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SYNTHANE PILOT PLANT, SOUTH PARK TOWNSHIP, PENNSYLVANIA

Final Report

Work Performed Under Contract No. EY-76-C-02-0003

C-E Lummus
Bloomfield, New Jersey

U. S. DEPARTMENT OF ENERGY

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SYNTHANE PILOT PLANT
SOUTH PARK TOWNSHIP, PENNSYLVANIA

FINAL REPORT

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BLOOMFIELD, NEW JERSEY

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TABLE OF CONTENTS

SUMMARY

- I. INTRODUCTION
- II. CHRONOLOGICAL HISTORY OF THE SYNTHANE PILOT PLANT
- III. OPERATING HISTORY OF THE SYNTHANE PILOT PLANT
- IV. TECHNICAL REPORT
- V. ENGINEERING REPORT
- VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT
- VII. ENVIRONMENTAL REPORT

APPENDICES

SUMMARY

The Synthane pilot plant was operated by the Lummus Company for the U.S. Department of Energy during the period 1975-1978 to test the feasibility of the Synthane process to produce pipeline quality gas from coal. The Synthane process was developed by the U.S. Bureau of Mines at Bruceton, Pa., now the Pittsburgh Energy Technical Center. The aim of the Synthane process was to gasify both caking and noncaking coals at high pressure and to maximize the methane concentration during the gasification step. The Bruceton pilot plant was designed and constructed following the completion of bench scale tests conducted by the Bureau of Mines. Construction was completed in 1975, and preliminary operations and shakedown of the pilot plant were carried out from completion of construction through mid 1976.

Coal gasification began in July, 1976, and continued intermittently through August, 1978. During its first year of operation, the Synthane pilot plant was used to test the Synthane process with Montana Rosebud, a noncaking sub-bituminous coal. A major modification of the initial operating mode was made in January, 1977, by changing the coal feed mechanism from free fall to a deep bed injection method. In August, 1977, the tests with Rosebud coal were completed with an extended run and yielded the following results:

1. The plant was operated and produced gas for a total of 556 hours processing 1304 tons of Montana Rosebud coal.
2. An extended uninterrupted run of 97 hours was achieved.
3. Carbon conversion up to 80% was obtained, considerably in excess of the 67% goal set by the operating directives of the DOE.

From September, 1977, through August, 1978, the Bruceton pilot plant was operated to demonstrate the gasification of a caking coal using Illinois No. 6, a bituminous coal. To gasify caking coals, the Synthane process employs a continuous inline pretreatment step at gasifier operating pressure directly ahead of gasification. This sequential operation has the advantage of retaining all hydrocarbons and volatile matter liberated during pretreatment in the product stream. In August, 1978, the sequential steps of pretreatment and gasification were accomplished after a satisfactory 7-day run was conducted with Illinois No. 6 coal. In summary, it was demonstrated that the Synthane process has the following characteristics:

1. A unique system for pretreating and gasifying various types of coals under conditions that maximize the methane concentration in the product gas at a pressure of 600 psig.
2. A dry coal feed system which is thermally more efficient than slurry coal feed systems.
3. A fluidized bed gasifier which does not contain any moving parts and can easily be scaled to a wide range of capacities.
4. The coal size used in the process minimizes or avoids the problem of the disposal of coal fines.
5. The Synthane process does not produce any liquid hydrocarbon byproducts which simplifies the gas treating steps and enhances the environmental aspects of coal gasification.
6. A process that produces a water condensate which is remarkably free of tars and phenols so that it can be treated for reuse thus reducing net rain water consumption and eliminating the potential hazards involved in the disposal of contaminated water.

7. A process that generates a high temperature gas stream that could be suitable for steam generation at various pressure levels to improve the overall thermal efficiency of coal gasification.

8. The Synthane process generates a product gas (on a dry, CO_2 and inert gas free basis) has a heating value of about 450 BTU/SCF. The composition of this gas makes it suitable as a feedstock for a variety of processes such as methanol, ammonia, and indirect coal liquefaction through the application of Fischer-Tropsch technology. The gas can be upgraded to pipeline quality with a heating value in excess of 950 BTU/SCF by means of a methanation step.

The operations of the Synthane pilot plant identified a number of specific process and equipment problems which remain to be resolved. The most important of these are the following:

1. Clinker formation

The formation of clinkers in the fluidized bed near the oxygen injection nozzles of the gasifier was the most significant and the most frequent limitation in achieving extended runs at the pilot plant. An analysis of the operation suggests that this clinker formation is a function of the oxygen concentration in the bed and more specifically at the point where oxygen is introduced to the bed. Plans were formulated to modify the oxygen addition system to control this problem but could not be tested as the plant was shut down by directive of the Department of Energy.

2. Carbon conversion

A basic component of the Synthane process as developed by the Bureau of Mines was that about 67% of the carbon in the coal was to be converted into the process gas, the remainder to be discharged as a char. In the pilot

2. Carbon conversion - cont'd

plant, carbon conversion from about 50% to about 80% were achieved. The process thus requires an efficient use of the char byproduct either as a fuel for direct combustion or for further gasification by means of a different process. It has been estimated that a carbon conversion in excess of 80% is necessary for an SNG plant to completely use the produced char within a plant of this configuration.

3. Char discharge

The Synthane pilot plant was operated in a manner which discharged the char from the gasifier into a cooler and from this vessel into a slurry tank. To make potential use of the char, it is necessary to develop a system under which the char can be recovered in a dry and preferably hot state. A system to demonstrate this approach for char disposal has been proposed but has not been tested.

The operations of the Synthane pilot plant were suspended in September, 1978. The unit has been mothballed and is presently being maintained in a standby mode ready for reactivation. At the time of its shutdown, the pilot plant had a total staff of 214, including administration, plant management, operations, engineering and technical departments and contract maintenance.

I. INTRODUCTION

The Final Report of the operation of the Synthane Pilot Plant represents a summary of various aspects of this project. It contains reports which cover the operation, technical evaluation, and engineering for the period 1976-1978. Additional data on the operation of the Synthane Pilot Plant have previously been recorded in various run reports submitted to the Department of Energy and are available from the National Technical Information Services (NTIS). This Final Report includes an appendix which supplements the individual sections and an index to the library that is part of the Synthane Pilot Plant in Bruceton, Pa. where all documents prepared for the design, engineering, and operation of this facility are filed.

II. CHRONOLOGICAL HISTORY OF THE SYNTHANE PILOT PLANT

The United States Bureau of Mines in Bruceton, Pennsylvania, now the Pittsburgh Energy Technology Center (P.E.T.C.) of the United States Department of Energy, began coal gasification experiments and studies in 1952 in a 4-inch bench scale reactor. This initial work was essentially completed in 1965.

Towards the end of the 1960's work proceeded to a point where it was decided that a program should be developed to design and build a pilot plant to test the Synthane Process. In June 1970 a contract (SO-101247) was awarded to the M.W. Kellogg Co. for a study to determine if the developed data were adequate to design a pilot plant. The study concluded that further testing of the gasification phase was required.

During December 1970 and July 1971 contracts (SO-110578 and HO-111934) were awarded to Hydrocarbon Research, Inc. under which a 26-inch diameter reactor of HRI's Trenton, N.J. facilities would be tested. Contract SO-110578 was let to prepare a cost estimate for the modification of HRI's gasifier in Trenton, New Jersey. Contract HO-111934 was let for the actual modification and operation of HRI's gasifier. A report dated April 19, 1973 was issued by HRI covering the operation of their 11 ton/day Fluid Bed Gasifier using the Synthane Process.

In June 1971 the Lummus Co. was awarded Contract E(36-2)-0050 for the process design of a 3 ton/hour coal gasification plant using the Synthane Process. Such a plant was to include the following facilities:

II. CHRONOLOGICAL HISTORY OF THE SYNTHANE PILOT PLANT - cont'd

- (a) Raw Coal Unloading and Storage
- (b) Raw Coal Crushing, Drying, and Dry Coal Storage
- (c) Dry Coal Feeding
- (d) Coal Pretreatment, Gasification, and Char Cooling
- (e) Char Filtration and Disposal
- (f) Gas Clean-up and Condensate Handling
- (g) Shift Converter
- (h) CO₂ and Sulfur Removal
- (i) Methanation
- (j) Auxiliary Facilities

The facilities were designed to test coal gasification at pressures up to 1000 psig.

In November 1972 the Rust Engineering Company was awarded Contract E(36-2)-0001 to construct a 72 tons per day Synthane Process Pilot Plant at Bruceton, Pennsylvania.

In August, 1974 The Lummus Co. was awarded Contract E(36-2)-003 to operate the Bruceton pilot plant and to demonstrate the Synthane Process feasibility for commercialization.

A listing of the various operating contracts is provided below. Test Directives and design bases for these contracts are in Appendix A.

II. CHRONOLOGICAL HISTORY OF THE SYNTHANE PILOT PLANT - cont'd

Contracts

- (a) United States Bureau of Mines Contract HO-356020 provided for operating the pilot plant from August 1, 1974 to July 31, 1975.
- (b) Contract HO-356020 was assigned to the Energy Research and Development Administration (ERDA) of the United States Government January 20, 1975 and redesignated E(36-2)-003 May 1, 1975.
- (c) A letter contract was issued to cover the period August 1, 1975 to April 12, 1976.
- (d) The Lummus Co. and ERDA executed modifications to continue the contract to September 30, 1978.
- (e) On October 1, 1977 the contract changed from ERDA to the Department of Energy (D.O.E.).
- (f) Contract extensions were executed from:
 - 1) September 30, 1973 to October 15, 1978
 - 2) October 15, 1978 to November 24, 1978
- (g) Terms, conditions and funds for a two year contract extension (October 16, 1978 thru September 30, 1980) were agreed upon on October 25, 1978 by D.O.E. and the Lummus Co.
- (h) A letter dated November 27, 1978 from D.O.E. was received stating that the plant was to be closed down in an orderly fashion by January 31, 1979. The letter requested that a proposal be prepared for maintaining the plant on a standby basis for two years beginning February 1, 1979.

II. CHRONOLOGICAL HISTORY OF THE SYNTHANE PILOT PLANT - cont'd

Between August, 1974, and November, 1974, administrative, technical and operating personnel were assembled at the pilot plant. Since most of the operating staff were inexperienced, an extensive training program was started under the direction of a Lummus training specialist and with the supervisory and technical staff at the site. Classroom instruction were conducted by the shift supervisor using the P&I drawings and operating manuals prepared by Lummus as study material. The trainees were used to check out the completed piping and equipment and enabled the future operators to become familiar with each line, each valve, and each unit. Instruction was supplemented by training films and program courses offered by DuPont and the American Petroleum Institute. The training program emphasized safety and fire protection using fire fighting crews and first aid squads. Each supervisor and operator had to attend a trained program conducted by the Red Cross in the area.

In November, 1974, shift work was initiated, and by the end of that month a number of utilities had been commissioned.

The construction of the pilot plant was originally scheduled for completion in July, 1974, but this goal was not achieved until mid March, 1975. During this last phase of construction, the operating contractor could not proceed with pre-operational checks, and this phase of the startup was delayed until March, 1975.

