capacity main condensate pumps convey condensate to the deaerating heater. Cycle losses are made up by demineralized water fed from the demineralized water storage tank.

Makeup water for boiler feedwater is treated Delaware River water which has been screened, clarified, filtered and demineralized. Two 50 percent demineralizer trains each consisting of a carbon filter, cation exchanger, and anion exchanger are provided. One train normally operates, while the second is being regenerated and placed in the standby mode. With 85 percent of the total generated steam returned as condensate, one demineralizer train operates at approximately 25 percent capacity. The demineralizer trains are sized such that in emergencies, when contaminated condensate is dumped, all boiler feedwater for one gasifier unit can be supplied by demineralized makeup water utilizing both trains. Near zero solids water quality is specified for gasifier steam generation and dictates the BFW treatment philosophy for pH control and oxygen scavenging. Chemical feed systems are provided to feed ammonia solution for pH control and hydrazine solution for oxygen scavenging. An emergency phosphate solution feed system is provided in the event of BFW contamination.

For maximum flexibility, especially during weekend operation, three 50 percent capacity L.P. boiler feedwater pumps and three 50 percent capacity H.P. boiler feedwater pumps are provided to convey boiler feedwater to the respective L.P. and H.P. steam drums in the gasifier units.

3.9.4 Other Plant Utility Support Systems

3.9.4.1 Firewater System (Unit 83)

A separate fire water protection system is provided for the gasification facility. The fire protection system consists of two fire water pumps (One electric driven and one diesel driven), a fire water jockey pump, a fire water storage tank, and an underground piping loop serving fire hydrants around each major plant facilities.

During normal operation, river water is the primary source of supply to the system. A diesel driven booster pump, taking suction from a 35,000 gallon storage tank, represents an auxiliary source of fire protection. The storage tank is fed from the city main. The fire water system pressure is maintained at a minimum of 125 psig by the fire water jockey pump.

3.9.4.2 Plant and Instrument Air (Unit 85)

The gasification plant requires instrument air, plant air and a supply of nitrogen for purging equipment.

During normal operation, utility air compressors supply air at 125 psig for plant and instrument air services. The air dried to a dew point of -40°F in a fully automatic desiccant type dryer.

3.9.4.3 Sewer and Sanitary Drains (Unit 86)

Sanitary sewer wastes from the gasification facility will be directed to the City of Philadelphia sanitary sewer system. In addition, excess gasification wash water (net condensate) from the Wash Water Treatment Unit (72) will also be discharged into the Philadelphia sanitary sewer system for treatment, in lieu of on-site biological treatment. The normal excess wash water flowrate is 72 gpm, while the design flowrate is 150 gpm.

Tie-in into the Philadelphia sanitary sewer system for the Riverside site shall be at Beach Street in accordance with the city regulations. A flow monitor and sampling chamber shall be constructed for the excess wash water stream in accordance to city regulations.

Storm water from the gasification facility will normally be discharged directly into the Delaware River. Storm drainage shall be diverted around coal and ash pile storage areas to prevent it from being contaminated.

Storm drainage from the process area, where the potential exists for chemical leaks or spills, shall be routed to a runoff monitoring pond before discharge. A valve shall be provided in the pond discharge line to be closed if an accidental leak or spill is detected.

3.9.4.4 Auxiliary Steam Generation (Unit 87)

A 20,000 lb per hour water-tube package boiler is provided for back-up steam generating capacity for the gasification facility. The boiler will not normally operate but will provide 150 psig saturated steam for steam tracing, space heating, and other critical services during plant shutdowns, start-ups, or turndowns. The boiler is designed to accommodate the firing of either medium-Btu producer gas, if available, or fuel oil. Fuel oil will be used during start-up or shutdown when medium- Btu gas is not available.

3.9.5 Plant Offsite Support Systems

3.9.5.1 Main Process Flare and Relief (Unit 91)

A main process flare and relief system is required for the gasification plant to vent medium-Btu gas during emergency shutdowns. The process flare is also required to vent producer gas during reduced consumer demand periods. The amount of producer gas vented can be minimized, however, by maintaining good communication between the gasification plant and the consumers. Normally, the gasification plant is turned down prior to an anticipated consumer producer gas cut-back.

The main process will be sized to accommodate a total plant emergency shutdown at the 20 billion Btu per day rate. The main process flare system includes the following items:

a. Flare stack,
b. Guyed supports,
c. Flare burner tip and flare stack alloy section,
d. Burner ancilliaries such as pilot and ignitor tubes,
e. Flame front generator panel for pilot ignition,
f. Molecular seal to prevent air diffusion back into the flare system, and
g. Flare knock-out drum and pump for condensate collection.

A minimum diameter flare stack of 30 inches is required to accommodate a total gasification plant blowdown. The flare stack for the GKT plant is elevated 50 feet above grade to minimize the danger of high heat radiation from the flare flame to personnel in the area. The high flare elevation also aids the dispersion of combustion gases into the atmosphere. The diameter of the safety circle (440 Btu per hour per ft^2 radiation intensity) for a 20 billion Btu per day flame would be approximately 280 feet. Outside the safety circle gasification plant personnel could remain for an indefinite period during a major plant blowdown without any heat radiation discomfort.

Relief headers to the flare system are provided at several points within the gasification plant. The following relief headers are recommended for the gasification facility:

a. Upstream of GKT gas holders,
b. Downstream of GKT gas holders,
c. Downstream of Stretford Desulfurization Unit, and
d. Producer gas line exiting battery limits.

For the flare stack a molecular seal installed immediately below the flare tip is recommended to prevent atmospheric air from entering the flare stack. The use of a molecular seal also reduces the amount of nitrogen required for stack purging.

3.9.5.2 Fly Ash Removal and Storage (Unit 92)

The main purpose of the fly ash removal system is to remove fly ash sludge generated in the Wash Water Treatment Unit, on a continuous basis. The 50 percent moisture fly ash cake discharged from the rotary vacuum filters is conveyed to the coal feed pulverizer for recycle or to a temporary storage enclosure for disposal. The conveying system is designed to recycle a maximum of 50 percent of the fly ash cake to the coal pulverizers. If the cake is not recycled, the total fly ash produced is conveyed to storage.

The amount and composition of fly ash discharged from the gasification plant via Unit 92 is shown below for the non- recycle and the 50 percent recycle cases:

	Non-Recycle Case	50% Recycle Case
Flowrate, tpd	345	202
Composition, Wt. percent		
Carbon	30.93	26.46
Ash	19.07	23.54
Water	50.00	50.00

One fly ash conveying system is required to serve both gasifiers. Both rotary vacuum filters discharge fly ash cake onto a belt conveyor which elevates the material to a material divider. One stream is directed to a covered enclosure for storage and the other stream is directed for recycle to the coal pulverizer. The recycle system comprises five belt conveyors. The storage system comprises four belt conveyors and a tripper, they are integrated together to allow material to be deposited on a selective basis, over the entire plant area of the enclosure.

In the storage system, the fly ash material will be removed by a front end loader. The front end loader transfers the material onto a belt conveyor which conveys the material to a truck/railcar loader station outside the building. The belt conveyor elevates the fly ash and discharges into a surge hopper outside the building above the rail tracks, for rail or truck removal. The hopper discharges by means of rotary feed valve.

3.9.5.3 Slag Removal and Storage (Unit 94)

The main purpose of the slag conveying and storage system is to remove, on a continuous basis, slag produced by the GKT gasification unit. The slag is transported from the GKT unit to a slag storage enclosure. Subsequently, the slag is removed from this enclosure on a batch basis and deposited in either a truck or railcar. The amount of slag generated varies with the fly ash recycle rate; it is 33 tpd at 0 percent recycle and 48 tpd at 50 percent recycle, respectively. The gasification slag has the following characteristics:

Bulk Density, lb/ft.^{3}	75
Moisture Content, Wt%	15
Maximum Particle Size, in.	1/4

One slag conveying system is required to serve both gasifiers.

Each gasifier will discharge slag onto a belt conveyor. The material, carried by these two conveyors, operating in parallel, is deposited onto a common conveying system which eventually discharges into a covered storage enclosure. The common conveying system comprises four belt conveyors and a tripper. They are integrated together to allow material to be deposited, on a selective basis, over the entire plan area of the enclosure.

The slag material will be removed from storage by a front end loader. The front end loader discharges the slag onto a belt conveyor. The belt conveyor then feeds a screw conveyor by means of a transfer chute. The screw conveyor transfers slag into a surge hopper above the rail tracks for rail or truck removal.

3.10 LABOR, RAW MATERIALS, AND UTILITY REQUIREMENTS

Summarized in Table 3-5 is the labor, raw materials, and utility requirements for the operation of the PGW coal gasification plant. The operating labor requirement is based on the estimates shown in Table 3-6 for each individual unit or area.

TABLE 3-5

ANNUAL RAW MATERIALS, UTILITY, LABOR, AND BY-PRODUCT SUMMARY(1)

(PGW Coal Gasification Plant, 20.58 x 10^9 Btu/day)

On-Stream Factor	0.8
Raw Materials	
As Received Coal	329,376 ton/year
Stretford Chemicals(2)	104,420 lb/year
Electricity	136,761 MWhr/year
Water(3)	
City Water	3.212 MM gal/year
River Water Consumed	308.732 MM gal/year
Sanitary Sewer Discharge	34.106 MM gal/year
River Water Used and Returned	101.120 MM gal/year
Steam	None
Operating Labor	14 men/shift 3 shifts/day plus 3 men/shift 1 shift/day
By-Products(4)	
Slag	14,016 ton/year
Fly Ash	58,984 ton/year
Molten Sulfur	7,972 ton/year

Notes:

(1) 50% fly ash recycle case

(2) Stretford chemicals at $6.45/lb. Approximately ten additional utility chemicals are required for treatment of makeup water, cooling water, boiler feedwater and wastewater at an annual cost of $482,000.

(3)

City Water	$1.05/1000 gallons
River Water consumed	$0.06/1000 gallons
Sanitary Sewer Discharge	$0.60/1000 gallons
River Water Used and Returned	$0.0006/1000 gallons

(4)

Slag and fly ash disposal cost at	$4-6/ton
Saleable molten sulfur credit at	$110-125/ton

TABLE 3-6

OPERATING LABOR REQUIREMENTS

(PGW Coal Gasification Plant, 20.58 x 10^9 Btu/day)

	Men/Shift	Shifts/Day
Coal Handling	3	1
Coal Preparation	1	3
GKT Gasification	5	3
Oxygen Plant	2	3
Stretford & Nittetu Incineration	1	3
Gas Compression & Dehydration	1	3
Water Treatment	1	3
Utilities	1	3
Auxiliary Boiler	1	3
Offsites - ash & slag handling	1	3

4.0 PLANT DESIGN

This section provides on overall description of the plant design and the operational characteristics of systems and equipment. For reference, design drawings are provided in Appendices D through G, and the equipment list is provided in Appendix J.

4.1 PLANT DESCRIPTION

The PGW Coal Gasification Plant is to be located on the Riverside Industrial Tract along the Delware River in Philadelphia. The plant will process 1,128 tons per day of bituminous coal and will produce approximately 20 billion Btu per day of fuel gas having a higher heating value of 290 Btu per standard cubic foot.

The coal will be delivered by unit train to the Port Richmond Coal Yard and into the plant via in-plant locomotion. The coal will then be pulverized, dried, and fed to the GKT Gasification Process in which it is entrained with steam and oxygen. The gas that is produced will pass through clean-up steps to remove both particulates and hydrogen sulfide. The clean gas will be compressed to 35 psig and dehydrated for distribution to industrial users of the gas.

The plant is designed to be environmentally acceptable. The process produces no phenols or tars, and waste water is either treated for discharge to the river or is acceptable for discharge to the Philadelphia sewer system. Solid waste from the plant, such as ash, will be landfilled, and pure molten sulfur will be marketed as a commodity.

The gas produced by the plant will be distributed via a dedicated distribution system to four major industrial recipients. It is their intent to burn the gas as a boiler fuel, displacing No. 6 fuel oil.

