Industrial Fuel Gas Demonstration Plant Program

DOE/ET/13046--T66

MASTER

DELIVERABLE No. - 38
DEMONSTRATION PLANT
OPERATION PLAN

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Prepared For
The Department of Energy
Under Contract #DE-AC02-77ET-13046

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INSTITUTE OF GAS TECHNOLOGY
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MEMPHIS INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROJECT

DEMONSTRATION PLANT OPERATION PLAN
(INCLUDING PRELIMINARY OPERATION
AND MAINTENANCE MANUAL)
(Deliverable #38)

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PREPARED FOR THE
U. S. DEPARTMENT OF ENERGY
ASSISTANT SECRETARY OF FOSSIL ENERGY

UNDER CONTRACT DE-AC02-77ET13406
(FORMERLY CONTRACT ET-77-C-01-2582)

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FOREWORD

DEMO PLANT OPERATING PLAN

The Demo Plant Operating Plan is composed of the following sequence of events starting with the training of personnel, familiarizing of the personnel with the plant and completing the long-term run in the following sequence: inspection during construction, plant completion, shakedown of equipment, process unit startup, shakedown of process units, variable run operation and a turnaround.

During the construction period, technical personnel from DRC, MLGW and IGT will be at the plant site becoming familiar with the equipment, its installation and all of the auxiliaries so that on completion of construction they will be well grounded on the plant detail and its configuration. At the same time the supervisory operating personnel will have hands on training the gasifier operation at the IGT pilot plant to develop a field for gasifier operation.

As the plant sections are completed, they will be checked out in accordance with the contractor and operator (client) procedure as outlined in Paragraph 3.3 and 3.4. Subsequent to this, various vendor designs and furnished equipment will be checked out operating-wise and a performance test run if feasible. The actual startup of the plant will be subsequential with the support areas as utilities, coal handling and waste treatment being placed in operation first. Subsequent to this the process units will be placed in operation starting from the rear of the process train and working forward. Thus the downstream units will be operating before the reactor is run on coal. The reactor will be checked out on coke operation. This sequence is outlined in the following Table B and in more detail in Paragraph 7.0.

TABLE B

Startup Sequence

A. Utilities

1. Electrical
2. Instrumentation
3. Fire Water Systems
4. Feed Water Treating
5. Boilers
6. Stack gas scrubbing
7. Incinerator
8. Cooling Tower

B. Coal

1. Coal Unloading
2. Coal Handling
3. Coal Drying
4. Coke Drying
5. Ash Handling

C. Waste Treating

1. Waste Water
2. Ozone Carbonization
3. Flare

D. Process

1. Sulfur Recovery and Tail Gas Treating
2. Sour Water Stripping
3. Selexol Circulation
4. Gas Scrubbing
5. Gas Cooling
6. Oxygen Plant
7. Reactor
8. Credit Unit

During this check-out operation, the number of gasifiers will vary depending upon the needs for checking the capacity of the downstream equipment. It is desirable to operate three units to provide full load as early as possible; however, if demand for full load is not available, it may be desirable to curtail length of full operation.

At this stage, any modifications of plant and/or equipment which are demonstrated to be desirable will be made prior to the plant variable study and the long-term run. The criteria for the variable runs are as follows: coal rates at various agglomerating temperatures, performance of equipment, and turn down capabilities.

A detailed experimental plan will be prepared prior to the start of the variable run. This run will be made with one reactor. After the variable run has been analyzed, the conditions for the long-term run will be set with the following purposes of establishing plant reliability, economics, and efficiency of process design. The long-term run will be made with one or more gasifiers depending on demand.

Section 1.0

INTRODUCTION

1.1 PROGRAM SUMMARY

The United States Department of Energy (DOE) executed a contract with Memphis Light, Gas and Water Division (MLGW) which requires MLGW to perform process analysis, design, procurement, construction, testing, operation, and evaluation of a plant which will demonstrate the feasibility of converting high sulfur bituminous coal to industrial fuel gas with a heating value of 300 ± 30 Btu per standard cubic foot (SCF). The demonstration plant is to be based on the U-Gas process, and its product gas is to be used in commercial applications in Memphis, Tennessee.

In order to perform this work, MLGW has established an industrial team, which includes:

MLGW - Memphis Light, Gas and Water Division, Memphis, Tennessee
The prime contractor and distributor of the industrial fuel gas.

FWEC - Foster Wheeler Energy Corporation, Livingston, N.J.
The engineer-construction manager.

IGT - Institute of Gas Technology, Chicago, Illinois
The process developer.

DRC - Delta Refining Company, Memphis, Tennessee
To provide operating experience.

The contract specifies that the work is to be conducted in three phases. Phase I costs are financed entirely by DOE. The phases are:

Phase I - Program Development and Conceptual Design

Phase II - Demonstration Plant Final Design, Procurement and Construction

Phase III - Demonstration Plant Operation

Task III of Phase I requires the preparation of a demonstration plant operating plan based on the U-Gas process. The demonstration plant operating plan consists of:

- Establish the basis of operational parameters of the demonstration plant and support facilities.
- Preparation of plant for operating.
- Overall schedule for Phase III operations.
- The Task III Report includes the description of the processes.

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TASK III-- DEMONSTRATION PLANT OPERATIONS

1.2 PLANT SUMMARY

The Industrial Fuel Gas Demonstration Plant produces a nominal 50 billion BTU/Day of product gas, which is equivalent in energy output to approximately a 10,000 barrel/day oil refinery. The product gas has a heating value of 300⁺ BTU/SCF. 45 billion BTU/Day of this gas is available as send-out gas to IFG customers. The remaining 5 billion BTU/Day of this gas is further processed to pipeline quality (950 BTU/SCF) and deposited in the Memphis natural gas distribution system to generate BTU credit. The BTU credit can be withdrawn and used to satisfy IFG customer demand when the U-gas production facility is totally or partially down for maintenance. By the use of the credit generation system the demand of IFG customers can thus be assured.

Drawing 2202-1-50-00104 is the plant block flow diagram showing the process sequence and process related support facilities of this demonstration plant. Each process unit as well as each process related support facility is described briefly in the following summary.

Section 310, Air Separation Plant

Compresses intake air and separates it into oxygen and nitrogen. The oxygen is compressed and sent to the gasifiers. A small portion of the nitrogen is returned for plant use. Liquid oxygen and nitrogen can also be produced to keep their respective storage tanks filled in order to provide the necessary reserve for an outage of the air separation plant.

Section 320, Coal/Coke Treating and Feed

Coal is crushed from 2" x 0" to 1/4" x 0" and dried to 2.5% moisture in a dryer mill. The dried, sized coal is stored in a coal silo. Sized coke received by the plant is also dried by a separate dryer and stored in a coke silo. Coal or coke is conveyed to the gasifier feeding systems from either the coal or coke silo. Dual conveying systems are provided to feed the gasifier feeding systems with one serving as a spare. Each gasifier has its own feeding system. The gasifier feeding system is a multi-feed hopper system, each consisting of a receiving hopper, two lock hoppers and two injection hoppers. Each injection hopper feeds into three pneumatic injection lines which transports coal or coke into the gasifier.

Section 330, Coal Gasification

Contains the coal gasifiers where steam and oxygen react with the coal in a fluidized bed at about 1875°F and 75 psig to produce hot, raw gas (CO, CO₂ and H₂). Within the reaction zone of the fluidized bed is an ash-agglomerating zone. The ash agglomerates drop into a water quench. Fines carried over with the hot, raw gas are returned to the gasifier through external cyclones.

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TASK III-- DEMONSTRATION PLANT OPERATIONS

Section 340, Gas Cooling and Scrubbing

Cools the gas from 1875°F to 450°F. For purposes of heat recovery, the gas passes in sequence through a high pressure steam generator, high pressure steam superheater, another high pressure steam generator, and a boiler feedwater preheater. After heat recovery the raw gas is quenched to saturation and passes through scrubbers. In the scrubbers particulate matter is removed by scrubbing with water. Sections 330 and 340 are four parallel trains and the balance of the plant is one train. Sour water from the knock-out drum, containing dissolved NH_3 and H_2S passes through a sour water stripper in Section 370; the overhead from the stripper goes to sulfur recovery. The water effluent goes to waste water treatment. The slurry water from the scrubber goes through a slurry water stripper. The slurry water after being stripped is clarified and filtered. The filter cake is sent to the steam generator for use as fuel. The filtrate water effluent is sent to waste water treatment.

Section 350, Gas Compression

Scrubbed gas is cooled, compressed and cooled again to sufficiently high pressure to go through gas treating and deliver the gas at 150 psig to the industrial fuel gas distribution header.

Section 360, Gas Treating

Receives the cooled gas from the compressor in Section 350. It then passes to a Selexol unit where H_2S and COS are removed to meet the product gas sulfur specification, and enough CO_2 is removed to obtain a constant heating value product gas. The product gas is then odorized and metered before being discharged to the industrial fuel gas distribution system.

Section 380, Sulfur Recovery

Receives sour gas from Section 370 and acid gas from Section 360. It converts the sulfur compound in three catalytic stages of Claus type sulfur recovery unit to achieve 96% sulfur recovery. Sulfur goes through condensers, seal pit and rundown pit, and storage tank before being loaded into tank trucks.

Section 390, Tail Gas Treating

Receives the tail gas from Section 380. It then goes to a Beavon unit package where remaining sulfur is converted to H_2S , and then removed in a Stretford Unit. The tail gas is reheated to achieve satisfactory buoyancy and discharged to the atmosphere.

Section 220, Credit Generation

Treats from 10% to 30% of the product gas from Section 360 to produce pipeline quality gas which will be deposited into the Memphis pipeline gas distribution system to generate a reserve of credit. This reserve which can be withdrawn during U-gas plant outage. Pipeline gas withdrawn from the Memphis pipeline gas distribution system will be adjusted to the U-gas heating value prior to its distribution to the U-gas customers.

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III- DEMONSTRATION PLANT OPERATIONS

Section 410, Coal/Coke Handling

Receives the incoming washed coal (2" x 0") from barges and transports it to a 14 day live coal storage pile. From there coal is transported to Section 320.

Section 420, Ash Treatment

Receives the agglomerated quenched ash slurry from the gasifiers (Section 330) and conveys it hydraulically to the dewatering bins. The dewatered ash is then discharged into trucks for disposal to the ash pile. The water from the dewatering bins is collected in the clarifier where clean water overflows into a sump tank while the underflow is pumped back to the dewatering bins. The clean water is then recycled to the gasifiers. A startup pump is provided for initial transport of slurry to the dewatering bins when the gasifier pressure is still low for conveying. The none process sections to support the process and to provide utilities to the process include the following functions:

Section 430, Utility Area which includes:

- Steam Generation
- Raw Water Storage
- BFW Treatment

Section 440, Waste Water Treatment

Section 450, Cooling Tower

Section 460, Flare

Section 470, General Facilities which include:

- Long Term Coal Storage for 90 days
- Long Term Ash & Solid Waste Storage
- Interconnecting Piping
- Roads and Fences
- Firewater System
- Power, Lighting, and Communication
- Sewers

1.2.1 Overall Material and Energy Balance

The overall thermal efficiency is 68.0%, i.e. 68.0 BTU's leave the system as Product Gas Fuel value for every 100 BTU's of energy charged to the system. The total energy charged being the sum of the raw coal fuel value plus purchased power.

About 5% of the energy charged to the system is imported electric power. 68% of the lost energy (energy that leaves the plant, but not as Product Gas fuel value) leaves the system as cooling tower evaporation and air fan losses. The remaining 32% of the lost energy is in the vents, heated discharges, insulation losses and unburned fuel value in the ash.

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TASK III- DEMONSTRATION PLANT OPERATIONS

The normal consumption of raw materials, utilities, chemicals, and catalysts when operating at design throughput, of 52.0 billion (See Note 1) BTU of equivalent IFG before part of it is methanated for credit generation are given in this section as follows:

- 1.2.1.1 Summary of Major Requirements
- 1.2.1.2 Catalyst and Chemical Requirements
- 1.2.1.3 Fuel Requirements
- 1.2.1.4 City Water Requirements
- 1.2.1.5 Electrical Power Requirements
- 1.2.1.6 Steam Generation and Distribution
- 1.2.1.7 Cooling Water Balance
- 1.2.1.8 Overall Material and Energy Balance
- 1.2.1.9 Overall Thermal Efficiency

1.2.1.1 Summary of Major Requirements

<u>Item</u>	<u>Usage</u>
Coal	3158 tons/day
Power	45,096 KW
Natural Gas	8 SCFM
Water	1882 GPM
Catalysts & Chemicals	10,783,981

1.2.1.2 Estimated Catalyst and Chemical Requirements

Estimated Catalyst and Chemical requirements for this demonstration is given in Table 1.2-1 attached.

- (1) Design basis assumed an inplant use of 2 billion BTU/D of product gas. Inplant use for final design is 0.7 billion BTU/D which includes 0.28 billion BTU/D indigenous to the CO₂ vent stream reporting to incineration. Therefore, developed capital and operating costs reflect a net production rate of 51.3 billion BTU/D. These numbers will be normalized, where required, to reflect a 50 billion BTU/D production rate.

TABLE 1.2-1 (Page 1)

Estimated Catalyst and Chemical Requirements

<u>Chemicals</u>	<u>Usage lb/day</u>	<u>Usage lb/yr (1)</u>	<u>Inventory lbs</u>		<u>Unit Prices \$/lb (2)</u>	<u>Usage \$/yr</u>	<u>Inventory \$</u>
			<u>Initial Charge</u>	<u>Carried Inventory</u>			
Phosphate (As $\text{Na}_{2.8} \text{H}_{0.2} \text{PO}_4$)	18.2	6,006	13	787	0.245	1471	196
Selexol Solution	123	40,590	710,000	-	1,025	41,605	727,750
Na_2CO_3 & Additives	599	197,670	29,300	-	0.381	75,312	11,163
K_2CO_3 & Additives	137	45,210	157,500	-	0.28	12,659	44,100
66 Baume H_2SO_4	1356	447,480	165,000	-	0.05	22,374	8,250
50% NaOH	36	11,880	42,636 (3)	-	0.10	1,188	4,264
Amine (40 WT% Morpholine Soln)	0.3	99	6	119 (3)	0.885	88	111
Hydrazine (35% WT% Soln.)	13	4290	6	36 (3)	2.525	10,832	106
Corrosion Inhibitor	130	42,900	-	3,900	0.54	23,166	2,106
Dispersant	70	23,100	-	2,640	0.54	12,474	1,425
Chlorine	90	29,700	-	4,000	0.10	2,970	400
Activated Carbon	303	100,000	96,000	56,000	0.675	67,500	37,800
Hydrated Lime	27,382	9,036,060	140,000	-	0.045	406,623	6,300
Polymer	4	1,320	900	100	8.025	10,593	8,025
Phosphoric Acid	10	6,600	-	300	0.12	789	36
Soda Ash	2160	712,800	50,000	20,000	0.071	50,609	4970
Subtotal Chemicals	32,432	10,705,705	1,391,361	87,882		740,253	857,002

- Notes:
- (1) One year = 330 working days.
 - (2) 2.5¢/lb is included as transportation cost in all chemicals and catalysts prices.
 - (3) Charge based on minimum purchase quantity.
 - (4) Because of large volume, system depletion is allowed to permit 1-2 times/year truckload delivery of replacement Selexol solvent.

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TASK III - DEMONSTRATION PLANT
OPERATIONS

TABLE 1.2-1 (Page 2)

Estimated Catalyst and Chemical Requirements (Continued)						
Catalysts	Usage lb/day	Usage lb/yr (1)	Inventory lbs		Unit Prices \$/lb (2)	Usage \$/yr
			Initial Charge	Carried Inventory		Inventory \$
Rhone Progil Type CR Catalyst	125	41,250	124,820		0.335	13,819
N-25 American Cyanamid	19.2	6,336	12,685		0.961	6,089
Methanation Catalyst	32	10,560	47,090		5.000	52,800
United - G - 3/C 12-3	24	7,920	38,730		0.893	7,073
United - C7-2	37	<u>12,210</u>	<u>83,150</u>		1.143	<u>13,956</u>
Subtotal Catalysts	237.2	78,276	306,475			93,737
Total	2669.2	10,783,981	1,697,836	87,882		833,990
						1,276,083

- Notes:
- (1) One year = 330 working days.
 - (2) 2.5¢/lb is included as transportation cost in all chemicals and catalysts prices.
 - (3) Charge based on minimum purchase quantity.

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1.2.1.3 Fuel Requirements

A. Normal

Product Gas	MMM BTU/D
Section 390	0.2
Section 430	<u>0.22</u>

TOTAL	0.42
-------	------

Natural Gas
Section 460

Usage	8 SCFM
-------	--------

B. Start-Up

Natural Gas	SCFM
Section 330	507.6
Section 380	646
Section 390	135
Section 220	250
Section 430	2200

1.2.1.4 City Water Requirements

Average Usage	1882 GPM
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**TASK III- DEMONSTRATION PLANT
OPERATIONS**

1.2.1.5 Electric Power Requirement (KW)

Section 310	11,940
Section 320	1,031
Section 330	1
Section 340	220
Section 350	16,520
Section 360	6,712
Section 370	72
Section 380	250
Section 390	480
Section 220	1,035
Section 410	75
Section 420	180
Section 430	2,000
Section 440	260
Section 450	4,000
Section 460	<u>20</u>
Subtotal	44,796
Lighting, air conditioning and Instrumentation	<u>300</u>
Total	45,096

1.2.1.6 Steam Generation and Distribution

Flow of steam generation and distribution may be followed on the Steam Balance Diagram, Dwg. No. 2202-1-50-00102.

1.2.1.7 Cooling Water Balance

Plant cooling water balance is shown on drawing 2202-4-50-00103 attached.

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TASK III - DEMONSTRATION PLANT
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TABLE 1.2-2

OVERALL MATERIAL & ENERGY BALANCE

	<u>Tons/Day</u>	<u>MM BTU/Hr.</u> (Notes 1 & 2)	<u>%Total BTU</u>
<u>INPUT</u>			
1. Coal to Coal Handling	3158	2936.1 ³	94.33
2. Air to Oxygen Plant	8055	16.4 ³	0.53
3. Water	11292		
4. Purchased Power	(45.1 MW)	153.9	4.94
5. Process & Reactor Air	973	1.9	0.06
6. Air to Steam Boilers	<u>2105</u>	<u>4.3</u>	<u>0.14</u>
<u>Total In</u>	25,583	3112.6	100.0
 <u>OUTPUT</u>			
1. Product Gas (U-Gas)	3840	2936.1 ¹	61.98
2. Credit Gas (Credit Generation)	93	16.4 ¹	5.50
3. Sulfur	100	33.86	1.09
4. Discharged Wastewater	4282	(note 2)	-
5. Wet Coal Ash (From Ash Handling)	520	70.2	2.26
6. Air Separation Waste Gas	6081	5.97	0.19
7. Utility Area Stack Gases	4206	74.77	2.40
8. Cooling Tower Losses	5620	460	14.78
9. Beavon Evaporation Water Loss	119	11	0.35
10. Beavon Absorber Vent	574	2.37	0.08
11. Air Fan Losses		218.82	7.03
12. Boiler Fly Ash	30	0	
13. Sanitary Wastewater	62	(note 2)	-
14. Vents	56	0.03	
15. Miscellaneous	<u>0</u>	<u>135.12</u>	<u>4.34</u>
<u>Total Out</u>	25,583	3112.6	100.00

- Notes:
- (1) All feeds and products assumed at ambient temperature.
 - (2) Energy datum for water is liquid at ambient temperature.
 - (3) Based on higher heating value.

MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM

TASK III- DEMONSTRATION PLANT
OPERATIONS

1.2.1.8 Overall Material and Energy Balance

Plant overall material and energy balance is shown on Table 1.2-2 attached.

1.2.1.9 Overall Thermal Efficiency

a) Overall Cold Thermal Efficiency

Overall Thermal Efficiency is defined as the percent of fuel entering the plant battery limits which exits the battery limits as IFG & SNG.

"Cold" means HHV taken at ambient temperatures without sensible heat increment.

$$\frac{1929.1 \text{ (U-Gas)} + 171.36 \text{ (SNG)}}{2936.1 \text{ (Total Coal)} + 153.9 \text{ (KW at B.L.)}} \times 100 = 68.0\%$$

b) Alternate Thermal Efficiencies

(1) Overall Cold Thermal Efficiency with Sulfur Product Cred.

$$\frac{1929.1 \text{ (U-Gas)} + 171.36 \text{ (SNG)} + 33.86 \text{ (Sulfur)}}{2936.1 \text{ (Total Coal)} + 153.9 \text{ (KW at B.L.)}} \times 100 = 69.1$$

(2) Overall Cold Thermal Efficiency with Imported Power Energy at Power Plant

It is assumed that the power plants efficiency for converting coal to KW's is 35%.

$$\frac{1929.1 \text{ (U-Gas)} + 171.36 \text{ (SNG)}}{2936.1 \text{ (Total Coal)} + \frac{153.9 \text{ (KW at B.L.)}}{0.35 \text{ (Power Plant Efficiency)}}} = 62.2$$

(3) Overall Cold Thermal Efficiency with Imported Power Energy at Power Plant and Sulfur Product Credit.

$$\frac{1929.1 \text{ (U-Gas)} + 171.36 \text{ (SNG)} + 33.86 \text{ (Sulfur)}}{2936.1 \text{ (Total Coal)} + \frac{153.9 \text{ (KW at B.L.)}}{0.35 \text{ (Power Plant Efficiency)}}} = 63.2$$

NOTES
GENERAL: ALL THE VALUES SHOWN ON THIS BALANCE CORRESPOND TO 3-100% CAPACITY OPERATING.

INDUSTRIAL FUEL GAS DEMONSTRATION PLANT
BIRMINGHAM, TENN.
CONTRACT NO. ST-77C-81-1582
DESIGNED BY: H. B. HARRIS & ASSOCIATES, INC.
ENGINEERED BY: H. B. HARRIS & ASSOCIATES, INC.
CHECKED BY: H. B. HARRIS & ASSOCIATES, INC.

UTILITY AREA
SECTION 430
STEAM BALANCE DIAGRAM
UTILITY AREA
SECTION 430

STEAM BALANCE DIAGRAM
UTILITY AREA
SECTION 430
DRAWING NO. 2002-450-0000

NOTES:

1.) FLOW RATES SHOWN HERE ARE FOR THE NORMAL OPERATING CASE (3 GASIFIERS OPERATING).

TASK II DEMONSTRATION PLANT

COOLING WATER BALANCE DIAGRAM
COOLING TOWER (SECTION 450)
INDUSTRIAL FUEL GAS DEMONSTRATION PLANT

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DRAWN BY: K.J.M. 6-179 SCALE: $\frac{1}{4}$ " = 1'-0"
CHECKED BY:
APPROVED BY:
2202-4-50-00103

INDUSTRIAL FUEL GAS DEMONSTRATION PLANT

MEMPHIS, TENN.

CONTRACT No. ET 77C-01-2582

MEMPHIS LIGHT, GAS
AND WATER DIVISION
MEMPHIS, TENN.

DEPARTMENT OF ENERGY
COAL CONVERSION DIVISION
WASHINGTON, D.C.

REVISION

A JULY 10, 1979 FINAL ISSUE MB ORDER NO. 15-2202

PLANT COMPLETIONSECTION 2.02.1 GENERAL COMMENTS

Startup and shakedown involves the careful and meticulous preparation of each process unit equipment for operation. Mechanical completion by the construction contractor represents the fabrication of process piping, instrumentation, electrical and the erection of major pieces of equipment. Preparation for the startup and shakedown phase begins as soon as there is enough piping erected to follow. Careful attention to details will assure that a smooth startup and shakedown period is achieved.

2.2 Vessel Inspection. Vessel inspection should be done as soon as the vessel has been erected and is available from the construction contractor. The actual installations must be compared against engineering drawings to assure that the vessel will function as was intended. Particular attention should be paid to the following details:

- A. Pressure and temperature ratings
- B. Tray types and spacing
- C. Gaps between tray sections
- D. Weir heights and trays
- E. Collector and accumulator trays (must be sealed)
- F. Weep holes
- G. Tray supports and tray levelness
- H. Nozzle sizes and locations
- I. Vortex breakers
- J. Thermowells (must be in vapor space above trays)
- K. Demister pads (size, materials, support)
- L. Slotted inlet pipes
- M. Extended nozzles
- N. Linings (concrete, monel, stainless steel, etc.)
- O. Vessel elevation above-grade

TASK III

DEMONSTRATION PLANT OPERATION

The inspection of all vessels requires careful attention to all details. Grids, distributor trays, nozzles and placement are all noted and if any deviations from engineering drawings are noted, they should be called to the contractor's attention for immediate correction of the problem.

- 2.3 Flow Check. As soon as construction has neared completion, and, if possible, even before completion, the unit must be carefully checked against the piping and instrument drawings issued during detailed engineering and design. The actual arrangement of lines, vessels and pumps, etc. must conform to the engineering drawings. The check must include not only the process flow, but also the following items:

- A. Line sizes and material
- B. Ring joint sizes and material (inspect rings for damage)
- C. Flanges and gaskets (facing, finish, ratings)
- D. Flange bolting
- E. Valves (are gear operators required? Trim, accessibility)
- F. Sample taps and locations
- G. Drains and vents
- H. Check valves (type, location, materials)
- I. Pump and compressor ratings
- J. Relief valves (settings witnessed by contractor representative)
- K. Line supports (particularly in high pressure drop and vibration prone areas)
- L. Instrument installation and location

All heat exchangers and air fin coolers must be checked for materials of construction, pressure and temperature ratings, nozzle sizes and ratings, vents and drains, expansion, etc.

Any items under question should be resolved prior to placing the unit on stream.

2.4

Hydrostatic Pressure Test. Prior to initial startup, the entire unit should have been hydrostatically pressure tested by the contractor to insure the vessels, exchangers, piping, pumps and other equipment meet the design pressure specifications. This special procedure is carried out by the construction contractor, however, the unit is not hydrostatically tested each time it is started and certain routine pressure testing by other means is included where required during the startup to insure tightness of flanges, piping, etc., and generally, to reveal leaks that may have developed subsequent to the last hydrostatic test. The process unit can be divided into convenient sections for hydrotesting and in any given section, pressure test applied should be equal to the allowable test pressure of the lowest rated equipment in the circuit where high alloy stainless steels are involved. The temperature of the water used for hydrotest should be at least 75°F and the content of chloride in the water checked. Before any testing is done, all orifice plates must be removed from the lines, and relief valves blinded off. In the case of some reactor sections, where exchangers handle both feed and effluent, excessive differential pressure across the tube bundle must be avoided. A temporary connection may have to be installed to assure that both sides of exchanger are pressured to the same level. The test pressure must be held until it is assured that the unit is tight and that all leaks have been eliminated. In addition to process lines, the utility lines (steam, air, etc.) should also be tested. The hydrostatic testings of various vessels and lines will always be witnessed by a representative of the contractor. It is usually recommended that pressure tests be carried out at the lower of the following two values:

1. 150% of operating pressure of the lowest rated equipment in the circuit.
2. 50 psi lower than the lowest shop test applied to any item on the circuit.

2.5

Utility Systems. The various utility lines should be tested and placed into service as soon as the construction schedule allows. Pressure tests should be carried out on the steam, condensate, air, fuel gas, and oxygen lines. Steam lines should be warmed up gradually to prevent damage by water hammer. At the same time, all steam traps and condensate lines should be placed into service. Scale and construction debris can be conveniently removed from the steam lines by blowing them as long as necessary with steam. Other utility lines can be cleaned by blowing them with steam or air, or by water flushing, if possible. All utility lines, with the exception of the flare, can be put into service as soon as construction makes the lines available for use.

2.6 Instruments. The construction contractor commits himself to the installation of the instrument and that the instrument will respond to a function check. This type of contractor check-out is not considered sufficient in guaranteeing that the instrumentation is functional for plant operation. The check-out of instruments should begin as soon as permissible. Actually the check-out of instruments begins with the flow check, in which all instrument points and installations should be checked against the engineering piping and instrument drawings. An instrument specialist would be of great assistance in doing the flow check and pointing out discrepancies in instrument installations. Several of the following items should be looked at in the check-out of the instrumentation:

- A. Pressure test of the instrument air lines
- B. Control valve action and calibration
- C. Positioner calibration
- D. Board calibration and loop check
- E. Thermocouple calibration and identification
- F. Level instrument calibration
- G. Thermometers, pressure gauges, and miscellaneous

All orifice plate bores should be measured, recorded and compared with the required sizes. The orifice plates should be checked to see if they are counter-bored, wherever required. A responsible operator expert should closely monitor the installation of all orifice plates so that the orifice plates are located in the correct lines and that the sharp edge of the orifice plate is facing the upstream flow in the line. Prior to the field check, instrumentation experts and process engineers will have been designing the software for the plant CRT data gathering system. The CRT system is not intended to relieve the operator of his responsibility to monitor and maintain a safe operating plant. It does, however, provide him with information, displayed in a way that will enable him to draw the correct conclusions about how the process is operating.

2.7 Acidizing the Compressor Lines. Mill scale must be removed from the compressor section by acid cleaning in order to reduce the possibility of solids entering the compressor itself. The exact procedure to be followed should be supplied by the construction contractor. The following items must be acid cleaned:

TASK III

DEMONSTRATION PLANT OPERATION

1. All the gas piping, including the spillback lines
2. The make-up suction drum
3. Make-up gas coolers and intercoolers

Any passivating agent must be flushed from the system prior to start-up. Normally, the construction contractor will sub-contract this item out to someone who is experienced in pickling the compressor lines. However, the whole operation should be witnessed by a representative of the contractor.

2. 8

Dry Out. In process units that require catalyst loading, excessive amounts of water must be driven out of the circuit. Under most circumstances, free water can be adequately removed by allowing it to drain from lines, heaters, reactors, exchangers, etc. while blowing through the lines with air. Where dry out of refractory is required, the operator should make sure to follow the dry out instructions as provided by the refractory vendor. During the dry out section, all steam systems should be degreased and boiled out. Another part of the dry out is the degreasing and boil out of all steam generation systems. A mixture of soda ash solution of approximately 2% will be required. The heater used for the boil out procedure is to be held between 230°F-250°F. These conditions should be held for approximately twelve hours. The rate of venting can be varied in order to shock scale from the tubes.

PLANT COMPLETIONSECTION 3.03.1 SCOPE

This standard is intended to define when the responsibility for care, custody and control of various units, systems or facilities of a plant is transferred from contractor to the client. The general principles differentiating the limits and responsibilities for the work for both parties are defined and a tabulation of the specific work performance responsibilities required to place common process equipment or systems into operation is presented.

3.2 DEFINITIONS

This section presents definitions which, along with the General and Specific Procedures given in Sections 3.3 and 3.4 serve to clarify the basic principles associated with the transfer of responsibility from the contractor to the client at commissioning time.

3.2.1 Pre-commissioning. Pre-commissioning activities are the non-operating adjustments and cold alignment checks made by the contractor as detailed in Sections III and IV.

3.2.2 Ready for Commissioning. The date when the plant or part thereof is "ready for commissioning" occurs when the plant, unit or facility or part thereof has been erected in accordance with drawings, specifications, and applicable codes, to the extent necessary to permit commissioning, and pre-commissioning activities have been completed by contractor as detailed in Sections 2.3 and 2.4.

3.2.3 Commissioning. Basically, commissioning activities are associated with the running or operating of the plant and are the client's responsibilities unless specifically directed otherwise by the contract.

The commissioning period by the client follows the completion of the pre-commissioning activities performed by contractor. During commissioning, the client makes operating adjustments required before the plant may be satisfactorily operated, and commences operation of the plant or part thereof, performing any further adjustments, settings, etc. that may be required.

3.2.4 Completion of Construction. Completion of construction means that the contractor has:

1. Provided erection in accordance with drawings and specifications.
2. Completed pre-commissioning work.
3. Completed final cleanup, painting and thermal insulation work.

PLANT COMPLETION3.3 GENERAL PROCEDURES

General work procedures tabulated in Table I outline the work to be performed by Foster Wheeler and by the client. Procedures applicable to specific systems or items of equipment are separately covered in Section 3.4.

PLANT COMPLETIONTABLE I

Item	By Contractor	By Client
<p>3.3.1</p> <p>Vendor and Service Assistance</p>	<p>Obtain manufacturer's (vendor) assistance when deemed necessary to render a satisfactory installation, as mutually agreed between Foster Wheeler and the client.</p>	<p>Obtain manufacturer's (vendor) assistance if desired, for operating, or run-in by the client's operating and maintenance personnel; and for training, or other informational and operating purposes.</p>
<p>3.3.2</p> <p>Leak and Pressure Tests</p>	<p>Make non-operating field leak or pressure tests on piping and field fabricated equipment. All tests will be conducted in accordance with Engineering Standards.</p> <p>Dispose of any special test media in accordance with client instructions.</p> <p>Notify client of test schedule.</p>	<p>Provide any special media for test purposes and facilities for disposal.</p> <p>Witness tests when notified by construction.</p> <p>Conduct all operational tightness testing.</p>
<p>3.3.3</p> <p>Inspection</p>	<p>Provide inspection of the plant to check conformity of erected facilities to flow diagrams, construction drawings, vendor prints, and specifications.</p> <p>Shop inspected equipment will not be reopened for inspection in the field except as specifically noted in item 3.4.4.</p>	<p>Provide for special inspections such as required by insurance or governmental agencies.</p> <p>Perform shop inspection as desired.</p> <p>Verify and approve plant check with any exceptions noted on a separate work order list (punch list).</p>

PLANT COMPLETION

TABLE I (contd)

Item	By Contractor	By Client
3.3.4 Permits	Secure permits and certifications required by or for his design work or for his erection work. Assist client in the procurement of all permits and certifications required to be secured by the client for initial use of the plant.	Make applications for all permits issued in his name and required for plant installation, use, occupancy, and operation.
3.3.5 Removal of Rust Preventives	Remove all rust preventives and oils used to protect the equipment during the construction period when such material will be detrimental to operation.	
3.3.6 Operating Supplies and Chemicals	Inspect vessel interior before loading of inert packing materials or chemicals to insure vessel is ready for proper installation.	Procure and install all inert packing materials and beds and/or all materials in apparatus containing chemicals, resins, dessicants, catalysts, and other such operating materials except as specifically noted in Section 3.4.

PLANT COMPLETION

TABLE I (contd)

Item	By Contractor	By Client
3.3.7 Lubricants	<p>Insure that the mechanical catalogs identify equipment vendors' recommended lubricants for use by the client.</p> <p>Install initial charge only of all lubricants as provided by the client.</p>	<p>Approve lubricant list and provide all lubricants.</p> <p>Maintain lubrication after initial charge.</p>
3.3.8 Rotation and Alignment	<p>Check rotating machinery for correct direction of rotation and freedom of moving parts before connecting driver.</p> <p>Make only cold alignment to manufacturer's tolerances.</p> <p>Foster Wheeler will not operate or run any piece of equipment.</p>	<p>Operate equipment and make vibration checks, trip checks governor checks, and safety device check, and other operating tests and adjustments required.</p> <p>Make hot alignment and any doweling required.</p>
3.3.9 Packing and Seals	<p>Install mechanical seals, permanent packing and accessories when required.</p>	<p>Make necessary adjustments and replacements to mechanical seals, packing, and accessories during commissioning period.</p>
3.3.10 Safety Devices	<p>Install all safety devices e.g. pressure relief valves, after testing and adjustment by the client.</p> <p>Provide client with proper settings of safety devices.</p>	<p>Test and adjust all safety devices and seal where necessary or desirable.</p> <p>Maintain the necessary records.</p>

PLANT COMPLETION

TABLE I (contd)

Item	By Contractor	By Client
3.3.11 Flushing and Chemical Cleaning	Turn systems over to the client free of trash and construction debris (not necessarily free of welding slag.)	Conduct all flushing, blowing and chemical cleaning operations and provide circulating media and chemicals required except as noted under items 3.4.2, 3.4.7 and 3.4.8.
3.3.12 Temporary Strainers, Screens and Blinds	Provide and install all required temporary strainers.	Clean strainers as required during circulation and remove when warranted. Provide, install, and remove all blinds required for flushing or operation. Maintain required records.
3.3.13 Drying Out	Dry out when required to complete further construction or where facilities supplemental to those required for normal operation are needed.	Dry out systems, refractories and linings when such drying can be accomplished with permanently installed equipment or as part of the commission-activities.
3.3.14 Purging	Install purge connections.	Provide purge materials and conduct necessary purge operations.

PLANT COMPLETION

TABLE I (contd)

Item	By Contractor	By Client
3.3.15 Maintenance and Spare Parts	<p>Protect equipment from normal weather conditions, corrosion, or damage prior to commissioning.</p> <p>Insure that mechanical catalog includes list of spare parts as recommended by vendors.</p>	<p>Provide adequate maintenance for equipment, including such items as the cleaning of strainers and the repairing of steam traps, after pre-commissioning is complete.</p> <p>Maintain adequate spare parts and supplies.</p>
3.3.16 Housekeeping	<p>Provide construction cleanup including removal of excess materials, temporary facilities and scaffolding, rough sweeping or raking the area, and trash pickup. Washing or further cleanup is not included.</p>	<p>Maintain adequate housekeeping practices after pre-commissioning is complete as required for safe operation.</p>
3.3.17 Tie-ins at Unit Limits	<p>Obtain client's approval and make the necessary tie-ins at the unit limits as required by the specifications.</p>	<p>Prepare all systems for safe tie-ins and observe same.</p>
3.3.18 Instructions	<p>Transmit to client any vendor's or manufacturer's instructions and drawings, as applicable.</p> <p>Provide client with any special instructions such as requirements for drying liners.</p>	<p>Maintain adequate vendor instruction file so that the information may readily be retrieved as may be required.</p>

PLANT COMPLETION

TABLE I (contd)

Item	By Contractor	By Client
3.3.19 Removal of Temporary Bracing, Supports, etc.	Remove all temporary supports, bracing, or other foreign objects which have been installed in equipment to prevent damage during shipping, storage, and erection e.g. vessels, transformers, rotating machinery, etc. including other items specified elsewhere for the appropriate equipment type.	

TASK III

DEMONSTRATION PLANT OPERATION

PLANT COMPLETION**3.4 SPECIFIC PROCEDURES**

In addition to the work to be performed in accordance with Section 3.3, General Procedures, the detailed procedures outlined in Table II below further define the work responsibilities of Foster Wheeler and client for specific systems and items of equipment.