During the checkout and testing of the gasifier, it was found that this reactor had to be internally insulated and that a leak had to be repaired. The pre-operational checkout revealed that a significant amount of off-specification piping in the high pressure steam system around the gasifier. The repair and modification extended the construction period

II. CHRONOLOGICAL HISTORY OF THE SYNTHANE PILOT PLANT - cont'd

to early 1976. Cold fluidization tests were conducted with Rosebud coal in the gasifier. During these tests, the internal head of the gasifier was damaged. Following the repair of the internal head, rupture disks were installed, and various gasifier alarm and shutdown circuits were installed to ensure the mechanical integrity of the gasifier. These steps delayed the start of gasification to early July. The highlights of the startup and operations of the pilot plant are graphically illustrated on Figure 1 and Figure 2 and also presented on Table 1. Both the planned programs and the actual achievements of the operations are shown. The significant dates of the operations conducted at the Synthane pilot plant are the following:

- July, 1976 - First gasification of Rosebud coal - Free fall mode
- January, 1977 - Phase one completed with Run 1T reaching an operating period of 37 hours
- February, 1977 - First gasification with deep bed injection
- August, 1977 - Run 1DB-0 completed showing successful gasification of Rosebud coal using deep bed injection - 10-day operating period totaling 201 hours
- September, 1977 - start of operation with Illinois No. 6 caking coal
- August, 1978 - Run 2 DB-0 completed showing that Illinois No. 6 coal can be successfully pretreated and gasified in the Synthane process. Operating period of 7 days achieved totaling 173 hours

II. CHRONOLOGICAL HISTORY OF THE SYNTHANE PILOT PLANT - cont'd

November, 1978 - notification by DOE that Synthane
pilot plant is to be shut down
in January, 1979

February 1, 1979 - Synthane pilot plant shut down
and placed in stand-by condition

TABLE 1
Schedule Of Unfinished Programs

Run No.	Type of Coal	Duration of Run	Rate (tons/hr)	% Carbon Conversion	Bed Height (FT)	Temperature (°F)	Pressure (PSIG)	Remarks
2-DB	Illinois No. 6	Sept. 1978 - May 15, 1979	2	65 - 80	20	1650-1750	600	Achieve 5 to 7 day feasibility run using pretreater. Bring Benfield & Stretford on line.
3-DB	Illinois No. 6	May 16, 1979 Oct. 30, 1979	2	65 - 70	20	1650-1700	300	Repeat Run No. 2-DB at 300 psig. Operate Benfield and Stretford.
4-DB	Pittsburgh	Nov. 1, 1979 Mar. 30, 1980	2	65 - 70	10	1650-1700	600	Run all downstream equipment up to methanation.
5-DB	Eastern Coal	Apr. 1, 1980 Sept. 30, 1980	3	65 - 70	10	1650-1700	1000	Run all downstream equipment including methanators.

Additionally, mechanical changes to the way oxygen is added to the fluid bed, and a change in the location of the coal feed line to the bottom of the bed were planned. These changes could eliminate clinkers and reduce the quantity of steam required in the gasifier.

SCHEDULE

I PLANT OPERATION

A. PREPARATION & TRAINING

POLICY & RECRUITING
OPERATOR TRAINING

START UP UTILITIES
START UP COAL GRINDING

B. PLANT SHUTDOWN

C. START UP OPERATION RUN NUMBER

NO. 1

NO. 2

NO. 3

NO. 4

NO. 5

NO. 6

NO. 7

D. TECH. ECO. EVALUATION

E. SHUT DOWN

F. MAJOR DELAYS

II CONTRACT

III. OPERATING HISTORY OF THE SYNTHANE PILOT PLANT

Operation of the Synthane pilot plant began in 1976 following completion of construction, pressure testing, and various commissioning activities carried out to check the various systems before beginning the actual gasification tests.

The construction of the pilot plant was scheduled for completion in July, 1974, but was actually achieved in mid-1975. In late 1974 and early 1975, the operating contractor assembled the management and operating staff for the pilot plant and carried out training programs to familiarize the operators with the components of the pilot plant. Operators, with little or no experience in chemical plant operations, were hired from local areas.

During the checkout and review of the pilot plant facilities, various segments of the plant were found to be inadequately constructed. For example, the piping of the high pressure steam system around the gasifier was incomplete. Repair of these facilities took several months during which cold coal fluidization tests were conducted in the gasifier to determine flow rate characteristics. During this operation, the internal head of the gasifier was damaged. A series of rupture discs were then installed to prevent further damage to the internal head. It was also found necessary to modify some of the instrumentation around the gasifier. The repairs and modifications to the plant were completed in June, 1976.

III. OPERATING HISTORY OF THE SYNTHANE PILOT PLANT - cont'd

The operations of the Synthane pilot plant were conducted in accordance with test directives issued by the Department of Energy. During the period June, 1976 through August, 1978, DOE issued three test directives to provide guidance in the development of the Synthane process.

Test directive No. 1 was issued in June, 1976, and specified that Rosebud coal was to be gasified at 600 psi and that a carbon conversion of 67% was to be achieved. Since Rosebud coal is a noncaking coal, the gasifier was to be operated without the pretreater and in a free fall mode with the coal feed line terminating in the upper portion of the gasifier above the fluidized bed. Downstream processing equipment including the Benfield, shift conversion, Stretford, and methanation units were to be bypassed. In February, 1977, Test Directive No. 1-DB was issued which required that the gasifier be operated with Montana Rosebud coal and that a carbon conversion of 70% or better be achieved. In addition, the gasifier was to be operated in the deep bed injection mode which required that the coal feed line be terminated several feet into the fluidized bed. In September, 1977, DOE issued the third test directive, Test Directive No. 2-DB, which specified that Illinois No. 6 coal was to be pretreated and gasified. The program required that the operation of the pretreater be tested before attempting gasification, as only limited pretreatment data was available from the bench scale tests conducted in previous years at the Bureau of Mines.

A record of the operations covering these periods follows.

III. OPERATING HISTORY OF THE SYNTHANE PILOT PLANT - cont'd

A. Operation Under Test Directive No. 1

The gasifier program for Test Directive No. 1 began on July 7, 1976 and was concluded on December 20, 1976. During this period, the plant produced gas for a period of 228 hours processing 709 tons of coal. A summary of the plant operation through this period is provided below:

<u>Date</u>	<u>Run No.</u>	<u>Duration, hrs.</u>	<u>Reason for Curtailment</u>
7/7/76	1-A	1.8	Instrument problems
7/8/76	1-B	6.5	Low CO ₂ capacity
7/19/76	1-C	10.5	Plugged line FA-403
7/20/76	1-D	14.5	Overgasified bed
8/11/76	1-E	2.5	Poor pressure control
8/12/76	1-F	8	No coal in primary injector
8/13/76	1-G	5	Plugged line FA-403
8/14/76	1-H	2	Plugged standpipe to char cooler
8/15/76	1-I	5	Plugged line FA-403
8/16/76	1-J	7	Boiler outage
9/15/76	1-K	4	Plugged standpipe to char cooler
9/30/76	1-L	4.5	Plugged standpipe to char cooler
10/10/76	1-M	17	No char removal, clinker in gasifier
10/29/76	1-N	11	Plugged line to filter area
10/30/76	1-O	19	No coal feed, wet coal
10/31/76	1-P	22	O ₂ pump shutdown
11/19/76	1-Q	16.7	Plugged standpipe to char cooler
11/20/76	1-R	6.6	PCV-338 failure, blown RD
11/21/76	1-R	7.7	Low CO ₂ capacity
11/22/76	1-S	19.5	Gasifier outlet plugged
12/20/76	1-T	37	PCV-2205, bypass leak

The plant achieved a continuous operating period of 37 hours with coal and oxygen feed during Run 1-T in December of 1976.

III. OPERATING HISTORY OF THE SYNTHANE PILOT PLANT - cont'd

B. Operation Under Test Directive No. 1-DB

The plant operated under Test Directive No. 1-DB from February 23 to August 16, 1977 during which time 1304 tons of Montana Rosebud coal were gasified. During this period, oxygen and coal were fed to the gasifier for more than 550 hours. Continuous operations of up to 97 hours and carbon conversions of up to 78% were achieved. The operations were carried out at a pressure of 600 psig, temperatures ranging from 1300°F to 1550°F, and coal feed rates of 1.5 to 3.0 tons per hour. The deep bed injection procedure produced little tar, phenols, or oils. Fouling of the gas scrubbing system was reduced when compared to previous runs using free fall injection of coal feed into the gasifier. The pre-treater was placed in service for run 1-DB-0.

A summary of the run 1-DB is shown as follows.

Run Series 1-DB

Run No. 1-DB	<u>Run Duration</u>		Date 1977	<u>Periods of Continuous Operation</u>	
	<u>Operation (Hours)</u>	<u>Elapsed* Time (Hours)</u>		<u>Duration (Hours)</u>	<u>Reason for Curtailment</u>
A	13		Feb. 23/24	13	Hole in char cooler steam vent line
B	48	74	Feb. 24/25	23	Char slurry line plugged
			Feb. 25/26	25	Leaking of skimming valves in scrubber surge drum
C	23		Feb. 27	4	Plug in char cooler standpipe
C/D		53	Feb. 27/ March 1	41	Circuit breaker trip
D	28		March 1	6	Plug in char cooler standpipe, clinker
E	18		March 15/16	8	Char slurry circul- ating pump problems
		27	March 16	7	Low bed density
			March 16	3	Low bed density, clinker, H.P. steam line failure
F	13		March 22	3	Char slurry recycle water pump down
		15	March 22	10	Plug in char cooler standpipe, clinker
G	7.5		March 31	7.5	Char slurry line plugged
H	35.5		April 1/2	35.5	Plug in char cooler standpipe

126

*Operation plus outages

Run Series 1-DB

(continued)

<u>Run Duration</u>			<u>Periods of Continuous Operation</u>		
<u>Run No.</u> <u>1-DB</u>	<u>Operation</u> <u>(Hours)</u>	<u>Elapsed*</u> <u>Time</u> <u>(Hours)</u>	<u>Date</u> <u>1977</u>	<u>Duration</u> <u>(Hours)</u>	<u>Reason for Curtailment</u>
I	13		April 2/3	13	Plug in char cooler standpipe
J	17		April 3/4	8.5	Char slurry line plugged
			April 4	5	Erratic temperature readings, instrument problems
			April 5	3.5	Plug in char cooler standpipe, clinker
K	15	18	April 15/16	15	Plug in char cooler standpipe, clinker
L	16		April 27/28	9	Char slurry recycle water pump down
		19	April 28	7	Plug in char cooler standpipe, clinker
M	26.5	31	May 16/17	26.5	Char slurry line plugged
N	85.5		May 20	6	Coal transport line plugged
			May 21/22	10	Char slurry recycle water pump down
			May 22/23	7.5	Char slurry line plugged
			May 23	6.5	External power failure
		174	May 24/25	16.5	Char slurry recycle water pump problems
			May 25/26	17	Low CO ₂ header pressure

(cont'd)

Run Series 1-DB

(continued)

<u>Run Duration</u>			<u>Periods of Continuous Operation</u>		
<u>Run No.</u>	<u>Operation</u>	<u>Elapsed*</u>	<u>Date</u>	<u>Duration</u>	<u>Reason for Curtailment</u>
<u>1-DB</u>	<u>(Hours)</u>	<u>(Hours)</u>	<u>1977</u>	<u>(Hours)</u>	
O	197.5	266	May 26	5	Nut in Petrocarb primary outlet valve
			May 27	6.5	Plug in char cooler standpipe
			May 27	4	Petrocarb problems
			May 27	6.5	Gasifier nozzle leak
			Aug. 5	2.5	Pretreater temperature trip
			Aug. 6-9	46*	Rupture disc failure
			Aug. 9-13	97	Low CO ₂ header pressure
			Aug. 14	5	Char slurry recycle water pump down
			Aug. 14-16	47	Plug in char cooler standpipe, clinker
	556.5	803		556.5	

*Ten outages occurred during this period due to repeated rupture disc failure. In some instances the outages were longer than the maximum 30 minutes allowed by the definition of a continuous operation period.

III. OPERATING HISTORY OF THE SYNTHANE PILOT PLANT

C. Operation Under Test Directive 2-DB, Pretreater Only

After successful completion of the gasification studies on Rosebud coal on August 17, the plant remained down until September 13 to prepare for the gasification of Illinois No. 6 coal, a medium sulphur, mildly caking coal.

After six additional hammers were installed in the grinding mill, the coal grinding system was tested using Illinois No. 6 coal to ensure design rates, a specific particle size, and desired moisture content. The initial grinding tests proved to be satisfactory.