4.1.1 **Risk Assessment**

4.1.1.1 Technological Risk

As stated previously, process selection criteria for this project was based upon the requirement to use commercially proven processes. As described in Section 1.3.4, the GKT gasification process and the Stretford desulfurization process are commercial processes that meet these criteria. Second generation processes were avoided for this project as were any support systems that could be considered unconventional or unproven.

It is anticipated that operational performance will be guaranteed by process and equipment suppliers. The terms and conditions of process guarantees differ, but they are generally sufficient to minimize technological risk. The oxygen plant and desulfurization processes are assured of performance based upon past experience and established technology applied to an operating specification.

The heat and material balance provided by GKT for this project were based upon an analytical evaluation of gasifier performance using the coal analysis provided. The model used in that analysis was derived from GKT operating experience. Upon initiating detailed design, a commercial scale test will be conducted, using the coal selected by PGW. The results of that test will serve as the basis for final plant design and level of gasifier production to be guaranteed by GKT.

4.1.1.2 Plant Availability

In designing the plant for baseload operation, it is recognized that all systems are to be operational or will not interfere with continuous plant operation. It is further recognized that the complexity of the process and the interdependence of the various systems, unless addressed, can lead to significant down time because of minor mechanical interruptions. For this reason, a sparing philosophy was incorporated into the plant design that ensures maximum availability.

Plant sparing was incorporated into the design beyond the gasification system and the oxygen plant (these items are discussed later in this section). The approach taken was to ensure continuous availability of equipment relevant to the production of the product gas. The following is a brief discussion of the levels or redundancy in each process area. More detailed discussion is provided in Section 4.3.

- Coal Handling - Minimum redundance required as system is used for single shift operation only.
- Coal Pulverization - Dual pulverizers rated at 95 percent availability. Provisions in budget for third pulverizer pending more detailed review.
- Pulverized Coal Conveying - Standby coal pumps on all trains.
- Stretford Desulfurization - Centrifugal booster compressor is duplicated. All pumps in this system that circulate Stretford solution are duplicated. Liquid sulfur pump is duplicated.
- Gas Compression - Two steam-driven compressors for normal plant operation; third electrically-driven unit for standby.
- Wastewater Treatment - All major pumps are duplicated.
- Plant Water System - Supply pumps and inlet screen are duplicated. Water circulation and main treatment pumps are duplicated. Boiler feed and condensate pumps are duplicated.
- Plant Air System - Compressor and filter are duplicated.

Redundant electrical power is provided by three lines from Philadelphia Electric Co. Twenty-four hour load can be maintained with the loss of one line. This is discussed in more detail in Section 4.4.

The GKT Gasification Process is a dual train process that is not redundant. The process can be expected to have 95 percent availability with periodic maintenance on weekends and a 20 to 30 day annual turnaround. The process is designed for continuous feedstock-type operation and has demonstrated commercial operation on that level.

The oxygen plant is considered to be a state-of-the-art design with availability approaching 98 percent. The plant is comprised of dual train cold boxes and a back-up capability of 24 hours production with one stream down, 12 hours production with total plant shut-down.

In summary, the plant has been designed to permit the highest possible availability short of total redundance. Accordingly, an availability of 93 percent has been estimated for the plant.

4.1.2 Operational Considerations

The gasification plant is designed to operate as a baseload gas producer. However, the use rate of the customers is expected to vary from 100 percent during the week to 50 percent on weekends. The plant is designed to follow the load by a combination of pressure control, gas holder volume, and gasifier production. The control methodology is discussed throughout Section 4.3 and in Section 4.4.6.

The gasifier is capable of turndown to 70 percent of capacity within a few minutes. Shut-down of one gasifier and turndown of the active gasifier would result in plant turndown to 35 percent, if required.

Restart of a gasifier that has been kept hot by the start-up burner will take about 30 minutes. Restart of a cold gasifier takes about 10 hours. It is expected that weekend shut-downs of one gasifier will be to a "keep hot" condition, and every three months, cold shut-down for routine boiler maintenance.

4.2 SITE WORK

4.2.1 Site Preparation

4.2.1.1 Geotechnical

The site is underlain with old shipyard facilities and rubble fill. The conditions at any specific location are unknown and are expected to be extremely variable. Since a comprehensive subsurface investigation was not made, certain assumptions were made so the foundations could be designed.

Pile foundations were considered unacceptable because of the buried structures and rubble fill. Therefore, the method used involved over-excavating; that is, removing all the rubble and existing structures to a depth of five feet below the bottoms of all the new structures and five feet on all sides, then backfilling with clean, select fill. The fill would be compacted to provide a firm bearing surface. The foundations were all sized to create a relatively low, 2,000 pounds per square foot, maximum bearing pressure at the bottom surface of the foundation. Because of the over-excavation, this pressure will be distributed over a larger area, creating a much smaller surcharge on the existing soil or fill. It was assumed that the underlying material can carry this low surcharge.

4.2.1.2 Site Improvements

The site improvements, grading, roads, drainage, and fencing were provided to create a functional and safe facility. Paved roads were provided to all the areas of the facility to discourage traffic from going through the areas of outdoor, grade- supported equipment. Grading and drainage were provided to keep the equipment areas dry and carry the runoff to the Delaware River for disposal. Fencing was provided around the perimeter of the site, except along the river, to keep unauthorized people from entering the facility. The fencing was used for both security and safety considerations.

4.2.2 Structural Design

4.2.2.1 Scope

The architectural and structural design work involved a large variety of buildings and structures. Each one was designed specifically for the equipment or process for which the construction was provided. The design philosophy centered on providing buildings and structures that in every way met the requirements of the process, were economical, occupied a minimum area of the site, and met the various building and safety codes.

4.2.2.2 Codes

The City of Philadelphia Building Code has jurisdiction at the site and controlled the design of each part of the architectural an structural work. Generally, the Code specifies the loads, materials, tests, and methods of construction. Additionally, the Code classifies the occupancy, use, and type of construction which all have an effect, architecturally, on details, exits and general layout of the buildings. As required by the Code, all steel design conforms to the "Specifications for the Design, Fabrication and Erection for Structural Steel Buildings" of the AISC. The masonry construction conforms to USA Standard A41.1 "Building Code Requirements for Masonry" except as modified by the Code, and the reinforced concrete design conforms to the ACI standard 318 "Building Code Requirements for Reinforced Concrete," also modified in the Code.

All the codes and standards were used to provide the minimum design requirements. Based on engineering judgement and good practice, some of the minimum requirements were exceeded to provide an extra measure of safety, durability, or servicability. The intent was to provide a design that meets or exceeds the codes, helps to provide a dependable plant and is reasonably economical to construct.

4.2.2.3 Concrete Structures

The underground structures, such as the coal dumper, coal reclaim and various water treating basins and sumps, were designed using the principles of concrete sanitary structures since they either contain water or must prevent water from entering. Lower allowable streses were used for these structures and special attention was given to details. Basically, these principles reduce cracking and extend the service life of the structure.

The concrete structures at "grade," such as equipment and building foundations were designed using the Strength Design Method, which includes load factors and strength reduction factors to obtain the most economical amounts of concrete and reinforcement.

4.2.2.4 Steel Buildings and Structures

The steel structures were designed using the Working Stress Method, which provides an economical design and results in fast, simple construction. All the connections were simple; that is, hinged, which allowed rapid design and also allows future changes to be made to parts of the structure without affecting the entire design. Horizontal loads, primarily wind, were carried to the foundations using cross-bracing, a time-proven, simple method. The two exceptions to this method were the pipe bridge and the gasification structure. For the pipe bridge, it was considered important to keep the ground area as clear as possible. For the gasification structure there was inadequate space for bracing because of the equipment and piping throughout the structure. Both of these structures used the more expensive "moment" connections and frame analysis.

4.2.2.5 Administration Building

The Administration Building was designed to provide a comfortable work environment for the plant superintendent and his administrative staff. A conference room, infirmary, and restrooms were included to provide a complete administrative center. Materials were selected to present a pleasing appearance, have low maintenance costs and provide a long service life.

4.2.2.6 Pre-Engineered Buildings

Pre-engineered buildings were used for the warehouse and the maintenance garage. Since neither of these buildings contain process equipment that requires a specific shaped enclosure or any equipment supported by the structure, they lend themselves to the less expensive "package" building.

4.3 PROCESS EQUIPMENT

4.3.1 Coal Receiving and Handling (Unit 10)

4.3.1.1 Coal Delivery to the Facility

From the standpoint of economics, the unit train concept has been selected as the delivery mode for obtaining coal for gasification. The coal receiving configuration, therefore, has been designed to be compatible with the Conrail unit train approach.

Coal will be delivered to the Gasification Facility by utilization of a 7,000 short ton unit train. This quantity represents, approximately, a six to seven day supply of coal based on the projected maximum plant usage. The 7,000 short ton unit train is the smallest unit train that Conrail can deliver, from an economic standpoint.

Because of the physical restrictions of the plant site, the unit train will have to be broken up into four sections. Assuming that the train is made up of 70 to 100 short ton cars, it will take two days to unload the coal shipment. The unit train will be brought into the Conrail switching yard adjacent to the gasification plant property. Conrail will then split the unit train into two 35-car sections. Conrail personnel will transfer the first 35-car section on to the Gasification Plant Property.

The car transfer activity by Conrail must be limited to one eight-hour shift per day. Therefore, Conrail must deliver each 35-car section of the train and retrieve the empty cars in that eight-hour shift. On the second day, Conrail will deliver and retrieve the second 35-car section of the unit train.

The on-site track layout can be seen on Drawing EE-071-001 (Appendix D). Two parallel tracks have been provided for car unloading with a switch at the northern boundary of the plant property. Conrail will move a 35-car section to the first switch. An engine, owned by the gasification plant, will link up with the first 18 of the 35 cars and pull them down the track until the last car is spotted in the thaw shed. The engine will then return to pick up the second 17 car section of Conrail's 35-car split train, utilizing the second track and a switch provided at the southern terminal of the track.

Conrail will locate the second segment of the 35-car section at the switch located at the property northern boundary so that the plant engine can transfer the remaining 17 cars. The plant engine will pull the 17 cars down the second track until the last car is spotted in the thaw shed.

Two hours have been allocated to spot the 35-car section in the plant for unloading. A time span of four hours has been allocated for the unloading all the cars. The final two hours of the eight hour Conrail shift has been allocated to transfer the empty cars back to the Conrail switching yard. The procedure for returning the cars to Conrail is the reverse, in sequence, of the method utilized to deliver the cars for unloading. Space has been allocated for an extra car on the west track (19 cars) to allow for a slightly greater train section length when smaller cars (less than 100 short ton capacity) are used by Conrail. On the second day, the entire unloading sequence is repeated.

4.3.1.2 Coal Unloading

After the cars have been spotted, the unloading procedure begins. Each day, for the two day operation, 3,500 short tons of coal must be thawed (only when frozen), unloaded and conveyed to the storage pile. As previously stated, the unloading sequence must be accomplished in four hours.

The plant engine will be utilized to spot each car over the unloading hoppers. The engine will push the cars. A double track thaw shed has been provided to achieve this mode of operation. A second option was considered for car spotting; that was the use of two hydraulic car spotters to move the cars to the unloading position (one for each track). This concept was rejected, since the double track thaw shed would still have to be used, the project capital cost would be significantly increased and the utilization of the plant engine would be significantly diminished.

Radiant heaters, within the thaw shed, will be used to thaw frozen coal contained in each car. The thawing system is designed to thaw one car every seven minutes.

Each car will be positioned over the unloading hoppers shown on Drawing EE-071-002 (Appendix D). The car hoppers will be opened and car shakers (10-ME-1A and B) will insure that all coal is removed from each car. Each track is provided with four hopper compartments whose combined storage capacity is 100 short tons. Each hopper compartment is provided with a shut-off gate (10-ME-3A through H) and vibrating feeder (10-ME-4A through H). The vibrating feeders discharge to belt conveyors (10-CV-1 and 2) and have a capacity of 250 short tons per hour each. Two sets of four-compartment hoppers were designed because of:

a. A need for two tracks to store 35 cars at the site, and
b. A time limitation to empty the cars (4 hours).

The four-compartment design was utilized because of:

a. A need to cover the entire span of the car for unloading;
b. Limiting the depth of excavation for the reclaim tunnel; and
c. Removing coal from the hoppers at a fast rate.