TABLE II

Item	By Contractor	By Client
3.4.1 Electrical Power and Lighting Systems	Notify client of test schedule Test electrical installations in accordance with Engineering Standards.	Witness tests when notified and record test data if desired.
3.4.2 Instrument Systems	<p>Contractor will not field calibrate any instrument component unless required by the job specifications. He will, however, make such non-operating checks which will assure instrument operability i.e. remove all shipping stops, check pointer travels, and verify instrument capability to measure, operate, and stroke in the direction and manner required by the process application.</p> <p>Install and connect all system components and verify their conformance with specifications and design criteria for function and range using dummy transmitted signals as needed.</p> <p>Clean all transmission and control tubing by blowing with cooled and filtered clean air prior to connecting to instrument components.</p> <p>Clean all air supply headers by blowing with clean air and check for tightness.</p> <p>Leak test pneumatic control circuits in accordance with ISA Recommended Practice RP 7.1.</p> <p>Check process lead piping for tightness.</p>	<p>As dictated by his practice, calibrate instruments with standard test equipment and make all required adjustments and control point setting.</p> <p>Fully pressurize and energize the transmitting and control signal system, opening process connections at primary sensors and final regulators and making control mode settings for automatic operation of equipment as the process unit is charged and brought on stream.</p>

PLANT COMPLETION

TABLE II (contd)

Item	By Contractor	By Client
<p>3.4.2</p> <p>Instru- ment Systems</p>	<p>Check all electrical signal and alarm wiring for continuity, correct source of power, and polarity.</p> <p>Check thermocouples for proper joining of wires, position of elements in wells, proper polarity and continuity of receiving instruments.</p> <p>Identify orifice plates by tagging and deliver to client.</p> <p>Isolate, or remove if necessary in-line components such as control valves, positive displacement meters, turbine meters, etc. for pressure testing and reinstall such items.</p>	<p>Check bores of orifice plates and install such plates after completion of flushing operations.</p> <p>Isolate or remove in-line components for client's flushing operations and reinstall them on the completion of such operations.</p>
<p>3.4.3</p> <p>Piping Systems</p>	<p>Notify client of test schedule.</p> <p>Hydrostatically or pneumatically test all piping as required by the drawings or specifications in accordance with Engineering Standards.</p> <p>Check pipehangers, supports, guides and pipe specialties for the removal of all shipping and erection stops; and for the correctness of cold settings for the design service. In addition provide the client with instructions for hot settings.</p> <p>Install car seals on valves where necessary.</p> <p>Correct support, vibration, and thermal expansion problems detected during commissioning.</p>	<p>Witness field pressure tests when notified by contractor.</p> <p>Perform all operational tightness testing.</p> <p>Check pipehangers, supports, guides and pipe specialties for hot settings and make minor adjustments as necessary.</p> <p>Check and record position of all car sealed valves.</p>

PLANT COMPLETION

TABLE II (contd)

Item	By Contractor	By Client
<p>3.4.4</p> <p>Vessels</p>	<p>Unhead after erection to place any internals requiring field installation. These internals will be inspected at time of installation. External manways on vessels will be opened for inspection by client even if they have been shop inspected. For these shop inspected vessels, internal manways will not be opened unless required by the job specifications.</p> <p>Head up upon proper execution of closure permits.</p> <p>When vessels have been subjected to a shop test, they will not be further tested in the field but may be included as part of a piping system test.</p>	<p>Witness inspections to the extent desired.</p> <p>Unhead after dryout and charge materials as designated in item 3.3.6 and head up.</p>
<p>3.4.5</p> <p>Shell and Tube Exchangers</p>	<p>Shop inspected exchangers will not be reopened in the field.</p> <p>When exchangers have been subjected to a shop test, they will not be further tested in the field, but may be included as part of a piping system test.</p>	
<p>3.4.6</p> <p>Air Cooled Exchangers</p>	<p>Inspect to assure that temporary shipping supports and erection material have been removed.</p> <p>When exchangers have been subjected to a shop test, they will not be further tested in the field, but may be included as part of a piping system test.</p>	

PLANT COMPLETION

TABLE II (contd)

Item	By Contractor	By Client
<p>3.4.7</p> <p>Fired Heaters</p>	<p>Pressure test in accordance with the applicable code, if required.</p> <p>Provide all non-operating prefiring checks in accordance with manufacturer's instructions.</p> <p>Blow fuel lines, check for cleanliness, and connect burner piping.</p> <p>Check operation of registers and dampers, and verify position of indicators.</p>	<p>Dry refractories during initial firing by following the manufacturer's temperature cycles.</p> <p>Conduct boil-out, and chemical cleaning and flushing operations as required.</p> <p>Obtain and charge liquid heat transfer media, if required.</p> <p>Conduct light-off, drying and purging operations.</p> <p>Obtain service engineer for start-up, if desired.</p>
<p>3.4.8</p> <p>Pumps, Compressors, and Drivers</p>	<p>Level baseplates and sole plates and grout all bearing surfaces.</p> <p>Check for and remove any excess piping stresses which may be imposed on the equipment.</p> <p>Chemically clean the completed installation of any seal and lube oil system, when specified.</p> <p>Charge the lube and seal oil systems.</p>	<p>Circulate for cleaning purposes any seal oil, lube oil, and cooling systems.</p> <p>Obtain service engineer for start-up, if desired.</p>

PLANT COMPLETION

TABLE II (contd)

Item	By Contractor	By Client
3.4.9 Miscellaneous (Agitators, Mixers Rotary Filters Weigh Scales Materials Handling Equipment, Etc.)	<p>Fully assemble rotary filters except for final filter media (cloth or screen).</p> <p>Level and calibrate weigh scales with assistance of the manufacturer's representative and set tare weights where possible.</p> <p>Manually check materials handling equipment for freedom and direction of movement.</p>	<p>Install all final filter media (cloth, precoat, etc.)</p> <p>Make all final adjustments during run-in and any performance tests required.</p> <p>Obtain service engineer for start-up, if desired.</p>
3.4.10 Boilers	<p>Make non-operating pressure test in accordance with applicable codes, if required.</p> <p>Inspect installation for completeness and correctness of installation and make other non-operating pre-firing checks.</p> <p>Check proper damper positioning and travel.</p>	<p>Dry refractories during initial firing by following the manufacturer's temperature cycles.</p> <p>Purge, flush, and drain steam mains as necessary.</p> <p>Obtain and charge treated water for boil-out and initial operation as required.</p> <p>Commission auxiliaries as detailed elsewhere under the appropriate equipment type.</p> <p>Conduct boil-out and chemical cleaning and flushing operations, as required.</p> <p>Conduct initial light-off with associated checks and adjustments.</p> <p>Obtain a service engineer for start-up, if desired.</p> <p>Conduct all operating tests and obtain required certification.</p>

TASK III

DEMONSTRATION PLANT OPERATION

PLANT COMPLETION

TABLE II (contd)

Item	By Contractor	By Client
<p>3.4.11</p> <p>Water Treating Plants</p>	<p>Inspect for completeness and correctness of installations and make any non-operating checks which may be required.</p> <p>Provide and install initial charge of ion-exchange resins and inert bed material.</p>	<p>Make the necessary operating tests and adjustments to water treatment systems.</p> <p>Provide all water treatment chemicals except initial charge of ion-exchange resins.</p> <p>Obtain services of water consultant to advise and monitor the water treatment operation as desired.</p>
<p>3.4.12</p> <p>Water Systems (service wells, cooling towers, sea water, fire water, etc.)</p>	<p>Inspect for completeness and correctness of installations and make any non-operating checks which may be required.</p> <p>Initially clean cooling tower basin and install screens in suction pit when specified on the drawings.</p> <p>Provide test pump for wells and test well delivery and flush wells when wells are provided by Foster Wheeler.</p>	<p>Flush, drain, and clean cooling tower basins.</p> <p>Clean in-take screens.</p> <p>Operate fire pumps to check output of systems.</p> <p>Fill reservoirs, head towers, etc.</p> <p>Provide insurance company inspection of fire system as required.</p> <p>Obtain and install all fire fighting chemicals, as required and portable equipment such as hoses, fire extinguishers and related equipment.</p> <p>Establish water treating program.</p> <p>Obtain services of water consultant to advise and monitor the water treatment operation as desired.</p>

TASK III

DEMONSTRATION PLANT OPERATION

PLANT COMPLETION

TABLE II (contd)

Item	By Contractor	By Client
3.4.13 Waste Disposal, Flares, and Stacks	Inspect facilities for completeness and correctness of installation and make any non-operating checks to ensure conformance with specifications.	Operate all equipment and supply all chemicals, agents, etc. related to waste treatment.
3.4.14 Buildings and Accessories	<p>Check installation of any buildings and accessories including all heating, ventilating, and air conditioning equipment to assure completeness and conformance with specifications.</p> <p>Obtain certification that all plumbing and elevator installations are in compliance with local governmental regulations.</p>	<p>Operate heating, ventilating, and air conditioning units and make all performance tests.</p> <p>Obtain certificate for occupancy and use, if required.</p>

PLANT COMPLETIONSECTION 4.04.1 EQUIPMENT PRELIMINARY SHAKEDOWN

The preliminary shakedown of equipment will involve pumps, compressors, degreasing boilers, synchronizing instrumentation loops and the initial commissioning of utility equipment. The meticulous and careful preparation of each piece of equipment will be required in order to satisfy the start-up objective. Compressors will be inspected and reassembled. Each part of the compressor will be carefully checked for damage that may have occurred during shipment and field installation. All of the support equipment around each compressor such as lube oil and seal oil systems will have each of its individual pieces carefully checked. Instrumentation associated with each compressor will be properly set according to vendor's recommendations. In many cases, the initial shakedown of rotating equipment will be in conjunction with dry out procedures, degreasing boilers and flushing out of piping and vessels. In some cases, equipment shakedown may be a repeat of some tests already conducted by the contractor. It is necessary to repeat some steps in order to include a certain part or parts of the plant that were not previously checked.

4.1.2 Water flushing and Pump Breakdown. Often the water left over from hydrostatic testing could be used to flush lines and to run in pumps. The running in of high head pumps with water should be avoided especially if the pumps were not designed to run on water, but on lighter material. Before proceeding with any water flushing operation, all orifice plates must be removed, control valves rolled out of the piping line to prevent the accumulation of dirt under the seats, and a fine mesh screen installed in all pump sections. Prior to the running of any pump, the Mechanical Department should check the pump for its proper alignment. The operator will assist the man who will flush out the unit by circulating the water through certain process loops. The flushing operation should be arranged such that debris will be flushed into the pump section screens and, therefore, the pumps should be watched very closely. An operator should stand by to see that the pump does not lose suction. The pump will have to be shut down immediately if it appears that this pump is losing suction.

The flushing operation will be judged complete when the suction screens stay clear for approximately six to twelve hours. While this time may seem excessively long, it accomplishes the purpose of knowing that the unit is clean and tests the pump for overheating and vibration. All process piping should have been first cleaned prior to flushing through an exchanger. Circulation should also be established with the exchangers blocked in and the exchangers will be placed in circulation only after it is felt that

there is no danger of debris being washed against the tube sheets. During the cleaning and flushing operations, most of the pumps will be running on a material which may be much heavier than what it was originally designed to pump. So it will be necessary to throttle the discharge of each pump to avoid overloading the driver. In any event, both the service pump and the spare should be operated together to obtain maximum circulation rate. During flushing, the compressor should be protected from the water by installing blinds in both the discharge and suction flanges. These lines must be thoroughly dried and drained prior to flanging up the connecting pipes to the compressors.

- 4.1.3 Compressor Break-in. The compressor break-in procedure will vary for the various units. The initial run in of any compressor should be carried out under the supervision of the manufacturer's representative. Prior to the running of any of the machines, the operator should be familiar with all pertinent operating instructions including interstage cooling, and safety requirements. The manufacturer's representative will check out all mechanical alignments and the supporting seal oil, lube oil systems where required. Fine mesh filters will be installed at the pressure inlet section to avoid large particles getting caught in the compressor veins. Compressor systems that are associated with a reactor circuit that need to be dried out can proceed with the dry out procedure and a running in of the compressor at the same time. The first few hours that a compressor is run, it will be run at an unloaded condition. In some cases, the driver is allowed to run uncoupled from the compressor. This allows one to check for vibration of the driver. When the driver and the compressor is connected together, the compressor should be loaded up in a step wise fashion, with pauses between each step to observe the performance of the machine. If at any time during the initial step wise loading of the compressor, mechanical malfunctions are observed, the machine should be stopped and steps taken to correct the problem.

PLANT COMPLETIONSECTION 5.05.1 CATALYST LOADING

In process units that require catalyst loading, excessive water must be driven out of the circuits, prior to the loading of any catalyst material. Under most circumstances, free water can be adequately removed by allowing it to drain from the lines. The reactor's internal catalyst and support material will be inspected to ensure that all meet engineering specifications established for the job. Grids trays must be leveled and sealed wherever necessary to prevent catalyst migration. There are several guidelines which should be followed in loading catalyst.

1. Be sure that each layer of catalyst support material is level. When standing on catalyst use wood planks to avoid damage to catalyst support material.
2. Load the required amount of catalyst closing the internal manway after the bed is completed.
3. Install the distributor basket at the top of the catalyst bed.
4. Make sure that all foreign materials have been removed from the reactor prior to closing up the head.
5. Catalyst loading should not be conducted during any rainy weather; otherwise, every effort should be made to complete the loading with minimal number of interruptions.
6. After the loading is completed, all reactor piping should be installed and bolted to the respective flanges.
7. After the reactor has been bolted up, preliminary steps will be taken to evacuate and purge reactor of catalytic active gases.

PLANT COMPLETION

SECTION 6.06.1 SAFETY REVIEW

The commissioning of the process systems are important, but before this is completely done, it is imperative that the plant be reviewed from the point of safety. The following checks should be made:

1. All portable fire equipment is in place.
2. The fire hydrant system is in service.
3. Miscellaneous safety equipment is available.
4. The area is reasonably clear of obstructions.
5. Necessary warning signs are posted.
6. All relief valve keys have been removed.
7. All construction foremen in the plant are aware of any pending changes in working conditions such as commissioning of gas or steam headers.
8. All operating personnel have been duly informed of all cautions in operating of each process unit.

PLANT COMPLETIONSECTION 7.07.1 START UP SEQUENCE

The successful instrumentation of any orderly startup of the various processing units is a key to a successful operation of the entire demonstration plan. In the preliminary startup, we have dealt specifically with each individual process unit and its' equipment. This section will deal with starting up the entire processing unit and interfacing them with other processing units in the IFG Demonstration Plant.

7.2 UTILITIES

One of the first items to be started up and go through an extensive shakedown test will be the utility system. The utility system is expected to operate day in and day out with very little problem and to be dependable throughout the entire operation of the plant.

- 7.2.1 Electrical. While part of the startup sequence has been dedicated to a preliminary check out of the electrical system, all sections of the electrical system will be brought up together. However, only part of the electrical system may have been used during the preliminary startup period. This is the second check on electrical system to ensure that all switch gear, sub-station transformers are operating in their proper sequence. It also provides an excellent opportunity to energize any power backup systems and check them out prior to actually bringing the process units on stream.
- 7.2.2 Instrumentation Nitrogen Package. This system will supply pressurized gas to control valves, I/P Converters, local mounted controllers, etc. and other instrument applications where required. It will be necessary for a while to continue blowing down low points in the nitrogen header to rid it of moisture that may have collected in the line due to lack of use.
- 7.2.3 City and Fire Water Systems. All fire monitors will be checked and operated to ensure that water is available at the monitor. This will be carried out by the safety inspectors. In some cases, the Memphis City Fire Department may want to provide cursory inspection to observe the operation and check out of each monitor.

- 7.2.4 Feed Water Treating. Feed water treating systems have historically been a trouble spot in the initial starting phase. The biggest problem area has always been the instrumentation system where numerous shutdown and override features begin to interfere with bringing the unit on stream. Once these problems have been overcome, feed water treating is very stable. It is necessary to have good clean treated water in preparation for all steam boilers.
- 7.2.5 Boiler and Stack Gas Scrubbing. Prior to placing all steam boilers on line, a degreasing and boilout procedure is necessary. A mixture of soda ash solution of approximately 2% will be required. The initial temperature is held between 230°F-250°F. These conditions should be held for approximately twelve hours. The rate of venting can be varied in order to shock scales from the tubes. After the initial degreasing and boilout procedure has been completed, the boilers can be brought up to pressure and steam started into the headers. The stack gas scrubbing operation will begin as soon as fuel fired boilers have been put into operation.
- 7.2.6 Incinerator. As soon as enough off gas is available, the incinerator will be placed on stream. The incinerator is used to burn toxic gases prior to exhausting them to atmosphere.
- 7.2.7 Cooling Tower and Pumps. Before any process unit can go on stream, the cooling tower and pumps must have been thoroughly checked and eradicated of any problems. The cooling tower will complete its startup when all the chemical addition systems have been established. Fans will run loaded for a reasonable period of time to determine whether or not the fans have a bearing or overheating problems. The cooling tower and its pumps will not realize the full load until the exchangers in all process units have been added to the cooling water circuit.

SECTION 7.07.3 COAL

All coal will come down the Mississippi River to the plant site by barge. These barges are expected to arrive on an irregular basis. It is necessary to stockpile enough coal in order to keep the plant on a continuous operating basis.

- 7.3.1 Coal Unloading. The coal will be received intermittently by the plant at a riverside dock. These barges will be approximately 1500 tons in size. The barges will be unloaded by a "Barge Unloader" and a conveying system. Once the barges have been unloaded, and all the coal has been conveyed to the live stock pile, then samples of the coal would be taken.
- 7.3.2 Coal Handling. After a sufficient inventory of coal has been established, stockpile dischargers would be put into operation. These dischargers will feed the coal to the coke coal treating section. It will be necessary for an initial shakedown of each of these conveyor systems. All motors, drives and belts are to be extensively checked for binding and unusually high tarquing of the motor drivers.
- 7.3.3 Coal Drying. The coal crusher and dry system consists of two crushing units and a single hot gas generation facility. It is fed from the hopper to the dryer primarily by means of a screw feeder. The coal is crushed to the appropriate size in the dryer mill. A stream of hot gas also enters the dryer and lifts the crushed coal out of the crusher. A spinning classifier inside of the dryer mill prevents the over-sized coal from being carried out of the mill. As the crushed coal is being conveyed by the hot gas, heat and hot gas is transferred to the moisture in the coal which results in evaporation of moisture. The dry sized coal from the treated coal separators is discharged through the treating coal feeders and conveyed by a conveyor to a coal silo. These coal silos have approximately twelve hours capacity. Both coal and coke silos are maintained under a nitrogen atmosphere to minimize the possibility of spontaneous combustion of coal fines. Here the coal remains in the silo until it is ready to be fed into the gasifiers.
- 7.3.4 Coke Drying. Coke received from the coke handling section is dried in a coke dryer. Drying is affected by air delivered from a coke dryer combustion air blower, and is heated by in-line burning of natural gas. A cyclone is used to remove coke fines with the exhausted drying gas. The dried coke is then fed into

the coke silo after it has been screened to remove the oversized coke particles. The coke silo is maintained under a nitrogen atmosphere to minimize the possibility of spontaneous combustion.

- 7.3.5 Ash Handling. The ash handling section is designed for both batch and continuous operation. In the batch operation, the Ash Slurry Lock Hopper of each gasifier is first filled with water with the Lock Hopper valve closed. The Lock Hopper pressure is equalized with the gasifier by opening the valve in the pressure equalizing line. The slurry feed valve is then opened. Agglomerated ash quenched in the bottom of the gasifier is discharged by gravity into the Ash Slurry Lock Hopper. After filling, both feed and pressure equalizing valves are closed. Pressure in the Lock Hopper can be reduced by opening the valve to the Lock Hopper Vent Pot. Once the collection of agglomerates has been started, they will be removed by Ash Eductors from the Slurry Hoppers. The ash is removed in the form of a slurry and is transferred to either one of two common ash dewatering bins. After the water has been drained from the ash agglomerates, the agglomerates can then be discharged into trucks for transport to an ash pile.

7.4 WASTE TREATMENT

Waste treatment is a method by which undesirable products or byproducts from the IFG Demonstration Plant can be treated and safely disposed of without harming the environment or personnel in the area.

- 7.4.1 Waste Water - Water Pumping Only. The main area of concern during the initial startup of the plant is storm water and process spent service water which is drained to the oily water sewer and to the storm water diverter. It would be necessary to initially fill all of the waste water holding areas with water in order to check out the various pumps and cleaning systems. The holding bases should be flooded, however, to make sure that recycle or overflow services are operational. This action will be needed to ensure IFG Demonstration Plant operators that the waste water system will protect itself during heavy rains.
- 7.4.2 Waste Water Ozone-Carbon Circulationing. Process waste water is then filtered into a carbon ozonation filter as a final pre-treatment step prior to the ozonation and biological carbon absorption. The waste water enters the ozone generation and contacting system where ozone is added from an ozone generator. The ozone reacts to organics in the water which makes it more readily bio-degradable. It will be necessary to run initial shakedown tests on all of the equipment involved in this area in order to protect the environment from possible pollutants that may come from the operating plant.

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- 7.4.3 Flares. The function of the flare system is to provide for the safe burning of combustible vapors released from process equipment during equipment commissioning and decommissioning or during operating upsets. It will be necessary to commission the knock out drum and all of the K. O. Drum Pumps. These pumps will have to start during excessive dumping of liquid to the flare.

7.5 PROCESS UNITS

The process units consist of approximately seven different processing areas. The orderly startup of each of these process units will be necessary in order to effect a smooth-operating facility. The IFG Demonstration Plant, when startup is completed, will produce a nominal 50 billion BTU's a day of product gas. The product gas has a heating value of approximately 300 BTU's per standard cubic foot. The gasification of bituminous coal to this product gas will be the objective of the entire processing facility.

- 7.5.1 Sulfur Recovery and Tail Gas Treating. A Claus-type sulfur recovery unit employing a thermal reaction step with a sulfur dioxide generation by oxidation of hydrogen sulfide makes up the processing facility of sulfur recovery. After the oxidation of the hydrogen sulfide to sulfur dioxide, the gas passes through three stages of catalytic reaction in order to effect an overall sulfur recovery in excess of 96% based on incoming gas feeds. Prior to the reaction step, the acid gas from the treating session is preheated to about 450°F using high-pressure steam. In addition, stoichiometric air is preheated to about 460°F in the process air heater. The preheated acid gas is split such that approximately 60% of the total incoming stream is passed to the Muffle furnace and 40% is bypassed to the first reactor. After the acid gas is passed through the Muffle Furnace zone, it reaches a combustion temperature of approximately 2400°F, which assists in the destruction of ammonia contained in the sour water stripper gas. The hot acid gas exits from the Muffle Furnace and is cooled out to a temperature of 500°F in the Waste Heat Boiler through the generation of 120 psig steam. The acid gas is then further cooled in the First Sulfur Condenser to a temperature of 350°F where sulfur is condensed and flows by gravity through a sulfur seal to the Sulfur Rundown Pit. The Sulfur Rundown Pit has a capacity of about two days production. Sulfur from the Rundown Pit is transferred to a storage tank which has approximately fifteen days capacity, based upon the design production rate.

Tail Gas Treatment from the Claus sulfur recovery unit is treated to remove essentially all of the remaining sulfur compounds before discharge to the atmosphere. This section consists of a hydrogenation/hydrolysis section followed by a Stretford absorber section. In the hydrogenation/hydrolysis section, the sulfur recovery unit tail gas is preheated to the desired reaction temperature. Additional reducing gas is added to ensure sulfur dioxide and free sulfur hydrogenation. The tail gas is then heated by mixing with hot products

of combustion of the fuel gas. The combined stream is then fed to the hydrogenation reactor where sulfur compounds are converted to hydrogen sulfide. The hot hydrogenation reactor effluent is first cooled in a waste heat exchanger and subsequently by a direct contact condenser tower. The cooled gas enters the absorber for counter current contact with a lean solution. The hydrogen sulfide is oxidized in an aqueous solution to elemental sulfur. The treated tail gas which is discharged to atmosphere from the top of the absorber is odor free and contains only a trace of hydrogen sulfide. The Stretford solution is oxidized and regenerated to allow sulfur slurry to decant from the solution. The decanted sulfur is returned to a Sulfur Rundown Pit in the Sulfur Recovery area.

7.5.2 Sour Water Stripping. The main objective of this section is to take sour condensate generated within the process and treated for the removal of hydrogen sulfide and ammonia. There are two forms of sour water to be regenerated: one being a 6% slurry and the other solids-free process condensate. This slurry system deserves some special consideration in that a Trayed Tower would plug if used to strip slurry. A baffled tower is used instead. The concentration of hydrogen sulfide and ammonia is relatively low with a slurry case. A Trayed tower of conventional design is used for solids-free sour process condensate. In both cases, slurry water and the process sour condensate is stripped by using live steam. Sour condensate will be coming from gas treating, gas compression, sulfur recovery and flare sections. Sour water stripper overhead vapors are cooled and partially condensed to a temperature of approximately 220°F in the overhead condenser. The vapor portion of the flow being separated from the condensed condensate flows to the Sulfur Recovery Unit and the condensate is returned to the sour water stripper as reflux. The water is pumped from the bottom of the stripper and is cooled to a temperature of approximately 95°F. The cooled stripped water is sent to the waste water treatment section for further processing there.

7.5.3 Selexol Circulation. The establishment of selexol circulation is the initial commissioning of the gas treating section. The function of this section will be the removal of almost all the sulfur compounds and some of the carbon dioxide compounds from the raw gas. The removal of carbon dioxide provides a means of controlling the product gas BTU value. The compressed raw gas comes from the gas compression section and is initially cooled in the feed exchanger. The condensed process water is removed from the raw gas stream in the hydrogen sulfide absorber knock-out drum. The raw gas leaves the knock-out drum and enters into the absorber where it comes in contact with cold lean Selexol solvent which physically absorbs essentially all of the H_2S as well as most of the carbonyl sulfide and some carbon dioxide. After the raw gas is passed through this section, it is considered to be a product gas and meeting product specifications. The cold rich solvent from the bottom of the H_2S absorber passes through three stages of preheating and flashing in order to provide an acid gas with sufficient concentration of

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hydrogen sulfide for treatment by the sulfur recovery section. The preheating is effected by counter-current heat exchange with hot rich solvent in the hydrogen sulfide high-pressure flash preheater, and the hydrogen sulfide medium-pressure flash preheater. The rich solvent from the bottom of the carbon dioxide absorber is regenerated in carbon dioxide stripper using carrier gas consisting of bone dry nitrogen delivered from the Air Separation Plant.

- 7.5.4 Gas Cooling. This section is to cool coal gasification effluent gas from approximately 1860° F down to 236° F. The gas is first cooled by a generation of 900 psig steam in the primary high-pressure steam generator, followed by the superheating of the 900 psig generated steam to a temperature of 850° F in the high-pressure steam super-heater. An additional amount of 900 psig steam is generated in a secondary high-pressure steam generator. Further cooling is achieved by preheating boiler feed water in a Gasifier Effluent Cooler and by quenching in the Raw Gas Spray Tower.
- 7.5.5 Gas Scrubbing. Cooling of the gas and scrubbing it for removal of entrained solids is almost a simultaneous operation. After the preheating of the boiler feed water in the Gasifier Effluent Cooler, it is then passed into the Raw Gas Spray Tower where the gas is sprayed by water to knock out ash that may have come over with the raw gas. The bulk of the entrained solids are removed from the raw gas by the action of the Raw Gas Spray Tower, Raw Gas High Energy Scrubber, and Raw Gas Venturi Scrubber. The scrub water is purged sufficiently to limit solids concentration to 6% by weight. The slurry water is then passed on to the Clarifier System Package which provides for the gravitational separation of solids which may either settle or rise from suspension. The clarified water then goes on to the waste water treatment section for further processing.
- 7.5.6 Oxygen Plant. The oxygen is essential to the operation of the gasifier. Oxygen is the main ingredient required for combustion of the coal. The reliability of this plant is essential to the continued operation of the gasifier.
- 7.5.6.1 Air Compressor. Air is compressed to approximately 85 psig and cooled to 100° F by means of the air compressors and the air compressor aftercooler. The aftercooler results in the separation of condensate in the knock-out drum. The condensate is then routed to the Cooling Tower as make-up water. The compressed air from the aftercooler knock-out drum is fed into the Air Separation Package.

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7.5.6.2 Oxygen Compressor. The product oxygen leaving the Air Separation Package at a temperature of 94° F and is compressed to a pressure of 105 psig by the oxygen compressor for delivery to the Coal Gasification Section. The oxygen compressor provides a lifeline to the operation of the gasifier. Once these two pieces of equipment have been satisfactorily operated, then the entire Air Separation Plant can be brought up to normal operation conditions.

7.5.6.3 Air Separation Package. Air Separation Package consists of heat exchangers, cryogenic distillation columns that produces gaseous oxygen as a primary product. Gaseous nitrogen, liquid oxygen are produced in limited quantities. The further separation of argon will be required in other separating towers of the Air Separation Package. When the Air Separation Package operates at less than its' designed capacity for gaseous oxygen production, it is capable of producing liquid oxygen for storage. Gaseous oxygen can be generated by the vaporiser. Liquid oxygen in the oxygen vaporization package also serves as an emergency back-up source of oxygen and for initial running-in of the oxygen compressor.

7.5.7.

Reactor. The reactor section on the Coal Gasifier is the heart of the entire IFG Demonstration Plant operation. The gasifier is dependent on oxygen, steam, and coal. Coal is the material to be combusted, Oxygen provides the catalytic active gas to stimulate the combustion. Steam provides a quench as well as a fluidization of the agglomerates in the gasifier bed.

7.5.7.1 Coke/Coal Feed. The Gasifier is initially started up on coke. There are four gasifiers involved in IFG Demonstration Plant processing scheme. Each of the four gasifiers has its own feed system. The Feed system consists of one receiving hopper, two feed lock hoppers, and two gasifier injection hoppers and six gasifier feeders. The gasifier feeders control the coal/coke flow into the individual transport lines servicing each of the gasifier's six feed points. The dried coke will come from a coke dryer and is discharged by means of the coke dryer discharge feeder, and coke dryer discharge conveyor to the coke screen which removes over-sized coke. After the screening, the coke is conveyed to the coke silo using sized coke conveyor elevator and transfer conveyor. During start-up, the transfer conveyor is to utilize the alternate conveyance system to the gasifier. The alternate system is considered to be a spare for utilizing either combined coke or a mixture of coal and coke to feed each of the gasifiers. Coal is dried and processed and put into holding areas in much the same way as described for the coke operation. Coal dust and Coke fines are disposed of by using them inside the plant as fuel. These fines are collected by Bag Filters. The gasifier will be started up gradually on coke until an agglomerating temperature is reached. When it has been determined that the operation of the gasifier has stabilized, coal will be gradually mixed in with the coke feed until the feed becomes 100% coal.

7.5.7.2 Pre-Heaters. The pre-heaters are only used during the initial start-up of the gasifier. It is necessary to warm the gas up in order to get it to a point where the combustion temperature may be reached. Once agglomerating temperature has been reached, on either coal or coke, the pre-heater will be shut down and the gasifier heat will be totally one of combustion of coal in the presence of oxygen and steam.

7.5.7.3 Gasifier and Solid Handling. With the essential ingredients of coal, oxygen and steam, and a temperature of approximately 1850°F, the agglomeration process will be taking place in the gasifier. During operation, only steam flows through the grid.

Flow to the venturi will be a mixture of steam and oxygen with the oxygen concentration limited to a maximum of 21 volume %. The flow to the center jet will be a mixture of oxygen and steam to insure a minimum velocity at the outlet of the jet of 100 feet per second. Bed temperature of the gasifier will be controlled by varying the flow of the steam to the grid.

Fines carried over from the fluidized bed with the raw gas are returned to the gasifier through the primary cyclones and the secondary cyclones. The ash agglomerates from the high-temperature zone in the gasifier drop into a water filled section where they are quenched. The accumulation of agglomerates are withdrawn from the bottom section as a slurry for transport to ash treatment section, where the slurry and the water is separated from the ash for re-circulation.

7.5.8

Credit Unit. The credit unit takes the Medium BTU Gas and methanates it up to a value equivalent pipeline gas. By being able to build a credit into the natural gas pipeline, the IFG customers are assured of a reliable industrial fuel gas supply. A portion of the desulfurized Medium BTU Gas from the gas treating section is fed into this system. The credit generation system consists of approximately six different processing areas.

7.5.8.1 Carbon Dioxide Removal. The objective of this section is removed mainly carbon dioxide and a residual quantity of hydrogen sulfide. The acid gas removal employs the Benfield Hot Potassium carbonate process. This section feeds on the gas produced by the shift conversion. Heat given up by the gas stream from the shift conversion section, is used for scrubbing solution regeneration. The cooled gas is scrubbed by the Benfield solution in a carbon dioxide absorber. The Benfield solution is introduced at the top of the tower and flows down counter-current to the gas flow and arrives at the bottom of the tower rich in carbon dioxide. The rich solution is expanded across a hydraulic turbine which helps to drive the carbonate solution circulation pump. Rich solution is regenerated in the carbonate solution regenerator by steam stripping. The cool carbon dioxide stream from the Absorber Tower, containing a trace of sulfur, is sent to the incinerator for disposal.

7.5.8.2 Shift Reactor. The main objective of the shift conversion is to take the carbon monoxide in the feed gas and react it over a bed of high-temperature shift catalyst in the presence of steam to form hydrogen and carbon dioxide. This reaction is exothermic.

The heat of reaction is carried away by the reactant, resulting in an increase in reactor temperature. The reactor, there-fore, is cooled by a heat exchanged with the feed gas in the shift reaction Feed heater. During start-up, a start-up heater is provided to heat up the feed gas while the reactor is still cold. The amount of gas directed to by-pass the shift reactor is controlled so that after the mixing with the shifted gas, the resultant mixture will have a hydrogen to carbon monoxide molar ratio of approximately 3 to 1.

- 7.5.8.3 Methanation. There are three primary methanation reactors. These reactors are connected in a series or paralld arrangement. Fresh feed to the methanation step is split so that portions flow to each reactor. A methane rich gas is circulated through the three primary reactors in series by the means of a recycle compressor. The circulating rich gas removes the exothermic reaction heat from the fixed bed reactors. Reactor temperature rises are limited by the control of the circulating of the gas rate.

The recycled gas is cooled in an exchanger by generating steam after each reactor for heat recovery. The bulk of the methanation reaction is completed in these reactors. A clean-up methanation reactor is used to balance up the methanation reaction. This reactor operates at a lower temperature than the primary methanation reactors in order to complete the additional reaction required. Methanated gas from the clean-up methanator is cooled and forwarded to the drying step. After the gas has gone through the drying package, which has been specified as as a glycol type drying system, the dried gas is odorized and then flows to the distribution network.

- 7.5.8.4 Credit Withdrawing System. When the IFG production facility is totally or partially down or when the gasifier cannot satisfy its demand, natural gas from MLGW's gas supply line will be withdrawn to fill the demands of the IFG customers. The natural gas has been diluted by the addition of dried air to bring the heating value of 1031 BTU per cubic foot down to 300 BTU per cubic foot. Air from the Air Separation Section is further compressed by Air Booster Compressors. The compressed air is cooled in the after coolers and dried by the air package. The dried air is then mixed with natural gas to achieve the proper heating value.

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8.0 SECTION

8.1 Variable Run

The plant variable study will begin at the conclusion of the shakedown and startup period. The variable run shall span over a period of about six months. Data will be collected from the operating units during this period of time to determine the effect of variation of operating conditions. Each variation from a normal design will note the effect upon yield, AFG production rate and quality, and the effect on byproduct production and characteristics. For each set of plant operating conditions, all sampling and analytical data will be worked up to identify yield structure, etc.

8.2 Coal Rates

Based on the candidate coal selected, various levels of thruput will be operated on a nine-day basis. It is expected that approximately 20 different runs will be conducted during the six-month variable test study. It is assumed that it takes approximately two days for the plant to line out from all setpoint changes. This would allow the plant to run at a steady rate for approximately seven days, then two days on the end of the run to gradually begin making adjustments toward the next step. Because of the size of the demonstration plant, we want to allow enough time for all the dynamics of the plant to settle down and achieve some stability. Regardless of what coal rates will be run, whether above design or below design, the following temperature adjustments will apply.

8.2.1 Increasing Temperatures

Increased temperature from the previous setpoints should be increased to no more than 10° increment. The 10° increment should be increased over a four-hour period to be sure that the gasifier is not unduly upset. Historically, all plant operations will respond better to a setpoint change if the changes are made gradually. This will allow the systems, both downstream and upstream, to adjust correspondingly and allow for the lag times involved. The maximum temperature in which the gasifier should be limited to is within 50° of the gasifier vessel design.

8.2.2 Holding at Setpoint Conditions

When the increment of temperature has been achieved at this coal rate thruput, the data collected for this increment of temperature and coal rate will begin only after all operating adjustments have ceased and the plant is considered to be stable. This plant will continue to run at this rate for approximately seven days to achieve good sound data. The data will be categorized at start of run, middle of run, and end of run. The start of run and end of run are considered to be changing conditions for the plant. This data should be categorized as such and used to identify certain dynamic characteristics in the plant when the plant is undergoing rate changes or temperature changes as well.

8.2.3 Equipment Observations

During this period of operation, the operators and plant engineers will continue to observe all pieces of equipment. Any detection of malfunctioning equipment will be quickly noted, and steps will be taken to correct the problem after consulting with various specialists. During the part of the run with temperatures being increased, particular attention will be paid to piping supports, vessels sitting on structures, etc.

8.2.4 Operator's Logs

A detailed log each day by the operator and the plant process engineer will be written for the previous eight-hour shift. Their log will be incorporated as part of the report included in the data for that particular shift. This will allow those analyzing the data to understand the operating problems that the operator and the process engineer observe during that eight-hour shift.

8.2.5 Decreasing Temperatures

It is assumed that the temperature had been brought back from a very high point down to the normal agglomerate temperature. From this point, the temperature will be decreased at ten-degree increments over a four-hour period. Again, this allows for the unit, both upstream and downstream, of the gasifier to respond to the combustion kinetics. When it appears that agglomerating is beginning to cease, the temperature should not be lowered any more, holding at setpoint conditions.

8.2.6 Holding at Setpoint Conditions

As stated in paragraph 5.2.2, the same criteria will apply for variable run when in the mode of decreasing temperatures for a particular coal rate.

8.2.7 Equipment Observations

A decrease in temperature may be requiring less product from a support plant or supplying less gas to a downstream processing unit. All observations of equipment should be made in terms of whether or not the equipment, such as compressors, is getting enough flow. Large swings in the gasifier operation will most severely affect tail gas cleaning plants or process plants that are on the fringe of the gasifier operation.

8.2.8 Operation Logs

The same applies here as was stated in paragraph 5.2.4.

8.2.9 Return to Baseline Temperature

The baseline temperature is considered to be the normal agglomerating temperature for which the gasifier is designed. The temperature should be taken at ten degrees increments with each ten degrees covering a four-hour period. When the baseline temperature has been reached, now coal rates can be readjusted to begin another series of temperature studies.

8.3 Variation of Gasifier Bed Height

In addition to coal rates and temperature changes, the bed height during the seven-day run can be varied a few feet one way or the other to determine the effect it has on IFG production and byproducts. The bed height study can easily be incorporated into the coal runs and temperature variable study.

8.4 Solids Residence Time

Certain points of the coal run temperature studies should include solids residence time. The rate of steam can be varied to the bed in order to determine how well the bed has been fluidized. Probably every setpoint would not want to have this type of change involved.

8.5 Maximum Thruput

Maximum thruput would be a case where one gasifier train would be in operation. Maximum amount of coal will be charged to the gasifier train in order to determine if there was a demand which would involve all four gasifiers and what would be the maximum output of the IFG demonstration plant. This particular run will allow the testing of all plants as far as our maximum capacity is concerned. The actual testing of the plant would be expected to last no longer than nine days.

8.6 Normal Baseline Operations

This mode of operation will have one to three gasifier trains on stream at the normal agglomerated temperature as determined in a heat and weight balance. This run would allow the collection of data to determine how close the engineering estimates were to actual plant operating conditions. This operation at this mode would be expected to last approximately nine days.

8.7 Minimum Rates

The minimum rate of one gasifier would be in operation. The gasifier will start out at the full design rate for that particular gasifier. All the support plants, both upstream and downstream of the gasifier would be checked to insure that their operation is still normal. Then the coal rate for the gasifier will be gradually reduced until it reaches approximately 60% of the design coal rate value. If it was determined that as the coal rate was being lowered that other support plants upstream and downstream of the gasifier were being adversely affected, the reduction rate would be discontinued immediately.

8.8 Preparation for Turnaround I

The plant will be gradually brought down to a point where it can be completely evacuated and all liquids drained out of the vessels to a safe disposal area. All vessels and pipes will be freed of toxic gases. All vessels and various pieces of equipment will be opened for inspection. All pipes and vessels will be checked for metal thicknesses to determine if excessive amounts of corrosion have taken place in a different process unit. This type of investigation will be the first clue to possible areas where equipment problems may be developing. The engineering staff will be alerted to the

possibility of having to inject inhibitors in order to hold down the corrosive properties of the process stream. The internal parts of the gasifier will be carefully examined. During the variable study after each operational mode has been accomplished, the data will have been carefully evaluated and put into a report form. The status should be no more than one or two runs behind. It is expected by the middle of the turnaround that all operating modes will have been examined and based on the data and operating history of the plant for the past six months, the industrial team will make a decision on what operating parameters to select for the long term run. This is to run in the variable run section.