PERC provided Test Directive 2-DB for Illinois No. 6 coal which specified the conditions for pretreatment and gasification. The program required that the operation of the pretreater be tested before attempting gasification. On September 13, 1977 pretreater tests were started and continued until February 5, 1978. During this time span seventeen tests were made. The most successful method of start-up for the pretreater consisted of two basic steps: Preheat of the empty vessel to 700°F, and commencement of continuous coal and oxygen via superheated steam transport. Sustained operation was obtained during run 2-DB-F using an operating temperature range of 750°F to 800°F with a superficial velocity through the vessel of approximately 1.0 FPS. Oxygen feed was injected into the transport line rather than the pretreater vessel.

III. OPERATING HISTORY OF THE SYNTHANE PILOT PLANT

C. Operation Under Test Directive 2-DB, Pretreater Only - cont'd

<u>Date</u> <u>1977</u>	<u>Run No.</u> <u>2-DB</u>	<u>Duration, hrs.</u> <u>Pretreater</u>	<u>Reason for</u> <u>Curtailment</u>
9/13	A-1	0.25	Agglomeration in pretreater
9/26	A-2	0.5	Agglomeration in pretreater
9/28	A-3	0.3	Agglomeration in pretreater
9/30	A-4	1.2	Agglomeration in pretreater
10/25	B-1	1.5	Agglomeration in pretreater
10/29	B-2	1.25	Agglomeration in pretreater
10/31	B-3	1.5	Petrocarb outlet plugged
11/9	C-1	0.2	Lost CO ₂ compressor
11/11	C-2	2	Agglomeration in pretreater
12/3	D-1	8	Agglomeration in pretreater
12/9	D-2	2.5	Agglomeration in pretreater due to loss on O ₂ header pressure
12/13	D-3	36	Agglomerated gasifier
12/30	E-1	6	Char cooler standpipe plugged
1/20	E-1	0.8	Char cooler standpipe plugged
2/3	F-1	2.9	Coal feed Venturi plugged
2/4	F-2	1	Coal feed Venturi plugged
2/5	F-3	<u>13.6</u>	Leak in line on gasifier RD pip
Total		79.25	

III. OPERATING HISTORY OF THE SYNTHANE PILOT PLANT - cont'd

D. Operation Under Test Directive 2-DB: Pretreater and Gasifier

The objective of the test 2-DB was to conduct a gasification feasibility run of 5 to 7 days operation at 600 psig with at least 67% carbon conversion using Illinois No. 6 bituminous coal at a feed rate of 1.8 tons per hour. Operational tests on the continuous inline pretreater began in September, 1977. Through August, 1978, a total of 49 test runs were made. In 14 of these, the gasifier was operated. Approximately 30% of these test runs failed due to external causes or process-unrelated equipment failures. The remaining 70% failed due to agglomeration of coal in the pretreater or clinkering in the gasifier.

In August, 1978, considerable success was achieved with the first demonstration of continuous pretreatment and gasification for an extended period of time in the integrated system that is one of the unique features of the SYNTHANE Pilot Plant. Between August 22 and August 29, 1978, approximately 240 tons of coal were fed to the gasification unit for 124 hours during a 173-hour period at rates of 1-1/2 to 2 tons per hour for an online percentage of 72%. Since the main objective of this run (2-DB-0) was to obtain operating experience, gasifier bed temperatures were held below 1500°F, resulting in lower than design carbon conversions.

The run was terminated due to the inability to remove char from the gasifier. Subsequent inspection revealed the presence of several small agglomerates in the pretreater which did not affect its operation. A large clinker was found in the gasifier above the new steam-oxygen sparger.

III. OPERATING HISTORY OF THE SYNTHANE PILOT PLANT

D. Operating Under Test Directive 2-DB Pretreater and Gasifier - cont'd

<u>Date</u> <u>1978</u>	<u>Run No.</u> <u>2-DB</u>	<u>Duration, hrs.</u>		<u>Reason for</u> <u>Curtailment</u>
		<u>Pretreater</u>	<u>Gasifier</u>	
3/26	G-1	5.5		Petrocarb Vessel Empty
3/26	G-2	4.5		Flange Leak In Gas Scrubbing
3/27	G-3	3		Flange Leak In Gas Scrubbing
4/2	G-4	3		Coal Feed Line Plugged
4/6	G-5	17.5	5.5	Char Slurry Lines Plugged
4/8	G-6	8.5	5.5	Char Cooler Standpipe Plugged
4/20	H-1	5.0	1.0	Leak in Pretreater Overflow Li
4/26	H-2	11.5	2.5	Char Cooler Standpipe Plugged
5/9	I-1	.5	0	Agglomerated Pretreater
5/17	I-2	5.1	0	Leak in Char Mix Tee
5/19	I-3	5.3	0	Agglomerated Pretreater
5/21	I-4	1.3	0	Plugged Coal Feed Venturi
5/23	I-5	2.3	0	Agglomerated Pretreater and Coal Transport Line
5/28	I-6	7.8	1.8	Agglomerated Pretreater and Gasifier
4/12	J-1	3.5	0	Plugged Coal Feed Venturi
6/17	J-2	9.2	0	Agglomerated Pretreater
6/19	J-3	12.4	7.6	Plugged Char Cooler Standpipe
7/4	K-1	2.5	0	Wet Coal in Petrocarb

III. OPERATING HISTORY OF THE SYNTHANE PILOT PLANT

D. Operating Under Test Directive 2-DB Pretreater and Gasifier - cont'd

<u>Date</u> <u>1978</u>	<u>Run No.</u> <u>2-DB</u>	<u>Duration, hrs.</u>		<u>Reason for</u> <u>Curtailment</u>
		<u>Pretreater</u>	<u>Gasifier</u>	
7/11	K-2	14.25	11.25	Poor Coal Feed and Pressure Upset in Petrocarb System
7/20	L-1	.7	0	Low CO ₂ Supply
7/21	L-2	6.7	0	Agglomerated Pretreater
7/23	L-3	6.7	0	Agglomerated Pretreater
7/27	M-1	11.75	10.6	Plugged Coal Feed Line
7/31	M-2	13.25	11.25	Loss of Gas Scrubbing Circulation
8/9	N-1	11.2	0	Agglomerated Pretreater
8/12	N-2	26.0	0	Agglomerated Pretreater
8/15	N-3	8.0	0	Agglomerated Pretreater
8/22	O-1	55.8	50.4	Leak In 3" Coal Lift Line
8/25	O-2A	7.6	6.9	Loss of Coal Feed
8/25	O-2B	28.6	25.5	Loss of Coal Feed
8/27	O-2C	30.45	30.45	Loss of Coal Feed
8/29	O-3	11.6	11.6	Hole in Char Life Line
	Totals	341	181.85	

III. OPERATING HISTORY OF THE SYNTHANE PILOT PLANT

E. Operating Problems

During the two years of operation of the Synthane Pilot Plant, a series of problems developed, as expected of any new technology and pilot operation. These problems are broken down into two categories:

- 1) problems typical of the coal gasification aspect of the synthane process, and
- 2) problems typical of coal handling operations involving two phase flow.

The various areas in which equipment failures took place, the specific problems interfering with operation, and modifications made to resolve the problems or reduce their impact are listed on Table III-1. A more detailed discussion of the individual operating problems can be found in the Engineering Report, Section V.

In analyzing the problems encountered with specific equipment, it is important to point out that various novel techniques and systems were incorporated in the Synthane Pilot Plant. A specific example is the method selected for conveying the coal from its storage at atmospheric pressure to the pre-treater and/or gasifier operating at 600 PSIG. The system is considered to be the first of its kind at the time that attempted to use a coal feed system in the dry state operating under this differential pressure.

Problems encountered in the operation which are considered to be typical of coal handling equipment included the following:

III. OPERATING HISTORY OF THE SYNTHANE PILOT PLANT

E. Operating Problems - cont'd

- 1) erosion of piping, valves, and pumps
- 2) corrosion of piping, valves, pumps, and vessels
- 3) plugging of piping, valves, and vessels.

All areas of operation in the plant were subject to the potential for damage from these causes. In general, the reliability and continuity were maintained by taking corrective measures such as the redesign of piping, the refacing of pump casings, change of valve trim, etc. A summary is given in Table III-1.

Problems specific to the features of Synthane Process include the following:

1. Clinkering of coal ash during gasification.
2. Difficult in operation of an internal cyclone during gasification.
3. Operation of the pretreater to modify the caking tendencies of some coals.
4. High pressure letdown of the (hot, dry, or slurry) char stream.
5. Flow control and measurement of a dry, continuous high pressure coal feed system.
6. Control of tar and phenol production during gasification.
7. Level control and measurement of a high temperature, high pressure fluidized coal bed.

III. OPERATING HISTORY OF THE SYNTHANE PILOT PLANT

E. Operating Problems - cont'd

Definitive solutions to many of these problems were achieved, but the unexpected early shutdown of the pilot plant prevented the implementation of programs that promised to be more effective. Discussion of these problems and the approaches taken to their solution can be found in the Technical Report, Section IV.

An example of the successful solution of a problem in clinker control was achieved with Rosebud Coal by using the pretreater as a preheater which allowed the temperature in the gasifier to be maintained below a critical point while achieving a reasonable carbon conversion. When gasifying Illinois #6, the technique of operating the pretreater had to be gradually developed and modified. This modification involved specific changes to the pretreater configuration and the oxygen/steam/coal flow patterns. The result was that the FSI of caking Illinois #6 coal was reduced to less than 0.5. The caking tendency was thereby destroyed, allowing gasification to proceed without agglomeration.

F. Future Operations

The Standard Operating Procedures (SOP) book and the technical test direction for gasifier operations are updated for use during future plant operations. One copy of this document is located in the library and one is in storage in Philadelphia.

G. Standby Operations

A Standard Operating Procedures book for standby operation was written and copies are located in the library, in the operating supervisor's office, and in the Utility Control Room.

Table III-I

OPERATING PROBLEMS AND MODIFICATIONS

<u>Area-Equipment</u>	<u>Problem</u>	<u>Modification</u>
<u>Coal Preparation and Handling</u>		
Raw Coal Bucket Elevator	Plugging of chute with lumps of coal.	Changed angle of chute.
Raw Coal Storage Bin	Freezing of coal during storage.	Added steam panels to bin.
Drying Air Heater	Unreliable start-up. Excessively high flue gas temperature. Insufficient firing rate turn-down ratio. Refractory erosion by coal fines entrained in recycle flue gas.	Changed pilot fuel from No. 2 oil to propane. Added water quench nozzles in discharge duct. Installed smaller nozzles in main burner. Adjusted louver angle.
Drying Mill	Coal fines in main shaft bearings. Plugging of star feeder.	Modified bearing and mill seals. Removed star feeder.
Vibrating Screen Rotary Feeder	Leakage of air into cyclone.	Added teflon strips to steel rotor blade edges to improve seal.
Vibrating Screen	Deterioration of rubber support wedges.	Replaced rubber support wedges.
Drying System Fan	Fan blades eroded and bent.	Rebuilt fan blades and modified casing drain.
Dust Collector	Explosion panels ruptured during back-blowing of bags. Plugging of discharge screw conveyor with foreign matter. Condensation during start-up.	Replaced panels with different manufacture. Modified snap-blow sequence - eliminated blowing when isolation valves were closed. Installed grating over screw conveyor.
Pulverized Coal Storage Bin	Condensation in bin.	Installed steam heating panels. Decommissioned steam tracing.
Weigh Hopper	Plugging of feed system with lumps of coal.	Installed screen in discharge.
Instruments	Plugging of pressure sensors with coal Unreliable level probes. Erratic and inconsistent weight load cell readings. Erratic weight totalizer readings.	Cleared lines periodically with blast purges. Replaced paddle and capacitance type with nuclear detectors. Adjusted sensitivity and revised piping and vessel supports. Added electronic noise suppressors.