Conveyors 10-CV-1 and 2 discharge to conveyor 10-CV-3. All three conveyors (10-CV-1, 2 and 3) have a maximum capacity of 1,000 short tons per hour, based on the unloading time restriction. Conveyors 10-CV-1 and 2 are not used simultaneously. All cars on one track are sequentially unloaded before the cars on the second track are unloaded. There is no redundancy in the conveyor design (parallel set of conveyors), since the conveying system is only used eight hours per week (approximately) and sufficient time would be available for preventative maintenance to assure conveyor availability and reliability.

Located along conveyor 10-CV-3, just before it emerges from the reclaim tunnel, is an electronic weigh scale (10-SC-1) which will indicate and totalize the coal going to the storage pile (read-out in main control room).

Located near the head pulley of conveyor 10-CV-3 is a tramp iron magnet (10-TM-1), which will remove tramp iron from the coal stream before it is stored in the pile.

Conveyor 10-CV-3 discharges to a lowering well (10-ME-5) as shown on Drawing EE-071-003 (Appendix D). The lowering well concept was utilized in the design because of:

a. The relatively low cost compared to other concepts;
b. The relatively low maintenance costs compared to other concepts; and
c. Its relative compactness with respect to retrieval of coal.

The lowering well, a vertical concrete cylinder with windows cut in its surface, will form a conical pile around it as the coal from conveyor 10-CV-3 fills it and the coal cascades out of the windows. The lowering well is at the southern end of a 65,000 short ton coal storage pile and represents the "live storage" segment of the pile (10,000 short tons). The balance of the pile is "dead storage" and will act as a buffer in case the scheduled coal shipments are interrupted (55,000 short tons representing 45 days of gas plant maximum production).

Three vibrating discharge hoppers (10-ME-6A through C) will retrieve coal from the "live storage" section of the storage pile. One hopper is located at the bottom of the lowering well. The other two hoppers are outside the lowering well, flanking it and at close proximity. Coal is drawn out of the lowering well first. When that supply is exhausted, the other two hoppers are used, drawing down the conical pile built up by the lowering well. Coal supply is replenished to the two outside hoppers by a bulldozer. The bulldozer, in one-eight hour shift per day, can pile enough coal over the hoppers to satisify the gasification plant maximum daily production.

Each vibrating hopper has a shut-off gate (10-ME-7A through C). The vibrating hoppers discharge to vibrating feeders (10-ME-8A through C). Only one vibrating feeder is used at a time.

Vibrating feeders (10-ME-8A through C) discharge to a transfer conveyor (10-CV-4) which has a nominal capacity of 200 short tons per hour. The conveyor, therefore, will operate six hours per day to meet plant demand at maximum gas output. Two hours are left, during an eight-hour shift, to start the conveying system and to perform daily preventative maintenance.

Conveyor 10-CV-4 discharges to conveyor 10-CV-5 at a transfer tower (See Drawings EE-071-003 and 004, Appendix D). Within the transfer tower structure, a tramp iron magnet (10-TM-2), a coal sampling assembly and a delumper are housed.

The tramp iron magnet will remove all steel from the coal stream. The coal sampling assembly will be utilized to analyze the coal, on a periodic basis, to adjust the coal feed quantity to the gasifiers and to inform the coal supplier of any deviation from the contract specification for the coal.

A Bifurcated chute is utilized to transfer coal from conveyor 10-CV-4 to conveyor 10-CV-5. One leg of the chute discharges directly to conveyor 10-CV-5. The second leg discharges to a de-lumper (10-CR-1). Should the coal be frozen, the de-lumper will reduce the coal size back to its original dimensions, 2-inches by 0-inch, and then discharge to conveyor 10-CV-5.

Conveyor 10-CV-5, having a nominal capacity of 200 short tons per hour (same as 10-CV-4), discharges to two - 600 short ton capacity coal bunkers, as shown on Drawing EE-071-005 (Appendix D). A tripper (10-TR-1), traversing the terminal of conveyor 10-CV-5 over the bunkers, discharges coal to the bunkers through slotted openings in the concrete floor above the bunkers.

There is no redundancy provided in the equipment from conveyor 10-CV-4 (originating at coal pile reclaim tunnel) through conveyor 10-CV-5 and its tripper, since the system is used only six hours per day.

4.3.1.3 Dust Suppression for Coal Receiving and Handling (Unit 15)

The dust suppression systems for the coal receiving, storage, and handling activities at the Gasification Facility can be generalized into the following catagories:

a. Fluid (Wetting) suppression systems;
b. Dry (bag type) collection systems; and
c. Air control (ventilation) systems.

a. Fluid (Wetting) Suppression Systems

Two fluid dust suppression systems will be provided: coal receiving and handling; and pile storage.

(1) A heated enclosure will be provided to house the dust suppression equipment for the coal receiving and handling areas. The enclosure will house all pumps, proportioning equipment, valves, and controls required to distribute the wetting fluid to the dust generating points in the coal receiving and handling areas. In the enclosure, a surfactant compound is proportionately mixed with pre-filtered water and pumped, via a network of distribution piping, to key points where controlled spraying nozzles are positioned.

Sprays will be located over the coal cars in the track unloading area, activated locally by the operator when the car unloading activity begins. The operator will de-activate the sprays, periodically, while successive cars are indexed into position for unloading.

Sprays will be located at the top of each unloading hopper (eight hoppers) just under the grating, to control dust generation. The sprays will be activated locally, by the operator, and left on until the entire unloading procedure is complete. Only the sprays on the track being utilized for unloading will be turned on.

Sprays will be located at each vibrating feeder transfer point (10-ME-4A through H). The sprays will be activated automatically when the vibrating feeder motors are started.

Sprays will be located at the transfer points of conveyors 10-CV-1 and 10-CV-2 where they discharge to conveyor 10-CV-3. The sprays will be activated automatically, receiving their signal from the current draw on the conveyor motors (activated when conveyors are started and coal loading is applied).

Sprays will be located at the head pulley of conveyor 10-CV-3 where it discharges to the lowering well. The sprays will also be activated by the conveyor motor current draw.

Sprays will be located at the discharge reclaim hopper vibrating feeders (10-ME-8A, B and C). The sprays will be activated automatically by the start of each vibrating feeder motor.

Sprays will be located at the head pulley of conveyor 10-CV-4 where it discharges to the de-lumper and de-lumper by-pass. Sprays will also be located at the feed point of conveyor 10-CV-5. All sprays will be activated automatically, receiving their signal from the conveyor motors current draw.

All flow controllers for the wetting systems will be weather protected and winterized by the use of local electric cartridge heaters. All weather exposed piping will be protected from freezing by the use of electrical tracing and lagged insulation.

(2) A heated enclosure will be provided to house the dust suppression equipment for the pile storage area. All (2)A heated enclosure will be provided to house the dust pumps, proportioning equipment, valves, and controls required to distribute the wetting fluid to the coal storage pile will be housed in the enclosure. The surfactant compound will be proportionally mixed with pre-filtered water and distributed to seven strategically placed points around the perimeter of the storage pile and four sprays attached to the top of the lowering well to coat the live portion of the storage pile.

The spray systems will coat both the dead storage portion of the storage pile and the live portion formed in a conical configuration around the lowering well.

Each spray zone (total of eight) are controlled individually and have both automatic and manual activation modes. Each spray zone can be activated manually by an operator in the central control room or locally, at each spray location. The normal mode of operation is automatic (for each zone).

Each spray zone will be activated by a timer, set to coat the storage pile every twenty minutes; however, each spray zone will also be activated by a wind velocity sensor set for twenty two miles per hour (32 feet per second), depending on which condition occurs first.

All flow controllers and distribution piping exposed to the weather will be electrically traced and covered with lagged insulation.

b. Dry (Bag Type) Collection Systems

(1) A bag collector (15-BF-1) will be provided at the transfer tower junction of conveyors 10-CV-4 and 10-CV-5. The bag collector will separate any dust generated at the conveyor transfer points and de-lumper and deposit the collected dust on the feed point of conveyor 10-CV-5.

(2) A bag collector (15-BF-3) will be provided at the operating floor above the two - 600 short ton coal storage bunkers. The space between the operating floor and the top of the bunkers will be air swept and directed to the inlet of the dust collector. The collector will deposit the collected coal dust into one of the bunkers. In case of fire, the dust collector fan is stopped automatically and the space over the coal bunkers is purged with nitrogen generated by the air reduction facility.

(3) Each bag collector is furnished with:

- CO_2 fire protection system;
- Explosion relief port;
- Class II, Division 1, Group F (explosion proof) Equipment;
- Isolation dampers;
- Internal heater for freeze protection;
- Broken bag detection;
- Automatic controls; and an
- Air handling package.

c. Air Control (Ventilation) Systems

Ventilation systems will be provided for:

- Coal unloading hopper and conveyor tunnel;

- Transfer tower; and
- Storage pile reclaim tunnel.

Air handling equipment has been provided to insure that all enclosed spaces have an air change every 10 minutes (six air changes per hour).

4.3.2 Coal Preparation and Conveying (Unit 20)

4.3.2.1 Coal Bunkers (20-TK-1A and B)

Two 600 short ton coal bunkers are provided to store 24 hours worth of coal feedstock for the gasifiers (1,200 short tons represents the daily coal requirements at maximum gas production). The bunker configuration is shown on drawing EE-071-005 (Appendix D).

A bifurcated chute is attached to tripper 10-TR-1, the mechanism used to fill the bunkers. The chute will traverse the bunkers and form two piles at the top of the bunkers, when full, to maximize bunker storage capability.

Each bunker is 25 ft 0 in. in diameter, has a 40 ft 6 in. high cylindrical segment and a 32 ft 0 in. high truncated cone segment at the bottom. The entire inner surface of each bunker is "Gunnite" coated for abrasion resistance.

Each bunker is supported on load cells, whose continual readout is displayed and monitored in the central control room. Both bunkers are used simultaneously; therefore, there are two weight indicators/recorders in the central control room.

An emergency chute is provided in each bunker, in the conical segment, to dump the bunker coal quickly if a fire is detected in a bunker (smoke and temperature sensors at each bunker).

Shutoff gates (20-ME-1 A and B), to isolate each bunker and vibrating feeder (20-ME-2 A and B), are provided in the design to meter coal to the pulverizers.

4.3.2.2 Coal Pulverization Systems

A general arrangement of the coal pulverization systems is depicted on Drawings EE-071-005 and EE-071-006 (Appendix D). The equipment configuration selected for the cost estimate is not exemplified on the equipment layout shown. The layout portrays three pulverizer assemblies, two of which operate in union to pulverize the quantity of coal required for maximum gas production, and the third assembly assigned to the standby mode. The configuration selected for the cost estimate is a two-pulverizer system with no standby. The reasons for selecting the two-pulverizer concept are:

a. A vendor warranty of 95 percent availability for the pulverizers, based on his past experience with his equipment and the availability factor of the gasifiers themselves;
b. A lower capital, installation and operational cost;
c. A less complex feed system to the pulverizers from the coal bunkers (direct feed from the bunkers to the pulverizers); and
d. A less complex control system for operating the pulverizers.

However, should unforseen circumstances dictate, in the detail design phase, that three Pulverizers be installed, a contingency has been inserted into the cost estimate to cover the implied cost. A description of the three-pulverizer operation will be undertaken, since the feed end is more involved, and, all equipment downstream of the pulverizers would be the same for both the two and three pulverizer options.

The two coal bunkers (20-TK-1A and B) have the capability of feeding three pulverizers. A diagramatic representation (flow diagram) of the process can be seen on Drawing EE-371-003 (Apprendix E).

Vibrating feeders (20ME-2A and B), one for each bunker, meter coal into bifuracated chutes. One leg of each chute transfers the coal directly to the operating pulverizers (20-PU-1A and B). The second leg of each chute is utilized to re-orient the coal flow when the third pulverizer assembly is used.

When Pulverizer 20-PU-1A is out of service, Screw Conveyor 20-CV-1A will transfer coal to Pulverizer 20-PU-1B and Screw Conveyor 20-CV-1B will transfer coal to the activated Pulverizer 20-PU-1C. When Pulverizer 20-PU-1B is out of service, Vibrating Feeder 20-ME-2A will feed coal directly to Pulverizer 20-PU-1A and Screw Conveyor 20-CV-1B will transfer coal to the activated Pulverizer 20-PU-1C.