8.9 Other Variables

The other variables that will be receiving attention during the variable run period will be pressure, turndown, and response changes. Pressure may be varied on certain coal rates to determine the effect on product yields. Turndown will allow the operators the access of the operating efficiency of the process and the lower performance limits of the plant equipment.

If COS Hydrolysis included a part of the process configuration, an economic cost analysis will be made of Selexol and COS Hydrolysis combination. The Selexol unit may be run separately for a few days to determine if improvement can be made in its removal sulfur.

The approach temperature to the waste heat boiler section should be considered in the light of possible fouling by the formation at lower temperatures.

Section 9.0

9.1 Turnaround

Turnaround will involve the complete shutdown of the entire IFG demonstration plant. It will give us the opportunity to examine all pieces of equipment and see how these pieces of equipment have survived the first nine months of operation. All vessels and major pieces of equipment will be subject to a thorough inspection. All minor defects as well as repairs that have to be made will be carefully documented. It will allow the project team to determine the source of possible mechanical problems that may have developed during the shakedown and variable run period.

9.2 Determination of Work Scope

A work scope is necessary to define the areas of work that will be required during turnaround. A major listing of items to be repaired or looked at will be part of this work scope. The work scope will list the objectives to be accomplished during the turnaround.

9.2.1 Work List

The work list will comprise a listing of items known to the management staff that will need attention during the turnaround period. The work list is provided so that work schedules can be developed and a manpower evaluation made. Certain items will appear on the work list to be looked at and inspected whether or not trouble has developed in this area.

9.2.2 Budget Preparation

Once the work list has been comprised, a budget is prepared. The budget will include the cost of materials and manpower to accomplish the items that appear on the work list.

9.2.3 Evaluate Manpower Requirements

After the work list has been prepared, manpower requirements will be evaluated in terms to accomplish the amount of work required during the four-week period of the initial turnaround. If inhouse manpower is not sufficient, an outside subcontractor will be brought in to balance out the manpower requirements during the turnaround. The subcontracted manpower will certainly be more costly than the inhouse manpower provided by IFG demonstration plant.

9.2.4 Submit Budget for Approval

Once the work list and the manpower requirement and the budget have been thoroughly prepared, it will be submitted to the appropriate personnel of the MLGW for their approval. MLGW will in turn submit it to the Department of Energy for their approval as well. Now that the budget has been approved, the requisition of materials and signing of subcontractors' contracts for this period of time can be implemented.

9.2.5 Development of CPM

A critical path for the work scope of a turnaround is essential. It allows one to evaluate the performance of the work during the turnaround and compares it to the original project schedule. It will tell people any time during the day whether a project is ahead of schedule or behind schedule. Usually the case is that as vessels are opened or equipment is inspected, additional work items develop as a result of equipment inspection. With these items in mind it could always be determined that if additional manpower should be brought on in order to maintain the schedule.

9.3 Preparation of Equipment

The preparation of equipment is essential when it has already been in operation for several months. The equipment must be placed at a condition such that it is safe to enter and work without the fear of being harmed by chemicals or toxic gases that might have been in the process equipment. It is expected that operations will initially prepare the equipment for the maintenance people.

9.3.1 Depressuring and Draining

Depressuring will include the venting of all gases and pressurized materials from the plant. Draining consists of dumping all liquids from the plant system into a holding storage or a safety area. This is the first step in preparing our equipment for inspection.

9.3.2 Steamout and Purging

Steamout and purging is an additional step in the preparation of the equipment for safe work. Many of the gases that may be harmful to workers who are entering enclosed vessels and areas where it is allowable, steam can be used to purge out these gases from vessels and areas where vapors may tend to hold up inside vessels and pipes.

9.3.3 Installation of Blinds

Installation of blinds is always a necessary procedure in order to isolate certain vessels or pieces of equipment in the plant. Reactors full of catalysts would be a particular item that may not require inspection. By isolating these with blinds, the catalyst is protected from the effects of air and moisture. Blinds also protect workers from processed gases that may be transmitted from one area to the other.

9.3.4 Opening Manways

Opening of manways is essentially the opening up of all equipment for inspection. Prior to entering any vessel or enclosed area, a safety inspector will be available with gas sniffers to determine if the enclosed vessel or area has any gases that might be harmful to the worker. Working areas will be provided with air equipment to ensure that a good circulation of air is in all vessels and pieces of equipment that are considered to be enclosed items. At no time will a single man or person enter a vessel alone. A co-worker will stand by to make sure that the worker inside does not get into trouble.

9.4 Inspection

In order to find out the mechanical problems with the plant, it is necessary to have an experienced person to inspect vessels and various pieces of equipment. These inspectors will verify the items on the work list. The inspection may also turn up additional items of work that the engineering staff was completely unaware of prior to opening up of the equipment. It is very important to pay close attention to the results of the inspection so that if additional work is required, it can be immediately scheduled and the proper materials ordered and manpower obtained to accomplish this additional work task.

9.4.1 Cleaning of Vessels, etc.

In order to adequately inspect some of the process equipment, it may have to be cleaned of process materials prior to getting a reasonable inspection. This procedure is not that highly unusual in most process plants. Workers should be very careful during this part of the inspection because many slippery liquids and materials may stick to distributors and metal supports that workers use for footing. First aid equipment and a safety inspector should stand by when the initial cleaning operation is begun.

9.4.2 Inspection of Equipment

Inspection specialists of certain pieces of equipment will begin their inspection of the equipment to look for major changes internally of the vessel and rotating pieces of equipment. Experienced engineers and specialists will examine all pieces of equipment carefully noting the changes from the original preliminary operations inspection. All items in need of repair will be noted and written up on a list for the maintenance people to repair.

9.4.2.1 Non Destructive Ultrasonic Testing

This is the type of testing that is normally done on piping and exchangers. It's a quick and easy way to determine the thickness of metal and of piping, this testing can be conducted prior to the shutdown of the unit. Detailed reports need to be made out at the point in which each ultrasonic testing point reading is taken. Elbows of piping is one of the key areas that should be checked. Because of the nature of the gasifiers, certain areas will not be familiar to the experienced piping inspectors. Ultrasonic tests will quickly identify areas that are being eroded away or where accelerated corrosion is taking place. By doing this testing prior to the turnaround, certain pieces of pipe can be replaced during the turnaround when the plant has been completely shut down. The results of the ultrasonic testing will be broken down by units and by individual pieces of pipe and equipment. This will be a separate report which will be included in a volume of the turnaround overall report.

9.4.2.2 Visual Inspection

Visual inspections and hammer testings are probably the most common types of inspections conducted at process plants. A good hammer test will turn up unusually thin-walled pipe and low pressure services. The visual inspection of a vessel or piece of equipment by an experienced engineer or specialist at a particular area will detect certain areas on which repair must be done.

9.5 Repair as Required

When all the inspections have been completed, repairs will be implemented as required to return the equipment to a condition like new. This is the additional work which was spoken of in earlier topics. This work will be required in addition to the work that was on the work list. This work will usually be the result of vessel refractory, compressor parts, pump parts, control valves, etc. As one can see, much of the work that will be generated during turnaround may have been unplanned because of lack of visual inspection while the IFG demonstration plant was in operation.

9.6 Clean Out and Final Inspection

Prior to putting the plant back into operation and closing up all open vessels and open pipe, cleanout and final inspection is required. The cleaning out is necessary to remove all foreign materials that may have been brought into the vessel or left in an open piece of equipment while trying to repair or inspect it. The inspection is to determine the quality of work or repair that has been made. Because of the large amount of work that has been done during a major turnaround, there will be a final review of procedures that have been implemented in making a repair. The inspection will include process engineers as well as inspection specialists so they can determine if all repairs have been done satisfactorily. Only after the approval of the inspectors will the equipment be turned over for testing.

9.7 Testing

Where welding has taken place on any major piece of equipment such as a vessel or pipe, a hydrostatic test will be required. Prior to a hydrostatic test, dye checking and X-ray may also be required to determine if the weld has been properly made. In some cases on large vessels where new nozzles have been installed and welded onto the vessel, a localized stress relieving procedure will have to be done. All of these items of repair will have to be carefully monitored to make sure that the follow-through is complete. A cold hydrostatic test will be placed on all vessels and piping that have been welded. This test will be very similar to the ones we conducted during the preliminary operation procedure. Not all vessels and piping in the plant will have to be hydrostatically tested because they may not have been subject to any welding. However, all process units will be subject to a gas test which will involve the checking of flanges and gaskets. In some cases purging of process units of unwanted amounts of oxygen may be necessary. The general procedure for doing this is to go through a series of evacuations and purges.

9.7.1 Pull Blinds and Close Vessels

After the initial testing has been satisfied, the pulling of blinds and closing of all vessels that are still open will be necessary. However, it is to be understood that certain blinds cannot be pulled until it is operationally required.

9.8 Operations Preparation

A major turnaround is very similar to the initial starting up of a plant. A shakedown test will have to be conducted of all equipment to ensure that the equipment has not been damaged in any way. In some cases where large amounts of refractory has been replaced, a dry-out procedure may be necessary. After this first turnaround, the operation's personnel such as the operators should have a better feel for this plant mechanically. The operators during the

turnaround will have to become part of the maintenance crew often participating in the repair work. Many of the operators will have been assigned to their unit on which they work. This allows maintenance to take care of any of the problems that may have gone unattended during the first nine months of operation. Turn-around #1 will have been completed and the long-term operation will have begun which should extend over a period of approximately nine months.

9.9 Turnaround Evaluation

In order to assess the problems and performance of turnaround, it will be necessary to evaluate the overall activities of the turnaround work scope.

9.9.1 Evaluate Work Performance

Evaluating of the work performance will be taking the CPM that was initially developed and comparing it with the actual work performed. This will allow the plant staff to determine what areas that were planned, or problems that occurred that can be corrected when the next turnaround is scheduled. An evaluation of work performance may involve such items as unavailability of materials when needed, not enough equipment to do the work required, inefficiencies in utilizing manpower for certain jobs. The base of the work performance is a self-analysis of how well the turnaround went during the period when an intensified amount of activities were scheduled to be done simultaneously.

9.9.2 Actual Expenses Versus Budgeted Cost

The actual expenses versus the budgeted cost will not be known for several months after the turnaround has been completed. It will take this long to get all the invoices from subcontractors and material vendors. Then the plant staff can determine what areas of the original budget were under and those that were over. Also, the actual expenditures will be used as a baseline for any future turnarounds that may occur.

9.9.3 Report on Turnaround

This report will include the work performance and the areas of budgeted costs versus actual costs and expenditures. This report will be a summary of all activities that occurred during the turnaround, including problems that resulted as part of inspection and were not originally listed in the work scope. This report will be made available to all those who desire a copy in order to determine what problem we experienced in the first nine months of the IFG plant operation.

LONG TERM RUN

10.0 Section

10.1 Long Term Operation

Long term operation will occur immediately after the startup and shakedown period resulting from the first turnaround. The long term run is expected to last approximately five months. A candidate coal will be selected for running during this period. The operating variables that will be put into effect have been determined from the variable run period as being the most economical for the safe and reliable operation of the IFG demonstration plant.

10.2 Operating Level of Effort

Level of effort and operating of the IFG demonstration plant will encompass all areas required to keep the plant operating reliably, safely, and economically over a long period of time. This effort will involve the Plant Manager all the way down to the apprentice and encompassing all of those employees that fall in between. The effort and dedication of each employee will be necessary to carry out the nine-month operation.

10.2.1 Coal Rates

Coal rates for each gasifier train will have been determined by the variable run studies from the previous six-month operating period. These coal rates will have been agreed upon by MLGW, DOE, and the industrial team as being the most efficient optimum operating point. A coal will be selected as the candidate for this long-term contract and will have been made in order to have a sufficient supply of this type of coal. Variation in coals can cause a change in the operating conditions of a plant.

10.2.2 Gasifier Temperature

The variable run study will have identified the best agglomerated temperature for gasifiers at the coal rate selected. It is expected that the temperature may have to be adjusted slightly to compensate for slight changes in coal composition. Coal compositions may change even though it comes from the same area. It is expected that the first month or so of the nine-month run will be spent in fine tuning the plant. The data and information received for the variable run study will certainly help us to identify the optimum conditions.

10.2.3 Level of Credit Generation

The amount of the IFG demonstration plant output that will be sent to Credit Generation will be largely a management decision made by MLGW with the approval of DOE. The Credit Generation system will have already been checked out during the variable run through. It is expected that the Credit Generation system will vary as required to maintain the gasifier at its optimum operating point.

10.2.4 Level of Environmental Monitoring

The level of environmental monitoring will be carried out in accordance with federal, state, and local standards. Monitoring devices and sensors will be placed wherever required in the plant to detect the amount of particulants, gas contamination, noise, and any other pollutants that might be considered to be detrimental to the working environment.

10.2.5 Analytical Requirements

Based on the variable run studies, analytical requirements of various process streams will have been identified. Additional analytical methods which may be required will have been added to laboratory facilities. Analytical requirements should remain constant for the entire nine-month period. However, additional analytical procedures may be required from time to time in order to check certain operating data. This is considered to be a normal practice at most process operating units. The analytical nature of the laboratory will be maintained at a high quality at all times in order to have results that are consistent.

10.2.6 Data Treatment

A tremendous amount of data will be obtained from the operation of this plant. This data will be collected by the microprocessors available to plant instrumentation control. The data from the measurement points will be routed to a microprocessor and collected on electronic tapes. These tapes will be moved to a main frame computer at the end of the yield day. The main frame computer will contain programs which have formats to produce data in the form that is required by the different agencies as well as different industrial teams. For example, management reports will not carry in detail data of each process unit, but only the highlighted information such as number of BTU's, and amount of gas produced by the plant. Management also will carry more marketing information than actual plant data. Other reports will be broken down to the various levels as required. Process engineers and those involved in detail scientific data will get the entire log sheet of the plant. In cases where desired, minute-to-minute data points throughout the entire 24-hour day would be available to those who desired it. Various programs on yields, heat and weight balances, and other scientific calculations will be available through the use of IFG computer.

10.2.7 Dispensing of Reports

Reports will follow the proper channel as set up by MLGW and DRC. Any and all data will be available to DOE and its on-site representatives. DRC has the capability to supply all the data collected from the initial startup to the end of Phase III. Any report or information going outside of the industrial team or DOE will be subject to the approval of MLGW and DOE. The objective is to have as much data available as possible and as often as required. The microprocessing equipment will be able to collect data points as quickly as every five seconds.

10.3 Maintenance

Maintenance will play a very important part in keeping the plant operating for a long term run. Maintenance will keep a very close tab on repairs for various pieces of equipment. Maintenance will continue to train and educate personnel to take care of all the equipment involved in IFG demonstration.

plant. The preventive maintenance supervisor will make sure that all preventive maintenance measures are carried out in the areas of instrumentation, pumps, compressors, exchangers, and other pieces of equipment that require frequent attention. The maintenance system will be set up in a way that a clean accounting of all time and materials spent in certain process areas will be easily identified. This should allow the demonstration plant to depict the real operating cost of keeping a plant on stream.

10.4 Byproduct Marketing

It is assumed prior to the operation of the demonstration plant and a great deal of marketing preparation for the sale of byproducts will have already been done. The byproduct gases should not be a real problem. It is expected as more coal gasification facilities are built that the market applications for ash agglomerates will increase. To market ash agglomerates will be the real challenge for the marketing group. Ash agglomerates have the possible marketing in the areas of road aggregates, heat exchange systems that contain solids, and sandblasting materials. Probably there are other marketing areas that are not mentioned here that can well be applicable.

10.5 IFG Marketing

It is assumed that MLGW will take the prime responsibility in marketing of the industrial fuel gas to the customers at Pidgeon Park at President's Island and other industrial areas of Memphis. The reliability of the demonstration plant should help their marketing appeal.

10.6 Assessment of Plant Reliability

By the end of the nine-month period the IFG demonstration plant engineers will have a good assessment of the plant's ability to operate day in and day out with few problems. The areas of frequent repairs will have been identified and steps to correct these weak areas will be taken. Combined with the studies of startup, shakedown, variable run, and the long term operation, a good assessment of all the plant's process units and equipment will allow an evaluation of the engineering design to determine if certain process changes should be modified to effect a reliable operating plant.

10.7 Assessment of Plant Economics

By the end of the nine-month operating period, a fairly decent handle on the operating economic to the plant should be available through the sale of byproducts, industrial fuel gas, and the actual cost of being able to produce the desired products. At this point MLGW and DOE may have enough data available to decide if the expansion of the present IFG demonstration plant should be done in order to facilitate a more reliable, safer, and economical plant.

10.8 Assessment of Plant Process Design

At the conclusion of the twenty months of operations of the IFG demonstration plant, the data collected will be a true evaluation of how close to process design engineering came to depicting real life situations. The experience obtained in operating this plant will clarify areas in judgement about selection of equipment.

operating data will be able to accurately define all the operating parameters in the IFG demonstration plant design which was previously assumed.

10.9 Turnaround II

After completion of nine months of long term operations, the IFG demonstration plant will be shut down for its final turnaround prior to the end of Phase III as described in Section 6 of this report. The same procedure will be followed in the preparation of the plant for turnaround. Turnaround items will have been listed and determined for a few months prior to this shutdown. Again, the areas that were determined in the first turnaround as being critical areas will be examined in detail to determine if previous actions have corrected the problem. If the problems have persisted in these areas, further study will have to be done and steps taken to correct the problems prior to placing the plant on stream for commercial operation.

Section 11.0

11.1 Operation Schedule

The operational plans and industrial fuel gas demonstration plans for Phase III will cover a twenty-month period. Figure 8-1 gives the entire schedule and a breakdown on per month basis. The operation plan will include a plant staff of approximately 250 people. This staff will be made up of approximately 94 operators which will include skilled craftsmen, apprentices, laborers, lab technicians, chemists, managers, supervisors, EDP, marketing, and administration personnel. All of these people filling each of these positions will be an integral part of keeping the industrial fuel gas demonstration plant in operation.

11.2 Startup and Shakedown

Startup and shakedown will be the initial part of Phase III. This period will cover approximately three months. It is expected to identify problem areas and correct equipment problems and other minor problems that may be associated with equipment and improper installation. Startup will include initial heating up and placing on stream each of the process units associated in the demonstration plant operation.

11.3 Variable Run

The variable run period will follow after the startup and shakedown period. The variable run period will be over a period of about six months. The variable run period is expected to be divided into twenty different operating modes. The data collected from the operating plant during this period will determine the long term operation rates.

11.4 Turnaround I

Turnaround I occurs just prior to the mid point of Phase III. It will allow the IFG demonstration plant team to look at the internal parts of the equipment as well as examine rotating equipment, piping, instrumentation, and other factors that are associated with the IFG demonstration plant and its operation. It will allow the plant team to identify problem areas and correct them after the initial nine months of operation. This period is expected to take approximately four weeks.

11.5 Long Term Run

The long term run will have the IFG demonstration plant operating at a set rate determined from data obtained during the variable run period. The long term run is expected to achieve the design objective that the plant will operate reliably and safely over a long period of time. It is expected to determine the economics more clearly and operate at a constant rate. The operating conditions should more closely reflect the one of a commercial operating plant. The data received from the long term operation will be an assistance in determining if a commercial plant of this size will be economically feasible. The long term run is expected to cover a period of nine months.

OPERATIONAL PLAN
INDUSTRIAL FUEL GAS DEMONSTRATION PLANT
PHASE III

- A - STARTUP & SHAKEDOWN
- B - VARIABLE RUN
- C - TURNAROUND I
- D - LONG TERM RUN
- E - TURNAROUND II

MONTHS

Figure 8-1

11.6 Turnaround II

One month prior to the end of Phase II a turnaround will be scheduled. This again is to assess the operating impact of the previous nine months on the process equipment. It will also give the demonstration plant team an opportunity to assess the corrections that were made during turnaround I. The turnaround procedure for number two will be the same as it was for number one. Because of the length of long term runs, more careful planning and evaluation of work habits and procedures for turnaround number two can be developed. The second turnaround will allow us to have two data points on plant equipment during Phase III prior to entering the commercial operation. Depressuring will include the venting of all gases and pressurized materials from the plant. Draining consists of dumping all liquids from the plant system into a holding storage or safety area. This is the first step in preparing equipment for inspection.

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III- DEMONSTRATION PLANT OPERATIONS

Section 12.0

DESCRIPTION OF PROCESS UNITS

12.1 AIR SEPARATION (Section 310)

12.1.1 Reference Material

- Process Flow Diagrams: FWEC Dwgs. No. 2202-I-50-31101
-31102
- Stream Data: Table 310-1
- Heat and Material Balances: Table 310-2
- Utilities, Chemicals and Catalysts: Table 310-3
- Equipment List: Table 310-4

12.1.2 Description of Flow

Air is compressed to approximately 85 psig and cooled to 100° F by means of Air Compressors (C-3101A/B) and Air Compressor Aftercooler (E-3102). The resulting condensate, separated by means of the Aftercooler K.O. Drum (D-3102), is routed to the cooling tower as make-up water. Compressed air from the Aftercooler K.O. Drum is fed to Air Separation Package (A-3101).

The Air Separation Package, consisting of heat exchangers and cryogenic distillation columns, produces gaseous oxygen (98 vol. %) as the primary product. Gaseous nitrogen (bone dry, 10 ppm O₂), liquid oxygen and liquid nitrogen are also produced in limited quantities.

The product oxygen leaving the Air Separation Package at a temperature of 94° F and a pressure of 2.7 psig is compressed to a pressure of 105 psig by the Oxygen Compressor (C-3102) for delivery to Coal Gasification (Section 330).

Product gaseous bone-dry nitrogen reports to the Plant Nitrogen Package (A-3105) and to Gas Treating (Section 360) where it is employed as a stripping medium in the CO₂ Stripper (T-3604).

**MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM**

**TASK III - DEMONSTRATION PLANT
OPERATIONS**

Liquid nitrogen, which will be produced continually, is stored in Liquid Nitrogen Storage Tank (TK-3101) for subsequent vaporization by either the Liquid Nitrogen Vaporization Package (A-3102) or the Instrument Nitrogen Vaporization Package (A-3103). The Liquid Nitrogen Vaporization Package will provide start-up and shutdown to the plant.

When the Air Separation Package operates at less than its design capacity for gaseous oxygen production, it is capable of producing liquid oxygen for storing in the Liquid Oxygen Storage Tank (TK-3102). Gaseous oxygen, generated by vaporizing liquid oxygen in the Oxygen Vaporization Package (A-3104) will be used as an emergency back-up source of oxygen feed gas. The 1000 tons of storage capacity specified for liquid oxygen allows over 13 hours of back-up at full capacity (3 gasifiers).

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INDUSTRIAL FUEL GAS DEMONSTRATION PLANT
 DESIGN, ENGINEERING, AND CONSTRUCTION
 CONTRACT NO. 67-77C-01-2-242
 DEPARTMENT OF ENERGY
 COAL CONVERSION DIVISION
 WASHINGTON, D.C.

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TASK II DEMONSTRATION PLANT
PROCESS FLOW DIAGRAM
AIR SEPARATION
SECTION 310
52X10 DWG NO. 222.1-100-1111
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CUSTOMER: MLGW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: AIR SEPARATIONREF. DWG.: 2202-1-50-31101CONTRACT NO.: ET-77-C-01-2582REV.: 0SECTION NO.: 310PAGE NO.: 1 of 6DATE: July 10, 1979

STREAM NUMBER		3101		3102		3103	
STREAM DESCRIPTION		AIR SUPPLY		AIR SEPARATION FEED		(H.P.) CONDENSED MOISTURE	
COMPONENTS	(MW)	MOI./HR	LB/HR	MOI./HR	LB/HR	MOI./HR	LB/HR
HYDROGEN	2.016						
CARBON MONOXIDE	28.011						
NITROGEN	28.016	18044.5	505535	18044.5	505535		
OXYGEN	32.000	4769.4	152620	4769.4	152620		
CARBON DIOXIDE	44.011						
HYDROGEN SULFIDE	34.082						
SULFUR DIOXIDE	64.066						
CARBONYL SULFIDE	60.077						
CARBON DISULFIDE	76.143						
METHANE	16.043						
SULFUR	32.066						
AMMONIA	17.032						
TOTAL DRY		22813.9	658155	22813.9	658155		
WATER	18.016	726.8	13094	231.7	4174	435.7	7850
TOTAL WET		23540.7	671249	23045.6	662329	435.7	7850
CO ₂ (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SELEXOL							
TOTAL STREAM		23540.7	671249	23045.6	662329	435.7	7850

TABLE 310-1

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MILGW/DOE

LOCATION: MEMPHIS, TENNESSEE

SECTION NAME: AIR SEPARATION

REF. DWG.: 2202-1-50-31101

CONTRACT NO.: ET-77-C-01-2582

REV.: 0

SECTION NO.: 310

PAGE NO.: 2 of 6

DATE: July 10, 1979

STREAM NUMBER		3104		3105		3106	
STREAM DESCRIPTION		NITROGEN TO SEC. 360		OXYGEN TO C-3102		NITROGEN TO A-3105	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016						
CARBON MONOXIDE	28.011						
NITROGEN	28.016	53.0	1485	92.4	2588	239.1	6700
OXYGEN	32.000			4525.0	144800		
CARBON DIOXIDE	44.011						
HYDROGEN SULFIDE	34.082						
SULFUR DIOXIDE	64.066						
CARBONYL SULFIDE	60.077						
CARBON DISULFIDE	76.143						
METHANE	16.043						
SULFUR	32.066						
AMMONIA	17.032						
TOTAL DRY		53.0	1485	4617.4	147388	239.1	6700
WATER	18.016						
TOTAL WET		53.0	1485	4617.4	147388	239.1	6700
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SELEXOL							
TOTAL STREAM		53.0	1485	4617.4	147388	239.1	6700

TABLE 310-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOE

LOCATION: MEMPHIS, TENNESSEE

SECTION NAME: AIR SEPARATION

REF. DWG.: 2202-1-50-31101

CONTRACT NO.: ET-77-C-01-2582

REV.: 0

SECTION NO.: 310

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DATE: July 10, 1979

STREAM NUMBER		3107		3108		3109	
STREAM DESCRIPTION		(L.P.) CONDENSED MOISTURE		LIQUID NITROGEN TO TK-3101		WET WASTE GAS	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016						
CARBON MONOXIDE	28.011						
NITROGEN	28.016					17660.0	494762
OXYGEN	32.000					244.4	7820
CARBON DIOXIDE	44.011						
HYDROGEN SULFIDE	34.082						
SULFUR DIOXIDE	64.066						
CARBONYL SULFIDE	60.077						
CARBON DISULFIDE	76.143						
METHANE	16.043						
SULFUR	32.066						
AMMONIA	17.032						
TOTAL DRY						17904.4	502582
WATER	18.016	59.4	1070			231.7	4174
TOTAL WET		59.4	1070			18136.1	506756
CO ₂ (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SELEXOL							
TOTAL STREAM		59.4	1070	No Normal Flow		18136.1	506756

TABLE 310-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: AIR SEPARATIONREF. DWG.: 2202-1-50-31102

CONTRACT NO.:

ET-77-C-01-2582

REV.: 0SECTION NO.: 310PAGE NO.: 4 of 6DATE: July 10, 1979

STREAM NUMBER		3110		3111		3112	
STREAM DESCRIPTION		NITROGEN TO OTHER USERS		OXYGEN TO SEC 440		OXYGEN TO SEC. 330	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016						
CARBON MONOXIDE	28.011						
NITROGEN	28.016	239.1	6700	0.3	8	92.1	2580
OXYGEN	32.000			13.8	442	4511.2	144358
CARBON DIOXIDE	44.011						
HYDROGEN SULFIDE	34.082						
SULFUR DIOXIDE	64.066						
CARBONYL SULFIDE	60.077						
CARBON DISULFIDE	76.143						
METHANE	16.043						
SULFUR	32.066						
AMMONIA	17.032						
TOTAL DRY		239.1	6700	14.1	450	4603.4	146938
WATER	18.016						
TOTAL WET		239.1	6700	14.1	450	4603.3	146938
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SELEXOL							
TOTAL STREAM		239.1	6700	14.1	450	4603.3	146938

TABLE 310-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: AIR SEPARATIONREF. DWG.: 2201-1-50-31101CONTRACT NO.: ET-77-C-01-2582REV.: 0SECTION NO.: 310PAGE NO.: 5 of 6DATE: July 10, 1979

STREAM NUMBER		3114		3115		3116	
STREAM DESCRIPTION		LIQUID OXYGEN TO TK-3102		AIR TO SEC 330		AIR TO SEC. 220	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016						
CARBON MONOXIDE	28.011						
NITROGEN	28.016						
OXYGEN	32.000						
CARBON DIOXIDE	44.011						
HYDROGEN SULFIDE	34.082						
SULFUR DIOXIDE	64.066						
CARBONYL SULFIDE	60.077						
CARBON DISULFIDE	76.143						
METHANE	16.043						
SULFUR	32.066						
AMMONIA	17.032						
TOTAL DRY							
WATER	18.016						
TOTAL WET							
CO (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SELEXOL							
TOTAL STREAM		NO NORMAL FLOW		FOR STARTUP ONLY		NO NORMAL FLOW	

TABLE 310-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: AIR SEPARATIONREF. DWG.: 2202-1-50-31102CONTRACT NO.: REV.: 0

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STREAM NUMBER		3117					
STREAM DESCRIPTION		NITROGEN TO SEC. 330					
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016						
CARBON MONOXIDE	28.011						
NITROGEN	28.016						
OXYGEN	32.000						
CARBON DIOXIDE	44.011						
HYDROGEN SULFIDE	34.082						
SULFUR DIOXIDE	64.066						
CARBONYL SULFIDE	60.077						
CARBON DISULFIDE	76.143						
METHANE	16.043						
SULFUR	32.066						
AMMONIA	17.032						
TOTAL DRY							
WATER	18.016						
TOTAL WET							
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SELEXOL							
TOTAL STREAM		FOR STARTUP ONLY					

TABLE 310-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

PROGRAM P1110
HEAT AND MATERIAL BALANCE

15-2202
DATE 08/09/79

MLGW/DOE IFG DEMO PLANT, NORMAL OPERATION (3 GASIFIERS OPERATING)
AIR SEPARATION MATERIAL AND HEAT BALANCES (SECTION 310)

INPUT DESCRIPTION	FLOW RATE LB/HR	TEMP. DEG F	+ - - MILLION BTU/HR - - +		
			HEATING VALUE	SENSIBLE +LATENT	TOTAL HEAT
AIR SUPPLY	671249.	95.0		16.41	16.41
C-3101A AIR COMPRESSOR BHP					41.49
C-3101B AIR COMPRESSOR BHP					41.49
PLANT NITROGEN PACKAGE KW USAGE					1.04
AIR SEPARATION PACKAGE					0.11
C-3102 OXYGEN COMPRESSOR BHP					15.02
<hr/>					
TOTAL INPUT	671249.		0.0	16.41	115.56

NOTE: ENTHALPIES AT BASE TEMPERATURE OF 77. DEG F.
HEATING VALUES GIVEN ON GROSS BASIS.

TABLE 310-2

FOSTER WHEELER ENERGY CORPORATION

PROGRAM P1110
HEAT AND MATERIAL BALANCE15-2202
DATE 08/09/79MLGW/DOE IFG DEMO PLANT, NORMAL OPERATION (3 GASIFIERS OPERATING)
AIR SEPARATION MATERIAL AND HEAT BALANCES (SECTION 310)

OUTPUT DESCRIPTION	FLOW RATE LB/HR	TEMP. DEG F	HEATING VALUE	MILLION BTU/HR SENSIBLE +LATENT	TOTAL HEAT
NITROGEN TO SEC 360	1485.	94.0		0.01	0.01
HP CONDENSED MOISTURE	7850.	100.0		0.18	0.18
LP CONDENSED MOISTURE	1070.	102.0		0.03	0.03
WET WASTE GAS	506757.	100.0		5.97	5.97
NITROGEN TO PLANT USERS	6699.	110.0		0.04	0.04
OXYGEN TO SEC 440	450.	100.0		0.00	0.00
OXYGEN TO SEC 330	146938.	216.0		4.38	4.38
E-3101A AIR COMPRESSOR INTERCOOLER					19.54
E-3101B AIR COMPRESSOR INTERCOOLER					19.54
E-3102 AIR COMPRESSOR AFTERCOOLER					51.18
E-3103 O2 COMPR 1ST STG INTERCOOLER					3.13
E-3104 O2 COMPR 2ND STG INTERCOOLER					3.91
E-3105 O2 COMPR 3RD STG INTERCOOLER					3.69
PLANT NITROGEN PACKAGE					0.98
AIR SEPARATION PACKAGE KW GENERATED					0.75
HEAT LOSS					2.23
TOTAL OUTPUT	671248.		0.0	10.61	115.56

TABLE 310-2 (Cont.)

NOTE: ENTHALPIES AT BASE TEMPERATURE OF 77. DEG F.
HEATING VALUES GIVEN ON GROSS BASIS.

MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM

DEMONSTRATION PLANT

TABLE 310-3

UTILITIES, CHEMICALS AND CATALYSTS

	<u>Normal</u>
<u>Steam</u> , HP (900 psig, 840°F) Consumed	363,000 lbs/hr
<u>Steam</u> , MP (125 psig, sat'd) Produced	275,000 lbs/hr
<u>Steam</u> , LP (85 psig, sat'd) Produced	88,000 lbs/hr
<u>Steam</u> , LP (85 psig, sat'd) Consumed	120 lbs/hr
<u>Condensate</u> Produced	7,850 lbs/hr
<u>Cooling Water</u>	6,864 GPM
<u>Power</u> Consumed	12,160 Kilowatts
<u>Power</u> Produced	220 Kilowatts

TABLE 310-4

CONTRACT:

EQUIPMENT LIST

AIR SEPARATION

PAGE 2 OF 3

REVISION

ORIGINAL

1

2

3

4

5

DATE _____

5/8/79

6/21/79

TABLE 310-4 (cont.)

CONTRACT:

SECTION: 310

EQUIPMENT LIST

NAME OF UNIT

PAGE 3 OF 3

AIR SEPARATION

CLIENT: MLGW/DOE ET-77-C-01-2582

REVISION

ORIGINAL

•

2

2

1

2

LOCATION: MEMPHIS, TENNESSEE

DATE _____

5/8/79

6/21/79

[illegible]

TABLE 310-4 (cont.)

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III - DEMONSTRATION PLANT OPERATIONS

12.2 COAL/COKE TREATING & FEED (Section 320)

12.2.1 Reference Material

- Process Flow Diagram: FWEC Dwg. 2202-1-50-32101
- Steam Data: Table 320-1
- Heat and Material Balance: Table 320-2
- Utilities, Chemicals and Catalysts: Table 320-3
- Equipment List: Table 320-4

12.2.2 Description of Flow

12.2.2.1 Coal Treating and Feed

Raw Coal, size 2" x 0", received by Coal/Coke Handling (Section 410) is conveyed to the Coal Crushing/Drying System (A-3201). The Coal Crushing/Drying System consists of two crushing units and a single hot gas generation facility. Raw coal is delivered to the Dryer Mill Surge Hopper (TK-3201) in each crushing unit. It is fed from the hopper to the Dryer Mill (SR-3201) by means of a screw feeder, the Dryer Mill Feeder (FD-3201). Coal is crushed to 1/4" x 0" in the Dryer Mill. A stream of hot gas also enters the Dryer Mill. The hot gas pneumatically lifts the crushed coal out of the crusher. A spinner classifier inside of the Dryer Mill prevents oversized coal from being carried out of the Dryer Mill. The classifier separates the oversized coal from the crushed material and returns it to the crusher. As the crushed coal is being conveyed by the hot gas, heat in the hot gas is transferred to the moisture in the coal which results in evaporation of the moisture, thus drying the coal. Dry crushed coal is separated from the moist conveying gas by the Treated Coal Separator (S-3201). The moist conveying gas from the Treated Coal Separator is recycled by the Dryer Mill Recirculation Blower (B-3202). Air-borne fines in the recirculated gas are removed by passing the gas through the common Dryer Mill Bag Filter (F-3201). Part of the moist conveying gas is vented downstream of the bag filter by means of the Dryer Mill Exhaust Booster Fan (B-3206) to the Stack Gas Cleanup Facility in the Utility Area (Section 430) to purge out the evaporated moisture. The majority of the filtered gas reports to the Dryer Mill Furnace (H-3201) where it joins with furnace flue gas generated by burning coal fines from the bag filter. Combustion air is provided by the Dryer Mill Combustion/Makeup Air Blower (B-3201).

The dry sized coal from the Treated Coal Separators is discharged through Treated Coal Feeders (FD-3202) and conveyed by Treated Coal Conveyor (CR-3201) to Coal Silo (TK-3202) which has a surge capacity of 12 hours.

Coal from the Coal Silo is conveyed to the gasifier feed system by the use of one of the two (2) parallel conveying systems. One system contains Coal Silo Discharge Feeder (FD-3206A), Coal Elevating Conveyor

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III - DEMONSTRATION PLANT OPERATIONS

(CR-3211A), Gasifier Feed Magnetic Separator (S-3203A), Gasifier Feed Transfer Conveyor (CR-3211A), and Gasifier Feed Conveyors (CR-3212A and CR-3213A). This system is operated continuously to feed coal to the gasifiers.

The other system contains Coal Silo Discharge Feeder (FD-3206B), Coal/Coke Transfer Conveyor (CR-3209), Coal/Coke Elevating Conveyor (CR-3211B), Gasifier Magnetic Separator (S-3203B), Gasifier Feed Transfer Conveyor (C-3211B), and Gasifier Feed Conveyors (CR-3212B and CR-3213B). This system is to be utilized as spare or be utilized for handling coke or mixture of coal and coke.

Each of the four gasifiers has its own feed system. The gasifier feed system consists of one Gasifier Feed Receiving Hooper (TK-3204), two Gasifier Feed Lock Hoppers (D-3201A & B), two Gasifier Feed Injection Hoppers (D-3202 A & B) and six Gasifier Feeders (FD-3208A/B/C/D/E & F). Gasifier Feeders control coal flow to the individual transport lines servicing each of the gasifiers' six feed points.

The Gasifier Feed Injection Hoppers are provided with scales which are used for both inventory control and monitoring of the feed control system.

For purposes of handling, coke received from Coal/Coke Handling (Section 410) is dried in Coke Dryer (DR-3201). Drying is affected by air delivered from Coke Dryer Combustion Air Blower (B-3204) and heated by inline burning of natural gas. Coke fines entrained with the exhausted drying gas are removed within Coke Dryer Exhaust Cyclone (S-3202) and Coke Dryer Exhaust Filter (F-3203). Fines recovered by the Coke Dryer Exhaust Cyclone are fed to the Coke Silo (TK-3203) by means of Exhaust Cyclone Discharge Feeder (FD-3204).

Dried coke from the Coke Dryer is discharged by means of Coke Dryer Discharge Feeder (FD-3211) and Coke Dryer Discharge Conveyor (CR-3204) to the Coke Screen (SN-3201) which removes the oversized coke.

After screening, the coke is conveyed to Coke Silo (TK-3203) using Sized Coke Conveyor (CR-3205), Coke Elevator (CR-3206), and Coke Transfer Conveyor (CR-3207). Both Coal and Coke Silos are maintained under nitrogen atmosphere to minimize the possibility of spontaneous combustion.

During plant start-up or gasifier restart-up, coke is fed from the Coke Silo by the Coke Silo Discharge Feeder (FD-3207) into the Coal/Coke Transfer Conveyor to utilize the alternate conveying system to the gasifier previously described.

12.2.2.2 Fines Disposal

Both the coal fines recovered from the Dryer Mill Bag Filter and the coke fines recovered from the Coke Dryer Exhaust Filter are disposed of by using them inside the plant as fuel.

**MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM**

**TASK III - DEMONSTRATION PLANT
OPERATIONS**

Coal fines collected by the Dryer Mill Bag Filter are delivered to the Coal Fines Transfer Conveyor (CR-3203) by means of Coal Fines Discharge Conveyor (CR-3202) and Coal Fines Discharge Feeder (FD-3203).