Table III-I - (cont'd)

<u>Area-Equipment</u>	<u>Problem</u>	<u>Modification</u>
<u>Coal Preparation and Handling - cont'd</u>		
Piping and Valves	Broken valve stems due to excessive torque. Leakage due to coal fines hampering ball movement.	Reduced actuator closure speed. Proposed a modification of EBV valve internals.
	Failure of piston-type check valves to seal. Erosion of 1" high pressure coal transport line.	Replaced EBV valve with Grove Flex Flow valve. Replaced with disc-type from Technocheck Company. Studied through use of a special instrumentated line supplied by Argonne National Laboratories.
Material	Raw coal bucket elevator chain failed due to corrosion.	Purge gas generator feed changed from sulfur-containing #2 fuel oil to propane. Pure CO ₂ used as alternate purge gas. Replaced 440 S/S with 316 S/S steel.
	EBV valves in coal handling service showed erosion of the balls.	Experimented with various coating on the ball surface.
<u>Pretreatment and Gasification</u>		
Pretreater	Agglomeration of caking coal during attempted pretreatment.	Installed an oxygen/steam distribution cone in bottom head. Changed the coal feed nozzle from a vertical bottom head location to a side nozzle with internal downward discharge. Modified the external electric tracing to allow for higher temperature. Installed additional instrumentation. Changed the coal feed nozzle back to the vertical bottom head location and installed a diverter baffle in the distribution cone.

Table III-I - (cont'd)

<u>Area-Equipment</u>	<u>Problem</u>	<u>Modification</u>
<u>Pretreatment and Gasification - cont'd</u>		
Gasifier	<p>Flanged joints of gasifier shell leaked during initial pressure test.</p> <p>Internal head between the plenum and char cooler buckled.</p> <p>Internal shroud above the cone buckled.</p> <p>Upper shroud section buckled.</p> <p>Cracks developed in manway shroud.</p> <p>Eroded tail-piece of the internal cyclone.</p> <p>Eroded the 2" coal feed injection pipe.</p>	<p>Gasket ring plates rewelded to the vessel at the inner edges and seal welded at the outer edges.</p> <p>Reinforced the head with braces.</p> <p>Installed two pressure equalization rupture discs.</p> <p>Replaced the damaged sections.</p> <p>No corrective action.</p> <p>Stopped propagation by drilling of holes at the ends of the cracks.</p> <p>Fabricated and installed a new cyclone.</p> <p>Replaced the 2" pipe with a 3" pipe.</p>
Instruments	<p>Failure of thermocouples inside gasifier.</p> <p>Unsatisfactory performance of differential pressure cells.</p> <p>Premature rupture disc failure.</p>	<p>Removed thermocouples from the reaction zone.</p> <p>Revised inert gas purges to prevent the collection of water and coal fines in the sensing lines.</p> <p>Rebuilt disc holders.</p>
Piping and Valves	<p>Failure of isolation valves between pretreater and gasifier.</p> <p>Leakage of the bonnet flange and erosion of the seat and gate of the char cooler slide gate char flow control valve.</p> <p>Erosion of the char cooler steam let-down valve.</p> <p>Erosion of the char cooler steam vent piping.</p> <p>Eroded a 1" elbow on the char cooler steam let-down valve bypass.</p>	<p>Tested several valve types.</p> <p>Redesigned the bonnet flange for 1190 psig, 625°F.</p> <p>Rebuilt the gate and seat. Recoated the gate and seat with Stellite #6.</p> <p>Replaced Stellite #6 trim coating with tungsten carbide coating. Revised the plug attachment design.</p> <p>Eliminated an elbow at the let-down valve discharge.</p> <p>Replaced the elbow with a capped tee.</p>

Table III-I - (cont'd)

<u>Area-Equipment</u>	<u>Problem</u>	<u>Modification</u>
<u>Pretreatment and Gasification</u> - cont'd		
Piping and Valves - cont'd	Erosion of the transfer line between the pre-treater and gasifier. Erosion of the char lift line from the char cooler to the h.p. slurry tank.	Changed the line to 3" and installed a capped extension in the bend. Replaced mixing cross and piping with 304 S/S. Changed fittings from socket weld to butt weld.
Materials	Sulfidation of Inconel 600 pipes inside the gasifier. Stress-corrosion cracking of Incoloy 800 gasifier nozzles. Sulfidation of Hastelloy C-276 thermowell in gasifier reaction zone. Failure of Incoloy 800 thermocouple sheaths in gasifier plenum chamber. Stress-corrosion cracking in the 304 S/S gasifier heat-up line and rupture disc piping. Stress-corrosion cracking in the 304 S/S oxygen line. Corrosion of an orifice run in the 304 S/S oxygen line. Corrosion of carbon - 1/2 moly steel purge gas lines.	Replaced with Incoloy 800. Replaced nozzles with carbon steel overlayed with Monel and Incoloy 825. Removed thermowell from reaction zone. Tested stainless steel sheaths. Modified piping to relieve excess stress and replaced with 316 S/S. Replaced damaged components with new 304 S/S. Replaced section with new 304 S/S. Replaced purge gas lines with 304 S/S.

Table III-I - (cont'd)

<u>Area-Equipment</u>	<u>Problem</u>	<u>Modification</u>
<u>Gas Scrubbing</u>		
Venturi Scrubber	600°F design temperature unsuitable for upset conditions.	Replaced original Graham unit with General Ionics Corp. unit designed for 1800°F.
Scrubber Surge Tank	Unsatisfactory removal of solids from circulation system.	Internal modifications to allow for more effective solids settling and greater surge capacity.
Second Stage Venturi Scrubber	Plugging of raw gas scrubber tower packing with entrained solids from the surge tank.	Installed this unit to scrub gas from the surge tank.
Raw Gas Scrubber	Plugging of packing with solids and tars.	Replaced carbon steel pall rings with S/S pall rings. Finally removed packing entirely and used as a spray tower.
Pumps	Erosion of the water inlet nozzle flange.	Replaced flange and changed an eccentric restriction orifice to a concentric type.
	Seal failures on all wash water circulating pumps. Shaft failure. Shaft corrosion. Bearing failures. Pump casing failures.	Modified seal flushes to increase flow. Replaced shafts with larger impeller connections. Replaced shafts with 316 S/S. Frequent vibration and rotor balance checks made. Lined cast steel casings with 316 S/S (eroded in 50 hrs). Overlaid casings with two passes of hard-facing (cracked). Weld overlay of hard-facing depositing 88% nickel (400 hrs. life).
Exchangers	Corrosion of tubes and tubesheets. Plugging of tubes with solids and tars.	Welded casing with martensitic chrome steel (200 hr. life). Hard-faced with nickel - chrome-boron (eroded quickly).
		Controlled water pH with caustic injection. Controlled pH of water by caustic injection. Increased tube side velocity by recirculation of effluent.

Table III-I - (cont'd)

<u>Area-Equipment</u>	<u>Problem</u>	<u>Modification</u>
<u>Gas Scrubbing - cont'd</u>		
Instruments	Plugging of pressure sensing lines.	Flushed periodically with boiler feed water.
	Plugging of vessel level taps.	Flushed periodically with boiler feed water. Replaced with bubbler type level sensors.
Piping and Valves	Erosion of bypass around gasifier pressure control valve.	Revised piping and installed new exchanger and knockout pot upstream of control valve.
	Leakage of circulating pump suction valves due to partial plugging.	Replaced gate valves with cylinder operated plug valves.
	Erosion of waste water let-down valve.	Replaced stellite #6 coated 316 S/S trim with stellite #1016 coated tungsten carbide.
	Erosion of Venturi scrubber water flow control valve.	Replaced valve.
	Failure of 6" carbon steel water line in Venturi scrubber circulation due to erosion and corrosion.	Replaced piping with 304 S/S.
	Erosion and corrosion of carbon steel piping and valves in circulating water lines.	Controlled water pH by caustic injection. Replaced carbon steel bodies of control valves.

Table III-I - (cont'd)

<u>Area-Equipment</u>	<u>Problem</u>	<u>Modification</u>
<u>Char Slurry System</u>		
H.P. Char Slurry Tank	Insufficient surge capacity to handle fluctuations in the char flow.	Recommended replacement with a large tank.
Slurry Filter Feed Tank	Erosion and mechanical damage to turbine agitator.	Replaced damaged blades and added second agitator.
Slurry Filter Feed Pumps	Erosion and cracking of casings.	Replaced casings.
Slurry Filters	Filter capacity 38% of design. Filter cloth failure due to tearing by scrappers.	No corrective action. Replaced filter cloths with heavier nylon type.
Slurry Filter Vacuum Pumps	Cracked casing due to freezing water.	Replaced casing.
Char Slurry Recycle Water Pump	Seal failures. Erosion of the impellers and casing. Plugging of the casing.	Installed liquid cyclones and filters on suction side. Replaced centrifugal pump with reciprocating pump.
Char Slurry Recycle Water Booster Pump	Seal failures.	Replaced mechanical seal with a packed stuffing box.
Char Quench Water Cooler	Ruptured shell due to freezing water.	Removed exchanger from service and by-passed.
Char Lock Hoppers	Failure of ball valves between char cooler and lock hoppers at 600 psi differential.	Lock hoppers never put into service.
Slurry Filter Cake Conveyor	Overloading of drive due to slurry freezing in the conveyor.	Steam-traced the conveyor house.
Instruments	Plugged HP slurry tank level taps with char. Failure of electronic sensor of sonic-type char slurry flow meter.	Installed nuclear high level switch. Replaced sensor but continued to have calibration problems.
Piping and Valves	Failure of pressure relief valve in HP char slurry tank. Unreliable operation of reciprocating char slurry recycle water pump relief valve.	Revised piping to eliminate freezing problems. Replaced shear pin-type valve with spring-loaded type.

Table III-I - (cont'd)

<u>Area-Equipment</u>	<u>Problem</u>	<u>Modification</u>
<u>Char Slurry System - cont'd</u>		
Piping and Valves - cont'd	Erosion and binding of plug valves in the char slurry line.	Replaced the valves with full-ore type.
	Erosion of the discs and sleeves of the HP char slurry let-down valves (Willis Choke Valves).	Replacement of discs and sleeves with varied materials.
	Erosion/corrosion failure of the HP char slurry line.	Replaced socket weld fittings with butt welds.
<u>Support Systems</u>		
Inert Gas Generators	Severe corrosion in downstream piping and equipment.	Modified the fuel system from #2 fuel oil to desulfurized propane.
		Installed catalytic convertors to remove NO _x from the inert gas.
		Installed refrigerant dryer to remove moisture from the inert gas.
Inline Burner	Stress corrosion cracking failures in gasifier heat-up line.	Modified fuel system from #2 fuel oil to desulfurized propane.
	Firebox refractory failure due to flame impingement.	Replaced deteriorated burner nozzle with a stainless steel nozzle.
		Patched C-E Litewate-70 refractory with Harbison-Walker high temperature plastic.
High Pressure Boiler	Malfunctioning flame detector resulted in several boiler trips.	Purchased a second flame detector.
	Fire-box explosion causing serious damage to the system.	Repairs were in progress at the time of the plant deactivation.

Table III-I - (cont'd)

<u>Area-Equipment</u>	<u>Problem</u>	<u>Modification</u>
<u>Support Systems - cont'd</u>		
Flare	High noise level resulting from higher than design gas flow.	Replaced 6" tip with 14" tip.
Thermal Oxidizer	Flame impingement on the walls, vibration.	Modified the burner tip and combustion air restriction details to shorten and steady the flame.
	Corrosion of water spray nozzles.	Replaced brass nozzles with stainless steel.
	Water collected in the bottom of the firebox.	Plugged downward directed water spray nozzles.
	Refractory spalling and slag-type chemical attack.	Tested various refractory materials.
CO ₂ System	Corrosion and erosion.	Revised piping to eliminate pockets for condensation.
		Installed entrainment separators with continuous condensate bleeds.
		Installed exchanger to reheat compressed CO ₂ above water dew point.
		Discontinued use of recycled CO ₂ .