Each Pulverizer assembly is identical and generally consists of:

a. A weighbelt feeder 20-PU-1(A, B, and C)-CV(A, B, and C);
b. A pug mill (for mixing coal with recycle ash) 20-PU-1(A, B, and C)-PM(A, B, and C);
c. A screw charger 20-PU-1(A, B, and C)-CV(A, B, and C);
d. A vertical roller mill pulverizer (20-PU-1A, B and C);
e. A combustion air fan 20-ME-8(A, B, and C)-F(A, B, and C); and
f. An air heater (20-ME-8A, B, and C).

The weighbelt feeder controls the coal feed to the Pulverizer. It insures that the Pulverizer is not overfed and can vary the coal feed quantity to follow plant gas output variations.

The pug mill is utilized to mix the coal feed from the bunkers with the recycled ash from the gas production facility (see Section 4.3.8.6).

The screw charger is utilized to plugfeed the pulverizer and has variable diameter screw flights to compact the conveyed material so that blow-back from the pressurized pulverizing chamber is minimized.

The pulverizer is a vertical machine, having rollers arranged in a radial configuration around its perimeter. The coal and recycled ash are ground, mostly by the attrition of the material against itself (when trapped between the revolving rollers), and partially by the rollers. This type of machine was selected for the project because:

a. The wear on machine parts (maintenance and downtime costs) is minimized compared to other types of vertical type ball and hammer mills, and

b. Product costs and contamination associated with the constant feed of steel balls to a horizontal ball mill do not exist.

The pulverized coal is dried and swept out of the pulverizer by a stream of hot gas which enters at the bottom of the machine and exits at the top. A heater and combustion air fan are provided to elevate the temperature of the conveying gas to perform the drying function. Normally, the heater is fired by product gas from the process; however, at start-up and during emergencies, fuel oil is provided for the gas heating requirement. The heat input to the pulverizer is controlled by the gas exit temperature. The design gas exit temperature is nominally 600°F. The exit gas temperature cannot exceed this limit, since it would cause damage to the pulverized coal separation equipment and severely affect the gas temperature balance of the system.

Two bagtype coal dust separators (20-BF-1A and B) are provided to separate the pulverized coal from its conveying gas. It shall be noted that the two and three pulverizer options become identical at this point. A series of ductwork interconnections and isolation valves (as seen on Drawing EE-371-006, Appendix E) provide the option of directing the gas flow from the three pulverizers to two coal dust separators. It is at this point that the coal handling and conveying system is split into two equal and parallel trains.

The pulverized coal is separated from the gas stream at the bag-type collectors. The coal drops to the bottom hoppers of the collectors and is directed, via rotary and "double dump" valves to isolate interconnecting equipment, to the pulverized coal storage bins (20TK-2A and B), which offer temporary surge capacity for fluctuating coal demand (30 minutes or 12 1/2 short tons per bin).

The coal dust separators, as well as the surge bins and connecting piping, are constantly pressurized with nitrogen to prohibit air from entering the system. Also, the pulse system used in the dust separators to knock the coal dust from the bags utilizes pressured nitrogen from the air separation facility.

The gas leaving the dust separators is then split into two streams. Approximately 83 percent of the gas is recirculated to the system, 73 percent to the gas heater and 10 percent to the pulverizer seals. Recirculating fans (20-FA-1A and B) are used to recycle the gas to the heaters and pulverizers. The gas recirculation to the heaters has a three-fold purpose:

a. To provide conveying pressure for the pulverizer gases;
b. To control gas temperature to and from the pulverizers; and
c. To minimize pollution from coal dust sub-particulate passing through the bags in the coal dust separators.

The remaining 17 percent of the gases exiting the coal dust separators is vented to atmosphere. Dampers (20-DP-1A and B and 20-DP-3A and B), upstream of the recirculating fans, are provided for this purpose. The dampers are automatically modulated, their control coming from the exit temperature of the pulverizers (moisture content of the coal and ash).

The pulverized coal surge bins are supported on weigh cells which constantly monitor the quantity of coal in the bins. Indication of coal stock in the bins is shown in the central control room, monitored by the operator. Also, as stated previously, the weigh feeders metering coal to the pulverizers can be controlled by the rate of change of coal stock in the surge bins.

Nitrogen from the air separation plant is utilized for purging the pulverization system at start-up or during normal and emergency shut-down situations.

4.3.2.3 Pulverized Coal Conveying Systems

At the bottom of the pulverized coal surge bins (20-TK-2A and B), rotary feed valves (20-RT-2A and B) meter the pulverized coal to the pumps which transfer the coal to the gasification facility (Unit 30). The purpose of the rotary valves is two-fold:

a. To seal the conveying system from the surge bins, and
b. To control the flow of coal to the system.

The rotary feed valves are driven by a variable speed drives. When the plant output varies, the operator in the central control room can proportion the coal feed rate to the changes in gas output (speed indicator/regulator in the control room). However, the rotary feed valves will be stopped automatically if the storage bins in the gasifier area become full. An alarm will sound in the central control room to alert the operator if this occurs.

Four pumps (20-P-1A and B and 20-P-2A and B) are provided to transport the pulverized coal from the surge bins (20-TK-2A and B) to the eight services bunkers (30-V-2A through H) in the gasification area (Unit 30). There are two pumps for each conveying train, one normally operating and one standby for each train. Plant layout negated the concept of utilizing only one standby pump for both trains (spacing too far for common coal feed from surge bins to standby pump). The availability factor for coal pumps is such that standby capability must be present to assure continuous system operation.

The media used by the pumps to convey the pulverized coal to the gasifier service bins is nitrogen. Nitrogen is delivered, on a continuous basis, to the inlet of the pumps from the air separation facility. The pressured nitrogen is discharged from the pumps at high velocity. Pulverized coal is injected into the nitrogen stream, from the surge bin rotary feed valves, and is entrained in the fast moving gas.

Since each gasifier has four service bins (will be discussed in the operation of Unit 30), the coal laden nitrogen must be split into four equal streams to satisfy process requirements. A Flow Splitter (20ME-10A and B) is provided for each nitrogen pumping system. The mechanism is specially designed to split the flow from each pump into four equal streams. A shut-off valve, downstream of each leg of the splitter (four for each splitter) will automatically close if the service bin being fed by the splitter leg becomes full. The entire nitrogen volume will then be split into three equal streams. If more than one shut-off valve closes (two service bins full), the rotary feed valve on the surge bin of the train affected will stop, cutting off coal flow in the train. The nitrogen will continue to flow. When the level of coal in one of the gasification service bins drops, the closed valve will open and the surge bin rotary feed valve will admit coal to the system. The operator in the central control room will monitor the system on a continuous basis.

The piping from the flow splitters (20-ME-10A and B) transfers the coal laden nitrogen streams to the gasifier service bins located in the Unit 30 area of the plant. The service bins, whose basic function is discussed in the next section of this report, have integral separators. Most of the coal in the nitrogen streams is separated at this point, collected and stored in the service bins. The nitrogen streams then pass through bag-type Dust Collectors (20-BF-2A through H, Drawing EE-371-001, Apprendix E), where the remainder of the pulverized coal dust is discharged to the service bins. The relatively dust free nitrogen is then vented to atmosphere.

The bag-type dust collectors utilize nitrogen gas, from the air separation facility, for bag cleaning. Nitrogen is also utilized to pressurize and purge the dust collectors to keep air from leaking into the collector internals.

4.3.3 GKT Coal Gasification Facility (Unit 30)

The "GKT" coal gasification technology has been selected as the process that will be utilized to convert pulverized coal stock into a medum BTU gas, which is the primary product of the facility. A technical description of the process is contained in Section 3.4 of this report; therefore, the discussion in this segment will be limited to the design criteria from an operational viewpoint, describing the interaction of various components in the gasification trains.

The "GKT" complex is comprised of two equal and parallel gas-producing trains, each capable of generating fifty per cent of the total facility gas production. The two trains are joined together, at their terminals, and share a common gas holder and final clean-up precipitator.

The "GKT" gas producing components can be generally classed into two major performance functions. They are: The gas generating function, and the gas clean-up function.

a. Gas Generation (Drawing EE-371-001, Appendix E)

Eight services bunkers (30-V-2A through H) are provided, four for each gasifier, to temporarily store the coal feed. The service bunkers are part of the "GKT" proprietary control system. Each service bunker has a cyclone separator at its upper section. The cyclone separator diverts a major portion of the entrained coal from the nitrogen conveying system (Unit 20) into the bunker. System constraints (by GKT) dictate that four service bunkers be utilized for each gasifier.

Each service bunker is mounted on weigh cells. The weigh cells provide a constant indication (in the central control room) of the coal quantity in each bunker. The weigh cells are also utilized to limit the amount of coal in each service bunker (overflow). Should the high level point be reached in any service bunker, a shut-off valve in the feed pipe will close and isolate the bunker. When the coal level in the bunker drops sufficiently, the isolation valve will re-open, introducing coal into the bunker again.

Underneath each service bunker, there is a feed bunker (30-V-3A through H). As in the services bunkers, there are four feed bunkers per gasifier. The feed bunkers are used to insure that the gasifier coal feed screws are kept full of coal to prohibit a back-flash condition from occuring.

Each feed bunker is placed on weigh cells. The weigh cells are used, primarily, to automatically activate and control the coal feeders (30-ME-3A through H) between the service bunkers and the feed bunkers to insure sufficient coal feed to the gasifiers as demand varies. The quantity of coal in the feed bunkers is also indicated in the central control room. The operator in the control room has the capability of varying the coal feeder speed to meet system demands.

Each feed bunker provides a "choke feed" supply of coal to a double-screw assembly (30-ME-4A through P). There a four double screw assemblies per gasifier, one set for each lobe of the gasifier (total of sixteen screws for two gasifiers). The screws have variable speed drives so that the coal quantity to the gasifiers can be changed (automatically or by operator selection) to follow system demand.

A mixture of low pressure steam and oxygen is introduced at the discharge of the screws (30-ME-4A through P). The steam-oxygen mixture is used as the conveying medium for the introduction of pulverized coal to the reaction zones of the gasifiers. The steam-oxygen mixture is proportioned, by automatic control, to the coal demand of the gasifier to meet facility gas production requirements. As the gas output of the facility varies, the coal feed to the gasifiers will vary proportionately. The steam-oxygen mixture will be proportioned directly to the coal flow from each feed screw, taking its signal from each feed screw rotational speed.

The pulverized coal, carried by the steam-oxygen mixture, enters the gasifier reaction zone at a slightly higher pressure than the reaction zone. The elevated pressure requirement is important because:

1. The coal must be propelled and dispersed into the gasification stream, and
2. The gas and heat being generated in the reaction zone must be prohibited from flashing back through the feed system.

Burner tubes (30-ME-5A through P) are provided in the walls of the reaction zone, two per lobe, to insect the coal-steam-oxygen mixture into the gasifiers (16 burner tubes for two gasifiers).

An ignition burner assembly (30-ME-10A through H) is provided for each lobe of the gasifier reaction zone (eight assemblies for two gasifiers) to start up the gasifier or to re-start a gasifier lobe section. Each assembly is provided with an ignition system and burner management system. The ignition burner assemblies normally utilize the gas produced by the facility as their fuel source. However, for start-up, an auxiliary fuel oil system is used for gasifier ignition.

Ignition lances (30-ME-6A through D) are provided, two for each gasifier, to dry out the reaction zone refractory linings at start-up. The ignition lances utilize fuel oil as their energy source.

The arrangement and configuration of the gasifiers can be seen on Drawings EE-071-007 and 008 (Appendix D). Each gasifier assembly is a "four lobed" weldment, which is refractory lined and is enveloped by a steel water jacket. The water jacket performs two functions:

1. It cools the refractory lining of the gasifier, and
2. It generates low pressure steam which is used in the gasification process (the steam generated is in excess of quantity required for gasification).