Coke fines collected by the Coke Dryer Exhaust Filter are delivered to the Coal Fines Transfer Conveyor by means of Coke Filter Discharge Conveyor (CR-3215), Coke Filter Discharge Feeder (FD-3205), and Coke Fines Transfer Conveyor (CR-3214).

The Coal Fines Transfer Conveyor delivers both coal and coke fines to Dryer Mill Furnace Surge Bin (TK-3205) from which fines are fed to the Dryer Mill Furnace by Furnace Coal Feeder (FD-3210).

Excess fines not required by the Dryer Makeup Furnace are fed to either the Coal Silo or the Fines Receiving Bin (TK-4310) in the Utility Area (Section 430) by means of the Fines Blow Pot (D-3204).

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: COAL & COKE TREATING & FEEDREF. DWG.: 2202-1-50-32101CONTRACT NO.: REV.: 0SECTION NO.: 320PAGE NO.: 1 of 4DATE: July 10, 1979

ET-77-C-01-2582

STREAM NUMBER		3201		3202		3203	
STREAM DESCRIPTION		RAW COAL		COKE FROM SEC 410		COAL TO SEC 330	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016					425.5	858
CARBON MONOXIDE	28.011					349.6	9793
NITROGEN	28.016					9.3	261
OXYGEN	32.000					-	-
CARBON DIOXIDE	44.011					230.7	10153
HYDROGEN SULFIDE	34.082					13.4	457
SULFUR DIOXIDE	64.066					-	-
CARBONYL SULFIDE	60.077					0.6	36
CARBON DISULFIDE	76.143					-	-
METHANE	16.043					57.3	919
SULFUR	32.066					-	-
AMMONIA	17.032					-	-
TOTAL DRY						1086.4	22477
WATER	18.016	1582.3	28507			338.3	6094
TOTAL WET		1582.3	28507			1424.7	28571
COAL (MAF)			199013				191350
C	12.011		158347				152249
H	1.008		11142				10713
O	16.000		17877				17189
N	14.008		2583				2484
S	32.066		9064				8715
ASH			31672				30452
SELEXOL							
TOTAL STREAM		1582.3	259192	NO NORMAL FLOW		1424.7	250373

TABLE 320-1

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: COAL & COKE TREATING & FEEDREF. DWG.: 2202-1-50-32101CONTRACT NO.: REV.: 0

ET-77-C-01-2582

SECTION NO.: 320PAGE NO.: 2 of 4DATE: July 10, 1979

STREAM NUMBER		3204		3205		3206	
STREAM DESCRIPTION		TRANSPORT GAS		VENT GAS TO SEC 430		COAL FINES TO SEC 430	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB / HR	MOL/HR	LB/HR
HYDROGEN	2.016	425.5	858	26.3	53		
CARBON MONOXIDE	28.011	349.6	9793	21.6	605		
NITROGEN	28.016	9.3	261	72.3	2024		
OXYGEN	32.000	-	-	-	-		
CARBON DIOXIDE	44.011	230.7	10153	11.5	506		
HYDROGEN SULFIDE	34.082	13.4	457	-			
SULFUR DIOXIDE	64.066	-	-				
CARBONYL SULFIDE	60.077	0.6	36				
CARBON DISULFIDE	76.143	-	-				
METHANE	16.043	57.3	919	3.6	58		
SULFUR	32.066	-	-				
AMMONIA	17.032	-	-				
TOTAL DRY		1086.4	22477	135.3	3246		
WATER	18.016	22.6	407		-	7.9	142
TOTAL WET		1109.0	22884	135.3	3246	7.9	142
COAL (MAF)							4774
C	12.011						3799
H	1.008						267
O	16.000						429
N	14.008						62
S	32.066						217
ASH							1218
SELEXOL							
TOTAL STREAM		1109.0	22884	135.3	3246	7.9	6134

TABLE 320-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: COAL & COKE TREATING & FEEDREF. DWG.: 2202-1-50-32101CONTRACT NO.: ET-77-C-01-2582REV.: 0SECTION NO.: 320PAGE NO.: 3 of 4DATE: July 10, 1979

STREAM NUMBER		3207		3208		3209	
STREAM DESCRIPTION		FLUE GAS TO SEC 430		DESULFURIZED U-GAS		NITROGEN	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016			26.3	53		
CARBON MONOXIDE	28.011	0.1	3	21.6	605		
NITROGEN	28.016	1394.9	39080	0.6	17	71.7	2007
OXYGEN	32.000	142.6	4563	-	-		
CARBON DIOXIDE	44.011	191.2	8415	11.5	506		
HYDROGEN SULFIDE	34.082			-	-		
SULFUR DIOXIDE	64.066	4.1	263	-	-		
CARBONYL SULFIDE	60.077			-	-		
CARBON DISULFIDE	76.143			-	-		
METHANE	16.043	0.1	1	3.6	58		
SULFUR	32.066			-	-		
AMMONIA	17.032			-	-		
NO _x (As NO ₂)		0.5	22				
TOTAL DRY		1733.5	52347	63.6	1239	71.7	2007
WATER	18.016	1395.4	25139				
TOTAL WET		3128.9	77486	63.6	1239	71.7	2007
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH			2				
SELEXOL							
TOTAL STREAM		3128.9	77488	63.6	1239	71.7	2007

TABLE 320-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MT.GW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: COAL & COKE TREATING & FEEDREF. DWG.: 2202-1-50-32101CONTRACT NO.: ET-77-C-01-2582REV.: 0SECTION NO.: 320PAGE NO.: 4 of 4DATE: July 10, 1979

STREAM NUMBER		3210					
STREAM DESCRIPTION		AIR					
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016						
CARBON MONOXIDE	28.011						
NITROGEN	28.016	1393.8	39050				
OXYGEN	32.000	370.5	11856				
CARBON DIOXIDE	44.011						
HYDROGEN SULFIDE	34.082						
SULFUR DIOXIDE	64.066						
CARBONYL SULFIDE	60.077						
CARBON DISULFIDE	76.143						
METHANE	16.043						
SULFUR	32.066						
AMMONIA	17.032						
TOTAL DRY		1764.3	50906				
WATER	18.016	56.3	1013				
TOTAL WET		1820.6	51919				
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SELEXOL							
TOTAL STREAM		1820.6	51919				

TABLE 320-1 (cont.)

MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM

TASK III- DEMONSTRATION PLANT
OPERATIONS

TABLE 330-3

UTILITIES, CHEMICALS AND CATALYSTS

	<u>Normal</u>
<u>Steam</u> , MP (120 psig, 485°F) Consumed	268,644 lbs/hr
<u>Power</u> Consumed	1.1 Kilowatts

FOSTER WHEELER ENERGY CORP.

PROCESS PLANTS DIVISION

CONTRACT:

SECTION: 330

EQUIPMENT LIST

NAME OF UNIT

COAL GASIFICATION

PAGE 1 OF 3

CLIENT: MLGW

ET-77-C-01-2582

REVISION

ORIGINAL

1

2

3

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5

LOCATION: MEMPHIS, TENNESSEE

DATE

3/21/79

6/14/79

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.	REV.
<u>DRUMS</u>	D-3301-1	Fines Receiving Hopper				
	D-3301-2	Fines Receiving Hopper				
	D-3301-3	Fines Receiving Hopper				
	D-3301-4	Fines Receiving Hopper				
	D-3302-1	Fines Injection Hopper				
	D-3302-2	Fines Injection Hopper				
	D-3302-3	Fines Injection Hopper				
	D-3302-4	Fines Injection Hopper				
	D-3303	Fines Silo				
	D-3304-1	Seal Pot				
	D-3304-2	Seal Pot				
	D-3304-3	Seal Pot				
	D-3304-4	Seal Pot				
<u>COOLER</u>	E-3301-1	Rotary Cooler				
	E-3301-2	Rotary Cooler				
	E-3301-3	Rotary Cooler				
	E-3301-4	Rotary Cooler				
	E-3302-1	Boiler Feed Water Cooler				1
	E-3302-2	Boiler Feed Water Cooler				1
	E-3302-3	Boiler Feed Water Cooler				1
	E-3302-4	Boiler Feed Water Cooler				1
<u>BAG FILTER</u>	F-3301	Fines Filter Bag				

TABLE 330-4

FOSTER WHEELER ENERGY CORPORATION

PROGRAM P1110
HEAT AND MATERIAL BALANCE

15-2202
DATE 08/09/79

MLGW/DOE IFG DEMO PLANT, NORMAL OPERATION (3 GASIFIERS OPERATING)
COAL GASIFICATION MATERIAL AND HEAT BALANCES (SECTION 330)

OUTPUT DESCRIPTION	FLOW RATE LB/HR	TEMP. DEG F	+- - - MILLION BTU/HR HEATING VALUE	- - - SENSIBLE +LATENT	- - - TOTAL HEAT
AGGLOMERATE SLURRY	34049.	326.0	69.80	1.62	71.43
FINES IN GASIFIER EFFLUENT	6824.	1860.0	77.16	3.93	81.09
GASIFIER EFFLUENT	630570.	1860.0	2352.21	705.66	3057.87
HEAT LOSS					28.27
<hr/>					
TOTAL OUTPUT	671443.		2499.18	711.21	3238.66

NOTE: ENTHALPIES AT BASE TEMPERATURE OF 77. DEG F.
HEATING VALUES GIVEN ON GROSS BASIS.

TABLE 330-2 (cont.)

FOSTER WHEELER ENERGY CORPORATION

PROGRAM P1110
HEAT AND MATERIAL BALANCE

15-2202
DATE 08/09/79

MLGW/DOE IFG DEMO PLANT, NORMAL OPERATION (3 GASIFIERS OPERATING)
COAL GASIFICATION MATERIAL AND HEAT BALANCES (SECTION 330)

INPUT DESCRIPTION	FLOW RATE LB/HR	TEMP. DEG F	+ - - - MILLION BTU/HR - - - + HEATING SENSIBLE TOTAL VALUE +LATENT HEAT		
FEED COAL	227489.	100.0	2780.37	1.51	2781.88
TRANSPORT GAS	22884.	369.0	120.23	2.91	123.13
STEAM FEED	268644.	485.0		328.67	328.67
OXYGEN FROM SEC 310	146938.	215.0		4.35	4.35
MAKEUP WATER FROM SEC 420	5489.	191.0		0.63	0.63

TOTAL INPUT	671444.		2900.60	338.07	3238.66

NOTE: ENTHALPIES AT BASE TEMPERATURE OF 77. DEG F.
HEATING VALUES GIVEN ON GROSS BASIS.

TABLE 330-2

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOE

LOCATION: MEMPHIS, TENNESSEE

SECTION NAME: COAL GASIFICATION

REF. DWG.: 2202-1-50-33101

CONTRACT NO.: REV.: 0

ET-77-C-01-2582

SECTION NO.: 330

PAGE NO.: 4 of 4

DATE: July 10, 1979

STREAM NUMBER		3310					
STREAM DESCRIPTION		RETURN BFW					
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016						
CARBON MONOXIDE	28.011						
NITROGEN	28.016						
OXYGEN	32.000						
CARBON DIOXIDE	44.011						
HYDROGEN SULFIDE	34.082						
SULFUR DIOXIDE	64.066						
CARBONYL SULFIDE	60.077						
CARBON DISULFIDE	76.143						
METHANE	16.043						
SULFUR	32.066						
AMMONIA	17.032						
TOTAL DRY							
WATER	18.016						
TOTAL WET							
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SELEXOL							
TOTAL STREAM		NO NORMAL FLOW					

TABLE 330-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: COAL GASIFICATIONREF. DWG.: 2202-1-50-33101CONTRACT NO.: ET-77-C-01-2582REV.: 0SECTION NO.: 330PAGE NO.: 3 of 4DATE: July 10, 1979

STREAM NUMBER	3307	3308	3309
STREAM DESCRIPTION	FINES SILO VENT GAS	AIR	NITROGEN
COMPONENTS (MW)	MOL/HR	MOL/HR	MOL/HR
HYDROGEN	2.016		
CARBON MONOXIDE	28.011		
NITROGEN	28.016		
OXYGEN	32.000		
CARBON DIOXIDE	14.011		
HYDROGEN SULFIDE	34.082		
SULFUR DIOXIDE	64.066		
CARBONYL SULFIDE	60.077		
CARBON DISULFIDE	76.143		
METHANE	16.043		
SULFUR	32.066		
AMMONIA	17.032		
TOTAL DRY			
WATER	18.016		
TOTAL WET			
COAL (MAF)			
C	12.011		
H	1.008		
O	16.000		
N	14.008		
S	32.066		
ASH			
SEI, EXOL			
TOTAL STREAM	NO NORMAL FLOW	START-UP ONLY	START-UP ONLY

TABLE 320-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MI.GW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: COAL GASIFICATIONREF. DWG.: 2202-1-50-33101CONTRACT NO.: REV.: 0

ET-77-C-01-2582

SECTION NO.: 330PAGE NO.: 2 of 4DATE: July 10, 1979

STREAM NUMBER		3304		3305		3306	
STREAM DESCRIPTION		AGGLOMERATE SLURRY		GASIFIER EFFLUENT		MAKE-UP WATER	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016			8318.6	16770		
CARBON MONOXIDE	28.011			6835.5	191469		
NITROGEN	28.016			181.2	5076		
OXYGEN	32.000			-	-		
CARBON DIOXIDE	44.011			4520.4	198948		
HYDROGEN SULFIDE	34.082			264.6	9018		
SULFUR DIOXIDE	64.066			-	-		
CARBONYL SULFIDE	60.077			11.1	667		
CARBON DISULFIDE	76.143			-	-		
METHANE	16.043			1121.0	17984		
SULFUR	32.066			-	-		
AMMONIA	17.032			6.7	114		
TOTAL DRY				21259.1	440046		
WATER	18.016			10575.3	190525	304.7	5489
TOTAL WET				31834.4	630571	304.7	5489
COAL (MAF)			5080		5341		
C	12.011		4734		5187		
H	1.008		-		22		
O	16.000		-		-		
N	14.008		111		44		
S	32.066		235		88		
ASH			28969		1483		
SELEXOL							
TOTAL STREAM			34049		637395	304.7	5489

TABLE 330-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: COAL GASIFICATIONREF. DWG.: 2202-1-50-33101CONTRACT NO.: FT-77-C-01-2582REV.: 0SECTION NO.: 330PAGE NO.: 1 of 4DATE: July 10, 1979

STREAM NUMBER	3301		3302		3303	
STREAM DESCRIPTION	COAL FEED TO GASIFIER		OXYGEN FEED TO GASIFIER		STEAM FEED TO GASIFIER	
COMPONENTS (MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN 2.016	425.5	858				
CARBON MONOXIDE 28.011	349.6	9793				
NITROGEN 28.016	9.3	261	92.1	2580		
OXYGEN 32.000	-	-	4511.2	144358		
CARBON DIOXIDE 14.011	230.7	10153				
HYDROGEN SULFIDE 34.082	13.4	457				
SULFUR DIOXIDE 64.066	-	-				
CARBONYL SULFIDE 60.077	0.6	36				
CARBON DISULFIDE 76.143	-	-				
METHANE 16.043	57.3	919				
SULFUR 32.066	-	-				
AMMONIA 17.032	-	-				
	-	-				
TOTAL DRY	1086.4	22477	4603.3	146938		
WATER 18.016	338.3	6094	-	-	14911.4	268644
TOTAL WET	1424.7	28571	4603.3	146938	14911.4	268644
COAL (MAF)		191350				
C 12.011		152249				
H 1.008		10713				
O 16.000		17189				
N 14.008		2484				
S 32.066		8715				
ASH		30452				
SEL EXOL						
TOTAL STREAM	1424.7	250373	4603.3	146938	14911.4	268644

TABLE 330-1

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III- DEMONSTRATION PLANT OPERATIONS

12.3 COAL GASIFICATION (Section 330)

12.3.1 Reference Material

- Process Flow Diagram: FWEC Dwg. No. 2202-1-50-33101
- Stream Data: Table 330-1
- Heat and Material Balance: Table 330-2
- Utilities, Chemicals and Catalysts: Table 330-3
- Equipment List: Table 330-4

12.3.2 Description of Flow

The commercial plant design is based on Western Kentucky No. 9 coal with the characteristics specified in section 2.1.5 of the Design Basis.

Coal is fed from Coal/Coke Treating and Feed (Section 320) with recycle raw gas used as a carrier for transport into the Gasifiers (R-3301-1, 2, 3 and 4).

Oxygen from Air Separation (Section 310) and exhaust steam from steam turbine are also being fed to the gasifiers.

During normal operation only steam flows through the grid. Flow to the venturi will be a mixture of steam and oxygen with the oxygen concentration limited to a maximum of 21 vol. %.

The flow to the center jet will be a mixture of oxygen and steam to insure a minimum velocity at outlet of the jet of 100 fps. Bed temperature of the gasifier will be controlled by varying the flow of steam flow to the grid.

Fines elutriated from the fluidized bed with the raw gas are returned to the gasifier through the Primary Cyclones (S-3301-1A/B, 2A/B, 3A/B and 4A/B) and the Secondary Cyclones (S-3302-1A/B, 2A/B, 3A/B and 4A/B).

The ash agglomerates from the high-temperature zone in the gasifier drop into the water filled bottom section where they are quenched. The accumulated agglomerates are withdrawn from the bottom section as a slurry for transport to Ash Treatment (Section 420), where the slurry water is separated from the ash for recirculation.

**MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM**

**TASK III - DEMONSTRATION PLANT
OPERATIONS**

Recirculated fines may be removed from the Secondary Cyclone diplegs by first cooling within Rotary Cooler (E-3301-1, 2, 3 & 4) to a temperature of 200° F and depressuring to atmospheric pressure by means of the Fines Injection Hopper (D-3302-1, 2, 3 & 4). From the Fines Injection Hopper the fines will be transported pneumatically to the Fines Silo (D-3303).

PROCESS PLANTS DIVISION

SECTION: 320

NAME OF UNIT

PAGE 6 OF 6

ET-77-C-01-2582

ORIGINAL

5/9/79

Coal/Coke Treating & Feed

1

2

3

4

5

CLASS

ITEM NO.

DESCRIPTION

EFD

REQ'N. NO.

P. O. NO.

REV

D-3202-1A Gasifier Feed Injection Hopper

D-3202-1B Gasifier Feed Injection Hopper

D-3202-2A	Gasifier Feed Injection Hopper
-----------	--------------------------------

D-3202-28 Gasifier Feed Injection Hopper

D-3202-3A	Gasifier Feed Injection Hopper
-----------	--------------------------------

D-3202-3B	Gasifier Feed Injection Hopper
-----------	--------------------------------

D-3202-4	Gasifier Feed Injection Hopper
----------	--------------------------------

D-3202-4B	Gasifier Feed Injection Hopper
-----------	--------------------------------

D-3203	Nitrogen Receiver
--------	-------------------

D-3204	Fines Blow Pot
--------	----------------

Weigh
Scale

WS-3201-1	A Gasifier Feed Scale
-----------	-----------------------

WS-3201-1B Gasifier Feed Scale

WS-3201-1A Gasifier Feed Scale

WS-3201-2B Gasifier Feed Scale

WS-3201-1	A Gasifier Feed Scale
-----------	-----------------------

WS-3201-1B	Gasifier Feed Scale
------------	---------------------

WS-3201	A Casifier Feed Scale
---------	-----------------------

WS-3201-4	A Gasifier Feed Scale
WS-3201	B Gasifier Feed Scale

WS-3201-4B Gaslight Feed Scale	

TABLE 320-4 (cont.)

FOSTER WHEELER ENERGY CORP.

PROCESS PLANTS DIVISION

CONTRACT:

SECTION: 320

EQUIPMENT LIST

NAME OF UNIT

PAGE 5 OF 6

CLIENT: MLGW/DOE ET-77-C-01-2582

REVISION ORIGINAL

Coal/Coke Treating & Feed

1

2

3

4

5

LOCATION: MEMPHIS, TENNESSEE

DATE

5/9/79

6/25/79

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.						REV.
Screen	SN-3201	Coke Screen									
Size Reduction Equipment	SR-3201A	Dryer Mill								Part of A-3201	
	SR-3201B	Dryer Mill								Part of A-3201	
Sampler	SS-3201	Treated Coal Sampler									
Bins & Hoppers	TK-3201A	Dryer Mill Surge Hopper									
	TK-3201B	Dryer Mill Surge Hopper									
	TK-3202	Coal Silo									
	TK-3203	Coke Silo									
	TK-3204-1	Gasifier Feed Receiving Hopper									
	TK-3204-2	Gasifier Feed Receiving Hopper									
	TK-3204-3	Gasifier Feed Receiving Hopper									
	TK-3204-4	Gasifier Feed Receiving Hopper									
	TK-3205	Dryer Mill Furnace Surge Bin									
	D-3201-1A	Gasifier Feed Lock Hopper									
	D-3201-1B	Gasifier Feed Lock Hopper									
	D-3201-2A	Gasifier Feed Lock Hopper									
	D-3201-2B	Gasifier Feed Lock Hopper									
	D-3201-3A	Gasifier Feed Lock Hopper									
	D-3201-3B	Gasifier Feed Lock Hopper									
	D-3201-4A	Gasifier Feed Lock Hopper									
	D-3201-4B	Gasifier Feed Lock Hopper									

TABLE 320-4 (cont.)

001

FOSTER WHEELER ENERGY CORP.
 PROCESS PLANTS DIVISION

CONTRACT:

SECTION: 320

EQUIPMENT LIST

NAME OF UNIT

Coal/Coke Treating & Feed

PAGE 4 OF 6

CLIENT: M/GW/DOE

ET-77-C-01-2582

REVISION

ORIGINAL

1

2

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4

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LOCATION: MEMPHIS, TENNESSEE

DATE

5/9/79

6/25/79

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.						REV.
	FD-3208-2F	Gasifier Feeder									
	FD-3208-8A	Gasifier Feeder									
	FD-3208-8B	Gasifier Feeder									
	FD-3208-8C	Gasifier Feeder									
	FD-3208-8D	Gasifier Feeder									
	FD-3208-8E	Gasifier Feeder									
	FD-3208-8F	Gasifier Feeder									
	FD-3208-4A	Gasifier Feeder									
	FD-3208-4B	Gasifier Feeder									
	FD-3208-4C	Gasifier Feeder									
	FD-3208-4D	Gasifier Feeder									
	FD-3208-4E	Gasifier Feeder									
	FD-3208-4F	Gasifier Feeder									
	FD-3209-1	Vent Filter Discharge Feeder									
	FD-3209-2	Vent Filter Discharge Feeder									
	FD-3209-3	Vent Filter Discharge Feeder									
	FD-3209-4	Vent Filter Discharge Feeder									
	FD-3210	Furnace Coal Feeder									
	FD-3211	Coke Dryer Discharge Feeder									1
Heaters	H-3201	Dryer Mill Furnace								Part of A-3201	
Separators	S-3201A	Treated Coal Separator								Part of A-3201	
	S-3201B	Treated Coal Separator								Part of A-3201	
	S-3202	Coke Dryer Exhaust Cyclone								Part of A-3202	
	S-3203A	Gasifier Feed Magnetic Separator									
	S-3203B	Gasifier Feed Magnetic Separator									

TABLE 320-4 (cont.)

FOSTER WHEELER ENERGY CORP.

PROCESS PLANTS DIVISION

CONTRACT:

SECTION: 320

EQUIPMENT LIST

NAME OF UNIT

Coal/Coke Treating & Feed

PAGE 3 OF 6

CLIENT: MLGW/DOE ET-77-C-01-2582

REVISION

ORIGINAL

1

2

3

4

5

LOCATION: MEMPHIS, TENNESSEE

DATE

5/9/79

6/25/79

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.	REV.
Feeders	F-3205-1	Feed Hopper Vent Filter				
	F-3205-2	Feed Hopper Vent Filter				
	F-3205-3	Feed Hopper Vent Filter				
	F-3205-4	Feed Hopper Vent Filter				
	FD-3201A	Dryer Mill Feeder			Part of A-3201	
	FD-3201B	Dryer Mill Feeder			Part of A-3201	
	FD-3202A	Treated Coal Discharge Feeder			Part of A-3201	
	FD-3202B	Treated Coal Discharge Feeder			Part of A-3201	
	FD-3203A	Coal Fines Discharge Feeder			Part of A-3201	
	FD-3203B	Coal Fines Discharge Feeder			Part of A-3201	
	FD-3204	Exhaust Cyclone Discharge Feeder			Part of A-3202	
	FD-3205	Coke Filter Discharge Feeder				
	FD-3606A	Coal Silo Discharge Feeder				
	FD-3206B	Coal Silo Discharge Feeder				
	FD-3207	Coke Silo Discharge Feeder				
	FD-3208-1A	Gasifier Feeder				
	FD-3208-1B	Gasifier Feeder				
	FD-3208-1C	Gasifier Feeder				
	FD-3208-1D	Gasifier Feeder				
	FD-3208-1E	Gasifier Feeder				
	FD-3208-1F	Gasifier Feeder				
	FD-3208-2A	Gasifier Feeder				
	FD-3208-2B	Gasifier Feeder				
	FD-3208-2C	Gasifier Feeder				
	FD-3208-2D	Gasifier Feeder				
	FD-3208-2E	Gasifier Feeder				

TABLE 320-4 (cont.)

FOSTER WHEELER ENERGY CORP. PROCESS PLANTS DIVISION		CONTRACT: SECTION: 320		EQUIPMENT LIST			NAME OF UNIT Coal/Coke Treating & Feeding					PAGE 2 OF 6	
CLIENT: MLGW/DOE ET-77-C-01-2582				REVISION		ORIGINAL		1	2	3	4	5	
LOCATION: MEMPHIS, TENNESSEE				DATE		5/9/79		6/25/79					
CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.							REV.	
	CR-3206	Coke Elevator											
	CR-3207	Coke Transfer Conveyor											
	CR-3208					Deleted						1	
	CR-3209	Coal/Coke Transfer Conveyor											
	CR-3210A	Coal Elevating Conveyor										1	
	CR-3210B	Coal/Coke Elevating conveyor											
	CR-3211A/B	Gasifier Feed Transfer Conveyors										1	
	CR-3212A/B	Gasifier Feed Conveyors											
	CR-3213A/B	Gasifier Feed Conveyors											
	CR-3214	Coke Fines Transfer Conveyor											
	CR-3215	Coke Filter Discharge Conv.										1	
	Dust Collection	DC-3201	Treated Coal/Coke Dust Coll. Sys.										
DC-3202		Gasifier Feed Dust Coll. Sys.											
Dryer	DR-3201	Coke Dryer				Part of A-3202							
Filters	F-3201A	Dryer Mill Bag Filter				Part of A-3201							
	F-3201B	Dryer Mill Bag Filter				Part of A-3201							
	F-3202	Coal Silo Vent Filter											
	F-3203	Coke Dryer Exhaust Filter											
	F-3204	Coke Silo Vent Filter											

TABLE 320-4 (cont.)

FOSTER WHEELER ENERGY CORP.		CONTRACT:		EQUIPMENT LIST		NAME OF UNIT					PAGE 1 OF 6	
PROCESS PLANTS DIVISION		SECTION: 320				Coal/Coke Treating & Feed						
CLIENT: MLGW/DOE ET-77-C-01-2582				REVISION	ORIGINAL	1	2	3	4	5		
LOCATION: MEMPHIS, TENNESSEE				DATE	5/9/79	6/25/79						
CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO	P. O. NO.							REV.
Package Unit	A-3201	Coal Crushing/Drying System										
	A-3202	Coke Drying System										
Blowers	B-3201	Dryer Mill Combustion Air Blower				Part of A-3201						
	B-3202A	Dryer Mill Recirculation Blower				Part of A-3201						
	B-3202E	Dryer Mill Recirculation Blower				Part of A-3201						
	B-3203A	Dryer Mill Exhaust Fan				Part of A-3201						
	B-3203B	Dryer Mill Exhaust Fan				Part of A-3201						
	B-3204	Coke Dryer Comb/Make-Up Air Blo.				Part of A-3202						
	B-3205	Coke Dryer Exhaust Fan				Part of A-3202						
	B-3206A	Dryer Mill Exhaust Booster Fan				Part of A-3201						
	B-3206B	Dryer Mill Exhaust Booster Fan				Part of A-3201						
Bin Discharger	BV-3201	Coal Silo Discharger										
	BV-3202	Coke Silo Discharger										
	BV-3203	Fines Discharger										1
Conveyors	CR-3201	Treated Coal Conveyor										
	CR-3202A	Coal Fines Discharge Conveyor										
	CR-3202B	Coal Fines Discharge Conveyor										
	CR-3203	Coal Fines Transfer Conveyor										
	CR-3204	Coke Dryer Discharge Conveyor										
	CR-3205	Sized Coke Conveyor										

TABLE 320-4

MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM

TASK III - DEMONSTRATION PLANT
OPERATIONS

TABLE 320-3

UTILITIES, CHEMICALS AND CATALYSTS

Power

Consumed

1031 Kilowatts

FOSTER WHEELER ENERGY CORPORATION

PROGRAM P1110
HEAT AND MATERIAL BALANCE15-2202
DATE 08/09/79MLGW/DOE IFG DEMO PLANT, NORMAL OPERATION (3 GASIFIERS OPERATING)
COAL & COKE TREATING & FEED MATERIAL AND HEAT BALANCES (SEC 320)

OUTPUT DESCRIPTION	FLOW RATE LB/HR	TEMP. DEG F	HEATING VALUE	MILLION BTU/HR SENSIBLE +LATENT	TOTAL HEAT
GASIFIER FEED COAL	227489.	100.0	2780.37	1.51	2781.88
TRANSPORT GAS	22884.	369.0	120.23	2.91	123.13
VENT GAS	3246.	105.0	7.24	0.03	7.27
FLUE GAS	77488.	250.0	0.04	30.28	30.32
FINES TO SEC 430	6134.	250.0	69.36	0.30	69.67
HEAT LOSS					13.15

TOTAL OUTPUT	337241.		2977.24	35.03	3025.42

NOTE: ENTHALPIES AT BASE TEMPERATURE OF 77. DEG F.
HEATING VALUES GIVEN ON GROSS BASIS.

TABLE 320-2 (cont.)

FOSTER WHEELER ENERGY CORPORATION

PROGRAM P1110
HEAT AND MATERIAL BALANCE

15-2202
DATE 08/09/79

MLGW/DOE IFG DEMO PLANT, NORMAL OPERATION (3 GASIFIERS OPERATING)
COAL & COKE TREATING & FEED MATERIAL AND HEAT BALANCES (SEC 320)

INPUT DESCRIPTION	FLOW RATE LB/HR	TEMP. DEG F	+ - - - MILLION BTU/HR - - - + HEATING SENSIBLE TOTAL VALUE +LATENT HEAT		
RAW COAL	259192.	100.0	2891.68	2.09	2893.77
TRANSPORT GAS	22884.	369.0	120.23	2.89	123.12
DESULFURIZED U-GAS TO SEC 320	1239.	100.0	7.24	0.01	7.25
AIR	51919.	95.0		1.27	1.27
NITROGEN	2007.	110.0		0.01	0.01
----- TOTAL INPUT			3019.14	6.27	3025.42

NOTE: ENTHALPIES AT BASE TEMPERATURE OF 77. DEG F.
HEATING VALUES GIVEN ON GROSS BASIS.

TABLE 320-2

FOSTER WHEELER ENERGY CORP.

PROCESS PLANTS DIVISION

CONTRACT:

SECTION: 330

EQUIPMENT LIST

NAME OF UNIT

PAGE 3 OF 3

COAL GASIFICATION

CLIENT: MLGW

ET-77-C-01-2582

REVISION

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LOCATION: MEMPHIS, TENNESSEE

DATE

3/21/79

6/14/79

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.	REV.
REACTORS	R-3301-1	Gasifier				
	R-3301-2	Gasifier				
	R-3301-3	Gasifier				
	R-3301-4	Gasifier				
CYCLONES	S-3301-1A	Primary Cyclone				
	S-3301-1B	Primary Cyclone				
	S-3301-2A	Primary Cyclone				
	S-3301-2B	Primary Cyclone				
	S-3301-3A	Primary Cyclone				
	S-3301-3B	Primary Cyclone				
	S-3301-4A	Primary Cyclone				
	S-3301-4B	Primary Cyclone				
	S-3302-1A	Secondary Cyclone				
	S-3302-1B	Secondary Cyclone				
	S-3302-2A	Secondary Cyclone				
	S-3302-2B	Secondary Cyclone				
	S-3302-3A	Secondary Cyclone				
	S-3302-3B	Secondary Cyclone				
	S-3302-4A	Secondary Cyclone				
	S-3302-4B	Secondary Cyclone				

TABLE 330-4 (cont.)

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III - DEMONSTRATION PLANT OPERATIONS

12.4 GAS COOLING AND SCRUBBING (Section 340)

12.4.1 Reference Material

- Process Flow Diagrams: FWEC Dwg. No. 2202-1-50-34101
-34102
- Stream Data: Table 340-1
- Heat and Material Balances: Table 340-2
- Utilities, Chemicals and Catalysts: Table 340-3
- Equipment List: Table 340-4

12.4.2 Description of Flow

Within this section the gas produced in the Coal Gasification (Section 330) is cooled from 1860 F to 236 F and water scrubbed for the removal of entrained fines.

The gas is cooled first by the generation of 900 psig steam in Primary H.P. Steam Generator ((E-3401-1,2,3,&4), followed by superheating of the 900 psig generated steam to a temperature of 850 F in H.P. Steam Superheater (E-3402-1,2,3&4) and additional 900 psig steam generation in Secondary H.P. Steam Generator (E-3403-1,2,3&4). Further cooling is achieved by preheating boiler feed water in Gasifier Effluent Cooler (E-3404-1,2,3&4) and by quenching in Raw Gas Spray Tower (T-3401, 2,3&4).

At this point, the bulk of entrained solids are removed from the raw gas by action of the Raw Gas Spray Tower, Raw Gas High Energy Scrubber (S-3401,2,3&4) and Raw Gas Venturi Scrubber (S-3402-1,2,3&4). Scrubbing Water is purged sufficiently to limit solids concentration 6% by weight.

Scrubbed raw gas from the Raw Gas Venturi Scrubber is compressed in Gas Compression (Section 350).

Stripped slurry water from Sour Water Stripping (Section 370) is treated in the Clarifier System Package Unit (A-3403). The Clarifier System Package provides for the gravitational separation of solids which may either settle or rise from suspension. Clarifier Water Pump (P-3406) delivers the clarified water to Waste Water Treatment (Section 440) while Slurry Water Pump (P-3407) and Clarifier Decanter Pump (P-3408) delivers the fines as a concentrated 15% slurry to Utility Area (Section 430).

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: GAS COOLING & SCRUBBINGREF. DWG.: 2202-1-50-34101CONTRACT NO.: REV.: 0

ET-77-C-01-2582

SECTION NO.: 340PAGE NO.: 1 of 4DATE: July 10, 1979

STREAM NUMBER		3401		3402		3403	
STREAM DESCRIPTION		GASIFIER EFFLUENT		COOLED RAW GAS		H.P. BOILER FEED WATER	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB / HR	MOL/HR	LB/HR
HYDROGEN	2.016	8318.6	16770	8318.6	16770		
CARBON MONOXIDE	28.011	6835.5	191469	6835.5	191469		
NITROGEN	28.016	181.2	5076	181.2	5076		
OXYGEN	32.000	-	-	-	-		
CARBON DIOXIDE	44.011	4520.4	198948	4520.4	198948		
HYDROGEN SULFIDE	34.082	264.6	9018	264.6	9018		
SULFUR DIOXIDE	64.066	-	-	-	-		
CARBONYL SULFIDE	60.077	11.1	667	11.1	667		
CARBON DISULFIDE	76.143	-	-	-	-		
METHANE	16.013	1121.0	17984	1121.0	17984		
SULFUR	32.066	-	-	-	-		
AMMONIA	17.032	6.7	114	6.7	114		
TOTAL DRY		21259.1	440046	21259.1	440046		
WATER	18.016	10575.3	190525	10575.3	190525	18824.7	339147
TOTAL WET		31834.4	630571	31834.4	630571	18824.7	339147
COAL (MAF)			5341		5341		
C	12.011		5187		5187		
H	1.008		22		22		
O	16.000		-		-		
N	14.008		44		44		
S	32.066		88		88		
ASH			1483		1483		
SELEXOL							
TOTAL STREAM		31834.4	637395	31834.4	637395	18824.7	339147

TABLE 340-1

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOE

LOCATION: MEMPHIS, TENNESSEE

SECTION NAME: GAS COOLING & SCRUBBING

REF. DWG.: 2202-1-50-34101 & 34102

CONTRACT NO.: REV.: 0

ET-77-C-01-2582

SECTION NO.: 340

PAGE NO.: 2 of 4

DATE: July 10, 1979

STREAM NUMBER		3404		3405		3406	
STREAM DESCRIPTION		900 PSIG STEAM GENERATED		HIGH PRESSURE BLOWDOWN		SCRUBBED RAW GAS	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB / HR	MOL/HR	LB/HR
HYDROGEN	2.016					8318.6	16770
CARBON MONOXIDE	28.011					6835.5	191469
NITROGEN	28.016					181.2	5076
OXYGEN	32.000					-	-
CARBON DIOXIDE	44.011					4526.9	199234
HYDROGEN SULFIDE	34.082					265.1	9035
SULFUR DIOXIDE	64.066					-	-
CARBONYL SULFIDE	60.077					11.1	667
CARBON DISULFIDE	76.143					-	-
METHANE	16.043					1121.0	17984
SULFUR	32.066					-	-
AMMONIA	17.032					12.3	209
TOTAL DRY						21271.7	440444
WATER	18.016	18638.4	335790	186.3	3357	9778.9	176177
TOTAL WET		18638.4	335790	186.3	3357	31050.6	616621
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SELEXOL							
TOTAL STREAM		18638.4	335790	186.3	3357	31050.6	616621

TABLE 340-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: GAS COOLING & SCRUBBINGREF. DWG.: 2202-1-50-34102CONTRACT NO.: REV.: 0

ET-77-C-01-2582

SECTION NO.: 340PAGE NO.: 3 of 4DATE: July 10, 1979

STREAM NUMBER	3407		3408		3409	
STREAM DESCRIPTION	PROCESS COND. FROM SEC. 350		SLURRY WATER TO SEC. 370		STRIPPED SLURRY WATER	
COMPONENTS (MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN 2.016						
CARBON MONOXIDE 28.011						
NITROGEN 28.016						
OXYGEN 32.000						
CARBON DIOXIDE 44.011	8.1	356	1.6	70		
HYDROGEN SULFIDE 34.082	0.7	24	0.2	7		
SULFUR DIOXIDE 64.066						
CARBONYL SULFIDE 60.077						
CARBON DISULFIDE 76.143						
METHANE 16.043						
SULFUR 32.066						
AMMONIA 17.032	6.6	112	1.0	17		
TOTAL DRY	15.4	492	2.8	94		
WATER 18.016	5093.1	91758	5889.5	106106	6440.3	116029
TOTAL WET	5108.5	92250	5892.3	106200	6440.3	116029
COAL (MAF)				5341		5341
C 12.011				5187		5187
H 1.008				22		22
O 16.000				-		-
N 14.008				44		44
S 32.066				88		88
ASH				1483		1483
SETEXOL						
TOTAL STREAM	5108.5	92250	5892.3	113024	6440.3	122853

TABLE 340-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: GAS COOLING & SCRUBBINGREF. DWG.: 2202-1-50-34102CONTRACT NO.: ET-77-C-01-2582SECTION NO.: 340PAGE NO.: 4 of 4DATE: July 10, 1979

STREAM NUMBER		3410		3411			
STREAM DESCRIPTION		FINES SLURRY TO SEC 340		CLARIFIED WATER TO SEC 440			
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016						
CARBON MONOXIDE	28.011						
NITROGEN	28.016						
OXYGEN	32.000						
CARBON DIOXIDE	44.011						
HYDROGEN SULFIDE	34.082						
SULFUR DIOXIDE	64.066						
CARBONYL SULFIDE	60.077						
CARBON DISULFIDE	76.143						
METHANE	16.043						
SULFUR	32.066						
AMMONIA	17.032						
TOTAL DRY							
WATER	18.016	1136.3	20472	5304.0	95557		
TOTAL WET		1136.3	20472	5304.0	95557		
COAL (MAF)			5341				
C	12.011		5187				
H	1.008		22				
O	16.000		-				
N	14.008		44				
S	32.066		88				
ASH			1483				
SELEXOL							
TOTAL STREAM		1136.3	27296	5304.0	95557		

TABLE 340-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

PROGRAM P1110
HEAT AND MATERIAL BALANCE15-2202
DATE 08/09/79MLGW/DOE IFG DEMO PLANT, NORMAL OPERATION (3 GASIFIERS OPERATING)
GAS COOLING & SCRUBBING MATERIAL AND HEAT BALANCES (SECTION 340)

INPUT DESCRIPTION	FLOW RATE LB/HR	TEMP. DEG F	HEATING VALUE	MILLION BTU/HR SENSIBLE +LATENT	TOTAL HEAT
GASIFIER EFFLUENT GAS	630570.	1860.0	2352.21	705.66	3057.87
FINES IN GASIFIER EFFLUENT GAS	6824.	1860.0	77.16	3.93	81.09
PROCESS CONDENSATE FROM SEC 350	92250.	110.0	1.25	2.98	4.23
WATER IN STRIPPED SLURRY WATER	116029.	95.0		2.09	2.09
FINES IN STRIPPED SLURRY WATER	6824.	95.0	77.16	0.02	77.19
P-3403 KW USAGE					0.35
P-3404 KW USAGE					0.04
P-3405 KW USAGE					0.06
P-3406 KW USAGE					0.05
P-3407 KW USAGE					0.01
P-3408 KW USAGE					0.01

TOTAL INPUT	852497.		2507.79	714.68	3222.99

NOTE: ENTHALPIES AT BASE TEMPERATURE OF 77. DEG F.
HEATING VALUES GIVEN ON GROSS BASIS.