IV. TECHNICAL REPORT

CONTENTS

- A. Introduction
- B. Preliminary to Startup
 - 1. Cold Coal Fluidizations Test
 - 2. Hot Gas Test
- C. Free Fall Gasifier Operation
 - 1. Major Achievements
 - 2. Major Problems Remaining After Run 1-T
- D. Deep Bed Gasifier Operation
 - 1. Major Achievements During Run Series 1-DB
 - 2. Major Problems Remaining After Run Series 1-DB
- E. Illinois No. 6 Coal Operation
 - 1. Major Achievements During Run 2-DB
 - 2. Major Problems Remaining After Run Series 2-DB
- F. Conclusions and Recommendations
 - 1. Conclusions
 - 2. Recommendations for Further Study
 - 3. Recommended Equipment Modifications
 - a. Gasifier/Pretreater
 - b. Char Cooler
 - c. Petrocarb Unit
 - d. Gas Scrubbing Area
- G. Computer System
 - 1. System Description
 - a. Hardware
 - b. Software

CONTENTS

(cont'd)

G. Computer System - cont'd

2. Data Retrieval
3. Data Evaluation
4. Miscellaneous Procedures
5. Data Handling
6. Organization of Computer Group

H. Laboratory

1. Laboratory Space Arrangements
2. Staff
3. Equipment
4. Permanent Sample Points
5. Sample Schedule
6. Outside Laboratories
7. Data Reporting and Storage
 - a. Method
 - b. Discussion

I. Environmental Program

IV. TECHNICAL REPORT

A. Introduction

Operations of the Synthane Pilot Plant were divided into specific periods as follows:

1. Pre-startup operations and tests
2. Free fall gasifier operation (Test Directive 1 - Montana Rosebud coal)
3. Deep bed gasifier operation (Test Directive 1-DB - Montana Rosebud coal)
4. Deep bed gasifier operation (Test Directive 2-DB - Illinois No. 6 coal)

The results of the operation of the Synthane pilot plant over the calendar period 1975-1978 were recorded in run reports No. 1, 1-DB, and 2-DB previously issued. Copies of these reports can be obtained from NTIS and are stored in the library of the synthane pilot plant at Bruceton.

This segment of the final report summarizes the results of the operations and presents conclusions and recommendations on the Synthane process.

This segment of the report also includes a brief description of the computer systems and laboratory used to support the operation of the Synthane pilot plant.

IV. TECHNICAL REPORT

B. Startup Operations

1. Cold Coal Fluidizations Tests

Tests were made to determine the fluidizing characteristics of coal in the gasifier and char cooler. Additional tests were made to establish coal transport line properties and feed rate correlations. Due to the capacity gas compression equipment all tests were done at 75 PSIG.

A copy of the test results may be found in the Synthane Pilot Plant Bruceton Library.

2. Hot Gas Test

Tests were made using CO₂ and superheated steam to determine gas flow characteristics at 600 PSIG on all equipment being used for the initial gasification tests. Gas and steam flow meters were calibrated and control valves set at their operating ranges.

A copy of the test results may be found in the Synthane Pilot Plant Bruceton Library.

IV. TECHNICAL REPORT

C. Free Fall Gasifier Operation

Coal feed to the gasifier and light off with oxygen commenced on July 7, 1976 under Test Directive No. 1 issued by ERDA, on June 9, 1977. (See Appendix A for a copy of this directive.) The directive provided the operating conditions and process requirements for the gasification of Rosebud coal. Rosebud coal, a western sub-bituminous coal, was chosen because of its non-caking and high reactivity properties.

Under this directive, the pilot plant produced gas for a total of 228 hours and gasified 709 tons of Rosebud coal from July 7, to December 20, 1976. Most of the six-month period was spent in achieving process reliability and learning how to operate and control the gasifier. A number of equipment changes were required to achieve successful operation of the coal grinding and handling facilities, the Petrocarb feed system, and the char handling facilities. A complete revision of all gasifier instrumentation was necessary to achieve good control.

Twenty-one test runs were made within the 6-month period, the longest of which was 37 hours (Run 1T). During the 37-hour run, carbon conversions of 57 to 60% were achieved at bed temperatures of 1450 to 1475°F. Earlier attempts to operate the gasifier with bed temperatures of 1500 and 1650°F resulted in clinker formation in the gasifier and the inability to remove char.

IV. TECHNICAL REPORT

C. Free Fall Gasifier Operation - cont'd

TABLE IV-1 SUMMARY OF AVERAGE RUN CONDITIONS

RUN 1-T (Best Run)

Gasifier coal feed, ton/hr.	2.52
Gasifier O ₂ /ground coal, SCF/lb. a)	2.32
Gasifier steam/ground coal, lb/lb.	1.12
Gasifier bed height, ft.	15.0
Gasifier bed density, lb/ft. ³	19.6
Gasifier bed temperature, °F	1,434
Equivalent CH ₄ /MAF coal, SCF/lb. b)	2.52
Carbon conversion (char analysis), %	57.4
Raw gas production, dry, SCFH c)	102,200
Dry gas analysis, mole %	
CO ₂	51.5
CO	6.0
H ₂	31.0
CH ₄	10.0
C ₂ H ₆	0.9
H ₂ S	0.3
N ₂	0.3

a) Standard conditions: 60°F, 1 atm.

b) Equivalent CH₄/MAF Coal = (CH₄ + 2 x C₂H₆)
in SCF/lb. moisture and ash-free coal.

c) Includes approximately 21,500 SCFH of transport,
Petrocarb and purge CO₂.

SYNTHANE GASIFIER

FIG. IV - 2 GASIFIER SETUP FOR RUN No. 1 - FREE FALL

IV. TECHNICAL REPORT

C. Free Fall Gasifier Operation - cont'd

1. Major Achievements

a. The Plant operated producing gas for a total of 228 hours and processed 709 tons of coal under Test Directive No. 1.

b. During Run 1-T, a continuous operation of 37 hours with oxygen, coal feed, and char removal was achieved. The run was terminated due to a letdown valve failure in the process gas line to the flare because of solids erosion.

c. Carbon conversions of 57 to 60% were achieved during Run 1-T without clinker formation, at bed temperatures of 1450°F to 1470°F. Char conversions of more than 60% were achieved during other runs. These higher conversion runs, however, were terminated due to clinker formation.

d. The coal handling and coal grinding operations performed at design specifications.

e. Gas composition, carbon conversions, and yields were obtained for all test periods.

f. The Petrocarb coal feed system performed well at 600 psig.

g. The char filter area performed as per design and adequately handled the char produced over this period.

h. The gasifier required essentially no internal repairs and performed as per expectations.

IV. TECHNICAL REPORT

C. Free Fall Gasifier Operation

1. Major Achievements - cont'd

i. Gasifier differential pressure instrumentation required extensive modifications. These revisions resulted in excellent operability.

j. The utility facilities were reliable and performed as per design.

2. Major Problems Remaining After Run 1-T

a. Tar and fines carryover from the gasifier resulted in major plugging, fouling, and erosion of the gas scrubbing equipment. Extensive cleanout was required after each run. During the free fall program, the internal cyclone failed to function because of the plugging of the dip leg with tar and fines. Overhead temperatures of the gasifier did not exceed 800 to 900°F which is within the tar condensing range. The fouling was so extensive in the gas scrubbing area that runs of long duration could not be achieved.

b. Clinkers formed in the gasifier with Rosebud coal at 1500 to 1600°F fluid bed temperatures and with 0.3 ft/sec fluidizing velocities. The clinkers adhered to metal surfaces within the cone.

c. Control of bed level by manipulation of the differential pressure between the gasifier and the char cooler, as originally designed, was erratic and essentially uncontrollable. Bed level control was improved by the addition of an actuator controller to the trickle valve in the char cooler standpipe.

IV. TECHNICAL REPORT

C. Free Fall Gasifier Operation

2. Major Problems Remaining After Run-1T - cont'd

d. The transfer of char through the char line from the char cooler to the filter area was operable but further improvement was needed.

e. The thermal oxidizer did not perform at design levels.

f. Improvements in flow metering and the addition of new instrumentation were needed to achieve improved data. Material balance closure was not considered adequate.

g. The Test Directive was discontinued in January of 1977 without reaching steady state conditions or 67% conversion because the gas scrubbing area was unable to handle the tar, char, and fresh feed which carried over from the gasifier. Tar generated by the free fall of coal into the gasifier and the low overhead temperature of the gasifier continually plugged the cyclone dip leg. This allowed tar, char, and fresh coal feed to carry over into the gas scrubbing equipment. The scrubbing facilities were incapable of handling and disposing of the tar and char which caused continual plugging and fouling of the heat exchangers, pumps, vessels, and gas scrubber facilities.

FIG. IV - 3 MAJOR EQUIPMENT FOR RUN SERIES 1-DB

FIG. IV - 4 GASIFIER SETUP FOR RUN SERIES 1-DB

IV. TECHNICAL REPORT

D. Deep Bed Gasifier Operation

The first phase of the operation of the Synthane pilot plant--the gasification of Montana Rosebud coal, was completed in August, 1977. The gasification of this sub-bituminous coal was considered successful. The objective of the second phase of operation is outlined in Test Directive No. 2. The directive specified the gasification of Illinois No. 6 coal at 600 psig to a carbon conversion of 67%.

1. Major Achievements During Run Series 1-DB

(a) The plant produced gas for a total of 556 hours and processed 1,304 tons of Montana Rosebud coal at rates of 1.5 to 3.0 tons/hour.

(b) Run lengths of up to 97 hours of continuous operation were achieved.

(c) A carbon conversion of 65 to 78 percent was demonstrated.

(d) A total of 29 steady state periods ranging from 1 hour and 30 minutes to 14 hours and 54 minutes was obtained during Run Series 1-DB.

(e) Overall material balance closures to within 95 and 105% were achieved during the 18 steady state periods.

(f) A dry coal feed system operating continuously at 600 psig was demonstrated.

(g) A system for discharging char continuously from 600 psig to atmospheric pressure was operated successfully.

IV. TECHNICAL REPORT

D. Deep Bed Gasifier Operation

1. Major Achievements During Run Series 1-DB - cont'd

(h) A raw gas stream with an H_2 to CO molar ratio of 3:1 was obtained under the operating conditions of Run Series 1-DB. A CO shift converter may, therefore, not be required for upgrading the product gas to SNG through methanation.

(i) A process gas stream essentially free of tars and heavy oils was obtained. This gas stream simplifies the gas/liquid separation steps and enhances the environmental aspects of the Synthane Process.

(j) A high temperature non-fouling process gas stream suitable for steam generation from process heat exchangers was obtained from the gasifier.

(k) A condensate with low phenol content and low chemical oxygen demand was obtained from the gasifier overhead gas stream. This condensate quality should permit its reuse without extensive external treatment.

(l) Gas scrubbing recycle pump cases were hardfaced successfully thus permitting extended periods of continuous service.

(m) The thermal oxidizer was modified to operate at design capacity.

(n) Data obtained during Run Series 1-DB were adequate for the preliminary design of a commercial facility.

IV. TECHNICAL REPORT

D. Deep Bed Gasifier Operation - cont'd

2. Major Problems Remaining After Run Series 1-DB

- (a) Gasifier fluid bed height control improved over Run Series 1, but remained a problem.
- (b) Clinker formation at operating temperatures above 1,500°F persisted although it was controllable at the desired carbon conversion.
- (c) Fines carry-over from the gasifier to gas scrubbing system persisted.
- (d) Thermal oxidizer refractory life was undetermined.
- (e) Hydraulic and pump cavitation problems existed in the Gas Scrubbing Area.
- (f) Variation of the coal feed rate continued to be a problem in the Petrocarb Unit.