As stated previously, a mixture of coal, steam and oxygen are blown into each gasifier and is gasified in suspension. The hot gas flows upward and out of the gasifier to the waste heat recovery system (30-E-1A and B). As the hot gas exits the gasifiers, it is sprayed with water to knock out the larger particles of entrained slag. The slag drops to the bottom of the gasifiers and exits to slag extractors (30-ME-2A and B). The slag extractors, physically, are shrouded drag conveyors submerged in water. The water acts as a gasifier bottom seal and as a slurrying medium. The slag, in slurry form, is discharged to a slag conveying system which will be described in Section 4.3.8 of this report.

The waste heat recovery systems (30-E-1A and B) are situated above gasifiers. Their arrangement and configuration are shown on drawing EE-071-008 (Appendix D). In essence, each system is a steam generating unit that serves to:

1. Cool the gas to a temperature compatible with the rest of the process equipment, and
2. Generate high pressure steam for use at the facility.

Feedwater enters the bottom of the tubular generators, is heated, and high pressure steam is extracted at the top. The steam is collected in steam drums above the generators. The drums distribute the steam to facility users. A more "in depth" description of the steam distribution system is described in Section 4.3.8 of this report.

The lower pressure steam that is generated in the gasifier water jackets is also collected in steam drums. Again, this description will found in Section 4.3.8.

The cooled gas emerging from the waste heat recovery systems is tempered further by water sprays before the gas flows into the washers (30-E-2A and B).

b. Gas Cleanup (Drawing EE-371-015, Appendix E)

The cooler gas, still flowing in two parallel trains, is directed to the Cooling Washer Assemblies (30-E-2A and B). The arrangement and configuration of the assemblies are shown on Drawing EE-071-008 (Appendix D).

The gas enters the washer near the bottom and flows upward. A series of water sprays, directed counter current to the gas flow, both cool and remove entrained particulate from the gas stream.

The ash particulate, containing quantities of unreacted carbon, is washed to the bottom of each vessel and exits the system through a water-leg seal. The ash is directed to a covered through and flows, by gravity, to a treatment system that will be described in Section 4.3.7 of this report.

The gas stream in each parallel train exits the cooling washers and is piped to second stage particulate removal device called Disintegrators (30-ME-8A and B). In the disintergrator assemblies, rotating devices create turbulence in the gas stream. Water is sprayed into the turbulent gas stream. A large portion of the remaining particulate in the gas adheres to the water droplets and drops to the bottom of the disintegrators. The particulate laden water is drained to Separators (30-V-7A and B) through water-leg seals between the assemblies.

The gas streams leave the disintegrators and flow into Separator assemblies (30-V-7A and B) where entrained moisture is removed. The moisture is collected at the bottom of the vessel and, along with the water from the disintegrators (as previously stated, the disintegrator water flows into the separators), the combined liquid effluent is recirculated back to the Cooling Washer bottom sprays. Pumps (30-P-2A and B) are provided to recirculate the water back to the Cooling Washers. The pumps are automatically activated and stopped by a level control in each separator. The pumping action is monitored by the operator in the central control room.

The gas streams are then directed to secondary separation devices, passing through Seal Pots (30-V-10A and B). The Seal Pots are utilized to isolate the gas stream from the downstream process and equipment (acts as an isolation valve). The seal pots are normally vertical, cylindrical vessels that are installed in process gas piping. Water is piped to the vessels. The height of the vessel is determined by the upstream pressure of the gas stream. Should it become necessary to cut the gas flow off from the process stream, water is pumped into the Seal Pot to a sufficient height to compensate for the upstream pressure of the gas. Conversely, when gas flow is desired, the water is drained from the Seal

Pot. The Seal Pot concept is frequently used on large diameter piping systems where temperature and cost considerations are major design parameters. Both the introduction and the drainage of water from the seal pots is controlled by the operator in the central control room.

As stated in the previous paragraph, the gas streams pass through a final set of Separators (30-V-8A and B) to remove the remnants of entrained moisture from the gas. The moisture is collected at the bottom of the vessel and is periodically discharged to a collection sump. The periodic discharge is controlled by a level sensing device operating discharge valves at the bottom of the vessels.

After exiting the final Separators, the parallel gas stream pressures are boosted to propel the gases through the remainder of the cleanup devices. Two Raw Gas Blowers (30-BL-2A and B), one for each gas stream, are used to increase the pressure.

The two parallel gas streams are joined together downstream of the Raw Gas Blowers. The combined stream of gas is directed to a large Gas Holding Tank (30-TK-3) and then to an Electrostatic Precipitator (30-PR-1) for final gas cleanup. However, there are times when one or both of the parallel gas trains must be diverted from the main process stream. They are:

1. Initial startup of both gas trains;
2. Starting up one gas train while the other train is operational;
3. Malfunction of equipment in a gas train; and
4. Gradual shut-down and purging of a gas train.

A flare stack (30-ME-1A and B) and Seal Pot (30-V-20A and B) are provided for each gas train, connected downstream of the Raw Gas Blowers. The flare stacks are provided with ignition systems and fuel sources for ignition (product gas and fuel oil back-up). The Seal Pots, upstream of the Flare Stack assemblies, are normally full of water to isolate the flare system. When a gas stream must be diverted, the water is rapidly drained from the seal pot, opening the gas channel to the flare stack. The operator in the central control room has remote supervision and control of the flare activation.

As previously stated, the Raw Gas Blowers (30-BL-2A and B) boost the gas pressure. The two parallel gas streams are combined into one gas train and are directed to a Gas Holding Tank (30-TK-3). The Gas Holder acts as:

1. A biasing control for the gasifiers;
2. A storage reservoir for the untreated (raw) gas; and
3. A cushioning device to absorb system swings.

The Gas Holding Tank is a segmented, "floating roof," cylindrical steel vessel. The vessel is constructed of numerous circular sections, stacked vertically. The vessel is designed in this manner so that it can hold various volumes of gas at a constant pressure. The gas is pumped into the vessel. The gas pressure lifts the roof section vertically. All circular sections of the vessel are interlocked, in a telescope-type configuration, enabling the vessel to expand vertically to a pre-designed maximum height. Thus, the vessel can store various volumes of gas and still maintain a constant gas pressure downstream of the vessel. Should the gas demand suddenly increase, the gas stored in the vessel can compensate, temporarily, for the increase. Should the gas demand suddenly decrease, the constant gas production of the facility can be temporarily stored in the vessel. Water seals are provided between the vessel segments to allow for vertical movement and gas containment.

Seal Pots (30-V-11 and 12) are provided at both the inlet and outlet of the Gas Holding Tank to isolate the vessel for purging (planned maintenance and inspection plus emergency shutdown). As stated in previous seal pot descriptions, water would be pumped into the seal pots to isolate the vessel from the facility. A Purge Line and Seal Pot (30-V-13) are provided to the Main Flare Stack (91-ME-1) to evacuate the gas holding tank.

The gas stream from the Gas Holding Tank is directed to an Electrostatic Precipitator (30-PR-1) which performs the final particulate removal function. The ash particulate is deposited on electrically charged plates within the precipitator. The plates are continuously cleaned with water, which is collected at the bottom of the precipitator and drained to a sump.

Relatively clean gas (ash particulate free) emerges from the precipitator; however, the inherent sulfur must still be stripped from the gas stream before the gas can be considered clean. A description of the sulfur removal system is described in Section 4.3.4. All equipment and piping systems in the gasification facility have purge and vent connections, utilizing nitrogen manufactured by the air separation facility, that will be used:

1. At facility start-up;
2. At facility shut-down; and
3. To expel toxic and explosive gases from equipment and piping systems in case of emergency.

All purging and venting is actuated and controlled by the operator in the central control room.

4.3.4 Sulfur Removal and Recovery (Unit 40)

4.3.4.1 Desulfurization Process (Drawing EE-371-006, Appendix E)

After the coal has been gasified and all ash particulate removed from the gas stream, the remaining constituent that must be removed, an element present in the coal itself, is sulfur. Sufficient sulfur must be removed, before the gas is burned, to comply with all emission standards, both existing and projected, in the Philadelphia region.

The method selected to remove sulfur from the gas stream is the "Stretford" process. The "Stretford" process was selected because:

a. The size of the facility (total gas production) is economically amenable to the process;

b. The system pressures are compatible with the process; and

c. The sulfur content of the coal that was used for the design basis is compatible with the process.

The arrangement and configuration of the Desulfurization complex is shown on Drawings EE-071-009 and 010 (Appendix D).

a. Gas Boosters (42-BL-1A and B)

The pressure of the gas stream exiting the precipitator (30-PR-1) is slightly higher than atmospheric. Therefore, the gas stream pressure must be boosted to propel the gas through the desulfurization process equipment and piping. Two Gas Booster compressors (42-BL-1A and B) have been provided for that purpose.

Two stages of gas compression have been selected for the plant design basis, booster compressors to convey the gas through the desulfurization facility and a final compression stage (described in Section 4.3.6) for distribution of the gas to users. Thought was given to designing a single compression stage to provide the total pressure requirement for the desulfurization system and the distribution system. However, the cost of designing the desulfurization equipment for that higher pressure negated the concept.

The Booster Compressors are centrifugal, electrically driven machines, each sized for the maximum gas output of the plant. One compressor is used in the operation. The second machine is relegated to standby duty. Both boostor compressors have their own aftercoolers and condensed liquid separators.

The Booster Compressor that is in operation is controlled by an inlet valve which modulates the gas flow to the machine in proportion to the gas demand. The inlet control valve receives its direction (control signal) from the control system on the Plant master flow meter (see Section 4.3.6). That control system will transmit fluctuations in gas demand to the inlet control valve of the booster compressor; thereby, controlling the gas flow of the system downstream of the booster compressors.

b. Sulfur Removal from the Gas

The technical description of the sulfur removal process is described in Section 3.5 of this report; therefore, this section will be limited to a dissertation on how the individual components are inter-related and function.

The gas stream containing sulfur, primarily in the form of hydrogen sulfide, is passed through a parallel battery of nine

Static Mixers (42-MX-1A through J). The "Stretford" fluid is injected into the mixers, concurrent to the gas flow. Baffles, internal to the mixers, insure the homogeneity of the gas and the "Stretford" solution mixture. The formation of elemental sulfur begins within the mixers.

The sulfur laden gas stream passes up through the "Stretford" Reaction Vessel (42-V-1). The final separation of sulfur from the gas stream occurs within the reaction vessel. Trays within the vessel assist in the sulfur and "Stretford" solution separation from the gas stream. The sulfur, along with the reduced "Stretford" solution, is collected at the bottom of the reaction vessel. The gas stream, free of most of its sulfur content, exits the top of the Reaction Vessel to the Gas Compression System (Unit 60). A Cyclotube Filter (42-F-2) is provided at the discharge of the Reaction Vessel to remove entrained "Stretford" solution from the gas stream. A by-pass pipeline, around the Static Mixers and Reaction Vessel, is provided to permit gas production at the plant when the desulfurization process is not operating (emergency situation).

The "Stretford" solution, containing the sulfur removed from the gas stream, flows by gravity from the bottom of the reaction vessel to the Oxidizer Tank (42-TK-1). In the Oxidizer Tank, two recovery steps are performed:

1. The sulfur is separated from the solution, and
2. The "Stretford" solution is oxidized back to its original state.

As in the gasification process, purging and venting (with nitrogen from the air reduction facility) is provided for the Static Mixers, the Reaction Vessel and the gas piping.

c. Sulfur and "Stretford" Solution Recovery

The sulfur laden "Stretford" solution is collected in the Oxidizer Tank (42-TK-1). The solution liquid level in the Oxidizer Tank, which is vented to atmosphere, is determined by:

1. An equalization pipe between the Reaction Vessel and the Oxidizer Tank, and
2. The pressure in the Reaction Vessel created by the Booster Compressor.

Atmospheric air is introduced at the bottom of the Oxidizer Tank by the use of "Diffuser Nozzles" and piping connected to an Air Blower (42-BL-2A and B). Two air blowers are provided, one operating and one stand-by.

The air disperses up through the "Stretford" solution, both oxidizing the solution back to its original form and lifting the released elemental sulfur to the surface of the liquid contained within the tank. The elemental sulfur forms a "Foam" layer at the surface of the "Stretford" solution.