TABLE 340-2

FOSTER WHEELER ENERGY CORPORATION

PROGRAM P1110
HEAT AND MATERIAL BALANCE15-2202
DATE 08/09/79MLGW/DOE IFG DEMO PLANT, NORMAL OPERATION (3 GASIFIERS OPERATING)
GAS COOLING & SCRUBBING MATERIAL AND HEAT BALANCES (SECTION 340)

OUTPUT DESCRIPTION	FLOW RATE LB/HR	TEMP. DEG F	HEATING VALUE	MILLION BTU/HR SENSIBLE +LATENT	TOTAL HEAT
SCRUBBED RAW GAS	616620.	236.0	2353.25	220.42	2573.67
ACID GAS SOLUTION IN SLURRY WATER	106200.	180.0	0.21	10.93	11.15
FINES IN SLURRY WATER	6824.	180.0	77.16	0.14	77.31
CLARIED WATER	95557.	95.0		1.74	1.74
H2O IN SLURRY TO FILTRATION	20472.	95.0		0.37	0.37
FINES IN SLURRY TO FILTRATION	6824.	95.0	77.16	0.02	77.19
HEAT FOR 900 PSIG SUPERHEATED STEAM					412.97
E-3405 SPRAY TOWER WATER COOLER					60.00
HEAT LOSS					8.60
TOTAL OUTPUT	852497.		2507.79	233.62	3222.99

NOTE: ENTHALPIES AT BASE TEMPERATURE OF 77. DEG F.
HEATING VALUES GIVEN ON GROSS BASIS.

TABLE 340-2 (cont.)

MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM

TASK III- DEMONSTRATION PLANT
OPERATIONS

TABLE 340-3

UTILITIES, CHEMICALS AND CATALYSTS

	<u>Normal</u>
<u>Steam, HP (900 psig, 840°F)</u> Produced	335,790 lbs/hr
<u>Steam, LP (85 psig, sat'd.)</u> Produced	890 lbs/hr
<u>Boiler Feed Water</u> Consumed	339,150 lbs/hr
<u>Blowdown</u> Produced	2,470 lbs/hr
<u>Power</u> Consumed	220 Kilowatts
<u>Chemical Consumption</u> Phosphate Dosage (As Na 2.8 Ho.2 PO ₄)	13.1 lbs/day

FOSTER WHEELER ENERGY CORP.

PROCESS PLANTS DIVISION

CONTRACT:

SECTION: 340

EQUIPMENT LIST

NAME OF UNIT

Gas Cooling & Scrubbing

PAGE 1 OF 4

CLIENT: MLGW

ET-77-C-01-2582

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LOCATION:

DATE

4-11-79

7-13-79

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.	REV.
TOWERS	T-3401-1	Raw Gas Spray Tower				
	T-3401-2	Raw Gas Spray Tower				
	T-3401-3	Raw Gas Spray Tower				
	T-3401-4	Raw Gas Spray Tower				
DRUMS	D-3401-1	H.P. Steam Drum				
	D-3401-2	H.P. Steam Drum				
	D-3401-3	H.P. Steam Drum				
	D-3401-4	H.P. Steam Drum				
EXCHANGERS	E-3401-1	Primary H.P. Steam Generator				
	E-3401-2	Primary H.P. Steam Generator				
	E-3401-3	Primary H.P. Steam Generator				
	E-3401-4	Primary H.P. Steam Generator				
	E-3402-1	H.P. Steam Superheater				
	E-3402-2	H.P. Steam Superheater				
	E-3402-3	H.P. Steam Superheater				
	E-3402-4	H.P. Steam Superheater				
	E-3403-1	Secondary H.P. Steam Generator				
	E-3403-2	Secondary H.P. Steam Generator				
	E-3403-3	Secondary H.P. Steam Generator				
	E-3403-4	Secondary H.P. Steam Generator				

TABLE 340-4

FOSTER WHEELER ENERGY CORP. PROCESS PLANTS DIVISION		CONTRACT: SECTION: 340		EQUIPMENT LIST		NAME OF UNIT Gas Cooling & Scrubbing					PAGE 2 OF 4	
CLIENT: MLGW		ET-77-C-01-2582		REVISION		ORIGINAL		1	2	3	4	5
LOCATION:		DATE		4-11-79		7-13-79						
CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.							REV
EXCHANGERS (cont'd)	E-3404-1	Gasifier Effluent Cooler										1
	E-3404-2	Gasifier Effluent Cooler										1
	E-3404-3	Gasifier Effluent Cooler										1
	E-3404-4	Gasifier Effluent Cooler										1
	E-3405-1A	Spray Tower Water Cooler										1
	E-3405-1B	Spray Tower Water Cooler										1
	E-3405-2A	Spray Tower Water Cooler										1
	E-3405-2B	Spray Tower Water Cooler										1
	E-3405-3A	Spray Tower Water Cooler										1
	E-3405-3B	Spray Tower Water Cooler										1
	E-3405-4A	Spray Tower Water Cooler										1
	E-3405-4B	Spray Tower Water Cooler										1
	E-3406-1	BFW Preheater										1
	E-3406-2	BFW Preheater										1
	E-3406-3	BFW Preheater										1
	E-3406-4	BFW Preheater										1
PUMPS												1
												1
												1
												1
												1
												1
												1
												1
												1
												1

TABLE 340-4 (cont.)

PROCESS PLANTS DIVISION

SECTION: 340

NAME OF UNIT

PAGE 3 OF 4

CLIENT: MLGW ET-77-C-01-2582

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LOCATION:

DATE _____

4-11-79

7-13-79

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.		REV
<u>PUMPS</u> (cont'd)							1
							1
							1
							1
							1
							1
							1
							1
	P-3403-1A	Spray Tower Circulation Pump					
	P-3403-1B	Spare for P-3403-1A					
	P-3403-2A	Spray Tower Circulation Pump					
	P-3403-2B	Spare for P-3403-2A					
	P-3403-3A	Spray Tower Circulation Pump					
	P-3403-3B	Spare for P-3403-3A					
	P-3403-4A	Spray Tower Circulation Pump					
	P-3403-4B	Spare for P-3403-4A					
	P-3404-1A	High Energy Scrubber Circ. Pump					
	P-3404-1B	Spare for P-3404-1A					
	P-3404-2A	High Energy Scrubber Circ. Pump					
	P-3404-2B	Spare for P-3404-2A					
	P-3404-3A	High Energy Scrubber Circ. Pump					
	P-3404-3B	Spare for P-3404-3A					
	P-3404-4A	High Energy Scrubber Circ. Pump					
	P-3404-4B	Spare for P-3404-4A					
	P-3405-1A	Venturi Scrubber Circulation Pump					
	P-3405-1B	Spare for P-3405-1A					
	P-3405-2A	Venturi Scrubber Circulation Pump					
	P-3405-2B	Spare for P-3405-2A					
	P-3405-3A	Venturi Scrubber Circulation Pump					
	P-3405-3B	Spare for P-3405-3A					
	P-3405-4A	Venturi Scrubber Circulation Pump					
	P-3405-4B	Spare for P-3405-4A					

TABLE 340-4 (cont.)

FOSTER WHEELER ENERGY CORP. PROCESS PLANTS DIVISION		CONTRACT: SECTION: 340		EQUIPMENT LIST			NAME OF UNIT Gas Cooling & Scrubbing					PAGE 4 OF 4	
CLIENT: MLGW		ET-77-C-01-2582		REVISION		ORIGINAL		1	2	3	4	5	
LOCATION:				DATE		4-11-79		7-13-79					
CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.							REV.	
<u>PUMPS</u> (cont'd)	P-3406A	Clarifier Water Pump											
	P-3406B	Spare for P-3406A											
	P-3407A	Slurry Water Pump											
	P-3407B	Spare for P-3407A											
	P-3408A	Clarifier Decanter Pump											
	P-3408B	Spare for P-3408A											
												1	
												1	
<u>SCRUBBERS</u>	S-3401-1	Raw Gas High Energy Scrubber											
	S-3401-2	Raw Gas High Energy Scrubber											
	S-3401-3	Raw Gas High Energy Scrubber											
	S-3401-4	Raw Gas High Energy Scrubber											
	S-3402-1	Raw Gas Venturi Scrubber											
	S-3402-2	Raw Gas Venturi Scrubber											
	S-3402-3	Raw Gas Venturi Scrubber											
	S-3402-4	Raw Gas Venturi Scrubber											
<u>MISC.</u>	A-3401	Phosphate Addition Package											
	A-3403	Clarifier System Package										1	
	M-3401	Phosphate Tank Mixer											

TABLE 340-4 (cont.)

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III- DEMONSTRATION PLANT OPERATIONS

12.5 GAS COMPRESSION (Section 350)

12.5.1 Reference Material

- Process Flow Diagrams: FWEC Dwg. No. 2202-1-50-35101
- Stream Data: Table 350-1
- Heat and Material Balance: Table 350-2
- Utilities, Chemicals and Catalysts: Table 350-3
- Equipment List: Table 350-4

12.5.2 Description of Flow

Scrubbed raw gas leaving Gas Cooling and Scrubbing (Section 340) at a temperature of 236°F is cooled to 110°F in Scrubbed Gas Air Cooler (E-3501) and Scrubbed Gas Cooler (E-3502). The water condensed from the raw gas is removed in Scrubbed Gas KO Drum (D-3503).

The raw gas leaving the Scrubbed Gas KO Drum is compressed from 49 psig to 192 psig by the Raw Gas Compressor (C-3501).

After compression, the raw gas is cooled in Compressor Aftercooler (E-3505). This results in additional condensate which is removed in Compressed Gas KO Drum (D-3504).

Part of the condensate from the Scrubbed Gas KO Drum is sent to Gas Cooling and Scrubbing (Section 340). The remaining condensate is combined with that from the Compressed Gas KO Drum for delivery to Sour Water Stripping (Section 370).

The compressed raw gas from the overhead of the Compressed Gas KO Drum reports to Gas Treating (Section 360).

L.P. recycle gas, M.P. recycle gas and H.P. recycle gas from Gas Treating (Section 360) are compressed and recycled by L.P. Recycle Gas Compressor (C-3503) and H.P. Recycle Gas Compressor (C-3502) with intermediate cooling being provided by 1st Compressor Intercooler (E-3503) and 2nd Compressor Intercooler (E-3504). Removal of condensate resulting from intermediate cooling is provided by 1st Intercooler KO Drum (D-3501) and 2nd Intercooler KO Drum (D-3502). Since this condensate will contain Selexol solvent, it is returned in total to Gas Treating (Section 360).

FOSTER WHEELER ENERGY CORPORATION
CUSTOMER: MLCW/DOM
LOCATION: MEMPHIS, TENNESSEE

SECTION NAME: GAS COMPRESSION

RFF. DWG.: 2201-1-50-35101

CONTRACT NO.: REV.: 0

SECTION NO.: 350

PAGE NO.: 1 OF 3

DATE: July 10, 1979

ET-77-C-01-2582

STREAM NUMBER		3504		3505		3506	
STREAM DESCRIPTION		SCRUBBED RAW GAS		LP CONDENSATE TO SWS		PROCESS COND. TO SEC. 340	
COMPONENTS	(MM)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016	8318.6	16770				
CARBON MONOXIDE	28.011	6835.5	191469				
NITROGEN	28.016	181.2	5076				
OXYGEN	32.000	-	-				
CARBON DIOXIDE	44.011	4526.9	199234	6.8	299	8.1	356
HYDROGEN SULFIDE	34.082	265.1	9035	0.6	20	0.7	24
SULFUR DIOXIDE	64.066	-	-				
CARBONYL SULFIDE	60.077	11.1	667				
CARBON DISULFIDE	76.143	-	-				
METHANE	16.043	1121.0	17984				
SULFUR	32.066	-	-				
AMMONIA	17.032	12.3	209	5.6	95	6.6	112
TOTAL DRY		21271.7	440444	13.0	414	15.4	492
WATER	18.016	9778.9	176177	4251.5	76595	5093.1	91758
TOTAL WET		31050.6	616621	4264.5	77009	5108.5	92250
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SELEXOL							
TOTAL STREAM		31050.6	616621	4264.5	77009	5108.5	92250

TABLE 350-1

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: GAS COMPRESSIONREF. DWG.: 2202-1-50-35101CONTRACT NO.: ET-77-C-01-2582REV.: 0SECTION NO.: 350PAGE NO.: 2 of 3DATE: July 10, 1979

STREAM NUMBER		3507		3508		3509	
STREAM DESCRIPTION		COMPRESSED RAW GAS		TRANSPORT GAS		COMPRESSED RAW GAS TO SEC 360	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016	8318.6	16770	425.5	858	7893.1	15912
CARBON MONOXIDE	28.011	6835.5	191469	349.6	9793	6485.9	181676
NITROGEN	28.016	181.2	5076	9.3	261	171.9	4815
OXYGEN	32.000	-	-	-	-	-	-
CARBON DIOXIDE	44.011	4512.0	198579	230.7	10153	4280.6	188395
HYDROGEN SULFIDE	34.082	263.8	8991	13.4	457	250.3	8530
SULFUR DIOXIDE	64.066	-	-	-	-	-	-
CARBONYL SULFIDE	60.077	11.1	667	0.6	36	10.5	631
CARBON DISULFIDE	76.143	-	-	-	-	-	-
METHANE	16.043	1121.0	17984	57.3	919	1063.7	17065
SULFUR	32.066	-	-	-	-	-	-
AMMONIA	17.032	12.3	209	-	-	0.1	2
TOTAL DRY		21243.3	439538	1086.4	22477	20156.1	417026
WATER	18.016	434.3	7824	22.6	407	129.0	2324
TOTAL WET		21677.6	447362	1109.0	22884	20285.1	419350
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SEL EXOL							
TOTAL STREAM		21667.6	447362	1109.0	22884	20285.1	419350

TABLE 350-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MT.GW/DOE

LOCATION: MEMPHIS, TENNESSEE

SECTION NAME: GAS COMPRESSION

REF. DWG.: 2202-1-50-35101

CONTRACT NO.: REV.: 0

SECTION NO.: 350

PAGE NO.: 3 of 3

DATE: July 10, 1979

ET-77-C-01-2582

STREAM NUMBER		3510		3512			
STREAM DESCRIPTION		HP CONDENSATE		SOUR CONDENSATE TO SEC 370			
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016						
CARBON MONOXIDE	28.011						
NITROGEN	28.016						
OXYGEN	32.000						
CARBON DIOXIDE	44.011	0.7	31	7.5	330		
HYDROGEN SULFIDE	34.082	0.1	4	0.7	24		
SULFUR DIOXIDE	64.066						
CARBONYL SULFIDE	60.077						
CARBON DISULFIDE	76.143						
METHANE	16.043						
SULFUR	32.066						
AMMONIA	17.032			5.6	95		
TOTAL DRY		0.8	35	13.8	449		
WATER	18.016	282.7	5093	4534.2	81688		
TOTAL WET		283.5	5128	4548.0	82137		
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SELEXOL							
TOTAL STREAM		283.5	5128	4548.0	82137		

TABLE 350-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

PROGRAM P1110
HEAT AND MATERIAL BALANCE

15-2202
DATE 08/09/79

MLGW/DOE IFG DEMO PLANT, NORMAL OPERATION (3 GASIFIERS OPERATING)
GAS COMPRESSION MATERIAL AND HEAT BALANCES (SECTION 350)

INPUT DESCRIPTION	FLOW RATE LB/HR	TEMP. DEG F	+ - - MILLION BTU/HR - - - +		
			HEATING VALUE	SENSIBLE +LATENT	TOTAL HEAT
SCRUBBED RAW GAS	616620.	236.0	2353.25	220.42	2573.67
C-3501 RAW GAS COMPRESSOR BHP					46.84
<hr/>					
TOTAL INPUT	616620.		2353.25	220.42	2620.51

NOTE: ENTHALPIES AT BASE TEMPERATURE OF 77. DEG F.
HEATING VALUES GIVEN ON GROSS BASIS.

TABLE 350-2

FOSTER WHEELER ENERGY CORPORATION

PROGRAM P1110
HEAT AND MATERIAL BALANCE15-2202
DATE 08/09/79MLGW/DOE IFG DEMO PLANT, NORMAL OPERATION (3 GASIFIERS OPERATING)
GAS COMPRESSION MATERIAL AND HEAT BALANCES (SECTION 350)

OUTPUT DESCRIPTION	FLOW RATE LB/HR	TEMP. DEG F	HEATING VALUE	MILLION BTU/HR SENSIBLE +LATENT	TOTAL HEAT
PROCESS CONDENSATE TO SEC 340	92250.	110.0	1.25	2.98	4.23
TRANSPORT GAS	22884.	369.0	120.23	2.89	123.12
SOUR CONDENSATE TO SEC 370	82137.	110.0	1.09	2.65	3.74
COMPRESSED RAW GAS	419349.	110.0	2230.69	6.61	2237.30
E-3501 SCRUBBED GAS AIR COOLER					183.70
E-3502 SCRUBBED GAS COOLER					14.60
E-3505 COMPRESSOR AFTERCOOLER					52.87
HEAT LOSS					0.94
TOTAL OUTPUT	616620.		2353.25	15.13	2620.51

TABLE 350-2 (cont.)

NOTE: ENTHALPIES AT BASE TEMPERATURE OF 77. DEG F.
HEATING VALUES GIVEN ON GROSS BASIS.

MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM

TASK - DEMONSTRATION PLANT

TABLE 350-3

UTILITIES, CHEMICALS AND CATALYSTS

	<u>Normal</u>
<u>Cooling Water</u>	5234 GPM
<u>Power</u> Consumed	16,520 Kilowatts

12.6 GAS TREATING (Section 360)

12.6.1 Reference Material

- Process Flow Diagrams: FWEC Dwg. No. 2202-1-50-36101
-36102
- Stream Data: Table 360-1
- Heat and Material Balances: Table 360-2
- Utilities, Chemicals and Catalysts: Table 360-3
- Equipment List: Table 360-4

12.6.2 Description of Flow

The function of this section is the removal of almost all the sulfur compounds and some of the CO_2 from the raw gas. The removal of some of the CO_2 provides a means of controlling the product gas BTU value.

Compressed raw gas reporting from the Gas Compression (Section 350) is cooled in the Feed Product Exchanger (E-3601). Condensed process water removed from the raw gas stream in the H_2S Absorber K.O. Drum (D-3601) is split with part being delivered to the H_2S Stripper (T-3602) for maintaining water balance and the remainder being sent to Sour Water Stripping (Section 370).

The raw gas leaving the H_2S Absorber K.O. Drum enters H_2S Absorber (T-3601) where cold lean Selexol solvent physically absorbs essentially all of the H_2S as well as most of the COS and some CO_2 . The resulting product gas meets the required sulfur specifications. Absorber overhead gas after exchanging heat with the incoming raw gas and recycle gas in Feed Product Exchanger (E-3601) and Recycle Product Exchanger (E-3602), passes to the CO_2 Absorber (T-3603) for the removal of sufficient CO_2 to maintain a HHV of 300 BTU/SCF in the IFG product.

The cold rich solvent from the bottom of the H_2S Absorber passes through 3 stages of preheating and flashing in order to provide an acid gas with sufficient concentration of H_2S for treatment by Sulfur Recovery (Section 380). Preheating is effected by countercurrent heat exchange with hot lean solvent in H_2S High Pressure Flash Preheater (E-3605), H_2S Medium Pressure Flash Preheater (E-3606) and H_2S Stripper Feed Preheater (E-3607).

**MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM**

**TASK III - DEMONSTRATION PLANT
OPERATIONS**

Preheating and flashing also provides for the recovery of co-absorbed fuel gases and for savings in utilities.

Preflashed solvent is further stripped in the H_2S stripper (T-3602) by vapors generated from H_2S Stripper Reboiler (E-3604). Overhead steam from the H_2S Stripper is condensed in H_2S Stripper Condenser (E-3603) and returned to the H_2S Stripper while the acid gas goes to Sulfur Recovery (Section 380).

Hot lean solvent from the bottom of the H_2S Stripper is cooled in heat exchangers with the cold rich solvent after which it is further chilled by Solvent Refrigeration Unit (A-3601). Chilled lean solvent is fed to the top tray of the H_2S Absorber. A slipstream of lean solvent is filtered by H_2S solution Filter (F-3601).

To conserve solvent and prevent pollution, solvent drains are sent to Solvent Sump (TK-3602), from which drained solvent is returned to the unit.

Rich solvent from the bottom of CO_2 Absorber (T-3603) is regenerated in CO_2 stripper (T-3604) using carrier gas consisting of bone dry nitrogen delivered from Air Separation (Section 310) to the bottom of the CO_2 stripper by means of Nitrogen Compressor (C-3601).

A slip stream of lean solvent is filtered by CO_2 Lean Solution Filter (F-3602).

Make up to the system is by way of the Solvent Sump (TK-3601) which has been sized for containing one truckload of Selexol solution.

NOTES:
1. PROCESS PARAMETERS SUMMARIZED FOR HIGH SULFUR 3.6 BBL/DAY CASE.

LEGEND

- ◇ MATERIAL BALANCE STREAM NUMBER
- TEMPERATURE °F
- PRESSURE PSIG UNLESS OTHERWISE INDICATED

INDUSTRIAL FUEL GAS DEMONSTRATION PLANT CONTRACT NO. 77C-01-3103 RESEARCH, DESIGN AND WATER DIVISION MEMPHIS, TENN.		THIS PROJECT IS A PART OF THE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT RESEARCH, DESIGN AND WATER DIVISION MEMPHIS, TENN.		TRUCK II DEMONSTRATION PLANT GAS TREATING SECTION 360	
DRAWN BY: [Signature] CHECKED BY: [Signature] DATE: [Date]		DESIGNED BY: [Signature] CHECKED BY: [Signature] DATE: [Date]		DWG. NO. 2002-10-2600 SHEET NO. 1 OF 1

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOE

LOCATION: MEMPHIS, TENNESSEE

SECTION NAME: GAS TREATING

REF. DWG.: 2202-1-50-36101

CONTRACT NO.: REV.: 0

SECTION NO.: 360

PAGE NO.: 1 of 4

DATE: July 10, 1979

STREAM NUMBER		3601		3608		3616	
STREAM DESCRIPTION		COMPRESSED RAW GAS		ACID GAS TO SEC 380		CONDENSATE TO SEC 370	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016	7893.1	15912	0.1	-		
CARBON MONOXIDE	28.011	6485.9	181676	0.2	6		
NITROGEN	28.016	171.9	4815	-	-		
OXYGEN	32.000	-	-	-	-		
CARBON DIOXIDE	44.011	4280.6	188395	596.1	26235	0.4	18
HYDROGEN SULFIDE	34.082	250.3	8530	250.2	8527	0.1	3
SULFUR DIOXIDE	64.066	-	-	-	-		
CARBONYL SULFIDE	60.077	10.5	631	9.7	583		
CARBON DISULFIDE	76.143	-	-	-	-		
METHANE	16.043	1063.7	17065	0.3	5		
SULFUR	32.066	-	-	-	-		
AMMONIA	17.032	0.1	2	0.1	2		
TOTAL DRY		20156.1	417026	856.7	35358	0.5	21
WATER	18.016	129.0	2324	42.6	767	80.1	1443
TOTAL WET		20285.1	4193350	899.3	36125	80.6	1464
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SELEXOL							
TOTAL STREAM		20285.1	419350	899.3	36125	80.6	1464

TABLE 360-1

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: M.G.W./DOE

LOCATION: MEMPHIS, TENNESSEE

SECTION NAME: GAS TREATING

REF. DWG.: 2202-1-50-36102

CONTRACT NO.: 0

SECTION NO.: 360

PAGE NO.: 2 OF 4

DATE: July 10, 1979

STREAM NUMBER		3607		3609		3618	
STREAM DESCRIPTION		GROSS PRODUCT GAS		CO ₂ VENT GAS TO SEC 430		NITROGEN FROM SEC. 310	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016	7856.3	15838	10.4	21		
CARBON MONOXIDE	28.011	6448.7	180634	15.4	431		
NITROGEN	28.016	171.0	4789	53.3	1494	53.0	1485
OXYGEN	32.000	-	-	-	-		
CARBON DIOXIDE	44.011	3394.0	149374	278.6	12262		
HYDROGEN SULFIDE	34.082	-	-	-	-		
SULFUR DIOXIDE	64.066	-	-	-	-		
CARBONYL SULFIDE	60.077	0.8	48	-	-		
CARBON DISULFIDE	76.143	-	-	-	-		
METHANE	16.043	1052.7	16888	7.1	114		
SULFUR	32.066	-	-	-	-		
AMMONIA	17.032	-	-	-	-		
TOTAL DRY		18923.5	367571	364.8	14322	53.0	1485
WATER	18.016	5.0	89	1.3	24	-	-
TOTAL WET		18928.5	367660	366.1	14346	53.0	1485
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SELEXOL							
TOTAL STREAM		18928.5	367660	366.1	14346	53.0	1485

TABLE 360-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: GAS TREATINGREF. DWG.: 2202-1-50-36102/36103CONTRACT NO.: REV.: 0SECTION NO.: 360PAGE NO.: 3 of 4DATE: July 10, 1979

STREAM NUMBER		3619		3620		3621	
STREAM DESCRIPTION		DESULFURIZED U-GAS TO SEC.		FEED GAS TO SEC. 220		INTERNAL USE IFG	
COMPONENTS	(MW)	MOL/HR	LB/HR 320	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016	26.3	53	759.5	1531	63.8	129
CARBON MONOXIDE	28.011	21.6	605	623.4	17462	52.4	1467
NITROGEN	28.016	0.6	17	16.5	462	1.4	39
OXYGEN	32.000	-	-	-	-	-	-
CARBON DIOXIDE	111.011	11.5	506	328.1	14440	27.6	1213
HYDROGEN SULFIDE	34.082	-	-	-	-	-	-
SULFUR DIOXIDE	64.066	-	-	-	-	-	-
CARBONYL SULFIDE	60.077	-	-	0.1	6	-	-
CARBON DISULFIDE	76.113	-	-	-	-	-	-
METHANE	16.043	3.6	58	101.8	1633	8.5	137
SULFUR	32.066	-	-	-	-	-	-
AMMONIA	17.032	-	-	-	-	-	-
TETRAHYDROTHIOPHENE	88.174	-	-	-	-	-	-
TOTAL DRY		63.6	1239	1829.4	35534	153.7	2985
WATER	18.016	-	-	0.5	9	-	-
TOTAL WET		63.6	1239	1829.9	35543	153.7	2985
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SELEXOL							
TOTAL STREAM		63.6	1239	1829.9	35543	153.7	2985

TABLE 360-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOE

LOCATION: MEMPHIS, TENNESSEE

SECTION NAME: GAS TREATING

REF. DWG.: 2202-1-50-36103

CONTRACT NO.: REV.: 0

SECTION NO.: 360

PAGE NO.: 4 of 4

DATE: July 10, 1979

STREAM NUMBER		3622		3623		3624	
STREAM DESCRIPTION		IFG SEND OUT		ORDORANT		SUBSTITUTE IFG	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB / HR	MOL/HR	LB/HR
HYDROGEN	2.016	7033.0	14,178				
CARBON MONOXIDE	28.011	5772.9	161,705				
NITROGEN	28.016	153.1	4,288				
OXYGEN	32.000	-	-				
CARBON DIOXIDE	44.011	3038.3	133,721				
HYDROGEN SULFIDE	34.082	-	-				
SULFUR DIOXIDE	64.066	-	-				
CARBONYL SULFIDE	60.077	0.7	42				
CARBON DISULFIDE	76.143	-	-				
METHANE	16.043	942.4	15,118				
SULFUR	32.066	-	-				
AMMONIA	17.032	-	-				
TETRAHYDROTHIOPHENE	88.174	0.1	7	0.1	7		
TOTAL DRY		16940.5	329,059	0.1	7		
WATER	18.016	4.5	81				
TOTAL WET		16,945	329,140	0.1	7		
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SELEXOL							
TOTAL STREAM		16,945	329,140	0.1	7	No Normal Flow	

TABLE 360-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

PROGRAM P1110
HEAT AND MATERIAL BALANCE15-2202
DATE 08/09/79MLGW/DOE IFG DEMO PLANT, NORMAL OPERATION (3 GASIFIERS OPERATING)
GAS TREATING MATERIAL AND HEAT BALANCES (SECTION 360)

INPUT DESCRIPTION	FLOW RATE LB/HR	TEMP. DEG F	+ - - - MILLION BTU/HR - - - + HEATING SENSIBLE TOTAL VALUE +LATENT HEAT		
COMPRESSED RAW GAS	419349.	110.0	2230.69	6.61	2237.30
STRIPPING NITROGEN	1485.	94.0		0.01	0.01
ORDORANT	7.	110.0		0.00	0.00
C-3502 H. P. RECYCLE COMPRESSOR					
C-3503 L. P. RECYCLE COMPRESSOR BHP					
A-3601 SOLVENT REFRIG UNIT BHP					
P-3601 H2S RICH SOLN PUMP KW					
P-3602 H2S L. P. LEAN SOLN PUMP KW					148.87
P-3603 H2S STRIPPER REFLUX PUMP KW					
P-3604 CO2 LEAN SOLN PUMP KW					
P-3606 H2S H. P. LEAN SOLN PUMP KW					
C-3601 NITROGEN COMPRESSOR BHP					
E-3604 H2S STRIPPER REBOILER					
TOTAL INPUT	420841.		2230.69	6.62	2386.18

NOTE: ENTHALPIES AT BASE TEMPERATURE OF 77. DEG F.
HEATING VALUES GIVEN ON GROSS BASIS.

TABLE 360-2

FOSTER WHEELER ENERGY CORPORATION

PROGRAM P1110
HEAT AND MATERIAL BALANCE15-2202
DATE 08/09/79MLGW/DOE IFG DEMO PLANT, NORMAL OPERATION (3 GASIFIERS OPERATING)
GAS TREATING MATERIAL AND HEAT BALANCES (SECTION 360)

OUTPUT DESCRIPTION	FLOW RATE LB/HR	TEMP. DEG F	+ - - - MILLION BTU/HR - - - +		
			HEATING VALUE	SENSIBLE +LATENT	TOTAL HEAT
CONDENSATE TO SEC 370	1464.	62.0	0.02	-0.02	0.00
ACID GAS TO SEC 380	36125.	110.0	63.02	1.01	64.03
CO2 VENT GAS TO SEC 430	14346.	100.0	5.88	0.10	5.97
DESULFURIZED U-GAS TO SEC 320	1239.	100.0	7.24	0.01	7.25
FEED GAS TO SEC 220	35543.	100.0	208.30	0.26	208.56
INTERNAL USE IFG	12134.	100.0	71.11	0.09	71.19
IFG SEND-OUT	319991.	100.0	1875.13	2.35	1877.48
E-3503 1ST COMPR INTERCODLER	}				
E-3504 2ND COMPR INTERCODLER					
E-3506 RECYCLE GAS AFTERCOOLER					
A-3601 SOLVENT REFRIGERATION UNIT					150.23
E-3603 H2S STRIPPER CONDENSER					
E-3609 CO2 LEAN SOLN COOLER					
E-3608 N2 COMPRESSOR COOLER					
HEAT LOSS					1.48
<hr/>					
TOTAL OUTPUT	420840.		2230.70	3.79	2386.18

NOTE: ENTHALPIES AT BASE TEMPERATURE OF 77. DEG F.
HEATING VALUES GIVEN ON GROSS BASIS.

TABLE 360-2 (cont.)

MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM

TASK III- DEMONSTRATION PLANT
OPERATIONS

TABLE 360-3

UTILITIES, CHEMICALS AND CATALYSTS

	<u>Normal</u>
<u>Steam</u> , HP (900 spig, 840°F) Consumed	75,230 lbs/hr
<u>Steam</u> , LP (85 psig, sat'd.) Consumed	119,159 lbs/hr
<u>Condensate</u> , LP (59 psig) Produced	119,159 lbs/hr
<u>Cooling Water</u>	7,669 GPM
<u>Power</u> Consumed	6,712 Kilowatts
<u>Chemical Consumption</u> Selexol Solution	123 lbs/day

PROCESS PLANTS DIVISION

SECTION: 360

NAME OF UNIT

PAGE 1 OF 7

Gas Treating

REVISION

ORIGINAL

1

2

3

4

5

DATE _____

5-30-79

6-21-79

7-10-79

CLASS

ITEM NO.

DESCRIPTION

EFD

REQ'N. NO.	
------------	--

P. O. NO.

REV

TOWERS

T-3601

H₂S Absorber

T-3602

H₂S Stripper

T-3603

CO₂ Absorber

T-3604

CO₂ Stripper

DRUMS

D-3601

H₂S Absorber K.O. Drum

D-3603

H₂S High Pressure Flash Drum

TABLE 360-4

FOSTER WHEELER ENERGY CORP.

PROCESS PLANTS DIVISION

CONTRACT:

SECTION: 360

EQUIPMENT LIST

NAME OF UNIT

Gas Treating

PAGE 2 OF 7

CLIENT: MLGW/DOE			REVISION		ORIGINAL	1	2	3	4	5
LOCATION: Memphis, Tennessee			DATE		5-30-79	6-21-79	7-10-79			
CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.					REV
DRUMS	D-3604	H ₂ S Medium Pressure Flash Drum								
	D-3605	Stripper Reflux Drum								
	D-3606	H ₂ S Low Pressure Flash Drum								1
	D-3607	H ₂ S Lean Solution Pressure Break Drum								1

TABLE 360-4 (cont.)

CONTRACT:

EQUIPMENT LIST

Gas Treating

PAGE 3 OF 7

REVISION

ORIGINAL

1

2

3

4

5

DATE _____

5-30-79

6-21-79

7-10-79

CLASS

ITEM NO.

DESCRIPTION

EFD

REQ'N. NO.

P. O. NO.

REV

EXCHANGERS

E-3601

Feed Product Exchanger

E-3602

Recycle Product Exchanger

1

E-3603

H₂S Stripper Condenser

1

E-3604

H₂S Stripper Reboiler

1

E-3605

H₂S High Pressure Flash Preheater

E-3606

H₂S Medium Pressure Flash Preheater

E-3607

H₂S Stripper Feed Preheater

E-3608

N ₂ Blower Cooler

2

E-3609

CO₂ Lean Solution Cooler

1

PROCESS PLANTS DIVISION

SECTION: 360

NAME OF UNIT

Gas Treating

PAGE 4 OF 7

CLIENT: MLGW/DOE

REVISION

ORIGINAL

1

2

3

4

5

LOCATION: Memphis, Tennessee

DATE _____

5-30-79

6-21-79

7-10-79

CLASS

ITEM NO.

DESCRIPTION

EFD

REQ'N. NO

P. O. NO.

REV

PUMPS

P-3601A	H ₂ S Rich Solution Pump
---------	-------------------------------------

P-3601B	Spare for P-3601A
---------	-------------------

P-3602A	H ₂ S Low Pressure Lean Solution Pump
---------	--

P-3602B	Spare for P-3602A
---------	-------------------

P-3603A	H ₂ S Stripper Reflux Pump
---------	---------------------------------------

P-3603B	Spare for P-3603A
---------	-------------------

P-3604A	CO ₂ Lean Solution Pump
---------	------------------------------------

P-3604B	Spare for P-3604A
---------	-------------------

TABLE 360-4 (cont.)

CONTRACT:

EQUIPMENT LIST

PAGE 5 OF 7

Gas Treating

REVISION

ORIGINAL

1

2

3

4

9

DATE _____

5-30-79

6-21-79

7-10-79

ITEM NO.

DESCRIPTION

EFD

REQ'N. NO.

P. O. NO.

REV

PUMPS

P-3605A

Solvent Sump Pump

P-3605B

Spare for P-3605A

P-3606A

H₂S Lean Solution High Pressure
. Pump

P-3606B

Spare for P-3606A

TABLE 360-4 (cont.)

FOSTER WHEELER ENERGY CORP.
 PROCESS PLANTS DIVISION

CONTRACT:

SECTION: 360

EQUIPMENT LIST

NAME OF UNIT

Gas Treating

PAGE 6 OF 7

CLIENT: MLGW/DOE			REVISION		ORIGINAL	1	2	3	4	5
LOCATION: Memphis, Tennessee			DATE		5-30-79	6-21-79	7-10-79			
CLASS	ITEM NO	DESCRIPTION	LED	REVISION NO	P. O. NO.					HLV
COMPRESSORS	C-3601	Nitrogen Blower								2
FILTERS	F-3601	H ₂ S Lean Solution Filter								
	F-3602	CO ₂ Lean Solution Filter								

TABLE 360-4 (cont.)

FOSTER WHEELER ENERGY CORP.

PROCESS PLANTS DIVISION

CONTRACT:

SECTION: 360

EQUIPMENT LIST

NAME OF UNIT

Gas Treating

PAGE 7 OF 7

CLIENT: MLGW/DOE			REVISION		ORIGINAL	1	2	3	4	5
LOCATION: Memphis, Tennessee			DATE		5-30-79	6-21-79	7-10-79			
CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.					REV.
TANKS										2
MISCELLANEOUS	TK-3601	Solvent Sump								2
	A-3601	Solvent Refrigeration Unit								
	A-3602	IFG Odorization Package								2

TABLE 360-4 (cont.)

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III- DEMONSTRATION PLANT OPERATIONS

12.7 SOUR WATER STRIPPING (Section 370)

12.7.1 Reference Material

- Process Flow Sheets: FWEC Dwg. No. 2202-1-50-37101
- Stream Data: Table 370-1
- Heat & Material Balance: Table 370-2
- Utilities, Chemicals and Catalysts: Table 370-3
- Equipment List Table 370-4

12.7.2 Description of Flow

In this section sour condensate generated within the process is treated for the removal of H_2S and NH_3 .

The two distinct forms of sour water generated -- one being a 6% slurry and the other solids free process condensate -- required special design considerations. Since a trayed tower would plug if used to strip slurry, a baffled tower is used instead. Since the concentration of absorbed H_2S and NH_3 is relatively low for the slurry case, the low stripping efficiency of baffled towers was not a problem. A trayed tower of conventional design is used for the solids free sour process condensate.