IV. TECHNICAL REPORT

E. Illinois No. 6 Coal Operation

Forty-seven test runs, designated as Run Series 2-DB and numbered from 2-DB-A-1 through 2-DB-O-3, were conducted at the Synthane Coal Gasification Pilot Plant, South Park Township, Pennsylvania from September 1977 through September 1978 under Test Directive No. 2-DB.

Test Directive No. 2-DB directed that the plant be operated with Illinois #6 coal from the River King Mine of the Peabody Coal Company at a pressure of 600 psig. Concurrent pretreater/gasifier operation was specified at coal feed rates from 1.5 to 2.5 tons/hour. Carbon conversion was to be 67%. Gas was produced for 182 hours and 1,100 tons of coal were fed to the pretreater and gasifier. Continuous operation up to 56 hours and carbon conversions based on char up to 72% were achieved.

The operations were carried out at a pressure of 600 psig, the gasifier temperatures ranged from 1,300°F to 1,550°F, and the coal feed rates were 1.5 to 2.5 tons/hour. The pretreater was placed in service for the first time during this test period. The "deep bed" injection method produced little tar, phenols, or oils in the waste water.

The successful operation of the pilot plant with Illinois #6 coal demonstrated the feasibility of the Synthane Pilot Plant to process a caking type of coal. The ability to successfully pretreat a caking coal at high pressure in a plant of this size is a first and a direct result of the successful operation of the Synthane Process.

FIG. IV - 5 MAJOR EQUIPMENT FOR RUN SERIES 2-DB

FIG. IV - 6 GASIFIER SETUP FOR RUN SERIES 2-DB

IV. TECHNICAL REPORT

E. Illinois No. 6 Coal Operation

1. Major Achievements During Run Series 2-DB

(a) The plant produced gas for a total of 182 hours and processed 1,100 tons of Illinois No. 6 coal at feed rates of 1.5 to 2.5 tons/hour.

(b) An online pretreater operating sequentially with the gasifier at 600 psig was demonstrated. This was the first time a caking coal was pretreated at operating pressure in a plant of this size.

(c) A carbon conversion of 72 percent based on char analysis was achieved.

(d) Extended run lengths of up to 56 continuous operating hours were achieved.

(e) A total of 7 steady state periods ranging from 1 hour and 30 minutes to 8 hours and 30 minutes were achieved.

(f) Overall material balance closures to within 80 to 92 percent were achieved in the 7 steady state periods.

(g) A dry coal feed system operating continuously at 600 psig was demonstrated.

(h) A system for discharging char continuously from 600 psig to atmospheric pressure was operated successfully.

(i) A process gas stream essentially free of tars and heavy oils was obtained. This gas stream simplified the downstream gas/liquid separation steps and enhanced the environmental aspects of the Synthane Process.

IV. TECHNICAL REPORT

E. Illinois No. 6 Coal Operation

1. Major Achievements During Run Series 2-DB - cont'd

(j) An aqueous condensate with low phenol content and low chemical oxygen demand was obtained from the overhead gas stream to permit water to be reused without extensive treatment.

2. Major Problems Remaining After Run Series 2-DB

(a) Gasifier fluid bed height control improved over Run Series 1 and 1-DB, but remained a problem.

(b) Clinker formation in the gasifier at operating temperatures persisted.

(c) Fines carry-over from the gasifier to the gas scrubbing system due to inefficient internal cyclone performance remained a problem.

(d) Operating techniques for char removal from the gasifier needed to be improved.

(e) Occasional problems with wet coal lumps, unground coal, and foreign objects in the coal feed system persisted.

(f) Coal feed rates were not accurate and an improved system or mechanism needs to be developed.

IV. TECHNICAL REPORT

F. Conclusions and Recommendations

1. Conclusions

(a) Run Series 1-DB demonstrated the Synthane Process for Montana Rosebud coal. Run Series 2-DB demonstrated that the Synthane Process is a viable route to coal gasification for coking Illinois No. 6 coal. The general operability of the system was significantly since Run Series No. 1 and 1-DB.

(b) It has been demonstrated that the Synthane Process is capable of producing a raw gas of satisfactory quality for extended periods of time. The cleaner raw gas (compared to Run Series No. 1) leaving the gas scrubbing area will result in lower cost scrubbing and heat recovery equipment.

(c) The important advantage of "deep bed" injection over the "free fall" method of the coal feed for both Montana Rosebud and Illinois No. 6 coals is the significant reduction of tars, phenols, and other pollutants in the gasifier waste water effluent. The cleaner waste water leaving the gas scrubbing area will result in much simpler effluent treatment equipment. This advantage must be offset, in part, by the higher oxygen requirement associated with the "deep bed" injection of the coal feed.

(d) Run Series 2-DB was characterized by considerably higher gasifier fluid bed densities than in Run Series 1 and 1-DB. The cause of this phenomenon is attributed to improved control on the char removal system and standpipe operation.

(e) In view of the progress made in Run Series 1-DB, and 2-DB additional time and effort should be expended towards the solution of the few remaining operating problems.

IV. TECHNICAL REPORT

F. Conclusions and Recommendations - cont'd

1. Conclusions - cont'd

(f) Operating problems which persisted through Run Series 2-DB include control of the gasifier bed height, clinker formation in the gasifier, high solids carry-over from the gasifier to the gas scrubbing system, and coal feed control.

(1) Bed height control improved over the runs conducted under Run Series No. 1 and 1-DB to the extent that steady state heights could be maintained for extended periods of time. Control, however, in the sense that changes in the bed height can be made at will, was not achieved.

(2) Clinker formation continued to be the major cause of run termination during the Run Series 2-DB. Recommended steps toward correcting this problem are detailed later in this section under RECOMMENDED EQUIPMENT MODIFICATIONS.

(3) Solids carry-over from the gasifier into the gas scrubbing system continued to create equipment operating problems. Addition of a second cyclone, a modification of the existing cyclone discharge piping, should be considered.

(4) The Petrocarb system had operating problems with the control of the rate of coal. Certain modifications, previously explained, were made to the coal feed line.

2. Recommendations for Further Study

Additional test runs and studies of the Synthane Process on other Eastern caking coals should be done to improve the process.

IV. TECHNICAL REPORT

F. Conclusions and Recommendations - cont'd

3. Recommended Equipment Modifications

a. Gasifier/Pretreater

The major problem in the operation of the Synthane gasifier was clinker formation. Based on the analyses of the runs conducted with Montana Rosebud and Illinois No. 6 coals, a conclusion has been reached that an oxygen/steam ratio in excess of 10 mol.% invariably resulted in clinker information.

Changes in the gasifier and the pretreater are recommended to be made to reduce the oxygen/steam ratio, while at the same time allowing sufficient oxygen to be added to the gasification system to achieve the desired carbon conversion. The discussions in Section X of Run Report No. 2-DB lead to the following specific recommendations.

(a) Provide a steam and oxygen feed connection to the existing "deep bed" coal feed pipe inside the gasifier.

(b) Extend the "deep bed" feed pipe in the gasifier to the cone line.

(c) Extend the gasifier/char cooler standpipe to a point above the coal feed line inside the gasifier.

(d) The existing pretreater affords little flexibility in operation. The following modification is expected to improve the operability of this system and to increase its tolerance for operational upsets and errors.

IV. TECHNICAL REPORT

F. Conclusions and Recommendations

3. Recommended Equipment Modifications

a. Gasifier/Pretreater - cont'd

Install a separate 3-inch line connecting the existing 3/4-inch horizontal coal transport line to the gasifier. This new line will bypass the existing pretreater and its existing 3-inch transport line. The new 3-inch line is to function as an alternate pretreater. Steam-oxygen injection points are to be provided on this line at its start as well as inside the gasifier similar to item 1 above. The "deep bed" feed pipe connected to this new 3-inch line will be extended inside the gasifier to the cone line. Figure IV-10 illustrates this recommendation.

The recommended equipment modifications are shown in Figures IV-9 through IV-15. The anticipated operating conditions are summarized on Tables IV-4, 5 and 6 at the end of this section. The flow rates are set to ensure that the oxygen concentration in the steam-oxygen mixture that contacts coal is kept at about 8 mol%.

Figure IV-9 exhibits a scheme whereby supplemental steam-oxygen injection is added to the pretreater overflow line inside the gasifier. The "deep bed" injection line is extended and the gasifier/char cooler standpipe is raised above the "deep bed" line. Two alternate ways of raising the standpipe are shown.

Figure IV-10 shows the existing pretreater bypassed. The bypass can be mechanically erected around the existing pretreater. Acceptance of one of the standpipe alternates of Figure-IV-9 is assumed. Extension of the "deep bed" feed pipe is assumed. Supplemental steam-oxygen as shown is required. Figure-IV-10 is an entrained bed pretreater.

IV. TECHNICAL REPORT

F. Conclusions and Recommendations

3. Recommended Equipment Modifications

a. Gasifier/Pretreater

Figure IV-11 exhibits the installation of a baffle to provide a quiet zone for the prevention of cyclone fines removal re-entrainment. The pretreated coal is injected vertically upward through the apex of the distributor cone.

Figure IV-11 is an alternate to Figure IV-10. Char cooler steam and plenum zone steam are not mixed.

The preferred modification is Figure IV-10 using an entrained pretreater.

The addition of oxygen into the 3-inch lines makes use of the steam that is introduced into these lines for gasification which is not possible with the existing arrangement. This will mean that the overall steam/coal ratio for pretreatment and gasification will be about 1.75-1.8 lb/lb compared to a ratio of 3.1 lb/lb employed during previous operations. The savings in steam consumption will overcome the potential loss of methane that may occur during the oxygen coal reactions that will take place in the 3-inch line located inside the gasifier.

b. Char Cooler

The char cooler of the Synthane pilot plant operated by cooling the hot char from 1500°F to 600°F by means of desuperheating steam. The char was then discharged from the char cooler into a slurry vessel from which it was transported to the filtration area. The economics of the Synthane process require that the char can be reused as a

LEGEND

TEMPERATURE, °F

SUPERFICIAL VELOCITY, FPS

OXYGEN CONCENTRATION %

DESIGN FLOWS

FIGURE IV-7 LEGEND FOR FIGURES IV-8, 9, 10, 11, 13

FIG. IV - 8 GASIFIER OPERATION WITH CONE ONLY

FIG. IV - 9 SUPPLEMENTAL OXYGEN ADDITION TO GASIFIER – ALTERNATE No. 1

FIG. IV - 10 SUPPLEMENTAL OXYGEN ADDITION TO GASIFIER
WITH ENTRAINED PRETREATER

TABLE IV-1 ASSUMPTION FOR FIGURES IV-8, -9, -10, -11, AND -13

Pretreater in Service FIG-IV-9, 11, & 13

- 1) Maximum temperature 900°F in pretreater
- 2) No steam-carbon (endothermic) reactions in overflow line.
- 3) 446 Btu/SCF O₂ in overflow line (due to $C + O_2 = CO_2$)
- 4) 527 Btu/SCF O₂ for Pretreatment reaction.
- 5) Total O₂ required 15352 SCFH for 1550°F bed.
- 6) Superficial velocity in gasifier
 - a) due to plenum steam 0.25 FPS
 - b) due to total steam 0.5 FPS
- 7) Steam/coal (as received) = 1.78 lbs/lb.
- 8) O₂/Coal = 3.8 SCF/lb (as received)
- 9) O₂/Steam (Total) = 0.102 mol/mol. or 9.3 mol% O₂ in total mixture
- 10) O₂/Coal in Pretreater = 0.825 SCF/lb (as received)
- 11) No steam and CO₂ flow to pretreater plenum.