The sulfur "Foam" overflows the Oxidizer Tank, by gravity, to a Slurry Tank (42-TK-3). The Slurry Tank represents the first stage of the sulfur recovery process. The regenerated "Stretford" solution at the bottom of the Oxidizing Tank is connected to the "Stretford" Solution Tank (42-TK-2), a storage vessel utilized to return the sulfur-stripping solution to the process. The Oxidizer Tank, therefore, performs two functions:

1. It separates the elemental sulfur from the solution for recovery, and
2. It regenerates the solution and returns it to the process for re-use.

In the Slurry Tank (42-TK-3), the sulfur "Foam" is mixed with water, using a mixer (42-AG-1), to form a sulfur slurry. The slurry is then pumped to a Centrifuge (42-CE-1). Pumps 42-P-3A and B are used. Only one pump is operational, the other acting as a stand-by. In the Centrifuge, the sulfur is concentrated. The sulfur-stripped liquid is re-circulated back to the Oxidizer Tank, since it still contains small quantities of elemental sulfur. The concentrated sulfur drops out of the centrifuge into a Re-Slurry Tank (42-TK-4), where the concentrate is mixed with water to form a slurry. The slurry is "Homogenized" by a Re-Slurry Agitator (42-AG-2). The slurry is drawn off at the bottom of the tank by a Re-Slurry Pump (42-P-4A and B, one operating and one stand-by). The slurry passes through a Sulfur Melter (42-E-3), a shell and tube heat exchanger that utilizes process steam to convert the slurried sulfur to its molten state. Since the slurry contains water, the heating is performed under pressure to keep the water from flashing to steam. The molten sulfur slurry passes from the Sulfur Melter to a Sulfur Separator (42-V-2), where the molten sulfur is separated, by gravity, and is discharged to a Sulfur Storage Pit (42-TK-5) to await transfer from the plant site. The Sulfur Storage Pit is a closed, lined, and insulated "in-the-ground" containment vessel, constructed of reinforced concrete with removable sectional covers. The molten state of the sulfur is maintained by a Platecoil Pit Heater (42-E-6), a stainless steel heat exchanger that uses process steam as the heating medium. Submersible Sulfur Pumps (42-P-5A and B, one operating and one stand-by) are utilized to empty the pit to heated trucks. The pressurized hot water in the Sulfur Separator is circulated back to the Reaction Vessel (42-V-1) where the water is flashed into a greater mass of fluid to absorb all the energy.

The regenerated "Stretford" solution flows, via gravity, from the Oxidizer Tank (42-TK-1) to the "Stretford" Solution Tank

(42-TK-2). The "Stretford" Solution Tank is the storage vessel for all the solution that is used in the sulfur-stripping process. The solution is drawn from the bottom of the tank by the "Stretford" Solution Pump (42-P-1A and B, one operating and one stand-by). The solution takes three separate paths:

1. To the Static Mixers (42-MX-1A thru J) for re-introduction to the process;
2. To an Evaporative Cooler (42-E-2) for heat balance; and
3. To a Reductive Incineration Facility (Unit 44) for treatment of spent chemicals.

The largest portion of the flow from the "Stretford" solution tank is pumped back to the system for stripping sulfur from the gas stream. The flow is introduced to the gas stream by nozzles at the inlet of the nine Static Mixers. However, it shall be noted that the "Stretford" solution picks up excess water in its journey through the regenerative process. Water from the slurry process, and from the gas itself, is added to the circulating fluid. Heat is also added from the pumping action on the fluid. Therefore, a stream is taken from the discharge of the "Stretford" solution pump and directed to an Evaporative Cooler (42-E-2). The Evaporative Cooler is, in essence, a cooling tower, where heat is extracted by evaporating water by an induced air stream that is vented to atmosphere. After the excess water and heat are removed by the Cooler, the "Stretford" solution is pumped back to the "Stretford" Solution Tank by a pump (42-P-2A and B, one operating and one stand-by).

A small liquid stream is taken from the fluid being pumped to the Evaporative Cooler. That stream is directed to a Reductive Incineration System (Unit 44) to process the spent chemicals that have been exhausted in the sulfur-removal action of the "Stretford" fluid.

The spent liquid stream is directed to a Furnace (44-H-1). Before being injected into the furnace, the spent liquid stream passes through a Heater (44-E-2) and an Evaporator (44-E-1).

The spent liquid is pre-heated in Heater 44-E-2. The heating energy is provided by a hot gas stream from the furnace Quench Tank (44-TK-1). The pre-heated spent liquid stream then flows into Evaporator 44-E-1. In the evaporator, water is flashed off from the liquid. The remaining liquid, now more concentrated, collects at the bottom of the separator and is drawn out by a Concentrated Liquor Feed Pump (44-P-3A and B, one operating and one stand-by). The Concentrated Liquor Feed Pump transfers the liquid to the Reduction Furnace (44-H-1). The vapor from Evaporator 44-E-1, is condensed by Condenser 44-E-4 and Ejector Cooler 44-E-5. Cooling water is used in both Condenser 44-E-4 and Elector Cooler 44-E-5. As the vapor from Evaporator 44-E-1 is cooled in Condenser 44-E-4, liquid and a secondary vapor stream are generated. The liquid, primarily water, is fed into the water make-up line to the Furnace Quench Tank (44-TK-1). The secondary vapor stream is drawn out of Condenser 44-E-4 by a steam Ejector 44-EJ-1. The ejector pumps the vapor into the Ejector Cooler 44-E-5 (a water cooled heat exchanger). The entire vapor stream is condensed in the ejector cooler and the effluent, as with the Condenser 44-E-4 effluent, added to the make-up water line to the furnace quench tank.

As stated previously, the spent liquid effluent (now called concentrated liquor) flows out of Separator 44-E-1 to the Concentrated Liquor Pump (44-P-3A and 3B) which feeds Furnace 44-H-1. However, the concentrated liquor must be metered to the furnace. Therefore, a portion of the concentrated liquor from Separator 44-E-1 is circulated back to Heater 44-E-2 to maintain this control. Evaporator Circulation Pumps (44-P-5A and B, one operating and one stand-by) are provided for this purpose. Therefore, as seen on flow Diagram EE-371-006, Heater 44-E-2 is fed by two liquid streams:

1. A recirculated concentrated liquor stream from Evaporator 44-E-1, and
2. The spent "Stretford" liquid stream from the process.

The spent "Stretford" liquid stream is controlled to assure a constant feed quantity to Heater 44-E-2.

In Furnace 44-H-1, the concentrated liquor stream is incinerated. Product gas taken from the process is used as an energy source and combustion air is provided by Blower 44-BL-1. The incineration function is a "closed" process; that is, all contents of the reduction reaction within the furnace are recirculated to the "Stretford" facility.

In the reduction process within Heater 44-H-1, hot gases are generated (carbon monoxide, carbon dioxide, nitrogen and hydrogen sulfide). The gases are passed through Heater 44-E-2 to pre-heat the spent liquid going to Separator 44-E-1 (described previously). The hot gases exit the furnace through the Quench Tank (44-TK-1), which is attached to the furnace. After being cooled by the heater exchange occurring at Heater 44-E-2, the gases are further cooled in the decomposed Gas Cooler (44-E-3) by use of a cooling water loop. The cooled gases are then re-injected into the process gas stream just upstream of the Booster Compressor (42-BL-1A and B).

The second phase of the reduction process within Furnace 44-H-1 results in a hot liquid formation. The hot liquid, a further concentrated form of the liquor feed to the furnace, flows into the attached Quench Tank (44-TK-1). A Quench Pump (44-P-1A and B, one operating and one stand-by) is provided to keep the hot liquid circulating. The hot liquid being produced by the furnace overflows the Quench Tank and is collected in the Recovered Solution Tank (44-TK-2). A Solution Pump (44-P-2A and B, one operating and one stand-by) meters the hot liquid back to the system by injecting the liquid into the Reaction Vessel (42-V-1).

The spent chemicals used in the "Stretford" desulfurization process are replenished by a chemical make-up system. A Chemical Mix Tank (42-TK-6) and Chemical Mix Pump (42-P-6) are provided for chemical addition to the desulfurization system. The chemicals, diluted in water, are added at the "Stretford" Solution Tank (42-TK-2).

A Start-Up Heater (42-E-4) is provided in the "Stretford" solution loop. The heater, a heat exchanger utilizing steam as an energy source, is located in the piping between the "Stretford" Solution Pump (42-P-1A and B) and the Static Mixers (42-MS-1A through J). When the desulfurization system is first started, the solution is cold. To enhance stream reactivity, the solution must be heated. By a system of manual valving, the "Stretford" solution can be channeled through the Start-up Heater before it is injected into the Static Mixers.

4.3.5 Air Separation Facility (Unit 50)

The operation of the Air Separation Facility has been thoroughly described in Section 3.6 of this report; therefore, this section will deal only with the facility's inter-relationship with the rest of the process. The equipment arrangement is shown on Drawings EE-071-001 and EE-071-011 (Appendix D).

4.3.5.1 Oxygen Supply and Control

Since the Gasification Process consists of two independent and equal gas-producing trains, the Air Separation Facility is similarly designed; that is, two parallel and equal oxygen producing trains are provided, each capable of producing, 50 percent of the maximum oxygen demand of the plant.

The turndown capability of the Air Separation Facility is not the same as the Gasification Process. Each Air Separation train can be turned down to 65 percent of its maximum design capacity, 5 percent more than the gasifiers (70 percent of maximum capacity). It follows that the Oxygen Facility can track the gas demand load further down the "use curve" than the gasifiers. Therefore, flexibility of the system operation is limited by the gasifiers and not the Air Separation Facility.

The control of the oxygen and nitrogen producing facility is tied directly to the gasification control system. When gas production increases or diminishes at the gasifier reactors, a signal will be sent to the oxygen control system to alter the output, automatically, in proportion to the gas production.

As previously described, the Air Separation Facility has two trains. The air compressor of one train (50-C-1) is steam turbine driven, and the second train air compressor (50-C-2) is electric motor driven, since the Gasification Process does not produce sufficient high pressure steam to run both compressors to match the maximum plant oxygen requirement. The turbine driven oxygen train will automatically cut back its production capacity in proportion to the steam available from the gasifiers. The motor driven oxygen train will be automatically cut back, proportionately, to compensate for the balance of the gas demand cut-back. Due to design limitations of the gasifiers, the minimum amount of gas production, when both gasifiers are operational, is 70 percent of the plant maximum capacity. Therefore, for any gas demand between 50 and 70 percent of plant maximum capacity, the Air Separation plant will continue to produce oxygen at the 70 percent demand level, since one of the Gasification Trains will be forced to flare the excess gas to atmosphere (see Sections 4.3.3 and 4.3.6).

Should the gas demand from the Users become 50 percent of the plant maximum design capacity, the following sequence will occur:

a. The oxygen producing train having the motor driven compressor will automatically shut down;
b. The oxygen producing train having the steam turbine driven compressor will then carry the total plant oxygen demand (one gasifier will be taken out of the operation at this time);
c. An alarm, in the Air Separation control room, will be activated, warning the operator of the condition; and
d. The Air Separation Facility operator will then place the "shut-down" oxygen train in a stand-by mode.

The operational oxygen train will then follow the oxygen demand automatically, using the same control philosophy utilized for the two-train operation.

When the gas demand increases above 50 percent of the plant maximum design capacity, close coordination, between the gasifier operator and the oxygen facility operator, will be required to bring the oxygen train in the stand-by mode back "on-line."

At plant start-up, the oxygen train with the motor driven compressor will be used, since there will be no high pressure steam available to operate the other train. In case of a power failure, the stored oxygen at the plant site will automatically supply oxygen to the Gasification Process, to replace the loss of one oxygen train serviced by the motor driven compressor. An emergency generator, provided at the Air Separation Facility, will supply power to operate all controls and instrumentation, in case of a power failure.

The Air Separation Facility also produces nitrogen which is used in the Gasification Process for:

a. Conveying the pulverized coal to the gasifiers (see Section 4.3.2);
b. Shrouding equipment in the process to keep air out (see Sections 4.3.1 and 4.3.2);
c. Purging of process equipment and piping for start-up, maintenance, and shut-down; and
d. Smothering fires in equipment.