Slurry water reporting from Gas Cooling and Scrubbing (Section 340) is stripped of H_2S and NH_3 by means of live steam within Slurry Water Stripper (T-3701). Stripped slurry water exiting the Slurry Water Stripper at a temperature of 271°F is cooled to 95°F by means of Slurry Sour Water Exchanger (E-3706) and Slurry Water Cooler (E-3701) after which it passes to the clarifier in the Gas Cooling and Scrubbing (Section 340). Overhead stripping steam from the Slurry Water Stripper is introduced at an intermediate feed point to Sour Water Stripper (T-3702). This double use of live-stripping steam provides for an economical use of overall stripping steam.

Sour condensate from Gas Treating (Section 360), Gas Compression (Section 350), Sulfur Recovery (Section 380) and Flare (Section 460) is stripped of H_2S and NH_3 within Sour Water Stripper (T-3702) by means of overhead steam from the Slurry Water Stripper and internally generated steam from Stripper Reboiler (F-3704).

**MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM**

**TASK III- DEMONSTRATION PLANT
OPERATIONS**

The Sour Water Stripper overhead vapors are cooled and partially condensed to a temperature of 220°F in Stripper Overhead Condenser (E-3705). The vapor portion of the flow being separated from the condensate flows to Sulfur Recovery (Section 380) and the condensate is returned to the Sour Water Stripper as reflux.

Stripped water pumped from the bottom of the Sour Water Stripper by means of Stripper Water Pump (P-3701) is cooled from a temperature of 268°F to 95°F in the Sour Water Preheater (E-3702) and Stripped Water Cooler (3-3703).

The cooled stripped water is sent to Waste Water Treatment (Section 440).

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOE

LOCATION: MEMPHIS, TENNESSEE

SECTION NAME: SOUR WATER STRIPPING

REF. DWG.: 2202-1-50-37101

CONTRACT NO.: REV.: 0

ET-77-C-01-2582

SECTION NO.: 370

PAGE NO.: 1 of 4

DATE: July 10, 1979

STREAM NUMBER	3701		3702		3703	
STREAM DESCRIPTION	SLURRY WATER		STRIPPING STEAM		STRIPPED SLURRY WATER	
COMPONENTS (MW)	MOL/HR	LB/HR	MOL/HR	LB / HR	MOL/HR	LB/HR
HYDROGEN 2.016						
CARBON MONOXIDE 28.011						
NITROGEN 28.016						
OXYGEN 32.000						
CARBON DIOXIDE 44.011	1.6	70				
HYDROGEN SULFIDE 34.082	0.2	7				
SULFUR DIOXIDE 64.066						
CARBONYL SULFIDE 60.077						
CARBON DISULFIDE 76.143						
METHANE 16.043						
SULFUR 32.066						
AMMONIA 17.032	1.0	17				
TOTAL DRY	2.8	94				
WATER 18.016	5889.5	106106	1320.0	23781	6440.3	116029
TOTAL WET	5892.3	106200	1320.0	23781	6440.3	116029
COAL (MAF)		5341				5341
C 12.011		5187				5187
H 1.008		22				22
O 16.000		-				-
N 14.008		44				44
S 32.066		88				88
ASH		1483				1483
SELEXOL						
TOTAL STREAM	5892.3	113024	1320.0	23781	6440.3	122853

TABLE 370-1

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MI.GW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: SOUR WATER STRIPPINGREF. DWG.: 2202-1-50-37101CONTRACT NO.: ET-77-C-01-2582REV.: 0SECTION NO.: 370PAGE NO.: 2 of 4DATE: July 10, 1979

STREAM NUMBER		3704		3705		3706	
STREAM DESCRIPTION		T-3701 EFFLUENT		SOUR COND. FROM SEC 350		T-3702 REFLUX	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016						
CARBON MONOXIDE	28.011						
NITROGEN	28.016						
OXYGEN	32.000						
CARBON DIOXIDE	44.011	1.6	70	7.5	330	42.4	1866
HYDROGEN SULFIDE	34.082	0.2	7	0.7	24	9.3	31.7
SULFUR DIOXIDE	64.066						
CARBONYL SULFIDE	60.077						
CARBON DISULFIDE	76.143						
METHANE	16.043						
SULFUR	32.066						
AMMONIA	17.032	1.0	17	5.6	95	118.3	2015
TOTAL DRY		2.8	94	13.8	449	170.0	4198
WATER	18.016	769.2	13858	4534.2	81688	1688.5	30420
TOTAL WET		772.0	13952	4548.0	82137	1858.5	34618
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SEL EXOT.							
TOTAL STREAM		772.0	13952	4548.0	82137	1858.5	34618

TABLE 370-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: M/GW/DOE

LOCATION: MEMPHIS, TENNESSEE

SECTION NAME: SOUR WATER STRIPPING

REF. DWG.: 2202-1-50-37101

CONTRACT NO.: REV.: 0

ET-77-C-01-2582

SECTION NO.: 370

PAGE NO.: 3 of 4

DATE: July 10, 1979

STREAM NUMBER		3707		3708		3709	
STREAM DESCRIPTION		T-3702 EFFLUENT		SWS GAS TO SEC 380		STRIPPED WATER TO SEC. 460	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016						
CARBON MONOXIDE	28.011						
NITROGEN	28.016						
OXYGEN	32.000						
CARBON DIOXIDE	44.011	51.9	2284	9.5	418		
HYDROGEN SULFIDE	34.082	10.3	351	1.0	34		
SULFUR DIOXIDE	64.066						
CARBONYL SULFIDE	60.077						
CARBON DISULFIDE	76.143						
METHANE	16.043						
SULFUR	32.066						
AMMONIA	17.032	124.9	2127	6.6	112		
TOTAL DRY		187.1	4762	17.1	564		
WATER	18.016	1702.2	30667	13.7	247	5369.8	96742
TOTAL WET		1889.3	35429	30.8	811	5369.8	96742
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SELEXOL							
TOTAL STREAM		1889.3	35429	30.8	811	5369.8	96742

TABLE 370-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOE

LOCATION: MEMPHIS, TENNESSEE

SECTION NAME: SOUR WATER STRIPPING

REF. DWG.: 2202-1-50-37101

CONTRACT NO.: REV.: 0

SECTION NO.: 370

PAGE NO.: 4 of 4

DATE: July 10, 1979

ET-77-C-01-2582

STREAM NUMBER		3710		3711		3712	
STREAM DESCRIPTION		BLOWDOWN FROM SEC. 380		SOUR COND. FROM SEC. 360		DIRTY COND. FROM SEC. 460	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016						
CARBON MONOXIDE	28.011						
NITROGEN	28.016						
OXYGEN	32.000						
CARBON DIOXIDE	44.011			0.4	18		
HYDROGEN SULFIDE	34.082			0.1	3		
SULFUR DIOXIDE	64.066						
CARBONYL SULFIDE	60.077						
CARBON DISULFIDE	76.143						
METHANE	16.043						
SULFUR	32.066						
AMMONIA	17.032						
TOTAL DRY				0.5	21		
WATER	18.016			80.1	1443		
TOTAL WET				80.6	1464		
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SELEXOL							
TOTAL STRFAM		No Normal Flow		80.6	1464	No Normal Flow	

TABLE 370-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

PROGRAM P1110
HEAT AND MATERIAL BALANCE15-2202
DATE 08/09/79MLGW/DOE IFG DEMO PLANT, NORMAL OPERATION (3 GASIFIERS OPERATING)
SOUR WATER STRIPPING MATERIAL AND HEAT BALANCES (SECTION 370)

INPUT DESCRIPTION	FLOW RATE LB/HR	TEMP. DEG F	HEATING VALUE	MILLION BTU/HR SENSIBLE +LATENT	TOTAL HEAT
ACID GAS IN SLURRY WATER	106200.	180.0	0.21	10.93	11.15
FINES IN SLURRY WATER	6824.	180.0	76.50	0.14	76.64
STRIPPING STEAM	23781.	328.0		27.16	27.16
SOUR CONDENSATE FROM SEC 350	82137.	110.0	1.09	2.62	3.71
SOUR CONDENSATE FROM SEC 360	1464.	62.0	0.02	-0.02	-0.00
E-3704 STRIPPER REBOILER					21.69
P-3701 STRIPPED WATER PUMP KW USAGE					0.08
P-3702 STRIPPER REFLUX PUMP KW					0.02
TOTAL INPUT	220406.		77.82	40.83	140.44

NOTE: ENTHALPIES AT BASE TEMPERATURE OF 77. DEG F.
HEATING VALUES GIVEN ON GROSS BASIS.

TABLE 370-2

FOSTER WHEELER ENERGY CORPORATION

PROGRAM P1110
HEAT AND MATERIAL BALANCE15-2202
DATE 08/09/79MLGW/DOE IFG DEMO PLANT, NORMAL OPERATION (3 GASIFIERS OPERATING)
SOUR WATER STRIPPING MATERIAL AND HEAT BALANCES (SECTION 370)

OUTPUT DESCRIPTION	FLOW RATE LB/HR	TEMP. DEG F	HEATING VALUE	MILLION BTU/HR SENSIBLE +LATENT	TOTAL HEAT
H2O IN STRIPPED SLURRY WATER	116029.	95.0		2.09	2.09
FINES IN STRIPPED SLURRY WATER	6824.	95.0	76.50	0.02	76.52
STRIPPED WATER TO SEC 440	96742.	95.0		1.76	1.76
SOUR WATER STRIPPER GAS	811.	220.0	1.32	0.29	1.62
E-3701 SLURRY WATER COOLER					16.24
E-3703 STRIPPED WATER COOLER					9.30
E-3705 STRIPPER OVHD CONDENSER					32.07
HEAT LOSS					0.84
TOTAL OUTPUT	220406.		77.82	4.16	140.44

NOTE: ENTHALPIES AT BASE TEMPERATURE OF 77. DEG F.
HEATING VALUES GIVEN ON GROSS BASIS.

TABLE 370-2 (cont.)

MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM

TASK III - DEMONSTRATION PLANT
OPERATIONS

TABLE 370-3

UTILITIES, CHEMICALS AND CATALYSTS

	<u>Normal</u>
<u>Steam</u> , LP (85 psig, sat'd.) Consumed	48,175 lbs/hr
<u>Condensate</u> , LP (50 psig) Produced	24,392 lbs/hr
<u>Cooling Water</u>	2,127 GPM
<u>Power</u> Consumed	72.3 Kilowatts

FOSTER WHEELER ENERGY CORP.
PROCESS PLANTS DIVISION

CONTRACT:

SECTION: 370

EQUIPMENT LIST

NAME OF UNIT

SOUR WATER STRIPPING

PAGE 1 OF 1

CLIENT: MLGW		REVISION		ORIGINAL		SOUR WATER STRIPPING					
LOCATION: MEMPHIS, TENNESSEE		DATE		5/1/79		1	2	3	4	5	
CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.						REV.
<u>DRUMS</u>	D-3701	Stripper Reflux Drum									
<u>EXCHANGERS</u>	E-3701	Slurry Water Cooler									
	E-3702	Sour Water Preheater									
	E-3703	Stripped Water Cooler									
	E-3704	Stripper Reboiler									
	E-3705	Stripper Overhead Condenser									
	E-3706	Slurry-Sour Water Exchanger									
<u>PUMPS</u>	P-3701A	Stripped Water Pump									
	P-3701B	Spare For P-3701A									
	P-3702A	Stripper Reflux Pump									
	P-3702B	Spare For P-3702A									
<u>TOWERS</u>	T-3701	Slurry Water Stripper									
	T-3702	Sour Water Stripper									

PARIS 370-4

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III- DEMONSTRATION PLANT OPERATIONS

12.8 SULFUR RECOVERY (Section 380)

12.8.1 Reference Material

- Process Flowsheet: FWEC Dwg. No. 2202-1-50-38101
- Stream Data: Table 380-1 (3 pages)
- Heat and Material Balance: Table 380-2 (2 pages)
- Utilities, Chemicals and Catalysts: Table 380-3 (1 page)
- Equipment List: Table 380-4 (4 pages)

12.8.2 Description of Flow

This section consists of a Claus type sulfur recovery unit employing a thermal reaction step with a sulfur dioxide generation by oxidation of hydrogen sulfide followed by three stages of catalytic reaction in order to effect an overall sulfur recovery in excess of 96% based on the incoming gas feeds.

Prior to the reaction steps, acid gas from Gas Treating (Section 360) is preheated to 450°F in the Acid Gas Preheater (E-3809) using high pressure steam. In addition, stoichiometric air is preheated to 460°F in the Process Air Preheater (E-3810) using high pressure steam. The preheated acid gas is split such that 60% of the total incoming stream is passed to the Muffle Furnace (H-3802) and 40% is bypassed to the First Reactor (R-3801). The portion of acid gas passed to the Muffle Furnace is further split such that part of the gas is fed to the Muffle Furnace Burner and the remainder is fed to the second zone of the furnace. The acid gas fed to the burner is mixed with the sour water stripper gas from the Sour Water Stripper (Section 370) upstream of the burner.

The acid gas is partially combusted in the first zone of the Muffle Furnace where SO_2 is generated. The bypassed acid gas is added to the second zone of the furnace. The Claus reaction will proceed in the Muffle Furnace with the formation of sulfur vapors. (Bypassing of 33% of the furnace acid gas feed to the second zone allows the first zone combustion of acid gas and sour gas to take place at a temperature of 2400°F and will thus assist in the destruction of the ammonia contained in the sour water stripper gas.)

The hot acid gas exits the Muffle Furnace and is cooled to a temperature of 500°F in the Waste Heat Boiler (E-3801) through generation of 120 psig steam. The acid gas is then further cooled in the First Sulfur Condenser (E-3802) to a temperature of 350°F where sulfur is condensed and flows by gravity through a sulfur seal to the Sulfur Rundown Pit (TK-3802).

**MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM**

**TASK III- DEMONSTRATION PLANT
OPERATIONS**

The acid gas from the first condenser is reheated in the First Reactor Feed Heater (E-3806) above its sulfur dew point and then combined with the portion of the Gas Treating Section acid gas feed which is bypassed around the Muffle Furnace. The combined acid gas stream is then fed to the First Reactor where the Claus reaction proceeds. The First Reactor effluent is cooled in the Second Sulfur Condenser (E-3803) and the condensed sulfur flows by gravity through its seal leg. to the Sulfur Rundown Pit.

The acid gas from the Second Sulfur Condenser is reheated in the Second Reactor Feed Heater (E-3807) above its sulfur dew point and sent to the Second Reactor (R-3802). The sulfur formed in the Second Reactor is condensed from the acid gas in the Third Sulfur Condenser (E-3804) and flows by gravity to the Sulfur Rundown Pit. The acid gas is then reheated in the third Reactor Feed Heater (E-3808) above its sulfur dew point and sent to the Third Reactor (R-3801). The sulfur formed in the Third Reactor is condensed from the acid gas in the Final Sulfur Condenser (E-3805) and flows to the Sulfur Rundown Pit.

The tail gas exiting the Final Sulfur Condenser flows to Tail Gas Treating (Section 390) at a temperature of 280°F and a pressure of 3.0 psig for final cleanup.

The acid gas cooling in the First, Second and Third Sulfur Condensers is achieved through generation of 50 psig steam. In the Final Sulfur Condenser, cooling is achieved through preheating boiler feed water. Boiler feed water is preheated prior to entry to the Final Sulfur Condenser to avoid possible sulfur solidification. Sulfur from the Sulfur Rundown Pit, which has a capacity of two days production, is transferred by the Sulfur Transfer Pump (P-3801A/B) to the Liquid Sulfur Storage Tank (TK-3803). This storage tank has a fifteen day capacity based on the design sulfur production rate. The product liquid sulfur is loaded into tank trucks using the Sulfur Loading Pump (P-3802A/B).

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: SULFUR RECOVERYREF. DWG.: 2202-1-50-38101CONTRACT NO.: REV.: 0SECTION NO.: 380PAGE NO.: 1 of 3DATE: June 26, 1979

STREAM NUMBER		3801		3802		3803	
STREAM DESCRIPTION		ACID GAS FROM GAS TREATING		SOUR WATER STRIPPER GAS		AIR TO CALUS PLANT	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016	0.1	-				
CARBON MONOXIDE	28.011	0.2	6				
NITROGEN	28.016					499.5	13,994
OXYGEN	32.000					132.4	4,237
CARBON DIOXIDE	44.011	596.1	26,235	9.5	418		
HYDROGEN SULFIDE	34.082	250.2	8,527	1.0	34		
SULFUR DIOXIDE	64.066						
CARBONYL SULFIDE	60.077	9.7	583				
CARBON DISULFIDE	76.143						
METHANE	16.043	0.3	5				
SULFUR	32.066						
AMMONIA	17.032	0.1	2	6.6	112		
TOTAL DRY		856.7	35,358	17.1	564	631.9	18,231
WATER	18.016	42.6	767	13.7	247	19.5	351
TOTAL WET		899.3	36,125	30.8	811	651.4	18,582
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SELEXOL							
TOTAL STREAM			36,125		811		18,582

TABLE 380-1

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: SULFUR RECOVERYREF. DWG.: 2202-1-50-38101CONTRACT NO.: REV.: 0SECTION NO.: 380PAGE NO.: 2 of 3DATE: June 26, 1979

STREAM NUMBER	3804		3805		3806	
STREAM DESCRIPTION	CLAUS TAIL GAS		BEAVON UNIT LIQUID SULFUR		BLOWDOWN TO GAS TREATING	
COMPONENTS (MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN 2.016	1.8	4				
CARBON MONOXIDE 28.011	4.2	118				
NITROGEN 28.016	502.8	14,086				
OXYGEN 32.000						
CARBON DIOXIDE 44.011	610.6	26,873				
HYDROGEN SULFIDE 34.082	3.7	126				
SULFUR DIOXIDE 64.066	1.9	122				
CARBONYL SULFIDE 60.077	0.7	42				
CARBON DISULFIDE 76.143	0.3	23				
METHANE 16.043	0.1	2				
SULFUR 32.066	2.1	67	8.9	285		
AMMONIA 17.032	0.0	-				
TOTAL DRY	1,128.2	41,463	8.9	285		
WATER 18.016	332.0	5,981				
TOTAL WET	1,460.2	47,444	8.9	285	N.N.F.	N.N.F.
COAL (MAF)						
C 12.011						
H 1.008						
O 16.000						
N 14.008						
S 32.066						
ASH						
SEL EXOI.						
TOTAL STREAM		47,444		285		N.N.F.

TABLE 380-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: SULFUR RECOVERYREF. DWG.: 2202-1-50-38101CONTRACT NO.: 0SECTION NO.: 380PAGE NO.: 3 of 3DATE: June 26, 1979

STREAM NUMBER		3807		3808		3809	
STREAM DESCRIPTION		BLOWDOWN SWS		TOTAL LIQUID SULFUR PRODUCT		ACID GAS TO INCINERATOR	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB / HR	MOL/HR	LB/HR
HYDROGEN	2.016						
CARBON MONOXIDE	28.011						
NITROGEN	28.016						
OXYGEN	32.000						
CARBON DIOXIDE	44.011						
HYDROGEN SULFIDE	34.082						
SULFUR DIOXIDE	64.066						
CARBONYL SULFIDE	60.077						
CARBON DISULFIDE	76.143						
METHANE	16.043						
SULFUR	32.066			260.9	8364		
AMMONIA	17.032						
TOTAL DRY				260.9	8364		
WATER	18.016						
TOTAL WET		N.N.F.	N.N.F.	260.9	8364	N.N.F.	N.N.F.
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SELEXOL							
TOTAL STREAM			N.N.F.		8364		N.N.F.

TABLE 380-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

PROGRAM P1110
HEAT AND MATERIAL BALANCE15-2202
DATE 08/09/79MLGW/DOE IFG DEMO PLANT, NORMAL OPERATION (3 GASIFIERS OPERATING)
SULFUR RECOVERY HEAT AND MATERIAL BALANCE (SECTION 380)

INPUT DESCRIPTION	FLOW RATE LB/HR	TEMP. DEG F	+ - - - MILLION BTU/HR - - - +		
			HEATING VALUE	SENSIBLE +LATENT	TOTAL HEAT
ACID GAS FROM SECTION 360	36124.	110.0	63.02	1.04	64.06
SWS GAS FROM SECTION 370	811.	220.0	1.33	0.29	1.62
PROCESS AIR	18581.	95.0		0.44	0.44
FIRST REACTOR FEED HEATER					0.74
SECOND REACTOR FEED HEATER					1.07
THIRD REACTOR FEED HEATER					0.71
ACID GAS PREHEATER					2.89
PROCESS AIR PREHEATER					0.90
BOILER FEED WATER PREHEAT					0.68
PROCESS AIR BLOWER KW					0.84
TOTAL INPUT			55516.	64.35	73.95

NOTE: ENTHALPIES AT BASE TEMPERATURE OF 77. DEG F.
HEATING VALUES GIVEN ON GROSS BASIS.

TABLE 380-2

FOSTER WHEELER ENERGY CORPORATION

PROGRAM P1110
HEAT AND MATERIAL BALANCE15-2202
DATE 08/09/79MLGW/DOE IFG DEMO PLANT, NORMAL OPERATION (3 GASIFIERS OPERATING)
SULFUR RECOVERY HEAT AND MATERIAL BALANCE (SECTION 380)

OUTPUT DESCRIPTION	FLOW RATE LB/HR	TEMP. DEG F	+ - - - MILLION BTU/HR - - - +		
			HEATING VALUE	SENSIBLE +LATENT	TOTAL HEAT
CLAUS UNIT TAIL GAS	47370.	280.0	1.97	8.69	10.66
SULFUR IN TAIL GAS	67.	280.0	0.27	0.00	0.27
LIQUID SULFUR PRODUCT	8079.	290.0	32.29	0.41	32.71
WASTE HEAT EXCHANGER					19.65
1ST, 2ND AND 3RD SULFUR CONDENSERS					8.43
FINAL SULFUR CONDENSER					1.38
HEAT LOSS					0.85

TOTAL OUTPUT	55516.		34.54	9.10	73.95

NOTE: ENTHALPIES AT BASE TEMPERATURE OF 77. DEG F.
HEATING VALUES GIVEN ON GROSS BASIS.

TABLE 380-2 (cont.)

MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM

TASK III- DEMONSTRATION PLANT
OPERATIONS

TABLE 380-3

UTILITIES, CHEMICALS AND CATALYSTS

	<u>Normal</u>
<u>Steam</u> , HP (900 psig, 840°F) Consumed	9,530 lbs/hr
<u>Steam</u> , LP (85 psig, sat'd.) Produced	22,900 lbs/hr
<u>Steam</u> , LP (50 psig, sat'd.) Produced	8,600 lbs/hr
<u>Condensate</u> , LP (85 psig) Produced	6,940 lbs/hr
<u>Condensate</u> , LP (50 psig) Produced	550 lbs/hr
<u>Boiler Feed Water</u> Consumed	30,970 lbs/hr
<u>Blowdown</u> Produced	1,510 lbs/hr
<u>Power</u> Consumed	250 Kilowatts
<u>Catalysts</u> Rhone Progil Type CR Catalyst Consumed	125 lbs/day

PROCESS PLANTS DIVISION

SECTION: 380

NAME OF UNIT

PAGE 3 OF 4

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REVISION

ORIGINAL

SULFUR RECOVERY UNIT

1

2

3

4

5

LOCATION: MEMPHIS, TENNESSEE

DATE _____

5/1/79

6/26/79

TABLE 380-4 (cont.)

CONTRACT: _____
SECTION: 380

NAME OF UNIT

SULFUR RECOVERY UNIT

PAGE 4 OF 4

REVISION	ORIGINAL
----------	----------

DATE	5/1/79
------	--------

1	2	3	4	5
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[illegible]

TABLE 380-4 (cont.)

12.9 TAIL GAS TREATING (Section 390)

12.9.1 Reference Material

- Process Flow Diagram: FWEC Dwg. No. 2202-1-50-39101
- Stream Data: Table 390-1
- Heat and Material Balance: Table 390-2
- Utilities, Chemicals and Catalysts: Table 390-3
- Equipment List: Table 390-4

12.9.2 Description of Flow

The tail gas from the Claus sulfur recovery unit is treated to remove essentially all of the remaining sulfur compounds before discharge to the atmosphere.

The Tail Gas Treating section consists of a hydrogenation/hydrolysis section followed by a Stretford absorber section and Stretford solution oxidizer/sulfur recovery section.

In the hydrogenation/hydrolysis section the sulfur recovery unit tail gas is preheated to the desired hydrogenation and hydrolysis reaction temperatures. Additional reducing gas (H_2 and CO from sub-stoichiometric combustion) is added to ensure SO_2 and free sulfur hydrogenation. The tail gas is heated by mixing with the hot products of combustion of the fuel gas. The combined stream is fed to the hydrogenation reactor where the sulfur compounds are converted to hydrogen sulfide.

In the Stretford absorber section the hot hydrogenation reactor effluent is first cooled in a waste heat exchanger and subsequently by a direct contact condenser tower. The cooled tail gas enters the Stretford absorber for countercurrent contact with lean Stretford solution. The hydrogen sulfide is oxidized in an aqueous solution to elemental sulfur. The treated tail gas which is discharged to the atmosphere from the top of the absorber is odor free and contains less than 10 ppmv of hydrogen sulfide.

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III - DEMONSTRATION PLANT OPERATIONS

In the Stretford solution oxidizer/sulfur recovery section, the sulfur laden Stretford solution is oxidized by air blowing and regenerated to its original state. The regenerated Stretford solution is cooled prior to being returned to the Stretford absorber. The froth containing elemental sulfur, is floated off the Stretford solution oxidizer and collected. The sulfur slurry is heated to melt the sulfur. The hot solution and molten sulfur enters the sulfur decanter where the sulfur is separated from the solution. The decanted sulfur is returned to the sulfur rundown pit in the Sulfur Recovery (Section 380) and the solution is recycled to the cooling tower basin.

In the Stretford solution, some of the hydrogen sulfide undergoes side reactions and is converted to sodium thiosulfate and sodium sulfate. Eventually the buildup of these solids will require the solution to be purged. Purge Accumulation Tank (TK-3901) is provided to accumulate this purge. The purge will be carted away for disposal.

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: TAIL GAS TREATINGREF. DWG.: 2202-1-50-39101CONTRACT NO.: ET-77-C-01-2582SECTION NO.: 390PAGE NO.: 2 of 5DATE: July 18, 1979

STREAM NUMBER		3904		3905		3906	
STREAM DESCRIPTION		MAKEUP WATER		BEAVON UNIT LIQUID SULFUR		VENT GAS FROM BEAVON	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016					5.5	11
CARBON MONOXIDE	28.011					0.6	17
NITROGEN	28.016					627.7	17586
OXYGEN	32.000						
CARBON DIOXIDE	44.011					655.8	28862
HYDROGEN SULFIDE	34.082						
SULFUR DIOXIDE	64.066						
CARBONYL SULFIDE	60.077					0.0	2
CARBON DISULFIDE	76.143						
METHANE	16.043						
SULFUR	32.066			8.9	285		
AMMONIA	17.032						
TOTAL DRY				8.9	285	1289.6	46478
WATER	18.016	138.8	2500			75.8	1366
TOTAL WET		138.8	2500	8.9	285	1365.4	47844
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SELEXOL							
TOTAL STREAM			2500		285		47844

TABLE 390-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: TAIL GAS TREATINGREF. DWG.: 2202-1-50-39101CONTRACT NO.: ET-77-C-01-2582SECTION NO.: 390PAGE NO.: 2 of 5DATE: July 18, 1979

STREAM NUMBER		3904		3905		3906	
STREAM DESCRIPTION		MAKEUP WATER		BEAVON UNIT LIQUID SULFUR		VENT GAS FROM BEAVON	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016					5.5	11
CARBON MONOXIDE	28.011					0.6	17
NITROGEN	28.016					627.7	17586
OXYGEN	32.000						
CARBON DIOXIDE	44.011					655.8	28862
HYDROGEN SULFIDE	34.082						
SULFUR DIOXIDE	64.066						
CARBONYL SULFIDE	60.077					0.0	2
CARBON DISULFIDE	76.143						
METHANE	16.043						
SULFUR	32.066			8.9	285		
AMMONIA	17.032						
TOTAL DRY				8.9	285	1289.6	46478
WATER	18.016	138.8	2500			75.8	1366
TOTAL WET		138.8	2500	8.9	285	1365.4	47844
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SEIEXOL							
TOTAL STREAM			2500		285		47844

TABLE 390-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: TAIL GAS TREATINGREF. DWG.: 2202-1-50-39101CONTRACT NO.: REV.: 1SECTION NO.: 390PAGE NO.: 3 of 5DATE: July 18, 1979

ET-77-C-01-2582

STREAM NUMBER	3907		3908		3909	
STREAM DESCRIPTION	WATER EVAPORATED		VENT GAS TO ATMOSPHERE		VENT GAS TO SECTION 440	
COMPONENTS (MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN 2.016			5.5	11		
CARBON MONOXIDE 28.011			0.6	17		
NITROGEN 28.016			627.7	17586	2.6	73
OXYGEN 32.000						
CARBON DIOXIDE 44.011			653.4	28757	2.7	121
HYDROGEN SULFIDE 34.082						
SULFUR DIOXIDE 64.066						
CARBONYL SULFIDE 60.077			0.0	2		
CARBON DISULFIDE 76.143						
METHANE 16.043						
SULFUR 32.066						
AMMONIA 17.032						
TOTAL DRY			1287.2	46373	5.3	194
WATER 18.016	548.2	9877	75.5	1360	0.3	6
TOTAL WET	548.2	9877	1362.7	47733	5.6	200
COAL (MAF)						
C 12.011						
H 1.008						
O 16.000						
N 14.008						
S 32.066						
ASH						
SELEXOL						
TOTAL STREAM		9877		47733		200

TABLE 390-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: M.G.W./DOE

LOCATION: MEMPHIS, TENNESSEE

SECTION NAME: TAIL GAS TREATING

REF. DWG.: 2202-1-50-39101

CONTRACT NO.: REV.: 1

SECTION NO.: 390

PAGE NO.: 4 of 5

DATE: July 18, 1979

ET-77-C-01-2582

STREAM NUMBER		3910		3911		3912	
STREAM DESCRIPTION		VENT GAS FROM SECTION 440		AIR FROM OXIDIZERS		TAIL GAS TO INCINERATOR	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016						
CARBON MONOXIDE	28.011						
NITROGEN	28.016	2.6	73	160.6	4499		
OXYGEN	32.000			38.2	1222		
CARBON DIOXIDE	44.011	0.3	13				
HYDROGEN SULFIDE	34.082						
SULFUR DIOXIDE	64.066						
CARBONYL SULFIDE	60.077						
CARBON DISULFIDE	76.143						
METHANE	16.043						
SULFUR	32.066						
AMMONIA	17.032						
TOTAL DRY		2.9	86	198.8	5721		
WATER	18.016			13.7	247		
TOTAL WET		2.9	86	212.5	5968	N.N.F.	N.N.F.
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SEL EXOI.							
TOTAL STREAM			86		5968		N.N.F.

TABLE 390-1 (cont.)

SECTION NO.: 390

PAGE NO.: 5 of 5

CONTRACT NO.: _____ REV.: _____ 1

DATE: July 18, 1979

ET-77-C-01-2582

STREAM NUMBER		3913		3914		3915	
STREAM DESCRIPTION		STEAM TO SULFUR MELTER		STEAM TO COMBUSTOR BURNER		STRETTFORD SOLUTION PURGE	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB / HR	COMPONENTS	LB/DAY
HYDROGEN	2.016					ADA	6
CARBON MONOXIDE	28.011					VANADIUM	11
NITROGEN	28.016					NaHCO ₃	62
OXYGEN	32.000					Na ₂ S ₂ O ₃	530
CARBON DIOXIDE	44.011					N ₂ SO ₄	238
HYDROGEN SULFIDE	34.082					Water	2525
SULFUR DIOXIDE	64.066						
CARBONYL SULFIDE	60.077						
CARBON DISULFIDE	76.143						
METHANE	16.043						
SULFUR	32.066						
AMMONIA	17.032						
TOTAL DRY							
WATER	18.016	36.1	650	77.0	1387		
TOTAL WET		36.1	650	77.0	1387		
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
SELEXOL							
TOTAL STREAM			650		1387		3372

TABLE 390-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

PROGRAM P1110
HEAT AND MATERIAL BALANCE15-2202
DATE 08/09/79MLGW/DOE IFG DEMO PLANT, NORMAL OPERATION (3 GASIFIERS OPERATING)
TAIL GAS TREATING HEAT AND MATERIAL BALANCE (SECTION 390)

INPUT DESCRIPTION	FLOW RATE LB/HR	TEMP. DEG F	HEATING VALUE	MILLION BTU/HR SENSIBLE +LATENT	TOTAL HEAT
CLAUS UNIT TAIL GAS	47376.	280.0	1.97	8.69	10.66
SULFUR IN TAIL GAS	67.	280.0	0.27	0.00	0.27
TOTAL PROCESS AIR	10600.	95.0		0.25	0.25
FUEL GAS	1390.	100.0	8.56	0.01	8.57
STEAM TO COMBUSTION CHAMBER	1390.	298.0		1.58	1.58
MAKEUP WATER	2500.	65.0		-0.03	-0.03
STEAM TO SULFUR MELTER	650.	327.0		0.74	0.74
AIR TO SOLUTION COOLING TOWER	158685.	95.0		3.66	3.66
TOTAL KW USEAGE					1.71

TOTAL INPUT	222658.		10.80	14.90	27.40

NOTE: ENTHALPIES AT BASE TEMPERATURE OF 77. DEG F.
HEATING VALUES GIVEN ON GROSS BASIS.

TABLE 390-2

FOSTER WHEELER ENERGY CORPORATION

PROGRAM P1110
HEAT AND MATERIAL BALANCE15-2202
DATE 08/09/79MLGW/DOE IFG DEMO PLANT, NORMAL OPERATION (3 GASIFIERS OPERATING)
TAIL GAS TREATING HEAT AND MATERIAL BALANCE (SECTION 390)

OUTPUT DESCRIPTION	FLOW RATE LB/HR	TEMP. DEG F	+ - - - MILLION BTU/HR - - - +		
			HEATING VALUE	SENSIBLE +LATENT	TOTAL HEAT
ABSORBER VENT GAS	47843.	95.0	0.76	1.61	2.37
AIR FROM OXIDIZERS	5969.	100.0		0.29	0.29
LIQUID SULFUR PRODUCT	285.	270.0	1.14	0.01	1.15
AIR FROM SOLUTION COOLING TOWER	168562.	120.0		14.63	14.63
WASTE HEAT EXCHANGER					5.88
DESUPERHEATER COOLER					3.05
HEAT LOSS					0.03

TOTAL OUTPUT	222658.		1.90	16.55	27.40

NOTE: ENTHALPIES AT BASE TEMPERATURE OF 77. DEG F.
HEATING VALUES GIVEN ON GROSS BASIS.

TABLE 390-2 (cont.)

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

Task III- DEMONSTRATION PLANT
OPERATIONS

TABLE 390-3
UTILITIES, CHEMICALS AND CATALYSTS

	<u>Normal</u>
<u>STEAM</u> , LP (85 Psig, Sat'd.) Consumed	650 lbs/hr
<u>STEAM</u> , LP (50 Psig, Sat'd.) (1) Produced (Net)	2,430 lbs/hr
<u>CONDENSATE</u> , LP (50 Psig) (2) Produced	2,120 lbs/hr
<u>BOILER FEED WATER</u> (5) Consumed	8,740 lbs/hr
<u>BLOWDOWN</u> Produced	300 lbs/hr
<u>PRODUCT GAS</u> Consumed	0.2 MMM BTU/day
<u>POWER</u> Consumed	500 Kilowatts
<u>CATALYST</u> N-25 American Cyanamid (or equal) Consumed	19.2 lbs/day

CHEMICAL CONSUMPTION

	<u>Losses (4)</u>	<u>Purge (3)</u>	<u>Total Required (3)</u>
ADA	5.4	5.4	11 lbs/day
Vanadium	4.2	10.8	15 lbs/day
Na ₂ CO ₃	534	39	573 lbs/day

- (1) Summer operating conditions shown. For winter operation there is a net consumption of 11,180 lbs/hr of 50 psig sat'd steam.
- (2) Summer operating condition shown. For winter operation there is a production of 15,730 lbs/hr of L.P. Condensate.
- (3) Purge to begin after approximately 200 days of operation.
- (4) Total required before purge begins.
- (5) Includes 2500 lbs/hr for process makeup water.

FOSTER WHEELER ENERGY CORP.
 PROCESS PLANTS DIVISION

CONTRACT:

SECTION: 390

EQUIPMENT LIST

NAME OF UNIT

TAIL GAS TREATING UNIT

PAGE 1 OF 1

CLIENT: MLGW ET-77-C-01-2582

REVISION

ORIGINAL

1

2

3

4

5

LOCATION: MEMPHIS, TENN.

DATE

6/26/79

7/11/79

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.						REV.
<u>PACKAGE ITEM</u>	A-3901	Beavon Unit Package									
<u>TANKS</u>	TK-3901	Purge Accumulation Tank									1

TABLE 390-4

TASK III- DEMONSTRATION PLANT OPERATIONS

12.10.1 Reference Material

- ### 12.10.2 Description of Flow

A portion of the desulfurized U-Gas from Gas Treating (Section 360) is fed to the Credit Generation system. The Credit Generation system consists of the following process units:

- Gas Compression
- Shift Conversion
- Acid Gas Removal
- Methanation
- Rich Gas Drying and Odorization
- Credit Withdrawing System

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III- DEMONSTRATION PLANT OPERATIONS

12.10.2.1 Gas Compression

Gas from the Gas Treating unit enters the Credit Generation system through the Feed Gas KO Drum (D-2201). Gas from the Feed Gas KO Drum is drawn into the Feed Gas Compressor (C-2201 A/B) where it is compressed to 325 psig. Net flow forward from the compressor is monitored and controlled by the IFG dispatcher. Excess compressor discharge is recycled through the Recycle Cooler (E-2202).

12.10.2.2 Shift Conversion

A portion of the compressed gas is heated by heat exchange with shift reactor effluent in the Shift Reactor Feed Heater (E-2201). Steam required for shift reaction and to satisfy reaction equilibrium is added to the gas stream upstream of the Shift Reactor Feed Heater. The heated gas/steam mixture enters the Shift Reactor (R-2201) where carbon monoxide in the feed gas reacts with steam over a bed of high temperature shift catalyst to form hydrogen and carbon dioxide. This reaction is exothermic. The heat of reaction is carried away by the reactant resulting in an increase in reactant temperature. The reaction effluent is cooled by heat exchange with the feed gas in the Shift Reactor Feed Heater. A Shift Start-Up Heater (H-2201) has been provided to heat up the feed gas during startup. This heater is located upstream of the Shift Reactor. During startup, reactor feed gas from the Shift Reactor Feed Heater is directed to flow through the Shift Start-Up Heater where it is heated before entering the Shift Reactor. Balance of the compressed gas bypasses the Shift Reactor. The amount of gas directed to bypass the Shift Reactor is controlled so that after mixing with the shifted gas the resultant mixture will have a hydrogen to carbon monoxide molar ratio of approximately 3 to 1.

12.10.2.3 Acid Gas Removal

The acid gas removal step employs the proprietary Benfield hot potassium carbonate process to remove mainly CO_2 and a residual quantity of H_2S in the shifted gas. Gas from shift conversion is cooled successively in Condensate Reboiler (E-2234) and Carbonate Regenerator Reboiler (E-2232). Heat given up by the gas stream is used for scrubbing solution regeneration. Condensate separated from the gas stream is combined with excess reflux and cooled in Condensate Cooler (E-2236) before it is forwarded to Waste Water Treatment (Section 440).