Pretreater Bypassed Fig-IV-10

- 1) Maximum temperature in entrainment line 1200°F
- 2) No steam-carbon (endothermic) reactions in overflow line.
- 3) 446 Btu/SCF O₂ in overflow line ($C + O_2 + CO_2$)
- 4) 527 Btu/SCF O₂ for pretreatment reaction.
- 5) Total O₂ required 15352 SCFH for 1550°F bed.
- 6) Superficial velocity in gasifier
 - a) due to plenum steam 0.25 FPS
 - b) due to total steam 0.5 FPS
- 7) Steam/coal = 3.8 SCF/lb (as received)
- 8) O₂/coal = 3.8 SCF/lb (as received)
- 9) O₂/steam (Total) = 0.102 mol./mol or 9.3 mol% in total mixture
- 10) O₂/Coal in entrainment line = 1.25 SCF/lb (as received)

No Modifications FIG-IV-8

- 1) Maximum temperature in pretreater 900°F.
- 2) 446 Btu/SCF O₂ in distributor cone (due to $C + O_2$)
- 3) 527 Btu/SCF O₂ for pretreatment reaction.
- 4) Total oxygen required 15352 SCFH for 1550°F bed.
- 5) Superficial velocity at gasifier cone line 0.5 FPS.
- 6) No steam flow and CO₂ flow to pretreater plenum.

TABLE IV-2-DESIGN FLOWS FOR FIGURES IV-8, 9, 10, 11 AND 13

1) PRETREATER IN SERVICE FIG. IV-9, 11 & 13

STREAM	1	2	3	3	4	5	6	7	8	9
MATERIAL	STEAM	O ₂	COAL	CO ₂	O ₂	STEAM	O ₂	STEAM	STEAM	CO ₂
UNIT	LBS/HR	SCFH	LBS/HR	SCFH	SCFH	LBS/HR	SCFH	LBS/HR	LBS/HR	SCFH
QUANTITY	2500	3302	4000	16350	6527	3560	5523	1061	0	0
PSIG	610	700	610	610	610	700	700	700	700	750
TEMP. °F	1000	77	150	150	77	725	77	725	725	550

2) PRETREATER BYPASSED FIG.-IV-10

STREAM	1	2	3	3	4	5	6	7
MATERIAL	STEAM	O ₂	COAL	CO ₂	CO ₂	STEAM	O ₂	STEAM
UNIT	LBS/HR	SCFH	LBS/HR	SCFH	SCFH	LBS/HR	SCFH	LBS/HR
QUANTITY	2500	4987	4000	16350	6527	3560	3838	1061
PSIG	610	700	610	610	700	700	700	700
TEMP. °F	1000	77	150	150	77	725	77	725

3) NO MODIFICATION FIG.-IV-8

STREAM	1	2	3	3	4	5	8	9
MATERIAL	STEAM	O ₂	COAL	CO ₂	O ₂	STEAM	STEAM	CO ₂
UNIT	LBS/HR	SCFH	LBS/HR	SCFH	SCFH	LBS/HR	LBS/HR	SCFH
QUANTITY	2500	3302	4000	16350	12050	7121	0	0
PSIG	610	700	610	610	700	700	700	750
TEMP. °F	1000	77	150	150	77	725	725	550

4) SEE TABLE IV-1 FOR ASSUMPTIONS.

TABLE IV-3 OTHER DESIGN CONDITIONS FOR FIGURES IV-8, 9, 10, 11 AND 13

1) SUPERFICIAL VELOCITY FPS

LOCATION	1*	2*	3	4*	5	6	7	8*
WITH PRETREATER FIG. IV-9	0.25	0.5	51	0.5	26	0.6	23	0.5
FIG. IV-11 & IV-13	0.5	**	51	0.5	26	0.6	23	0.5
WITH BYPASS-FIG. IV-10	0.25	0.25	51	0.5	31	-	-	0.5
NO MODIFICATION (MECHANICAL)-FIG. IV-8	0.5	0.5	-	0.5	26	0.6	23	0.6

* DUE TO STEAM ONLY

** DEGASSING ZONE FIG.-IV-11 & 13 ONLY

2) TEMPERATURE °F

LOCATION	1+	2	3+	4	5+	
WITH PRETREATER -FIG. IV-9, 11, & 13	1550	1450	1550	900+	800	+SAME WITH NO MODIFICATION
WITH BYPASS-FIG. IV-10	1550	1450	1550	1200	-	PER FIG. IV-8

3) OXYGEN CONCENTRATION MOL. %

LOCATION	1	2	3	4	5	6
WITH PRETREATER -FIG. IV-9, 11, & 13	5.9	4.5	19.8	5.8	0	8
WITH BYPASS-FIG. IV-10	8.6	6.7	14.6	3.7-513	0-2.4	8
NO MODIFICATION (MECHANICAL) FIG. III-8	5.9	4.5	0	0	0	7.3

4) STEAM/COAL LBS/HR (AS FED)

FULL MODIFICATION	1.78
NO MODIFICATION (MECHANICAL)	2.4
PAST OPERATION	3.1

5) SEE TABLE-IV 1 FOR ASSUMPTIONS.

FIG. IV - 11 SUPPLEMENTAL OXYGEN ADDITION TO GASIFIER – ALTERNATE No. 2

FIG. IV - 12 OXYGEN DISTRIBUTER ARRANGEMENT FOR ALTERNATE No. 2

FIG. IV - 14 OXYGEN DISTRIBUTER ARRANGEMENT FOR ALTERNATE No. 3

ALTERNATE - 1

ALTERNATE - 2

FIG. IV - 15 DETAIL FOR SUPPLEMENTAL OXYGEN ADDITION

IV. TECHNICAL REPORT

F. Conclusions and Recommendations

3. Recommended Equipment Modifications

b. Char Cooler - cont'd

fuel. As about 25% of the coal feed to the gasifier is discharged from the gasifier in the form of char, it is preferable that the char be discharged from the gasifier unit in a dry and possibly hot form. One method for achieving that was developed by C-E Lummus into a "hot and dry char letdown system". A report covering the conceptual design of the system was issued in April and December, 1979 under DOE contract #EY-76-C-02-0058. Copies of these reports are located in the library of the Bruceton pilot plant. Should the Synthane pilot plant be reactivated, it is recommended that a hot and dry char letdown system be installed to demonstrate its viability and improve the potential of the Synthane process.

An alternative proposal to the "hot and dry char letdown system" is to use the existing char lock hoppers. During the operation of the Synthane pilot plant, the lock hoppers were not used, because of the inability of the isolating valves to hold the differential pressures required for this operation. It is conceivable that significant developmental work, on valves currently underway, will be successfully completed so that this alternative system could be tested with the availability of more adequate valves.

A third alternative that deserves consideration is the gasification of this char in a reactor of the type developed by the Texaco Development Corporation.

IV. TECHNICAL REPORT

F. Conclusions and Recommendations

3. Recommended Equipment Modifications

c. Petrocarb Unit

A major Petrocarb operating problem was plugging of the 3/4-inch transport line with wet coal lumps, unground coal, or foreign objects.

A separate report (8530-EOC-04-79 issued January 18, 1979) detailed proposals and made recommendations for the installation of an inert gas/CO₂ drying system to supply dry fluffing gas. The objective is to obtain minus 40°F water dewpoint gas.

A separate report (8530-EOC-05-79 issued February 2, 1979) discussed the process aspects of the operation of the Petrocarb pressurized coal feed system. This report concludes that the mechanical and process changes made to the system, in general, improved the operability of the system. Specifically, the report recommended that the Petrocarb primary injector be designed with a continuous flow of dry fluffing gas and a back pressure controller on the primary injector vent gas. The transport line should be designed for a sufficient pressure drop to overcome pressure fluctuations in downstream equipment. The design should also take into account means for avoiding plugging due to oversize material and wet lumps of coal.

d. Gas Scrubbing Area

Section X of Run Report No. 2-DB discussed operating problems in the gas scrubbing area. The following recommendations are made:

(a) Remove the scrubber surge tank baffles and operate the tank at a high liquid level to minimize pump cavitation.

IV. TECHNICAL REPORT

F. Conclusions and Recommendations

3. Recommended Equipment Modifications

d. Gas Scrubbing Area - cont'd

(b) Continue the addition of anti-foam and flocculating agents.

(c) Add caustic during initial plant start-up to keep the pH of the circulating water in the range of 7.5 to 8.5.

(d) Do not operate the decanter. It is presently blinded off.

(e) Maintain high liquid circulations of heat exchange equipment to minimize solid deposition.

IV. TECHNICAL REPORT

G. Computer System

The nature of a research project is such that a large amount of data and other information must be collected from the process in order to make any meaningful evaluation for design. These data must also be manipulated and presented in easily understood formats. This procedure of data acquisition and evaluation when done by hand is tedious and time-consuming. If data can be collected by an automatic system such as a computer, a large portion of this procedure can be accomplished more efficiently. If, in addition, the data can also be manipulated and evaluated automatically, engineers and technicians can be allowed to concentrate on decision-making and planning for future experimentation.

With these advantages in mind, an on-line data acquisition system was specified and installed in the Synthane Coal Gasification Pilot Plant in Bruceton, Pa. The system was designed to retrieve data from various instruments throughout the plant and store those data for later use. The computer was installed in March, 1976 in order to collect data. Eventually programs were written to manipulate and evaluate the data further. These programs retrieve data from storage and perform additional calculations and present the data in tabular or graphic forms. By the end of the project, the computer system produced approximately 95% of the data presentations used for each run report. The amount of time for the process engineers to prepare a report was thus cut from several months to several weeks.

IV. TECHNICAL REPORT

G. Computer System

1. System Description

a. Hardware

The Automatic Data Acquisition System was purchased from Modular Computer Systems, Inc. (Mod Comp) of Ft. Lauderdale, Florida. The central processing unit (CPU) was a Modcomp II/221 with 64K words of memory. The CPU included a Direct Memory Processor, System Protect, Power Failsafe/Auto Restart and Hardware Floating Point. The computer operator communicated with the system through a console device which was originally an ASR-33 teletype but was replaced by a rented GE Terminet 1200.

Data file and program storage was accomplished by use of two moving head disc systems with a total storage capacity of five million words. Two magnetic tape units were available for historical data storage. The plant operator could communicate with the system through either of two CRT terminals, one located in the Control Room, the other in the Computer Room. Also provided in the Control Room were two GE Terminets (300) which were used to print messages and data for the plant operator.

Since all program development was done with cards a punched card reader and Sperry-Univac keypunch were included with the system. The keypunch was tied to the computer system as an I/O device so that cards could be punched automatically. A centronics line printer provided output capability for development work. In addition, a Calcomp 565 Incremental Drum Plotter made graphic displays of data possible.

IV. TECHNICAL REPORT

G. Computer System

1. System Description

a. Hardware - cont'd

Data from the plant was interfaced with the computer in one of two ways. Thermocouple signals, analyzer values and digital inputs were tied directly to the system through a Wide Range Analog Input Subsystem (WRAIS) or Digital I/O Channels. All pneumatic signals travelled first to a Scanivalve where the signals were transduced and then relayed to the WRAIS. Four analog output channels were used to drive trend recorders for plotting data.

Power was supplied to the data acquisition system by an Uninterruptible Power Supply with battery backup. The computer room was air conditioned to maintain a temperature of 72°F and was protected from fire by a Halon Fire Detection system.

b. Software

The operating system to actually run the computer was a standard version of MAX III supplied by Modcomp. MAX III was a real time multiprogramming executive with foreground, middleground and background capabilities which provided complete task scheduling and I/O services. Additional system featured such as a macro assembler and Fortran IV compiler enable the addition to the system of userwritten programs. A Math Library and Utility functions completed the system package.

IV. TECHNICAL REPORT

G. Computer System

1. System Description

b. Software - cont'd

The data acquisition and storage functions of the computer system were accomplished chiefly by use of the Fortran Language Industrial Control (FLIC) as licensed from Metromation, Inc. of Princeton, N.J. FLIC was a modular package which retrieved and stored data from both analog and digital inputs. All current data was stored in a table in the computer memory and was available to the operator on command. The parameters used for conversion and display of the raw signals could be changed by use of simple "fill-in-the-blanks" type programs. FLIC controlled the action of the Scanivalve and analyzers as well as conversions of direct inputs.