As stated in Section 3.6, nitrogen is stored at the plant site in a pressurized vesel containing a 24 hour storage capacity for one gas train. An "emergency" trailer is also provided, but only for purging a gasification system and not for process use.

During normal plant operation, make-up to both the oxygen and nitrogen storage, in the receptacles provided, occurs only during periods of lower gas demand by the users.

4.3.6 Gas Compression and Dehydration (Units 62 and 64)

4.3.6.1 Gas Compression (Unit 62)

As stated in Section 4.3.4 of this report, gas compression has been designed in two stages, a compression boost to push the gas stream through the "Stretford" desulfurization facility and a final compression stage required to distribute the gas stream to the users. The booster compressor phase has already been described; therefore, this segment of the report deals with the final compression stage of the gasification plant.

The gas compression system is shown, diagrammatically, on Drawing EE-371-014 (Appendix E). The equipment arrangement is shown on Drawing EE-071-014 (Appendix D).

The gas stream exits the "Stretford" desulfurization facility, propelled by the booster compressor, and is then pressurized to approximately 40 psig by centrifugal Gas Compressors (62-C-1A and B and 62-C-2). Gas Compressors 62-C-1A and B are driven by condensing-type steam turbines. Gas Compressor 62-C-2 is driven by an electric motor. Two of the three compressors are utilized for the normal operation of the plant. The third compressor is used as a 50 percent stand-by for the other two.

In the normal operation of the plant, the two steam turbine driven compressors are used. Economics and total plant efficiency dictate this requirement. As described in Section 4.3.3, the gasifiers generate a low pressure steam (28 psig). As long as the gasifiers are operational, this steam must be generated, since it is part of the protective cooling system for the gasifier shells. The gasifiers are the only constant users of low pressure steam in the process. Part of the low pressure steam is used for the gasification of coal. However, the production of low pressure steam far exceeds the demand of steam for gasification. To optimize plant overall efficiency and, therefore, operational economics, the decision was made to use the low pressure steam to drive the gas compressors. Thought was given to using the low pressure steam for heat tracing plant equipment and piping; however, this steam usage is aperiodic (primarily used only in cold weather). Therefore, during most of the year, steam would have to be vented to atmosphere, causing a severe loss in overall system efficiency.

The third motor-driven compressor will be utilized for start-up of the plant and also as a stand-by for the two turbine-driven compressors. Since only one gasification train is started at a time, the 50 percent capacity of the motor-driven compressor is compatible with plant start-up criteria.

To increase the efficiency (water rate) of the gas compressor steam turbines, the saturated steam produced by the gasifiers will be superheated before being introduced to the turbines. A steam-to-steam heat exchanger (will be described in Section 4.3.8) is provided for this purpose. A portion of the high pressure steam generated by the gasifier waste heat recovery systems (30-E-1A and B) will be diverted through the tube side of a heat exchanger (82-E-1), which will superheat the low pressure steam before it is injected into the gas compressor steam turbines (62-C-1A and B-T).

A Condenser (82-CN-1), which will be described in Section 4.3.8, is provided for the gas compressor turbines. The condenser will return the turbine exhaust condensate back to the steam generation system (Unit 82).

At the discharge of the gas compressors, three Aftercoolers (62-E-3A, B, and C) are provided to remove the heat of compression from the gas stream. One aftercooler is provided for each compressor. The shell and tube-type heat exchangers utilize water from the plant cooling water system (described in Section 4.3.8).

A control system is provided to prevent the gas compressors from surging. As shown on Drawing EE-371-014 (Appendix E), control valves are designed both on the inlet and outlet of the gas compressors. Should the gas usage drop to approximately 30 percent of the maximum design flow, which would cause the compressors to surge, the following control sequence will be automatically activated:

a. Control valves FC-1416A and FC-1426A, located at the inlet of the compressors, will begin to close to maintain a positive pressure in the gas train upstream of the compressors and prevent back-flow of gas into the gasification train;
b. Control valves FC-1416B and FV-1426B, located in the 6-inch by-pass, will re-cycle gas back to the inlet of each compressor; and
c. Control valves FC-1416C and FV-1426C, located in the discharge line of each compressor, will begin to close to modulate the gas flow through the system proportionate to the decreased demand.

The automatic surge protection control is activated by a signal taken from the plant master flow meter (FE-1240), which is described in Section 4.3.6.2 (Unit 64).

During normal daily operations, the User gas demand can vary from 70 to 100 percent of maximum design capacity for the plant. Within this range, the compressor outputs will be modulated by the valves on the discharge of each compressor (FV-1416C, FV-1426, and 1446C). The valves will be controlled by a signal from the plant master flow meter (FE-1240, Unit 64). Of course, the same signal will be used to modulate the booster blowers (Unit 40 in Section 4.3.4), the gas producing trains (Unit 30 in Section 4.3.3) and the air separation facility (Unit 50 in Section 4.3.5).

Should the User gas demand drop within the range of 50 to 70 percent of maximum design capacity, as measured by the plant master flow meter, the control system is designed to react in this manner:

a. The control valve (PV-1243) modulating the gas to the Users will restrict the flow proportionate to the demand;
b. The control valve (PV-1240) will divert the excess gas being produced by the gasifiers to the Main Flare Stack (91-ME-1); and
c. The balance of the Gasification System will continue to produce at 70 percent of maximum plant capacity (gasifiers cannot be turned down below 70 percent of their capacity).

Should user gas demand fall below 50 percent of the maximum design capacity of the plant, for a sustained period, one of the two gasification trains, along with one gas compressor, must be taken out of the stream and placed in a stand-by mode. Ancillary facilities, such as air separation, coal pulverization and conveying, would be cut back to match the abridged plant output.

As in all other process facilities where gas is present, a nitrogen purging and gas venting system is provided for all equipment and piping systems.

4.3.6.2 Gas Dehydration (Unit 64)

The gas dehydration system is shown, diagrammatically, on Drawing EE-371-015 (Appendix E). The equipment arrangement is shown on Drawing EE-071-014 (Appendix D).

As stated in Section 3.7.2 of this report, sufficient water must be removed from the gas stream leaving the gasification plant to insure that no freezing will occur in the gas distribution pipe. Therefore, a glycol gas dehydration facility has been provided in the design to remove sufficient water from the gas to meet this requirement.

After leaving the gas compressor aftercoolers (62-E-3A, B, and C), the gas stream passes through a separator (64-SE-1) where the water condensed by the aftercoolers is removed from the stream. The liquid is drained, on a controlled basis, from the separator and is channeled to the waste water treatment system (Unit 70).

The gas stream then enters the Glycol-Gas Contactor (64-TK-1), a vertical tower where the water is removed from the stream. The gas enters the bottom of the tower and flows upward. The glycol stripping solution is sprayed into the tower at the top, counter-current to the gas flow. The glycol solution falls to the bottom of the tower, carrying the water stripped from the gas stream with it. The gas stream, now clean, desulfurized and relatively free of moisture, flows out of the top of the contactor tower and into the distribution system.

Before entering the distribution pipeline, the gas stream passes through the Glycol Cooler (64-E-1). The Glycol Cooler, a heat exchanger located near the contactor tower, heats the gas stream and, conversely, cools the hot glycol being recirculated back to the contact tower from the glycol regeneration facility.

As intimated in the previous paragraph, the glycol solution is not discharged to waste; rather, it is collected at the bottom of the contact tower, transferred to a regeneration facility and re-circulated back to the contactor tower for re-use.

The water-laden glycol is drained out of the bottom of the contactor tower by a control valve, activated by a level control at the tower base. The glycol-water mixture is directed to the top of the Glycol Still (64-TK-2). The mixture passes through a coil-type heat exchanger within the still where it is heated by water vapor being vented from the still. The mixture is then discharged into a Flash Tank (64-TK-3). The flash tank reduces the pressure of the mixture and vents a portion of the water vapor held by the glycol.

The mixture, at a lower pressure, then passes through a Glycol Filter (64-F-1A and B, one operating and one stand-by), which filters out any solid impurities in the circulating fluid. The mixture then passes through a coil located in the Glycol Accumulator (64-E-2), where it is heated again by the hot glycol solution returning to the contactor tower.

After being pre-heated, the glycol-water mixture is injected into the Glycol Still (64-TK-2) above contact-type trays. The mixture flows down through the trays into the Glycol Reservoir (64-B-1) below the Glycol Still.

In the Glycol Reservoir, the water and entrained gases absorbed from the gas stream are separated from the glycol fluid. Steam is passed through a coil housed within the reservoir. The steam heats the reservoir contents, boiling off the water and entrained gases from the glycol. Nitrogen, from the air separation facility, is also injected into the reservoir to provide the motive force for driving the water vapors and gases out of the system.

The water vapor and gases are liberated from the glycol liquid in the reservoir and flow up through the still. The hot vapors make contact with the glycol-water mixture that is dropping down to the reservoir; thus, the water stripping action on the mixture actually begins in the Glycol Still.

The water vapor and gases are vented to the atmosphere at the top of the Glycol Still. A back-pressure valve (PCF-1222) is provided to vent the vapors while maintaining the system pressure above atmospheric.

The hot glycol liquid in the reservoir, stripped of water and entrained gases, is discharged to the Glycol Accumulator (64-E-2), a reservoir for the pumps that will pressurize the liquid so that it can be returned to the contactor tower. As described previously, the Glycol Accumulator has a coil immersed in it. Heat is extracted from the glycol in the accumulator by the glycol-water mixture (from the bottom of the contactor tower) flowing through the coil on its way to the Glycol Still.

A Glycol Circulation Pump (64-P-1A and B, one operating and one standby) draws the warm glycol liquid out of the accumulator and circulates the liquid back to the contactor tower (64-TK-1). A control valve (FV-1207) regulates the flow of glycol in proportion to the gas flow through the system, taking its signal from the plant main flow meter (FE-1240).

Before entering the glycol contactor, the warm glycol liquid passes through the Glycol Cooler (64-E-1). This heat exchanger (described previously) transfers heat from the glycol liquid to the process gas stream exiting the plant.

As described in Sections 4.3.3, 4.3.4, and 4.3.5 of this report, the modulation of major process facilities in the gasification plant centers on the gas demand of the distribution system measured by the plant master flow meter (FE-1240). The transmitter connected to the flow meter represents the source of information required to: record the plant gas production; monitor gas flow on a continuous basis; and vary the output of contributing processes in the plant proportionate to the gas flow.

Although the plant master flow meter conveys the basic information required for plant operation, the gas flow from the plant is modulated by control valve PV-1243. Should the gas demand by the users decrease, the pressure in the distribution line will increase. Control valve PV-1243 will begin to close, restricting the gas flow until it matches the gas demand of the users. Should the gas demand increase, the pressure in the distribution line will decrease. Control valve PV-1243 will begin to open, increasing the gas flow until it matches the gas demand of the users. Flow meter FE-1240 monitors all flow changes and provides the signals that will modulate all process facilities in the plant accordingly.

Should the gas demand by the users exceed the maximum design capacity of the plant, the flow meter control circuitry will cause control valve PV-1243 to begin closing. It will continue to close until the flow in the pipeline equals the maximum design capacity of the plant. If the user gas demand does not drop to within the range of plant capacity (a continuing over-demand of gas), the pressure in the distribution line will continue to decrease. Should the pressure fall below the minimum requirement to maintain plant stability (an overload on the plant gas compressors), Control Valve PV-1243 shut and Control Valve PV-1240 will open to the main flare (91-ME-4) and activate an alarm in the central control room of the plant. The operator will contact the users to inform them that their usage must be cut back.

A decrease in gas demand by the users must be compensated for by decreasing gas production at the plant. Fluctuations in gas demand by the users are handled by Control Valve PV-1243 and the gas holder (30-TK-3). The control valve cuts back or increases gas flow to the distribution system and the gas holder stores or, conversely, exports gas to the system to follow the demand fluctuations. The gas flow to the Booster Compressors (42-BL-1A and B) is also modulated by an inlet control valve, taking its signal from the plant master flow meter. In this manner, fluctuations in gas flow do not have an instantaneous impact on the gas-producing facilities in the plant.