The cooled gas is scrubbed by the Benfield solution in CO₂ Absorber (T-2231). The solution, lean in CO₂ content, is introduced to the top of the tower. It flows downward counter-current to the gas flow and arrives at the bottom of the tower rich in CO₂ content. The rich solution from the CO₂ Absorber is expanded across a hydraulic turbine which helps to drive the Carbonate Solution Circulation Pump (P-2233). Rich solution from the hydraulic turbine is regenerated in the Carbonate Solution Regenerator (T-2232) by steam stripping. Regenerated solution is first flashed to generate part of the stripping steam, and then pumped back to the CO₂ Absorber. Steam in the CO₂ vent gas from the solution regenerator is condensed and returned to the solution regenerator. The cooled CO₂ stream from this step containing a trace of sulfur is forwarded to the incinerator for disposal.

Carbonate Solution Sump Tank (TK-2232) and Carbonate Solution Storage Tank (TK-2251) are provided for solution makeup, storage and recovery from drains.

12.10.2.4 Methanation

Scrubbed gas is preheated to 700°F and flows through two beds of zinc oxide catalyst which serve as guard chamber for the removal of final traces of sulfur compounds prior to entering the Methanation Reactors. The methanation step is based upon the CONOCO Methanation Company's proprietary technology. It converts the purified hydrogen and carbon monoxide containing gas stream into high-BTU pipeline quality gas which is essentially equivalent to natural gas. The methanation process is a catalytic fixed-bed, adiabatic, gas-recycle process. A highly active nickel catalyst is used to effect the methanation reactions. Reaction temperatures are controlled by recycling a portion of cooled product gas.

There are three primary methanation reactors. These reactors are connected in a series-parallel arrangement. Fresh feed to the methanation step is split so that portions flow to each reactor. A methane rich gas is circulated through the three primary reactors in series by means of Recycle Gas Compressor (C-2261). The circulating rich gas removes the exothermic reaction heat from the fixed bed reactors. Reactor temperature rises are limited by the judicious control of the circulating rich gas flow rate.

The circulating rich gas is itself cooled in an exchanger by generating steam after each reactor for heat recovery. Bulk of the methanation reaction is completed in these three reactors.

A clean-up methanation reactor is used to effect the balance of the methanation reaction. This reactor operates at a lower temperature than the primary methanation reactors in order to effect the additional reaction.

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III - DEMONSTRATION PLANT OPERATIONS

Methanated gas from the clean-up methanator is cooled and forwarded to the Gas Drying Step.

12.10.2.5 Rich Gas Drying and Odorization

Rich gas is dried in the Rich Gas Drying Package (A-2261) which has been specified as a glycol type drying system. Dried gas is odorized by the Rich Gas Odorization Package (A-2262). The dried and odorized rich gas flows to the MLGW Weaver Station through an existing 16" pipeline and reports to MLGW's natural gas distribution system generating BTU credit for the U-Gas generation facility.

12.10.2.6 Credit Withdrawing System

When the IFG production facility is totally or partially down or when the U-Gas production cannot satisfy its demand, natural gas from MLGW's natural gas supply pipeline will be withdrawn from the pipeline to satisfy the BTU demand of the IFG customers. Natural gas at 1031 BTU/SCF will be adjusted by the addition of dried air to the IFG heating value (300 BTU/SCF). Air from the discharges of one of the two air compressors in the air separation section is further compressed by the Air Booster Compressor (C-2291). The compressed air is cooled in Booster Compressor After Cooler (E-2291) and dried by Air Dryer Package (A-2291). The dried air is mixed with natural gas to achieve the proper heating value. NG/air mixture is forwarded to the IFG pipeline upstream of the IFG odorization package.

INDUSTRIAL FUEL GAS DEMONSTRATION PLANT CONTRACT NO. 17-C-61-3382		PREPARED BY: ENERGY AND HEAVY DIVISION WASHINGTON, D.C.	THIS DRAWING IS THE PROPERTY OF THE UNITED STATES ENERGY COMMISSION AND IS NOT TO BE REPRODUCED OR TRANSMITTED IN ANY FORM OR BY ANY MEANS, ELECTRONIC OR MECHANICAL, INCLUDING PHOTOCOPYING, RECORDING, OR BY ANY INFORMATION STORAGE AND RETRIEVAL SYSTEM, WITHOUT PERMISSION IN WRITING FROM THE UNITED STATES ENERGY COMMISSION.	PROJECT: FLOW LIAISON CREDIT GENERATION SECTION 220	TANK 2 (DEMONSTRATION PLANT)
DRAWING NO. 220-15-2202		DWG NO. 220-15-2202

LEGEND	
	MATERIAL BALANCE STREAM NO.
	TEMPERATURE °F
	PRESSURE PSIG (UNLESS OTHERWISE INDICATED)

INDUSTRIAL FUEL GAS DEMONSTRATION PLANT
CONTRACT NO. IT-77C-01-1582
RESEARCH LABORATORY
AMERICAN PETROLEUM INSTITUTE
WASHINGTON, D.C.

THIS DESIGN IS THE PROPERTY OF THE
FOSTER WHEELER ENERGY CORPORATION
1000 WEST 10TH AVENUE, SUITE 100
DENVER, COLORADO 80202
TELEPHONE (303) 733-1000
FAX (303) 733-1001

PROCESS FLOW DIAGRAM
CHEST GENERATION
CO2 REMOVAL STEP
SECTION 220
DWG NO. 223-1-15-202

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOELOCATION: MEMPHIS, TENNESSEESECTION NAME: CREDIT GENERATIONREF. DWG.: 2202-1-50-22101CONTRACT NO.: 0 REV.: 0

ET-77-C-01-2582

SECTION NO.: 220PAGE NO.: 1 of 4DATE: July 10, 1979

STREAM NUMBER		2201		2210		2231	
STREAM DESCRIPTION		FEED GAS FROM SEC. 360		STEAM TO SHIFT		SHIFTED PRODUCT GAS	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016	759.5	1531			1040.2	2097
CARBON MONOXIDE	28.011	623.4	17462			342.7	9599
NITROGEN	28.016	16.5	462			16.5	462
OXYGEN	32.000	-	-			-	-
CARBON DIOXIDE	14.011	328.1	14440			608.9	26798
HYDROGEN SULFIDE	31.082	-	-			0.1	4
SULFUR DIOXIDE	61.066	-	-			-	-
CARBONYL SULFIDE	60.077	0.1	6			-	-
CARBON DISULFIDE	76.143	-	-			-	-
METHANE	16.043	101.8	1633			101.8	1633
SULFUR	32.066	-	-			-	-
AMMONIA	17.032	-	-			-	-
TOTAL DRY		1829.4	35534			2110.2	40593
WATER	18.016	0.5	9	1009.5	18187	729.2	13137
TOTAL WET		1829.9	35543	1009.5	18187	2839.4	53730
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
TOTAL STREAM		1829.9	35543	1009.5	18187	2839.4	53730

TABLE 220-1

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: M/GW/DOE

LOCATION: MEMPHIS, TENNESSEE

SECTION NAME: CREDIT GENERATION

REF. DWG.: 2202-1-50-22102

CONTRACT NO.: REV.: 0

ET-77-C-01-2582

SECTION NO.: 220

PAGE NO.: 2 of 4

DATE: July 10, 1979

STREAM NUMBER		2232		2243		2249	
STREAM DESCRIPTION		PURIFIED GAS FROM CO ₂ ABSORBER		OFFGAS TO SEC. 430		PROCESS COND. FROM BENFIELD	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB/HR	MOL/HR	LB/HR
HYDROGEN	2.016	1037.3	2091	2.9	6		
CARBON MONOXIDE	28.011	342.1	9582	0.6	17		
NITROGEN	28.016	16.5	462	-	-		
OXYGEN	32.000	-	-	-	-		
CARBON DIOXIDE	44.011	2.7	119	606.2	26679		
HYDROGEN SULFIDE	34.082	-	-	0.1	4		
SULFUR DIOXIDE	64.066	-	-	-	-		
CARBONYL SULFIDE	60.077	-	-	-	-		
CARBON DISULFIDE	76.143	-	-	-	-		
METHANE	16.043	101.6	1630	0.2	3		
SULFUR	32.066	-	-	-	-		
AMMONIA	17.032	-	-	-	-		
TOTAL DRY		1500.2	13884	610.0	26709		
WATER	18.016	16.1	290	223.5	4026	489.6	8821
TOTAL WET		1516.3	14174	833.5	30735	489.6	8821
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
TOTAL STREAM		1516.3	14174	833.5	30735	489.6	8821

TABLE 220-1 (cont.)

FOSTER WHEELER ENERGY CORPORATION

CUSTOMER: MLGW/DOE

LOCATION: MEMPHIS, TENNESSEE

SECTION NAME: CREDIT GENERATION

REF. DWG.: 2202-1-50-22103/22104

CONTRACT NO.: REV.: 0

ET-77-C-01-2582

SECTION NO.: 220

PAGE NO.: 3 of 4

DATE: July 10, 1979

STREAM NUMBER		2270		2278		2279	
STREAM DESCRIPTION		RICH GAS TO RICH GAS DRYING		CONDENSATE FROM METHANATION		PIPELINE GAS	
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB / HR	MOL/HR	LB/HR
HYDROGEN	2.016	11.0	22			11.0	22
CARBON MONOXIDE	28.011	-	-			-	-
NITROGEN	28.016	16.5	462			16.5	462
OXYGEN	32.000	-	-			-	-
CARBON DIOXIDE	44.011	2.7	119			2.7	119
HYDROGEN SULFIDE	34.082	-	-			-	-
SULFUR DIOXIDE	64.066	-	-			-	-
CARBONYL SULFIDE	60.077	-	-			-	-
CARBON DISULFIDE	76.143	-	-			-	-
METHANE	16.043	443.7	7118			443.7	7118
SULFUR	32.066	-	-			-	-
AMMONIA	17.032	-	-			-	-
TOTAL DRY		473.9	7721			473.9	7721
WATER	18.016	1.5	27	356.7	6426	0.16	3
TOTAL WET		475.4	7748	356.7	6426	474.06	7724
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
TOTAL STREAM		475.4	7748	356.7	6426	474.06	7724

TABLE 220-1 (cont.)

SECTION NAME: CREDIT GENERATION

SECTION NO.: 220

REF. DWG.: 2202-1-50-22104

PAGE NO.: 4 of 4

CONTRACT NO.: — — — — — REV.: — — — — — 0

DATE: July 10, 1979

ET-77-C-61-2582

STREAM NUMBER		2280					
STREAM DESCRIPTION		DRYING UNIT VENT					
COMPONENTS	(MW)	MOL/HR	LB/HR	MOL/HR	LB / HR	MOL/HR	LB/HR
HYDROGEN	2.016						
CARBON MONOXIDE	28.011						
NITROGEN	28.016						
OXYGEN	32.000						
CARBON DIOXIDE	44.011						
HYDROGEN SULFIDE	34.082						
SULFUR DIOXIDE	64.066						
CARBONYL SULFIDE	60.077						
CARBON DISULFIDE	76.143						
METHANE	16.043						
SULFUR	32.066						
AMMONIA	17.032						
TOTAL DRY							
WATER	18.016	1.34	24				
TOTAL WET		1.34	24				
COAL (MAF)							
C	12.011						
H	1.008						
O	16.000						
N	14.008						
S	32.066						
ASH							
TOTAL STREAM		1.34	24				

FOSTER WHEELER ENERGY CORPORATION

PROGRAM P1110
HEAT AND MATERIAL BALANCE15-2202
DATE 08/09/79MLGW/DOE IFG DEMO PLANT, NORMAL OPERATION (3 GASIFIERS OPERATING)
CREDIT GENERATION MATERIAL AND HEAT BALANCES (SECTION 220)

INPUT DESCRIPTION	FLOW RATE LB/HR	TEMP. DEG F	+ - - - MILLION BTU/HR - - - +		
			HEATING VALUE	SENSIBLE +LATENT	TOTAL HEAT
FEED GAS TO SEC 220	35543.	100.0	208.30	0.26	208.56
STEAM TO SHIFT	18187.	651.0		22.82	22.82
HEAT INPUT FOR RICH GAS DRYING					0.09
STM TO E-2232 CARB REGN REBOILER					
C-2201 FEED GAS COMPRESSOR BHP					
C-2261 RECYCLE GAS COMPRESSOR BHP					14.95
P-2231 REGN REFLUX PUMP KW USAGE					
P-2232 CARB SOLN PUMP KW USAGE					
P-2233 CARB SOLN CIRC PUMP KW USAGE					
P-2234 COND FEED PUMP KW USAGE					
<hr/>					
TOTAL INPUT	53730.		208.30	23.08	246.42

NOTE: ENTHALPIES AT BASE TEMPERATURE OF 77. DEG F.
HEATING VALUES GIVEN ON GROSS BASIS.

TABLE 220-2

FOSTER WHEELER ENERGY CORPORATION

PROGRAM P1110
HEAT AND MATERIAL BALANCE15-2202
DATE 08/09/79MLGW/DOE IFG DEMO PLANT, NORMAL OPERATION (3 GASIFIERS OPERATING)
CREDIT GENERATION MATERIAL AND HEAT BALANCES (SECTION 220)

OUTPUT			+- - - MILLION	BTU/HR	- - - +
DESCRIPTION	FLOW RATE LB/HR	TEMP. DEG F	HEATING VALUE	SENSIBLE +LATENT	TOTAL HEAT
OFF GAS	30735.	166.0	0.53	4.83	5.36
PROCESS CONDENSATE FROM BENFIELD	8821.	100.0		0.20	0.20
CONDENSATE FROM METHANATION	6426.	100.0		0.15	0.15
DRYING UNIT VENT	24.	300.0		0.03	0.03
PIPELINE GAS	7724.	120.0	171.27	0.11	171.38
HEAT LOSS FROM METHANATION REACTORS	}	(Included in Unit Heat Loss)			
E-2202 RECYCLE COOLER					
E-2231 CARBONATE OVERHEAD CONDENSER					
E-2233 SOLUTION COOLER					
E-2235 CONDENSATE COOLER					68.47
E-2268 RICH GAS COOLER					
E-2269 PROCESS CONDENSATE COOLER					
E-2270 RECYCLE GAS COOLER					
HEAT FOR STEAM FROM D-2263					
HEAT LOSS					0.83
TOTAL OUTPUT	53729.		171.80	5.33	246.42

TABLE 220-2 (cont.)

NOTE: ENTHALPIES AT BASE TEMPERATURE OF 77. DEG F.
HEATING VALUES GIVEN ON GROSS BASIS.

MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM

TASK III- DEMONSTRATION PLANT
OPERATIONS

TABLE 220-3

UTILITIES, CHEMICALS AND CATALYSTS

	<u>Normal</u>
<u>Steam, HP (900 psig, 840°F)</u> Consumed	17,037 lbs/hr
<u>Steam, LP (85 psig, sat'd.)</u> Consumed	12,828 lbs/hr
<u>Steam, LP (85 psig, 339°F)</u> Produced	29,320 lbs/hr
<u>Condensate, LP (85 psig)</u> Produced	12,828 lbs/hr
 <u>Boiler Feed Water, HP</u>	 1,150 lbs/hr
<u>Boiler Feed Water, LP</u>	29,906 lbs/hr
<u>Blowdown</u> Produced	586 lbs/hr
<u>Cooling Water</u>	2,936 GPM
<u>Power</u> Consumed	1,035 Kilowatts
<u>Catalysts</u>	
Methanation Catalyst Consumed	32 lbs/day
United - G-3/C 12-3 (or equal) Consumed	24 lbs/day
United - C7-2 (or equal) Consumed	37 lbs/day
<u>Chemical Consumption</u>	
Potassium Carbonate	120 lbs/day
Diethanolamine	12 lbs/day
Vanadium Pentoxide	5 lbs/day

FOSTER WHEELER ENERGY CORP.
 PROCESS PLANTS DIVISION

CONTRACT:

SECTION: 220

EQUIPMENT LIST

NAME OF UNIT

Credit Generation

PAGE 1 OF 7

CLIENT: MLGW

ET-77-C-01-2582

REVISION

ORIGINAL

1

2

3

4

5

LOCATION: MEMPHIS, TENNESSEE

DATE

6/1/79

7/11/79

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.						REV.
<u>TOWERS</u>											
	T-2231	CO ₂ Absorber									
	T-2232	Carbonate Solution Regenerator									
<u>REACTORS</u>											
	R-2201	Shift Reactor									
	R-2261	First Methanation Reactor									
	R-2262	Second Methanation Reactor									
	R-2263	Third Methanation Reactor									
	R-2264	Fourth Methanation Reactor									
	R-2265A	Zinc Oxide Reactor									1
	R-2265B	Zinc Oxide Reactor									1

TABLE 220-4

PROCESS PLANTS DIVISION

SECTION: 220

NAME OF UNIT

PAGE 2 OF 7

Credit Generation

REVISION

ORIGINAL

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DATE _____

6/1/79

7/11/79

[illegible]

FOSTER WHEELER ENERGY CORP.
 PROCESS PLANTS DIVISION

CONTRACT:

SECTION: 220

EQUIPMENT LIST

NAME OF UNIT

Credit Generation

PAGE 3 OF 7

CLIENT: MLGW ET-77-C-01-2582

REVISION

ORIGINAL

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5

LOCATION: MEMPHIS, TENNESSEE

DATE

6/1/79

7/11/79

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.						REV.
TANKS											
EXCHANGERS	TK-2231	Carbonate Solution Storage Tank									1
	TK-2232	Carbonate Solution Sump Tank									1
	E-2201	Shift Reactor Feed Heater									
	E-2202	Recycle Cooler									1
	E-2231	Carbonate Overhead Condenser									
	E-2232	Carbonate Regenerator Reboiler									
	E-2233	Solution Cooler									
	E-2234	Condensate Reboiler									1
	E-2235	Condensate Cooler									1

TABLE 220-4 (cont.)

FOSTER WHEELER ENERGY CORP.

PROCESS PLANTS DIVISION

CONTRACT:

SECTION: 220

EQUIPMENT LIST

NAME OF UNIT

Credit Generation

PAGE 4 OF 7

CLIENT: MLGW		ET-77-C-01-2582		REVISION	ORIGINAL	1	2	3	4	5
LOCATION: MEMPHIS, TENNESSEE				DATE	6/1/79	7/11/79				
CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.					REV.
	E-2261	First Waste Heat Boiler								1
	E-2262	Second Waste Heat Boiler								1
	E-2263	Recycle Gas Heater								1
	E-2264	Third Waste Heat Boiler								1
	E-2265	Feed-Product Exchanger								1
	E-2266	Fourth Waste Heat Boiler								1
	E-2267	-BFW Heater								1
	E-2268	Rich Gas Cooler								1
	E-2269	Process Condensate Cooler								1
	E-2270	Recycle Gas Cooler								1
<u>HEATERS</u>	E-2291	Booster Compressor Aftercooler								
	H-2201	Shift Start-up Heater								
	H-2261	Methanation Start-up Heater								

TABLE 220-4 (cont.)

FOSTER WHEELER ENERGY CORP.

PROCESS PLANTS DIVISION

CONTRACT:

SECTION: 220

EQUIPMENT LIST

NAME OF UNIT

PAGE 5 OF 7

Credit Generation

CLIENT: MLGW		ET-77-C-01-2582		REVISION		ORIGINAL	1	2	3	4	5
LOCATION: MEMPHIS, TENNESSEE				DATE		6/1/79	7/11/79				
CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.	REV					
<u>EJECTORS</u>	J-2231	First Regenerator Steam Ejector									
	J-2232	Second Regenerator Steam Ejector									
	J-2233	Third Regenerator Steam Ejector									
	J-2234	Fourth Regenerator Steam Ejector									
<u>PUMPS</u>	P-2231A	Regenerator Reflux Pump				1					
	P-2231B	Regenerator Reflux Pump				1					
	P-2232A	Carbonate Solution Pump				1					
	P-2232B	Carbonate Solution Pump				1					
	P-2233A	Carbonate Solution Circulation Pump									
	P-2233B	Carbonate Solution Circulation Pump									
						1					
	P-2234A	Condensate Feed Pump				1					
	P-2234B	Condensate Feed Pump				1					
	P-2235	Carbonate Sump Pump				1					
	P-2236	Carbonate Solution Transfer Pump				1					

TABLE 220-4 (cont.)

FOSTER WHEELER ENERGY CORP.
 PROCESS PLANTS DIVISION

CONTRACT:

SECTION: 220

EQUIPMENT LIST

NAME OF UNIT

PAGE 6 OF 7

Credit Generation

CLIENT:		ET-77-C-01-2582		REVISION	ORIGINAL	1	2	3	4	5
LOCATION:		MEMPHIS, TENNESSEE		DATE	6/1/79	7/11/79				
CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.					REV.
COMPRESSOR	C-2201A	Feed Gas Compressor								
	C-2201B	Feed Gas Compressor								
	C-2261A	Recycle Gas Compressor								1
	C-2261B	Recycle Gas Compressor								1
	C-2291	Air Booster Compressor								
	A-2231	Anti-Foam Injection Package								1
	A-2261	Rich Gas Drying Package								1
	A-2262	Rich Gas Odorization Package								1
PACKAGE ITEMS	A-2291	Air Dryer Package								
										1

TABLE 220-4 (cont.)

CONTRACT:

EQUIPMENT LIST

NAME OF UNIT

Credit Generation

PAGE 7 OF 7

REVISION

ORIGINAL

1

2

3

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DATE _____

6/1/79

7/11/79

TABLE 220-4 (cont.)

LEGEND	
	MATERIAL BALANCE STREAM NUMBER
	TEMPERATURE, °F
	PRESSURE, PSIG (UNLESS OTHERWISE NOTED)

INDUSTRIAL FUEL GAS DEMONSTRATION PLANT
 BEAVER UNIT PACKAGE
 CONTRACT NO. 61-77C-01-2342
 MEMPHIS LIQUID GAS AND VAPOR BUSINESS RECOVERY, INC.
 BEAVER UNIT PACKAGE
 BEAVER UNIT PACKAGE

TASK II DEMONSTRATION PLANT
 PROCESS FLOW DIAGRAM
 TAIL GAS TREATING
 SECTION 390
 15-2202 PWS NO. 202-1-5020
 THIS DRAWING SUPERSEDES ALL PREVIOUS EDITIONS

Section 13.0

DESCRIPTION OF PROCESS RELATED FACILITIES

13.1 COAL/COKE HANDLING (Section 410)

13.1.2 Reference Material

- Process Flow Diagram: FWEC Dwg. No. 2202-1-50-41101
- Utilities, Chemicals and Catalysts: Table 410-1
- Equipment List: Table 410-2

13.1.3 Description of Flow

13.1.2.1 Coal Handling

"Raw Coal", size 2" x 0", is received intermittently in the plant from 1500-ton barges and transported via Barge Unloader (UD-4101) and a conveying system to the live storage pile. The conveying system consists of Raw Coal Conveyor (CR-4101), Raw Coal Sampling System (SS-4101), Stockpile Feed Conveyor (CR-4102), and Stockpile Stacker (SK-4101). Material in the live pile is continuously reclaimed by Stockpile Dischargers (BV-4101) and Stockpile Alternate Dischargers (BV-4102) and fed to Coal/Coke Treating & Feed (Section 320) and Utility Area (Section 430).

A Dead Storage Pile is provided which is formed by moving the material with Front-End Loaders or other mobile equipment from the Live Storage Pile to the Dead Storage Pile area. Reclaiming the material from the Dead Storage Pile is done in the same way through Raw Coal Reclaim Hopper (TK-4102) and Raw Coal Reclaim Feeder (FD-4102). Stockpile End Hoppers (TK-4103) and Stockpile End Feeders (FD-4104) located in the Live Storage Pile can also be used for reclaiming coal from the Dead Storage Pile as well as the dead areas in the Live Storage Pile.

An alternate system is provided for reclaiming coal from the Live Storage Pile. Through the use of the Coke Handling Equipment (see Coke Handling), coal reclaimed by Front-End Loaders can be handled through the Coke Handling Equipment and then diverted to the Dryer Mill Alternate Feed Conveyor (CR-4108) for transporting to the Coal/Coke Treating Section.

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III- DEMONSTRATION PLANT OPERATIONS

13.1.2.2 Coke Handling

Sized coke, 1/4" x 0", is received in the plant via trucks. Coke dumped on the ground is picked up by Front-End Loader and transferred to the Coal/Coke Treating Section via Coke Reclaim Hopper (TK-4104), Coke Reclaim Feeder (FD-4105), Coke Reclaim Conveyor (CR-4107), Dryer Mill Alternate Feed Conveyor (CR-4108) and Dryer Mill Transfer Conveyor (CR-4106).

13.1.2.3 Miscellaneous

Raw Coal Scale (WS-4101) is provided on the Raw Coal Conveyor for accounting and inventory of the incoming raw coal. A truck scale is provided in the plant for accounting and inventory of the coke shipment.

Two (2) 2-stage Coal Sampling Systems are provided. Raw Coal Sampling System (SS-4101) is used to sample the raw coal received and Dryer Mill Feed Sampling System (SS-4100) is used to sample the coal being processed.

Adequate Dust Collection and Suppression Systems are provided in the plant for proper environmental control.

DP-4101 STOCKPILE DUST SUPPRESSION SYSTEM

A-4101
HAULING
SYSTEM

CR-4101
RAW COAL
CONVEYOR

TK-4102
RAW COAL RECLAIM
HOPPER

FD-4102
RAW COAL RECLAIM
FEEDER

WS-4101
RAW COAL
SCALE

SS-4101
RAW COAL SAMPLING
SYSTEM

CR-4102
STOCKPILE FEED
CONVEYOR

SK-4101
STOCKPILE
STACKER

LIVE COAL STOCKPILE

DEAD COAL STORAGE STOCKPILE

BV-4102 A/B
STOCKPILE ALTERNATE
DISCHARGERS

BV-4101 A/B
STOCKPILE
DISCHARGERS

TK-4103 A/B
STOCKPILE END
HOPPERS

CR-4103 A/B
STOCKPILE TRANSFER
CONVEYOR

FD-4103 A/B
STOCKPILE DISCH.
FEEDERS

FD-4104 A/B
STOCKPILE END
FEEDERS

CR-4104
STOCKPILE GATHERING
CONVEYOR

CR-4105
DRIVER MILL FEED
CONVEYOR

SS-4102
DRIVER MILL FEED
SAMPLING SYSTEM

CR-4106
DRIVER MILL TRANSFER
CONVEYOR

CR-4108
DRIVER MILL ALTERNATE
FEED CONVEYOR

DC-4102
MATERIAL HANDLING
DUST COLLECTION
SYSTEM

CR-4107
COKE RECLAIM
CONVEYOR

P-4101
STOCKPILE
PUMP

TK-4104
COKE RECLAIM
HOPPER

FD-4105
COKE RECLAIM
FEEDER

(EMERGENCY)

COKE FROM TRUCKS

LEGEND	
◇	MATERIAL BALANCE STREAM NUMBER
□	TEMPERATURE, °F
○	PRESSURE PSIG

INDUSTRIAL FUEL GAS DEMONSTRATION PLANT
REACTOR FURNACE
CONTRACT NO. 67-FK-01-2302
DESIGNED BY: AMEC
AND WATER DIVISION
BIRMINGHAM, ALA.

POWER WORLD ENERGY CORPORATION
11000 WEST 10TH AVE., LITTLE ROCK, AR 72205
DESIGNED BY: AMEC
AND WATER DIVISION
BIRMINGHAM, ALA.

1550-11 PROCESS FLOW DIAGRAM
COAL AND COKE HANDLING
SECTION 410
15-2202 DWG NO. 102-1550-11

MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM

TASK III - DEMONSTRATION PLANT
OPERATIONS

TABLE 410-1

UTILITIES, CHEMICALS AND CATALYSTS

Power

Consumed

75 Kilowatts

City Water

Consumed

6 GPM

FOSTER WHEELER ENERGY CORP. PROCESS PLANTS DIVISION		CONTRACT: SECTION: 410		EQUIPMENT LIST		NAME OF UNIT Coal & Coke Handling					PAGE 1 OF 3
CLIENT: MLGW/DOE ET-77-C-01-2582				REVISION	ORIGINAL	1	2	3	4	5	
LOCATION: MEMPHIS, TENNESSEE				DATE	5/9/79	6/25/79					
CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO	P. O. NO.						REV.
Package Unit	A-4101	Barge Unloading System									
Discharger	BV-4101A	Stockpile Discharger									
	BV-4101B	Stockpile Discharger									
	BV-4102A	Stockpile Alternate Discharger									
	BV-4102B	Stockpile Alternate Discharger									
Conveyors	CR-4101	Raw Coal Conveyor									
	CR-4102	Stockpile Feed Conveyor									
	CR-4103A	Stockpile Transfer Conveyor									
	CR-4103B	Stockpile Transfer Conveyor									
	CR-4104	Stockpile Gathering Conveyor									
	CR-4105	Dryer Mill Feed Conveyor									
	CR-4106	Dryer Mill Transfer Conveyor									
	CR-4107	Coke Reclaim Conveyor									
	CR-4108	Dryer Mill Alternate Feed Conv.									
Dust Collection	DC-4101					Deleted					1
	DC-4102	Material Handling Dust Coll. Sys.									

TABLE 410-2

FOSTER WHEELER ENERGY CORP.
 PROCESS PLANTS DIVISION

CONTRACT:

SECTION: 410

EQUIPMENT LIST

NAME OF UNIT

Coal & Coke Handling

PAGE 2 OF 3

CLIENT: MLGW/DOE ET-77-C-01-2582			REVISION		ORIGINAL	1	2	3	4	5
LOCATION: MEMPHIS, TENNESSEE			DATE		5/9/79	6/25/79				
CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.					REV.
Dust Suppression	DP-4101	Stockpile Dust Suppression Sys.								
	DP-4102	Barge Unloader Dust Supp. Sys.					Part of A-4101			1
Feeders	FD-4101	Raw Coal Feeder					Part of A-4101			
	FD-4102	Raw Coal Reclaim Feeder								
	FD-4103A	Stockpile Discharge Feeder								
	FD-4103B	Stockpile Discharge Feeder								
	FD-4104A	Stockpile End Feeder								
	FD-4104B	Stockpile End Feeder								
	FD-4105	Coke Reclaim Feeder								
Hauling Machinery	HM-4101	Barge Haul System					Part of A-4101			
Mobile Equipment	ME-4101	Front End Loader					By Others			
	ME-4102	Front End Loader					By Others			
Pumps	P-4101	Stockpile Sump Pump								
Stacker	SK-4101	Stockpile Stacker								
Separator	S-4101	Dryer Mill Feed Mag. Sep.								1

TABLE 410-2 (cont.)

TABLE 410-2 (cont.)

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III - DEMONSTRATION PLANT OPERATIONS

13.2 ASH TREATMENT (Section 420)

13.2.1 Reference Material

- Process Flow Diagram: FWEC Dwg. No. 2202-1-50-42101
- Utilities, Chemicals and Catalysts: Table 420-1
- Equipment List: Table 420-2

13.2.2 Description of Flow

This section is designed for both batch and continuous operation.

In batch operation, Ash Slurry Lock Hopper (D-4201), of each gasifier, is first filled with water with its outlet valve closed. Lock Hopper pressure is equalized with the gasifier by opening the valve in the pressure equalizing line. The Ash Slurry feed valve is then opened. Agglomerated ash quenched in the bottom of the gasifiers is discharged by gravity into the Ash Slurry Lock Hopper. After filling, both feed and pressure equalizing valves are closed.

Pressure in the Ash Slurry Lock Hopper is now reduced by opening the valve to the Lock Hopper Vent Pot (D-4202). Since the makeup water to the Lock Hopper Vent Pot is relatively cold, no steam flashing will occur.

After the Lock Hopper pressure is reduced, its outlet valve is opened.

By action of the Ash Educators, agglomerates are removed from the Ash and Slurry Lock Hoppers in the form of a slurry and are transported as such to either one of the two common Ash Dewatering Dins (TK-4201). In the Dewatering Bin, water is drained from the ash agglomerates. After dewatering, the agglomerates are discharged into trucks for transport to the ash pile. The two Ash Dewatering Bins are used alternately, that is, while one is being unloaded, the other is being fed with ash slurry.

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III - DEMONSTRATION PLANT OPERATIONS

Water from the Dewatering Bins flows into the Clarifier (CL-4201) where ash fines are separated and pumped back to the Dewatering Bins by the Clarifier Underflow Pump (P-4202). The overflow water from the Clarifier is collected in the Recycle Water Surge Tank (TK-4202) And recirculated intermittently to the Ash Slurry Lock Hoppers, to fill the Lock Hopper, and continuously to the Ash Eductors by Recycle Water Pump (P-4201).

Cooling of the recirculated water is provided by Recycle Water Cooler (E-4201).

Besides a spare Ash Eductor, each gasifier is provided with a spare conveying line from the Ash Eductor to the Dewatering Bins.

Losses of recycle water due to steam generated during quenching of the agglomerates, along with atmospheric evaporation occurring at the Ash Dewatering Bins, the Clarifier, and the Recycle Water Surge Tank, are made up with treated effluent from Wastewater Treatment (Section 440).

In continuous operation, Ash Slurry Lock Hopper is never blocked in to serve as a lock hopper. Ash agglomerates from the gasifier fall directly through the lock hopper into the Eductor. From the Ash Eductor outlet to the recycle water return, the process for continuous operation is identical to that for batch operation. For continuous operation the Eductor serves only as a simple mixing tee. Motive force for slurry transport is provided by the gasifier operating pressure. Dissipation of this pressure in the transport piping is accomplished by using a novel means of modulating the recycle water flow.

In addition to the agglomerated ash from the gasifiers, bottom ash from the steam boilers located in the Utility Area (Section 430) is conveyed through a separate piping system into the Dewatering Bins. Impulse water used for conveying the bottom ash is provided by means of Recycle Sluiceway Pump (P-4203).

MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM

TASK III- DEMONSTRATION PLANT
OPERATIONS •

TABLE 420-1

UTILITIES, CHEMICALS AND CATALYSTS

<u>Cooling Water</u>	140 GPM
<u>Power</u>	
Consumed	180 Kilowatts

FOSTER WHEELER ENERGY CORP. PROCESS PLANTS DIVISION		CONTRACT: SECTION: 420		EQUIPMENT LIST			NAME OF UNIT Ash Handling					PAGE 1 OF 2					
CLIENT: MLGW/DOE ET-77-C-01-2582				REVISION		ORIGINAL		1		2		3		4		5	
LOCATION: MEMPHIS, TENNESSEE				DATE		5/9/79		6/25/79									
CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.	REV.											
Clarifier	CL-4201	Clarifier															
Drums	D-4201-1	Ash Slurry Lock Hopper															
	D-4201-2	Ash Slurry Lock Hopper															
	D-4201-3	Ash Slurry Lock Hopper															
	D-4201-4	Ash Slurry Lock Hopper															
	D-4202-1	Lock Hopper Vent Pot															
	D-4202-2	Lock Hopper Vent Pot															
	D-4202-3	Lock Hopper Vent Pot															
Exchanger	E-4201	Recycle Water Cooler															
Eductors	J-4201-1A	Ash Eductor															
	J-4201-1B	Ash Eductor															
	J-4201-2A	Ash Eductor															
	J-4201-2B	Ash Eductor															
	J-4201-3A	Ash Eductor															
	J-4201-3B	Ash Eductor															
Pumps	P-4201A	Recycle Water Pump															
	P-4201B	Recycle Water Pump															

TABLE 420-2

PROCESS PLANTS DIVISION

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NAME OF UNIT

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5

REV.

TK-4202	Recycle Water Surge Tank
---------	--------------------------

TABLE 420-2 (cont.)

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III- DEMONSTRATION PLANT OPERATIONS

13.3 UTILITY AREA (Section 430)

13.3.1 Reference Material

- Process Flow Diagrams: FWEC Dwg. No. 2202-1-50-43101
-43102
- Utilities, Chemicals and Catalysts: Table 430-1
- Equipment List: Table 430-2

13.3.2 Description of Flow

Flow through the utility area may be followed on the referenced Process Flow Diagrams. The utility area consists basically of the following water systems:

- Raw Water Distribution and Storage
- Boiler Feedwater Treatment
- Steam Generation and Distribution

Because of their inter-relationship with steam generation, geographical plot area and common ducting into Stack (ST-4301), Incinerator Package (A-4304) and Stack Gas Cleanup Package (A-4304), are both included in this section.

13.3.2.1 Raw Water

Raw water makeup consists of city water provided by the City of Memphis' Davis Pumping Station. Following is the analysis of water entering the plant battery limits:

City Water Analysis (Davis Pumping Station)

pH	7.5	
Alkalinity, (as CaCO ₃)	98.0	mg/l
Total Hardness, (as CaCO ₃)	86.0	mg/l
Calcium Hardness, (as CaCO ₃)	46.4	mg/l
Magnesium Hardness, (as CaCO ₃)	39.6	mg/l
Iron (Fe)	0.02	mg/l
Manganese (Mn)	0.00	mg/l
Fluoride (F)	1.00	mg/l
Sodium and Potassium, (as Na)	10.6	mg/l (calculated)
Sulfate (SO ₄)	4.0	mg/l
Chloride (Cl)	5.0	mg/l
Nitrate (NO ₃)	0.1	mg/l
Silica (SiO ₂)	14.8	mg/l
Dissolved Solids	118.0	mg/l

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III- DEMONSTRATION PLANT OPERATIONS

City Water/Firewater Storage Tank (TK-4301) contains water of suitable quality for use as makeup to the cooling tower, emergency potable and service water, and influent to the demineralizer package for boiler feedwater treating. This requirement is met by 44,000 barrels storage in the upper section of the City Water/Firewater Storage Tank based on eight hours holdup for process and utility use. The lower section of this tank also provides four hours reserved holdup of firewater, based on two 2000 GPM firewater pumps operating simultaneously. Together, the total tank capacity of both sections represents 70,000 barrels.

Water from the upper section of the City Water/Firewater Storage Tank flows by gravity directly to the cooling tower basin. Potable and service water are normally supplied by the city water piping main header under its own pressure of about 85 psig at the plant battery limits. If this supply is temporarily cut off, the City Water Pump (P-4301) taking suction from the upper section of the City Water/Firewater Storage Tank can supply such water by manually opening a valve, at about 65 psig. These pumps normally supply water to Demineralizer Package (A-4301) for use as boiler feedwater makeup.

13.3.2.2 Boiler Feedwater Treatment

City water at an average temperature of 65°F undergoes treatment in Demineralizer Package, (A-4301) to upgrade the water quality to that required for generating 900 psig superheated steam. This system consists of carbon filtration, deionization and degasification. Activated carbon filters remove chlorine normally found in potable water provided by the City of Memphis. This step is necessary to protect the deionization resin beds and the credit generation catalyst from being poisoned. Cation exchangers (weak acid unit) reduce hardness and alkalinity; a degasifier removes carbon dioxide and reduces the load on the mixed resin bed. The mixed bed units (with anion and cation resins mixed together) remove sodium, free mineral acids, silica and effluent CO₂ from the degasifier. Demineralized undeaerated water is stored in Demineralized Water Storage Tank (TK-4302) providing 8 hrs. holdup. From this tank, the demineralized water is pumped to Deaerator (DH-4301) by Demineralized Water Pump (P-4302). The Condensate/Demineralized Water Exchanger (E-4301) serves to both preheat the demineralized water before deaeration and cool the hot condensate to avoid flashing in Condensate Storage Tank (TK-4304). Condensate recovery has been maximized in order to minimize raw water intake. Four hours of condensate holdup is maintained to provide against possible leakage of a process stream into the condensate providing adequate holdup permits condensate dumping until the source of the problem is located and a course of action is taken. Condensate from TK-4304 is pumped by Condensate Pump (P-4307) to the Deaerator.

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III - DEMONSTRATION PLANT OPERATIONS

Deaeration provides water of quality suitable for high pressure steam generation at about 915 psig, 865°F at the superheater outlet of Steam Generators (SG-4301), and process heat recovery units. Deaerator (DH-4301) normally operates at 5 psig. Steam is used as the stripping medium and a nominal 1000 lbs/hr is vented to ensure adequate deaeration. Demineralized water is supplied as makeup water and maintains the storage compartment level in the deaerator.

Final oxygen scavenging is by addition of hydrazine, directly to the deaerator. Amine is added in the form of morpholine to the boiler feedwater pump suction line to control corrosion of piping, in the condensing portion of the steam system.

Neutralization Tank (TK-4303) is provided to collect rinse and regenerant streams from the Demineralizer Package. These wash streams are then neutralized with 66° BE sulfuric acid or 50% caustic, as required. Wastes are then drained and sent to Wastewater Treating (Section 440).

13.3.2.3 Steam Generation and Distribution

Flow of steam generation and distribution may be followed on the Steam Balance Diagram. Dwg. No. 2202-1-50-00102.

High pressure superheated steam (nominally 900 psig/840°F) is generated through waste heat recovery in Gas Cooling and Scrubbing (Section 340) and the Utility Area Steam Generators. Sufficient steam generating capacity is available to assure that an adequate supply of steam is available for an orderly shutdown under power outage conditions. The plant can maintain normal operations during boiler turnaround with one power boiler down for maintenance.

The steam header system consists of two main steam levels viz, 900# (900 psig, 840°F) and 85# (85 psig, 420°F). Two other steam levels are available in limited areas of the plant for dedicated services viz, 125# (125 psig, 505°F) and 50# (50 psig, 298°F).

Most of the generated high pressure steam is utilized in process units after expanding through back pressure turbines to the ultimate required steam conditions. Superheated 125# steam for the largest consumer, Gasifiers (R-3301) is produced by Air Compressor (C-3101B) turbine exhaust. In the event an emergency occurs requiring the air compressor topping turbine to be shutdown or bypassed, high pressure steam can be let down directly to the gasifiers through a pressure control valve. In order to avoid large letdown quantities of high pressure steam during four gasifier operation, resulting in wasted energy, turbine drive is provided for Cooling Water Pump (P-4501) operating between 900# and 125# levels.

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III - DEMONSTRATION PLANT OPERATIONS

Much of the low pressure 85# steam demand is derived from other onsite back pressure turbines including Oxygen Compressor (C-102), H₂SH.P. Lean Solution Pump (P-3606) and CO₂ Lean Solution Pump (P-3604). The remaining 85# steam production results from flashed boiler blowdowns, Sulfur Condensers (E-3802, 3 and 4), Credit Generation Steam Drum (D-2263) and a small quantity of letdown from 900 psig header for control purposes. The major consumers of this steam is the H₂S Stripper Reboiler (E-3609) in Gas Treating (Section 360) and the strippers in Sour Water Stripping (Section 370). The balance of the 85# steam is utilized in building, heating, Flare (Section 460), Carbonate Regenerator Reboiler (E-2232) of Credit Generation (Section 220) and other miscellaneous minor consumers.

A small amount of 50 psig, saturated steam is generated through waste heat recovery in Sulfur Recovery (Section 380) and the Beavon Package Unit of Tail Gas Treating (Section 390). Part of this steam is utilized within these two units; the excess is sent directly to the deaerator for boiler feedwater deaeration. The remainder of the deaerating stripping steam requirement is obtained from the 85# steam header and flashed steam from the Continuous Blowdown Drum (D-4303).

Each package boiler is designed to produce 225,000 lbs/hr of 915 psig, 865° F steam for use in the 900# superheated header. Both steam generators will normally operate at reduced capacity, producing about 132,000 lbs/hr of high pressure steam. Conventional pulverized coal fired boilers of special design to utilize both coal fines and char fines as part of the fuel requirement are used.

Coal fines from Coal/Coke Treating and Feed (Section 310) and gasifier fines from gasification (Section 330) are pneumatically conveyed to Fines Receiving Bin (TK-4310). The dry fines combined with filtered char fines containing a maximum of 25% moisture from Filter Cake Storage Bin (TK-4306), are mixed and homogenized with raw coal from Coal/Coke Handling (Section 410) in a pulverizer. The resultant material is fed to the pulverized coal burners.

Top and bottom ash is produced in the steam generator from coal combustion. Roughly 20% of the total ash is removed by a bottom ash sluicing system to Ash Treating (Section 420). The top ash passes through a dust collector, is thoroughly wetted within a mixing chamber in Fly Ash Unloader (A-4308) and is trucked away to the Ash Pile.

The resultant flue gas produced, after exchanging heat in an Air Preheater, is blown into Stack Gas Cleanup Package (A-4303) for removal of sulfur dioxide in order to meet environmental regulation for plant emission.

A sodium phosphate solution is injected into the boilers throughout the plant to control pH and reduce scaling problems.

13.3.2.4 Incineration

Various gas streams, originating in process units and normally requiring disposal to the ambient atmosphere are delivered to the Incinerator Package (A-4304). These gas streams contain atmosphere-polluting contaminants: sulfur compounds, carbon monoxide, combustible hydrocarbons, compounds and ammonia precluding direct emission to the atmosphere. Because controlled combustion is required during operating upsets or for intermittent periods, some additional streams as listed below are directed to the incinerator.

a. Normal Streams

1. An off gas from a Credit Generation (Section 220) which utilizes a Benfield Unit. The process basically removes CO_2 and the bulk of the sulfur compounds present in the product gas feed stream. The off gas is rich in carbon dioxide and water vapor with residual amounts of hydrogen sulfide present.
2. A vent gas from the Feed Lock Hoppers (Section 320) continuously feeds the incinerator on regular cycles. The hoppers are pressurized with a combination of product gas and nitrogen. This gas is sent to the incinerator during the dumping operation of the coal feed to the gasifiers.
3. A CO_2 rich vent gas from Gas Treating (Section 360) is produced from the two stage Selexol process. This gas contains carbon monoxide and traces of reduced sulfur compounds are continuously fed to the incinerator.

b. Emergency Operation Streams

1. An emergency load from the Claus Sulfur Recovery Plant (Section 380) will be combusted in the incinerator during upset conditions when the Sulfur Recovery Unit cannot accept feed. This vent gas stream is rich in hydrogen sulfide, carbonyl sulfide and ammonia.
2. An emergency load from the Tail Gas Treating Unit (Section 390) will be vented if the Beavon Package is shut down. This vent gas stream is rich in carbon dioxide, nitrogen and water.
3. If fines recycle to the gasifier is not operating, a vent stream containing carbon monoxide as the major pollutant will be sent to the incinerator from Coal Gasification (Section 330).

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TASK III- DEMONSTRATION PLANT OPERATIONS

The design criteria for destruction of the trace hydrocarbons, and the combustion of hydrogen and carbon monoxide, and the conversion of sulfur compounds into sulfur dioxide, are, that the off-gas be contacted with an excess of air, at a minimum residence time of 0.8 seconds, producing a 1500°F minimum flue gas temperature before air preheat. A high degree of turbulence, to ensure thorough mixing of the combustibles with oxygen, is desirable.

The heat available from the combustion process is not sufficient to make the incineration process self supporting. Product gas is normally burned as required to make the process self sustaining. During startup and emergency operations, natural gas will supply the necessary heat to sustain combustion.

Primary air needed for combustion of the fuel gas is preheated using the incinerator flue gas as the heating medium. Secondary air needed for combustion of the off gases is also preheated in a similar fashion. Quench air enters the incinerator at ambient conditions as required to prevent incinerator flue gas temperature to reach in excess of 1800°F. Combustion air is supplied by a motor driven blower included in the incineration package for all requirements including primary, secondary, and quench air.

The flue gases, after heat exchange with the combustion air are contacted with the flue gases from the Stack Gas Clean-up Package (A-4303) and then dispersed to the ambient atmosphere by means of a stack. To maintain good dispersion of the stack effluents a minimum combined temperature of 260°F is necessary. The incinerator flue gas will supply this heat under all operating conditions. A provision is furnished such that a fraction of the incinerator flue gas may be diverted around the air preheater maintaining the 260°F combined flue gas temperature. During plant operations in which no waste gases are available for combustion, product gas or natural gas will be burned to supply heat to the effluent of the stack gas cleanup package, maintaining a minimum 260°F flue gas temperature.

13.3.2.5 Stack Gas Cleanup Because high sulfur coal (4.54% S MAF) is used for fuel in the Steam Generators and the Dryer Mill (SR-3201) of Coal/Coke Treating and Feed (Section 320), environmentally unacceptable levels of sulfur dioxide (SO_2) are produced. In order to prevent pollution of the atmosphere over 90% of the SO_2 is selectively removed in a Concentrated Double Alkali Flue Gas Desulfurization Unit.

Basically, the Double Alkali System consists of sodium sulfite scrubbing of sulfur dioxide and regeneration of the scrubbing solution with hydrated lime. Steam generator flue gas after removal of particulate matter in a dust collector, is fed to the Stack Gas Cleanup Package by an ID Fan provided by the boiler vendor. Here it is combined with the Dryer Mill flue gas prior to entering the absorber. The flue gas upon entering the absorber is contacted with scrubbing solution containing sodium sulfite (Na_2SO_3), sodium bisulfite (NaHSO_3) and sodium sulfate (Na_2SO_4).

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III - DEMONSTRATION PLANT OPERATIONS

The principal reaction in the absorber is between sulfur dioxide in the flue gas and sodium sulfite in the absorbing solution:

Some oxidation of the sodium sulfite occurs in the absorber as follows:

The absorber is maintained at $\text{pH} = 6.5 \pm 0.5$ as a highly buffered sulfite-bisulfite system. This avoids calcium carbonate scaling at a higher pH and increased SO_2 vapor pressure reducing scrubbing effectiveness at a lower pH.

The recirculation scrubbing solution is constantly bled according to SO_2 inlet flow, maintaining a constant pH. From this bleed stream sodium sulfite is regenerated by reaction with hydrated lime as follows:

The above reaction takes place in low residence time stirred tank reaction at a controlled pH of 8.5, the titrametric endpoint. The calcium sulfate is thickened and filtered to produce a filter cake of 60 to 70% solids which is washed to minimize sodium losses. Sodium sulfite solution produced in the thickener and as filtrate is returned via a holding tank at $\text{pH} = 8.5$ to the absorber. In this manner required sodium makeup is in the range of 2 to 5% of SO_2 collected.

The resultant filter cake produced at vacuum filters must be disposed of. It is stable and of low permeability and has suitable land bearing properties to allow construction of small structures. This stable sludge will be mixed with flyash and trucked to the ash pile.

Makeup is in the form of a saturated soda ash solution (Na_2CO_3), according to the following reaction maintains the scrubbing solution:

MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM

TASK III - DEMONSTRATION PLANT
OPERATIONS

TABLE 430-1

UTILITIES, CHEMICALS AND CATALYSTS

	<u>Normal</u>
<u>Steam</u> , HP (900 psig, 840°F)	
produced	130,948 lbs/hr
<u>Steam</u> , LP (85 psig, sat'd)	
net consumed	21,519 lbs/hr
<u>Steam</u> , LP (50 psig, sat'd)	
consumed	11,102 lbs/hr
<u>Condensate</u>	
consumed	185,420 lbs/hr
<u>Blowdown</u>	
produced	1,820 lbs/hr
<u>Fuel consumed</u>	
fuel gas (product gas)	0.22 MMM BTU/day
coal (washed Kentucky No. 9)	82.6 tons/day
coal fines (from coal handling- 2.5 wt/moisture)	104.1 tons/day
char fines - (as 20 wt/(may) filter cake)	102.4 tons/day
<u>Power</u> *	
consumed	2,000 Kilowatts
<u>Chemical consumption</u> *	
phosphate (as Na_2HPO_4)	5.1 lbs/day
hydrazine (35 wt% soln)	13 lbs/day
amine (40% morpholine soln)	
sulfuric acid (66% H_2SO_4)	0.3 lbs/day
caustic (50 wt% NaOH)	36.3 lbs/day

* Power and chemical consumption used for vendor packages to be confirmed after the final equipment selection

Boiler Feedwater

Consumed (by Power Boiler) 133,620 lbs/hr

City Water

consumed 1,876 GPM

MLGW/DOE INDUSTRIAL FUEL GAS
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TASK III - DEMONSTRATION PLANT
OPERATIONS

TABLE 430-1 (cont.)

Normal

Steam (5 psig, 228°F sat'd)

dearator vent loss to atmosphere

1,000 lb/hr

INDUSTRIAL FUEL GAS DEMONSTRATION PLANT
 INTERIM, FINAL
 CONTRACT NO. 81-77C-01-7342
 DESIGNER: LOCKHEED AND WATER DIVISION
 BIRMINGHAM, ALA.
 DRAWING BY: J. L. BROWN
 DATE: 10-1-73

FOSTER WHEELER ENERGY CORPORATION
 10000 WILSON AVENUE
 BIRMINGHAM, ALA. 35202
 PHONE (205) 988-1000
 TELETYPE (205) 988-1000

PROJECT: FUEL GAS PLANT
 UTILITY AREA
 SECTION 420

15-220V DWG NO. 01-7342-843

15-220V DWG NO. 01-7342-843

NOTES
1. FUEL/SHR AT BURNER

LEGEND	
	MATERIAL BALANCE, STREAM NUMBER
	TEMPERATURE °F
	PRESSURE, PSIA (BARLESS / OTHERWISE INDICATED)

INDUSTRIAL FUEL GAS DEMONSTRATION PLANT
CONTRACT NO. 17-001-01-1587
RESEARCH LIGHT-GAS
AND HEATER BURNING
ALBANY, TENN.
DESIGNED BY
CONSULTING, S. C.

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OR BY ANY INFORMATION STORAGE
RETRIEVAL SYSTEM.

PROJECT: FUEL GAS
EST. BY: J. A. G.
DATE: 10-1-64
DWG. NO. 2-1-64-10

FOSTER WHEELER ENERGY CORP.

PROCESS PLANTS DIVISION

CONTRACT:

SECTION: 430

EQUIPMENT LIST

NAME OF UNIT

UTILITY AREA

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CLIENT: MLGW

ET-77-C-01-2582

REVISION

ORIGINAL

1

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3

4

5

LOCATION:

DATE

5-16-79

6-14-79

6-18-79

6-22-79

7-10-79

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.						REV.
DRUMS	D-4301	Sulfuric Acid Storage Drum									
	D-4302	Caustic Storage Drum									
	D-4303	Continuous Blowdown Drum									
	D-4304	Deleted									1
	D-4305	Deleted									1
	D-4306	Deleted									1
	D-4307	Intermittent Blowdown Drum									
TANKS	TK-4301	City Water/Fire Water Storage Tank									
	TK-4302	Demineralized Water Storage Tank									
	TK-4303-A	Neutralization Tank									4
	TK-4303-B	Neutralization Tank									4
	TK-4304	Condensate Storage Tank									
	TK-4305-A	Coal Storage Bin									1
	TK-4305-B	Coal Storage Bin									1
	TK-4306-A	Filter Cake Storage Bin									1
	TK-4306-B	Filter Cake Storage Bin									1
	TK-4307-A	Fly Ash Surge Bin									1
	TK-4307-B	Fly Ash Surge Bin									1
	TK-4308-A	Fly Ash Lock Hopper									1
	TK-4308-B	Fly Ash Lock Hopper									1
	TK-4309-A	Fly Ash Silo									1
	TK-4309-B	Fly Ash Silo									1
	TK-4310-A	Fines Receiving Bin									2
	TK-4310-B	Fines Receiving Bin									2
EXCHANGERS	E-4301	Condensate/Demineralized Water Exchanger									
PUMPS	P-4301-A	City Water Pump									
	P-4301-B	Spare for P-4301-A									
	P-4302-A	Demineralized Water Pump									4
	P-4302-B	Spare for P-4302-A									
	P-4303-A	HP BFW Pump									1

TABLE 430-2

FOSTER WHEELER ENERGY CORP.
 PROCESS PLANTS DIVISION

CONTRACT:

SECTION: 430.

EQUIPMENT LIST

NAME OF UNIT

UTILITY AREA

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CLIENT: MLGW		ET-77-C-01-2582		REVISION		ORIGINAL	1	2	3	4	5
LOCATION:				DATE		5-16-79	6-14-79	6-18-79	6-22-79	7-10-79	
CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.						REV.
<u>PUMPS</u>	P-4303-B	Spare For P-4303-A									4
	P-4303-C	Deleted									4
	P-4304-A	LP BFW Pump									1
	P-4304-B	Spare for P-4304-A									
	P-4305	Neutralization Acid Pump									
	P-4306	Neutralization Caustic Pump									4
	P-4307-A	Condensate Pump									
	P-4307-B	Spare for P-4307-A									1
	P-4308	Deleted									1
	P-4309	Deleted									1
	P-4310	Deleted									1
	P-4311-A	Char Fines Filtrate Pump									1
	P-4311-B	Spare for P-4311-A									
<u>EJECTOR</u>	J-4301-A	Bottom Ash Ejector									1
	J-4301-B	Bottom Ash Ejector									1
<u>MISCELLANEOUS</u>	A-4301	Demineralizer Package									4
	A-4302-A	Deleted									4
	A-4302-B	Deleted									2
	A-4303	Stack Gas Cleanup Package									
	A-4304	Incinerator Package									1
	A-4305-A	Filtration System Package									1
	A-4306-B	Filtration System Package									1
	A-4306-B	Sluiceway									1
	A-4306-B	Sluiceway									4
	A-4307-A	Deleted									4
	A-4307-B	Deleted									1
	A-4308-A	Fly Ash Unloader									1
	A-4307-B	Fly Ash Unloader									1
	A-4309	Amine Injection Package									1
	A-4310	Hydrazine Injection Package									1
	A-4311	Phosphate Injection Package									1

TABLE 430-2 (cont.)

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 PROCESS PLANTS DIVISION

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SECTION: 430

EQUIPMENT LIST

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CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.	REV.
MISCELLANEOUS	CR-4301-A	Coal Feed Conveyor			From Section 410.	1
	CR-4301-B	Coal Feed Conveyor			From Section 410	1
	CR-4302-A	Coal Feed Conveyor				1
	CR-4302-A	Char Transfer Conveyor				1
	CR-4303-B	Char Transfer Conveyor				1
	CR-4304-A	Fly Ash Conveyor				1
	CR-4304-B	Fly Ash Conveyor				1
	DC-4301-A	Dust Collector				3
	DC-4301-B	Dust Collector				3
	DH-4301	Deaerator				
	F-4301-A	Deleted				4
	F-4301-B	Deleted				4
	F-4302-A	Bin Filter				1
	F-4302-B	Bin Filter				1
	F-4303-A	Fines Bin Filter				2
	F-4303-B	Fines Bin Filter				2
	FD-4301-A	Fines Feeder				2
	FD-4301-B	Fines Feeder				2
	FD-4302-A	Table Feeder				2
	FD-4302-B	Table Feeder				2
	SG-4301-A	Steam Generator				3
	SG-4301-B	Steam Generator				3
	ST-4301	Stack			Common to Steam Generators & Incinerators	

TABLE 430-2 (cont.)

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III - DEMONSTRATION PLANT OPERATIONS

13.4 WASTE WATER TREATMENT (Section 440)

13.4.1 Reference Material

- Process Flow Diagrams: FWEC Dwg. Nos. 2202-1-50-44101
2202-1-50-44102
2202-1-50-44103
- Utilities and Chemicals: Table 440-1
- Equipment List: Table 440-2

13.4.2 Description of Flow

Waste waters generated in the demonstration plant will be from several sources. The type and degree of treatment and the ultimate disposal of these waste waters will depend on the source of the waste water and on the type and concentration of pollutants in the water. The waste waters and their sources are:

- Stormwater falling on, and drained from the area inside the limits of processing units (ISBL)
- Spent service water (deck washings, flushing, etc.)
- Cooling tower blowdown
- Stormwater falling on, and drained from the coal piles
- Stormwater falling on, and drained from the ash pile
- Process waste water consisting of clarified blowdown from gas scrubbing, filtrate from slurry filter, stripped condensate from sour water stripping and condensate from the credit generation
- Sanitary waste water generated by plant personnel
- Neutralized demineralizer chemicals

13.4.2.1 ISBL Stormwater and Spent Service Water The flow of ISBL stormwater and spent service water may be followed on Process Flow Diagram Dwg. No. 2202-1-50-44101 for non-process waste.

The ISBL stormwater and the spent service water drain to the oily water sewer and flow to the Stormwater Diverter (A-4407). During dry periods the water flows through the diverter and is pumped by the ISBL Wastewater Lift Pump (P-4402) to treatment area. During periods of heavy rain, the wastewater flow will exceed the capacity of the treatment system. The excess is automatically pumped by Stormwater Lift Pump (P-4401) to the

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TASK III - DEMONSTRATION PLANT OPERATIONS

Stormwater Holding Basin (A-4401) where it is stored and to be worked off through the treatment system after the rain ceases. Normally both spent service water and stormwater from the holding basin is pumped to the Dissolved Air Flotation (DAF) Unit (S-4401) for treatment.

The DAF Unit removes oil and solids in the waste water to acceptable limits. Floatable material removed as a froth from the DAF Unit flows by gravity to a sump from where it is transferred to the Froth Separation Tank (TK-4401). The oil-water mixture in the Froth Separation Tank can be heated (via steam coils in the tank) to 180°F to enhance oil and low density solids separation. Water separated in the Froth Separation Tank is returned by gravity to the Stormwater Holding Basin.

The separated oil and solids are drained by gravity to a sump from where they are pumped by the Recovered Oil Pump (P-4404) to the Slop Oil Storage Tank (TK-4407) for subsequent off-site disposal.

Solids from the bottom of the DAF Unit are drained to the Sludge Pit (A-4405).

Treated waste water leaving the DAF Unit flows to the Effluent Holding Basin (A-4406) from where it is normally recycled to the cooling tower, and to the Ash treatment (Section 410) as make-up. Excess treated water is discharged to the outfall.

The Effluent Holding Basin is divided into two sections. From the first section, treated waste waters can be recycled or overflowed into the second section. From the second section, treated waste water is discharged to the outfall.

13.4.2.2 Coal Pile Runoff and Cooling Tower Blowdown The flow of cooling tower blowdown and coal pile runoff may be followed on Process Flow Diagram, Dwg. No. 2202-1-50-44101 for non-process waste.

The cooling tower blowdown is first sent to a chromium destruct unit (A-4415) where chromium and zinc are precipitated as insoluble hydroxides. If the cooling tower blowdown leaving the chromium destruct unit is free of oil and grease, it will be discharged directly through the Effluent Holding Basin to the Plant outfall. If the blowdown contains oils and grease, it will be sent to the Stormwater Diverter from where it will flow through the DAF Unit described in item 1 above before flowing to the plant outfall.

Coal pile runoff is collected in the Coal Pile Runoff Holding Basin (A-4402), from which it is pumped by the Coal Pile Runoff Pump (P-4406) at a controlled rate to the Neutralization Tank (TK-4405). Lime is fed to this tank continuously to adjust the pH to approximately 8.5. The neutralized waste water flows by gravity to an Aerating Basin (A-4404).

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TASK III- DEMONSTRATION PLANT OPERATIONS

A fixed aerator aerates and mixes the incoming stream thereby oxidizing inorganic materials present in the waste water and causing them to form insoluble hydroxides. The aerated stream flows by gravity to the Coal Pile Runoff Clarifier (CL-4401) where the insoluble precipitate settles from the water and is pumped by the Coal Pile Clarifier Sludge Pump (P-4405) to the Sludge Pits (A-4405).

Decant from the Sludge Pits is returned by gravity to the coal pile runoff holding basin. Sludge is removed periodically from one of the sludge pit sections, while the other is maintained in operation. Sludge removed from the pit is trucked away. It can be used as land-fill off site or stored on-site. The clarified waste water from the clarifier flows to the Effluent Holding Basin from where it is recycled to the Cooling Tower or Ash treatment areas, or alternatively, discharged to the outfall.

13.4.2.3 Ash Pile Leachate Initial leachate tests performed on samples of bottom ash taken from the IGT pilot plant give strong indication that the ash pile leachate will be suitable for direct discharge. Therefore a separate treatment system will not be provided for this stream.

An area within the ash pile storage area sufficiently large to provide storage for the first five years of ash production will be lined to permit collection of leachate in a sump from where the leachate is pumped to the Effluent Holding Basin. Samples of this leachate will be tested to confirm that it is acceptable for discharge without treatment. If the analyses show that treatment is required, additional treatment facility will be provided as required.

13.4.2.4 Process Wastewaters Flow of process waste waters may be followed on the Process Flow Diagrams, Dwg. Nos. 2202-1-50-44102 & 3 for process waste.

The combined process waste water stream enters the Process Waste Flash Mix Tank (TK-4404) where lime is added as necessary to adjust the pH and form a floc which promotes the removal of suspended solids. In addition, spent oxygen from the Oxygen Knockout Drum (D-4401) is bubbled through the water to oxidize inorganics and to promote formation of insoluble precipitates. Polyelectrolyte is added to the water in the Process Waste Reactor Clarifier (CL-4402). Here, precipitated solids are internally recycled to promote additional flocculant growth. Settled sludge in the clarifier is drained to a sump from which it is pumped by the Sludge Dewatering Feed Pump (P-4409) to the Sludge Dewatering System (A-4401) consisting of a belt filter press mechanism. The water removed from the sludge is returned to the Flash Mix Tank via the Dirty Backwash Pump (P-4410). The dewatered sludge is transported to plant solid waste storage area on site.

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TASK III - DEMONSTRATION PLANT OPERATIONS

The clarifier effluent is pumped by the Recarbonation Drum Feed Pump (P-4416) into the Recarbonation Drum (D-4402). Recarbonation is accomplished by diffusion of carbon dioxide rich vent gas from tail gas treating, which returns the pH of the clarifier effluent to a normal level. Phosphoric acid is added to the water to provide nutrient for subsequent treatment steps.

Process waste water is then filtered in the Pre-Ozonation Filter (F-4401) as a final pre-treatment step prior to ozonation and biological carbon adsorption. The filtrate enters the Ozone Generation and Contacting System (A-4411) where ozone is added from an Ozone Generator. The ozone reacts with organics in the water to make them more readily biodegradable. The ozone generator is fed by oxygen from the Air Separation Plant. The effluent from the ozone contactor is pumped by Post Ozonation Feed Pump (P-4408) to the Post-Ozonation Pressure Filter (F-4402). A colony of biologically active organisms form on the bed of the filter and with the high oxygen content of the ozonated water the organisms remove a substantial amount of the organic pollutants from the water. The pressure filter effluent is mixed with the spent ozone off gas from the ozone contactor which is nearly pure oxygen in the Ozone Static Mixer (M-4402) before entering the Oxygen Knock-Out Drum. This raises the oxygen content of the waste water which had been depleted of oxygen by the biological activity in the filter.

The oxygenated water leaving the Oxygen Knock-Out Drum goes to either of two carbon adsorbers in the Carbon Adsorption System (A-4416). A colony of biologically active organisms forms on the carbon. The presence of the organisms maintains the adsorptive capacity of the carbon without the necessity for frequent regeneration.

When necessary, the carbon may be regenerated and reused. When the minimum effluent quality is reached, or when a predetermined carbon capacity is achieved, spent carbon is removed from the adsorbers and is regenerated thermally.

The thermal regeneration of carbon is as follows:

- a. Spent carbon is conveyed in a water slurry to the Regeneration System (A-4412) for preliminary dewatering.
- b. Dewatered spent carbon is fed to a reactivation furnace.
- c. The hot regenerated carbon is quenched in water.
- d. The cooled cleansed regenerated carbon is pumped to the Regenerated Carbon Storage Tank (TK-4402)
- e. Flue gas from the regenerating furnace is scrubbed before it is exhausted to the atmosphere.

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Treated process effluent is then stored in the Process Effluent Holding Tank (TK-4406). This water can then be used for various functions including: backwashing pressure filters and carbon adsorbers, motive water for carbon eductors, and other miscellaneous washing and dilution operations. The overflow from the Process Effluent Holding Tank flows to the Effluent Holding Basin, from where it can be recycled to the Cooling Tower or Ash Treating areas, or discharged to the outfall.

13.4.2.5 Sanitary Waste Water The sanitary waste water will be sent to the municipal sanitary sewer for treatment in the municipal waste water treatment plant.

13.4.2.6 Neutralized Demineralizer Chemicals After neutralization and pH adjustment, this stream is clean but high in dissolved solids. It is pumped directly to the Effluent Holding Basin for discharge to the outfall.

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DESIGNED BY: [Signature] CHECKED BY: [Signature] DRAWN BY: [Signature]	REVIEWED BY: [Signature] DATE: 10/11/87	DWG NO. 231-150-0400	THIS DRAWING SUPERSEDES THE DRAWING SUPERSEDED BY:

MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM

TASK III- DEMONSTRATION PLANT
OPERATIONS

TABLE 440-1

UTILITIES, CHEMICALS AND CATALYSTS

	<u>Normal</u>
<u>Steam</u> , LP (85 psig, sat'd)	
Consumed	300 lbs/hr
<u>Power</u>	
Consumed	260 Kilowatts
<u>Catalyst Consumption</u>	
Activated Carbon	303 lb/day
<u>Chemical Consumption</u>	
Phosphoric Acid (55% Solu)	240 lb/day
Polymer	100 lb/day
Hydrated Lime	70 lb/day

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CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.	REV
<u>Reactors</u>						1
						1
						1
<u>Tanks</u>	TK-4401	Froth Separation Tank				1
						1
						1
	TK-4404	Process Waste Flash Mix Tank				
	TK-4405	Neutralization Tank				1
	TK-4406	Process Effluent Holding Tank				1
	TK-4407	Slop Oil Storage Tank				1
<u>Drums</u>	D-4401	Oxygen Knock-Out Drum				
	D-4402	Recarbonation Drum				
<u>Heaters</u>	H-4401	Froth Separation Tank Heater				

TABLE 440-2

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FOSTER WHEELER ENERGY CORP.
PROCESS PLANTS DIVISION

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1 JUNE 79 2 JULY 79

CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.	REV.
<u>Ejectors & Eductors</u>						1
						1
<u>Pumps</u>	P-4401A	Stormwater Lift Pump				
	P-4401B	Stormwater Lift Pump				1
	P-4402A	ISBL Wastewater Lift Pump				1
	P-4402B	Spare for P-4402A				
	P-4403A	Froth Transfer Pump				
	P-4403B	Spare for P-4403A				
	P-4404A	Recovered Oil Pump				
	P-4404B	Spare for P-4404A				
	P-4405A	Coal Pile Clarifier Sludge Pump				
	P-4405B	Spare for P-4405A				
	P-4406A	Coal Pile Runoff Pump				1
	P-4406B	Spare for P-4406A				
	P-4407A	Pre-Ozonation Feed Pump				
	P-4407B	Spare for P-4407A				
	P-4408A	Post-Ozonation Feed Pump				
	P-4408B	Spare for P-4408A				
	P-4409A	Sludge Dewatering Feed Pump				
	P-4409B	Spare for P-4409A				
	P-4410A	Dirty Backwash Pump				
	P-4410B	Spare for P-4410A				
	P-4411A	Backwash Water Pump				1
	P-4411B	Spare for P-4411A				
	P-4412A	Carbon Column Feed Pump				
	P-4412B	Spare for P-4412A				
						1
						1
	P-4414A	Effluent Recycle Pump				1
	P-4414B	Spare for P-4414A				

TABLE 440-2 (cont.)

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TABLE 440-2 (cont.)

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CLASS	ITEM NO.	DESCRIPTION	EFD	REQ'N. NO.	P. O. NO.						REV.
<u>Package Units & Misc. Equipments</u>	A-4401	Stormwater Holding Basin									
	A-4402	Coal Pile Runoff Holding Basin									
											1
	A-4404	Aeration Basin									
	A-4405	Sludge Pits									
	A-4406	Effluent Holding Basin									1
	A-4407	Stormwater Diverter									
											1
											1
	A-4410	Sludge Dewatering System									
	A-4411	Ozone Generation and Contacting System									1
	A-4412	Carbon Regeneration System									
											1
	A-4414	Lime Storage and Feed System									
	A-4415	Chromate Destruct System									
	A-4416	Carbon Adsorption System									1
<u>Blowers</u>											
											1
<u>Clarifiers</u>	CL-4401	Coal Pile Runoff Clarifier									
	CL-4402	Process Waste Reactor Clarifier									

TABLE 440-2 (cont.)

FOSTER WHEELER ENERGY CORP. PROCESS PLANTS DIVISION		CONTRACT: SECTION: 440		EQUIPMENT LIST		NAME OF UNIT Waste Water Treatment					PAGE 5 OF 5	
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CLASS	ITEM NO.	DESCRIPTION	FFD	REQ'N. NO.	P. O. NO.							REV
Filters	F-4401A	Pre-Ozonation Pressure Filter										
	F-4401B	Spare for F-4401A										
	F-4402A	Post-Ozonation Pressure Filter										
	F-4402B	Spare for F-4402A										
Mixers	M-4401	Coal Pile Runoff Aerator										
	M-4402	Ozone Static Mixer										
	M-4403	Flash Mixer										
	M-4404	Neutralization Tank Mixer										1
	M-4405	In-Line Polymer Mixer										1
	M-4406	In-Line Polymer Mixer										1
	M-4407	In-Line Polymer Mixer										1
Separators	S-4401	Stormwater Dissolved Air Flotation (DAF) Unit										

TABLE 440-2 (cont.)

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III - DEMONSTRATION PLANT OPERATIONS

13.5 COOLING TOWER (Section 450)

13.5.1 Reference Material

- Process Flow Diagram: FWEC Dwg. No. 2202-1-50-45101
- Utilities & Chemicals: Table 450-1
- Equipment List: Table 450-2

13.5.2 Description of Flow

Flow of cooling water may be followed on the referenced Process Flow Diagram. Normal cooling water flow is shown on drawing 2202-4-50-00103.

The cooling water system consists of a mechanical draft cooling tower, cooling water circulation pumps and chemical treatment. Cooling water at 88°F is pumped by Cooling Water Circulating Pumps (P-4501A/B/C) from Cooling Tower (CT-4501) to the supply header. From the supply header it flows through the distribution system to users and then, into the return header at an average temperature of 114°F (design of 118°F). From the return header it flows back to the Cooling Tower, thus completing a closed-loop cycle.

Chemical feeding equipment associated with the cooling water system includes facilities for the addition of chlorine, corrosion inhibitor, dispersant and sulfuric acid. Cooling Tower Monitoring System (A-4504) provides for automatic and continuous sensing of circulating water quality. Resulting output signals are sent to Cooling Tower Sulfuric Acid Pump (P-4502), Corrosion Inhibitor Addition Package (A-4502), Dispersant Addition Package (A-4503), and Chlorination Package (A-4501). A cooling water bleed valve maintains non-scaling, minimum corrosion conditions. Gaseous chlorine from the Chlorination Package is fed directly into the cooling tower basin by means of an eductor, with water supplied by a tap off the Circulating Pumps discharge as motive fluid.

To control pH and total dissolved solids content of the cooling water, a bleed stream is taken off the discharge line of the Circulating Pumps. It is fed to Wastewater Treating (Section 440) for further treatment.

The primary source of makeup cooling water is the Davis Pumping Station City Water from Utility Area (Section 430). Makeup is also available from the Utility Area (demineralized backwash, carbon filter rinse and steam generation continuous blowdown) and from Air Separation (Section 310, condensed moisture from the air). Intermittent makeup streams are available from the Wastewater Treatment Section (rain water runoff) and the Credit Generation Section (process condensate).

It may be possible, after analyses of treated wastewater are conducted during plant operations, to send a normal continuous flow to the cooling tower from the Wastewater Treatment Section. In this way, makeup from the Davis Pumping Station would be substantially reduced.

NOTES
1. AT ENTRANCE TO COOLING WATER RETURN HEADER

LEGEND	
◇	MATERIAL BALANCE STREAM NO.
□	TEMPERATURE °F
○	PRESSURE PSIG (UNLESS OTHERWISE INDICATED)

INDUSTRIAL FUEL GAS DEMONSTRATION PLANT
MEMPHIS, TENN.
CONTRACT NO. 67 JFE-01-2382
HEATING, VENTILATION AND WATER DIVISION
MEMPHIS, TENN.

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PROCESS FLOW DIAGRAM
COOLING TOWER
SECTION 450
15-2000 DWG. NO. 20-100-000
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TASK III DEMONSTRATION PLANT
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TABLE 450-1

Utilities and Chemicals

POWER

Consumed	4000 KW
----------	---------

CHEMICALS

Sulfuric Acid

66° Baume H_2SO_4	1260 Lb/day
---------------------	-------------

Chromate/Zinc Corrosion Inhibitor	130 Lb/day
-----------------------------------	------------

General Dispersant	70 Lb/day
--------------------	-----------

Gaseous Cl_2	90 Lb/day
----------------	-----------

MLGW/DOE INDUSTRIAL FUEL GAS DEMONSTRATION PLANT PROGRAM

TASK III - DEMONSTRATION PLANT OPERATIONS

13.6 FLARE (Section 460)

13.6.1 Reference Material

- Process Flow Diagram: FWEC Dwg. No. 2202-1-50-46101
- Utilities & Chemicals: Table 460-1
- Equipment List: Table 460-2

13.6.2 Description of Flow

Flow to the flare may be followed on the referenced Process Flow Diagram.

The function of the flare system is to provide for safe burning of combustible vapors released from process equipment during equipment commissioning and decommissioning or during operating upsets.

Flare K.O. Drum (D-4601) receives the discharge from vents and safety valves in the various process units connected to a single flare header. Liquid collected in the Flare K.O. Drum is pumped to Sour Water Stripping (Section 370) by the automatic start electric motor driven centrifugal Flare K.O. Drum Pump (P-4601). Vapors from the Flare K.O. Drum are burned in Elevated Flare (FL-4601). A steam coil is provided in the Flare K.O. Drum to prevent water from freezing in cold weather and to vaporize any hydrocarbon liquid that might enter the drum. By maintaining a temperature of about 180° F, a minimum amount of water condensation in the drum occurs. This reduces the need to pump such liquid to Sour Water Stripping (Section 370).

The Elevated Flare includes the following features:

- Facilities for smokeless burning of hydrocarbon by the injection of steam into the flare tip.
- An air seal, located underneath the flare tip to prevent oxygen back-diffusion into the system.
- A flame front generator for igniting pilots. Since no plant air system is included in this plant, a separate air blower is included for pilot ignition.
- Facilities for automatic nitrogen injection into the Flare K.O. Drum to compensate for the system "contraction" after a hot blow.

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TASK III - DEMONSTRATION PLANT OPERATIONS

Pilot Gas K.O. Drum (D-4603) is provided in the pilot gas line to separate all liquid droplets from the gas. Similarly, Steam Separator (D-4602) removes entrained mist and bulk condensate from the steam line.

Dry nitrogen from Air Separation (Section 310) is continuously injected into the far end of the flare header for purge, maintaining a positive pressure in the system at all times, and for maintaining the header dry in order to minimize freeze-up problems.

The height and spacing of the flare is designed so that the heat radiation shall not be hazardous to personnel or equipment in its immediate vicinity. The flare is designed for a total heat flux at the base of the stack of 1500 BTU/hr-ft^2 , including solar radiation.

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TABLE 460-1

Utilities and Chemicals

Normal consumptions are listed below.

STEAM, (85 psig, sat'd)

Consumed

1,000 lb/hr

FUEL

Natural Gas

8 SCFM

Kilowatts
Operating

POWER

Consumed

20 Kilowatts

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FLARE

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TABLE 460-2

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TASK III- DEMONSTRATION PLANT OPERATIONS

13.7 FIRE PROTECTION (Section 470)

13.71 Reference Material

- . Equipment List: Table 470-1
- . Process Flow Diagram: FWEC Dwg. No. 2202-1-50-43101

13.72 Description of Flow

City water from the Davis Pumping Station is the source for fire water and is stored in tank TK-4301 which also serves as city water storage. The designated quantity of fire water (965,000 gallons) is protected from other use and will supply the plant fire water distribution system for four (4) hours with both fire water pumps, P-4701-A and B, in service (2000 gpm each pump).

Pump P-4701-A is motor driven with automatic start and P-4701-B is supplied with a diesel driver also with automatic start on high water demand or should P-4701-A fail to start. Fire water header design pressure is 150 psig. A jockey pump, P-4702, will automatically maintain the fire water distribution system at 50 psig. The pumps will conform to NFPA-20 regulations.

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General Facilities

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2.

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LOCATION: Memphis, Tennessee

DATE _____

7/13/79

[illegible]