Control systems are provided to compensate for gas demand cut-back within the range of 35 to 100 percent of maximum design capacity. There is no practical way to design a completely automated system, one requiring no operator input, that will address the problem of reduced user demand for gas. It is impractical to assume that gas usage will remain a constant at 100 percent of plant capacity, throughout the operating year. Therefore, control systems have been designed to respond to significant changes in gas demand.

For plant operation within the range of 70 to 100 percent of maximum design capacity, control is fully automatic. The plant master flow meter will automatically re-adjust the all process systems (gasification, oxygen feed, booster and final gas compression).

For plant operation within the range of 50 to 70 percent of maximum design capacity, the plant master flow meter will hold all gasification facilities at 70 percent of maximum gas production rate and flare the excess gas that is not required by the users.

Should gas demand fall below 50 percent of the plant maximum design capacity, the operator will have to shut down one of the gasification trains and its associated product gas compressor (venting of the train that is shut-down will be required).

With one of the gas trains taken out of service, the operation of the remaining portion of the plant is controlled in the same manner as the 70 to 100 percent control mode previously described. This will allow the gasification plant to follow the demand load down to 35 percent of the maximum design capacity.

Operation of the gasification plant below the quantity of 35 percent of maximum design capacity is not foreseen. However, it is possible to operate the plant at these lower outputs by flaring off a portion of the gas being produced.

As in all other parts of the gas-carrying portion of the plant, provision is made for purging (with nitrogen from the air separation facility) and venting the gas from all equipment and piping systems.

4.3.7 Wastewater Treatment (Unit 70)

4.3.7.1 Wash Water Treatment (Unit 72)

The fluid used to cool and remove particulate from the gas generated in the gasifiers is water. A description was given in Section 4.3.3 of how the water is utilized for the cooling and cleaning of the process gas. From the standpoint of economics, the water cannot be discarded; rather, it must be re-used when possible. A treatment system is provided to clarify, neutralize and cool the water so that it can be circulated back to the gasification process.

A diagrammatic representation of the wash water treatment system is shown on Drawing EE-371-004 (Appendix E). The treatment system arrangement is shown on Drawing EE-071-013 (Appendix D).

Wash water is drained to the treatment system from the following process equipment:

a. The Cooling Washers (30-E-2 A and B);
b. Separators 30-V-7A and B;

c. Separators 30-V-8 A and B;

d. Seal Pots 30-V-10 A and B, 30-V-20 A and B, 30-V-11, 39-V-12, and 30-V-13;

e. Slag Extractors 30-ME-2 A and B;

f. Fly Ash Classifiers 30-ME-9 A and B; and

g. The wash water sump collecting water from the Precipitator (30-PR-1), the Disintegrators (30-V-22 and 12) and Gas Holding Tank (30-TK-3) seal overflow.

The first six areas listed drain into covered troughs and flow, by gravity, to Settling Basins (72-TK-2 A and B). There are two troughs, one for each gasification train. The collected wash water in the sump is pumped to the troughs and, thereby, drained to the settling basins. Pumps (72-P-4 A and B, one operating and one stand-by) are required to lift the waste water out of the sump.

A Channel Fan (72-FA-1) is provided to exhaust gases escaping from the wash water traveling down the covered troughs.

There are two settling basins provided, one for each gasification train. The settling basins are, in essence, large, rectangular, in-the-ground, concrete containers. The wash water is distributed into the basins. Due to the process gases dissolved in the wash water, the basins are completely enclosed. A Settling Basin Fan (72-FA-2) is provided to exhaust the gases from the enclosure.

The ash particulate entrained in the wash water, the ash resulting from various gas washing equipment previously listed, settles to the bottom of the basins. The size of the basins is determined by the settling rate of the particulate. The bottom of each basin is sloped toward one end. A Scraping Mechanism (72-ME-3 A and B) is provided for each basin to plow the settled ash toward the deepest end of each basin.

The accumulated ash is lifted out of the basins by Sludge Pumps (72-P-1 A through D, two operating and two stand-by), and transfer the slurry to a Thickener (72-TK-2). The Thickener, in essence, is a wash water clarifier. The overflow from the Thickener flows back to the settling basins by gravity. The underflow (the ash particulate) is drawn out by a Sludge Pump (72-P-2 A and B, one operating and one stand-by). The Sludge Pump transfers the concentrated ash slurry (containing approximately 15 percent ash, by weight) to Rotary Vacuum Filters (72-F-1 A and B).

The Vacuum Filters extract a large portion of water from the slurry, concentrating it into a filter cake having a water content no greater than 50 percent (by weight). The filter cake from both Rotary Vacuum Filters drops on to a Belt Conveyor (92-CV-1) which removes the filter cake from the area. The filter cake handling will be described in Section 4.3.8.

The fluid extracted from the filter cake is drawn through Vacuum eceivers (72-V-2 A and B) by Vacuum Pumps (72-P-6 A, B and C, two operating and one stand-by). The underflow of the Vacuum Receivers is pumped back to the settling basins by Filtrate Pumps (72-3 A, B, and C, two operating and one stand-by). The moisture laden air leaves the top of the Vacuum Receivers and passes through Moisture Traps (72-V-2 A and B), which are separators. The liquid from the moisture traps flows back to the settling basins. The vacuum pumps vent the drier air to atmosphere.

After the ash particulate has been settled out of the wash water in the settling basins, the clarified portion of the water is drawn off by the Wash Water Return Pumps (30-P-3A). The warm, clarified water is pumped through Wash Water Coolers (30-E-3 A and B) on its way back to the gasifier particulate removal systems. The coolers are heat exchangers, utilizing cooling water from a facility which will be described in Section 4.3.8.

To aid in the settling process, a flocculating agent is provided for the settling basins. A Flocculant Mixing Tank (72-TK-1), an Agitator (72-AG-2) and a Flocculant Metering Pump (72-P-4) are provided for this purpose.

4.3.7.2 Wastewater Treatment (Unit 74)

For environmental reasons, no liquid discharge from the Gasification Plant can contain wastes of such concentration that could be deemed harmful to people or the underwater life of the Delaware River. Since the process material balance dictates that some water, containing chemicals, must be discharged from the plant, a wastewater treatment facility is provided to neutralize all liquid effluent and render it harmless.

The Wastewater Treatment Facility is shown, diagrammatically, on Drawing EE-371-002 (Appendix E). The facility arrangement is shown on Drawing EE-071-012 (Appendix D).

The plant process effluents that will be treated are:

a. The coal unloading area sump pump effluents;
b. Coal and ash pile basin transfer pump effluent;
c. In-plant floor sumps;
d. Gravity filter backwash;
e. Carbon filter backwash;
f. Demineralizer backwash; and
g. Demineralizer Neutralization tank.

All effluents are directed to an Equalization and Holding Tank (74-TK-1) where they are thoroughly mixed by Agitators (74-AG-1 A and B). Before entry into the Equilization and Holding Tank, lime is injected into the stream from the Coal and Ash Pile Runoff Basin (74-TK-8) for pre-treatment of the stream pH. The Coal and Ash Pile Basin Transfer Pump (74-P-9 A and B, one operating and one stand-by) normally operates during periods of damp weather when the runoff basin adjacent to the Coal Pile Dike becomes full. A control valve, activated by the pump in the Runoff Basin, in a lime line will open, injecting lime into the stream being pumped to the Equalization Tank. The lime is thoroughly mixed with the stream by an In-Line Mixer (74-MX-1) before it is discharged to the Equalization and Holding Tank.

After all the waste streams are thoroughly mixed, the fluid is transferred to a Neutralization Tank (74-TK-6) by a Pump (74-P-1 A & B, one operating and one stand-by) in the Equalization and Holding Tank. In the Neutralization Tank, the following chemical additions are made.

a. Lime;
b. Sulfuric Acid; and
c. A Coagulant Polymer.

The lime is mixed in a Lime Slurry Tank (74-TK-4) and is pumped to the Neutralization Tank by a Pump (74-P-4 A and B, one operating and one stand-by). In a similar manner, dilute sulfuric acid from Tank 74-TK-3 is pumped to the system by a positive displacement Pump (74-P-3 A and B, one operating and one stand-by). The polymer is mixed in Tank 74-TK-5 and added to the system by a positive displacement Pump (74-P-5 A and B, one operating and one stand-by). The addition of both lime and acid is controlled by a pH monitoring device in the Neutralization Tank. The flows are adjusted automatically, by a control valve on the lime line and a control on the acid metering pump. The polymer addition is controlled, by a setting on its metering pump, proportionate to the flow into the Neutralization Tank.

An Agitator (74-AG-6) in the Neutralization Tank both mixes the neutralizing chemicals in the vessel and keeps all solids in suspension. The contents of the Neutralization Tank overflow, by gravity, into the Oxidation/Flocculation Tank (74-TK-7).

In the Oxidation/Flocculation Tank, the waste fluid is aerated by a diffuser located at the bottom of the vessel. All solids are kept in suspension by an Agitator (74-AG-7). After aeration, the waste fluid overflows the top of the tank into the suction of the Oxidation/Flocculation Transfer Pump (74-P-11 A and B, one operating and one stand-by). The pump lifts the fluid to the top of the Gravity Settler (74-ME-2).

In the Gravity Settler, the waste fluid is clarified, the solids settling to the bottom cone of the vessel. The upper clarified fluid in the vessel flows, by gravity, out and through a Gravity Polishing Filter (74-F-1 A and B, one operating and one stand-by) where the remaining solids are removed from the waste effluent. The neutralized and clarified liquid then flows through a Waste Water Flow and Sampling Chamber (74-ME-4) where the effluent is monitored. The liquid stream is then discharged to the Delaware River. The Gravity Polishing Filters are continually backwashed by an Internal Control System. The backwash recirculates back to the Equalization and Holding Tank for re-treatment.

The under-flow from the Gravity Settler takes two paths. A slip-stream is taken from the main discharge line, at the bottom of the vessel, and recirculated back to the Oxidation/Flocculation Tank. The sludge is recirculated to act as a "seed" for flocculation in the tank. The main portion of the sludge stream is discharged to the Sludge Thickener (74-ME-3) by a Gravity Settler Waste Sludge Pump (74-P-6 A & B, one operating and one stand-by). Pump 74-P-7 A and B (one operating and one stand-by) recirculates the balance of the sludge back to the Oxidation/Flocculation Tank.

In the Sludge Thickener, the solids are concentrated and settle down to the cone-shaped bottom of the vessel. A slow-moving rake (74-ME-3) distributes the settling solids evenly across the bottom of the vessel.

The clarified overflow from the Sludge Thickener is directed back to the Oxidation/Flocculation Tank by a Sludge Thickener Discharge Pump (74-P-12 A and B, one operating and one stand-by). The concentrated sludge at the bottom of the vessel is discharged to a Sludge Dewatering Filter (74-F-2) by a Sludge Dewatering Filter Feed Pump (74-P-8 A and B, one operating and one stand-by).

In the Sludge Dewatering Filter, the sludge forms a filter cake. The filter cake is discharged to a Belt Conveyor (74-CV-2) which conveys it to disposal area described in Section 4.3.8. The clarified water is recirculated back to the Equalization and Holding Tank by the Sludge Dewatering Pump (74-P-10 A and B, one operating and one stand-by).

As shown on Drawing EE-371-002 (Appendix E), a liquid stream is discharged from the plant cooling towers. The flow is monitored by the Cooling Tower Blowdown Flow and Sample Chamber (74-ME-5) before being discharged to the Delaware River. Cooling tower blowdown control is described in Section 4.3.8.

4.3.8 Utilities And Supporting Systems

4.3.8.1 Plant Water Systems (Units 74, 81, 82, 83, and 84)

A diagrammatic representation of the plant water systems are shown on Drawings EE-371-010 and EE-371-011 (Appendix E). The entire process water requirement for the plant is taken from the Delaware River. An inlet channel will be dredged from the river to a Pump House (Drawing EE-071-001, Appendix D).

Within the inlet channel, at the shore line, a Bar Screen (84-SF-1) is provided to prohibit large pieces of debris from entering the Pump House. A Sluice Gate (84-CA-1) is provided, at the nlet to the Pump House, to isolate the river supply from the Pump House.