The data evaluation portion of the software system was developed specifically for the Synthane process on-site. Some functions to ready and display historical data were available to the operator while others could only be used by computer personnel. All of the applications programs were written in subroutine format with main programs calling many shorter subroutines. This allowed utility functions, such as reading from tape, which were used by more than one program to be written only once.

See Appendix E for a complete inventory of computer programs, documentation, tapes, discs, cards and manuals.

IV. TECHNICAL REPORT

G. Computer System - cont'd

2. Data Retrieval

a. On-line Functions

Retrieval and storage of data from plant instrumentation was the chief function of the on-line computer system. The system was very reliable in this respect, having been on-line for nearly all of the approximately 2800 hours of plant operation.

Pressure and flow data entered the system through the Scanivalve where the pneumatic signals were transduced to electronic signals. The electronic signals were processed by FLIC and converted to engineering units using information about each instrument located in data base files. Flow data could also be compensated for any pressure or temperature conditions which were also input into the system. Temperature data were input directly into the system and conversions were done based on the type of thermocouple located in the field. All engineering units values obtained by FLIC were placed in a 900 value table located in the computer memory. All data files which specify the parameters such as conversion, instrument type, range and other information necessary for correct operation of the system, were specified by the computer operator. Files were updated using punched cards and FLIC update routines.

All of the current data located in memory are available on-line to the operator through a CRT. Each value had a number, six-character name and twenty-four-character descriptor associated with it. Each program on the CRT had a unique function and was called by a simple three character mnemonic. The operator could request the current values for individual points or for groups of up to

IV. TECHNICAL REPORT

G. Computer System

2. Data Retrieval

a. On-line Functions - cont'd

sixteen points, called logs. The points to be contained in any log were normally preselected by the computer operator, but a log could also be built on-line. Logs could be displayed in various forms. These included an instantaneous log which showed only the current value for each point, a trend log which showed an hourly average in addition to current values and which could be refreshed every minute and an eight-hour log which gave the hourly average for the previous eight hour-long periods. An additional function was added to the CRT to enable the display of some analog data in graphic form. Current values could be displayed for specific instruments around either the Gasifier or Pretreater and could also be refreshed on a periodic basis. Such basis information as point names, descriptors and status (inactive or active) could also be displayed by the operator. The activity of the Scanivalve, trend recorders and on-line analyzers was controlled by CRT functions, though control parameters for the data files must be previously specified by the computer operator.

Digital inputs to the computer system were handled somewhat differently than analog inputs. Each digital input had an associated number, name and descriptor, which were available to the operator on command. However, the values or states (open or closed) were not recorded in the system and were used only as "triggers" when a change occurred. The user could write programs which were activated by a change in state and which could perform functions as simple as messages to the operator or as complicated as

IV. TECHNICAL REPORT

G. Computer System

2. Data Retrieval

a. On-line Functions - cont'd

elaborate calculations. This capability was part of the alarm action function in FLIC. Another major portion of the alarm action programs was the ability to alarm analog points. The system could be set to either print a message or activate a routine for an analog point that was experiencing either a high value, a low value or a high rate of change.

b. Automatic Functions

In addition to the alarm action functions in FLIC, several other procedures occurred automatically in retrieving data from the plant. While data in the form of logs was available on-line to the operator, hourly and eight-hour logs were printed on the typer at the end of each hour and shift, respectively, without intervention. In order to save all analog data, all 900 values in the engineering units table were transferred every six minutes to a disc storage area. At the end of each eight-hour period, all of this "six-minute data" is transferred from disc to permanent historical data storage on tape. The tape storage routines were constructed so that the tape was always positioned properly when a write operation began so that no data was lost. Because the historical data routines were operated by system timers, a backup routine was developed to ensure that the data was transferred at the appropriate times.

IV. TECHNICAL REPORT

G. Computer System

2. Data Retrieval - cont'd

c. Laboratory Data

All laboratory data was handled off-line by the computer system. Permanent data sheets were prepared by the laboratory and sent to the Computer Group. These data could be punched on cards. Whenever data were required, the cards are run using background tasks to produce data sheets. Laboratory data cards were also used for the preparation of process calculation data sheets. One CRT function was made available to the laboratory in order to produce coal and char analysis sheets and a limited number of punched cards. None of this data was stored or maintained in the computer.

IV. TECHNICAL REPORT

G. Computer System

3. Data Evaluation

a. Process Calculations

The second major function of the data acquisition system was further processing of the raw plant data. Raw data had to be obtained from storage in order to be further manipulated. Process calculations had to be performed in order to present the data in an easily understood manner. The presentation of data, both raw data and that which was further processed, was the final product of the computer system.

Some amount of further processing was done on-line by the computer system. FLIC provided the capability of performing calculations on-line using current engineering values from the computer memory. For the Synthane process, only simple calculations such as fluid bed heights and densities were done on-line. The remaining calculations were done after the plant operating period was completed, due mainly to the fact that current laboratory analyses were only available several hours after samples were taken. In some cases, approximate values for calculated variables were made available to the operator by maintaining an average analysis (especially for coal) in the engineering units table.

When a plant operating period was completed, historical data was obtained from magnetic tape for the use of the process engineers. From this data, steady-state operating periods could be defined and laboratory analyses specified. Using this steady-state information, raw data

IV. TECHNICAL REPORT

G. Computer System

3. Data Evaluation

a. Process Calculations - cont'd

was averaged over the proper time periods and again stored for further processing. When the laboratory analyses were available, calculated process values were produced using the averaged data values. Any adjustments to the data which were necessary were made at this time. In addition to the basic process variables calculated, both material and energy balances for the gasification process were also produced for each steady-state time period. These reports were generally used in each individual run report. At the end of each month, a summary table was produced showing the conditions for all of the gasification operations during the month.

b. Reporting Format

The presentation of data was done in several ways. Raw or averaged data for any particular time and data or steady-state period could be displayed in tabular form showing as many of the 900 engineering units values as requested. A tabular listing could also be made for up to five individual points over a period of time or a number of steady-state periods. Raw data could be plotted over time using the X/Y plotter. Up to five points could appear on each plot. Calculated process variables were presented in tabular form for up to five steady-state periods. Material and energy balances were originally presented as tables and then translated to graphic representations showing specific stream values for each steady state. In addition one point

IV. TECHNICAL REPORT

G. Computer System

3. Data Evaluation

b. Reporting Format - cont'd

could be plotted on the X/Y plotter as a function of a second variable. A curve could be fitted to this type of plot and a simple equation relating the variables would be determined.

Laboratory data was presented in tabular form. Each sample was handled by a different program and the specific output varies by type. Generally, only those samples related to a gasifier operating period were presented on the output. A statistical analysis of laboratory data which calculated such parameters as mean and standard deviation could also be done to show the variations which occurred within any particular sample group. All of these programs were run using data from punched cards.

IV. TECHNICAL REPORT

G. Computer System

4. Miscellaneous Procedures

The computer was a valuable aid to process engineers and plant operating personnel in several other areas. Since the computer was designed as an on-line data acquisition system, any functions which could not be directly related to the more efficient operation of the plant itself or the production of technical reports were excluded. In this way, operations such as warehouse inventory, financial problems and other administrative functions were kept out of the computer system. The major areas not directly related to data acquisition which were handled by the computer were plant raw materials inventory, test directive table production and SEMPEP.

a. Plant Inventory

The plant raw material inventory was handled exclusively by the computer. A data sheet was received each morning from utilities personnel along with receipts detailing all shipments received. These data were punched on cards and fed into the system. One data file on disc was reserved to maintain the information required to perform the plant inventory. Each day, a daily and month-to-date report was produced detailing the receipts, consumption and shipments for each raw material which entered the plant. At the end of each week, a weekly report showing values for the week was also produced. Written monthly reports were produced from the computer-generated data.

IV. TECHNICAL REPORT

G. Computer System

4. Miscellaneous Procedures - cont'd

b. Test Directive Procedures

Tables for the Technical Department's test directive issued prior to each plant operating period were produced on request by the computer system. Tables 5-2 (Purge Rotameter Settings), 5-4 (Flow Transmitter Specifications) and 5-5 (Control Valve Specifications) were all made available for insertion in the test directive. All of the tables were made by a simple translation of data cards into a printed table. The use of data cards allowed easy alteration of any entry in the table. A computer hookup list and instrument specification sheet were also printed to aid the process engineers in specifying changes to the test directive tables. Data for these tables were maintained on disc files.

c. SEMPEP

A new function which was not finalized was the use of the computer to maintain SEMPEP (Synthane Equipment and Material Performance Evaluation Program) data. The SEMPEP project was designed to allow easy storage and access for plant equipment failures. It was planned to utilize the computer system to maintain records on magnetic tape and produce failure reports on request. All functions would be done off-line during non-critical time periods. Only preliminary design and programming of the computer aspect of this project was completed.

IV. TECHNICAL REPORT

G. Computer System - cont'd

5. Data Handling

During the nearly three years that the computer system was in operation, large amounts of data were collected and processed. These data were in the form of magnetic tapes, data cards and printouts.

All historical plant data was maintained on magnetic tape. Whenever a tape was completed and removed from the system, a working copy was made and the original was sent to Record Retention for permanent storage. A procedure was also written to edit data tapes in order to remove any parity errors or condense the tape. Most of the historical data tapes were edited. Tape copies were also used as system backup and program files.

Since punched cards were used almost exclusively for program development, copies of all user-written programs were maintained on cards. Program card files were divided according to function for easy access. Laboratory data were maintained on cards and filed in chronological order. The inventory data cards were also maintained in chronological order so that corrections can be easily made if problems arise. Permanent data sheets for both laboratory data and inventory information were turned over to Record Retention. FLIC required that system initialization and update information be prepared on punched cards. This allowed simple procedures to be established for changing system parameters.

In addition to the data which was maintained on magnetic tape and cards, the alarming and logging functions automatically produced printouts on the Terminet typers. A log of system operations was also developed by the Console Device. These printouts were kept as primary data files since alarming functions and system operations were not recorded elsewhere.

IV. TECHNICAL REPORT

G. Computer System - cont'd

6. Organization of the Computer Group

The functions of the Computer Group Personnel were divided into three major areas:

1. Applications Programming
2. Systems Programming
3. Utility Programming

The Applications Programming function consisted of all those programming efforts which involved the plant operation. This included programming of process calculations, balances and CRT functions which evaluated data. The Systems Programming function included all programming efforts directed to the efficient operation of the computer system. Some of the projects in this area were integration of Scanitemp panels into the Scanivalve operation, CRT functions such as a calculator not directly related to the plant operation and establishment of the on-line analyzer system. The Utility Programming function consisted of all functions which could be used by a large number of programs or those which could be written on a general basis as opposed to solving a specific problem. These programs included search and read operations for magnetic tape, automatic plotting routines and background tasks to handle data.

In addition to these major functions, support functions such as liaison activities with process engineers, keypunching services and other organizational activities were also required.

IV. TECHNICAL REPORT

G. Computer System

6. Organization of the Computer Group - cont'd

The Computer Group Personnel consisted of a Supervisor, two Chemical Engineer/Programmers, one for applications programming and one for systems programming, one Junior Programmer and one Data Clerk.

IV. TECHNICAL REPORT

H. Laboratory

1. Laboratory Space Arrangements

The laboratory of the Synthane Plant, Bruceton, Pennsylvania covered a total area of 1,440 square feet.

The breakdown of the space available in each area of the laboratory is shown in Figure III-8 and is listed below:

1.	Coal Preparation Room	160 sq. ft.
2.	Laboratory Area	759 sq. ft.
3.	Gas Chromatograph Room	96 sq. ft.
4.	Office	108 sq. ft.
5.	Stock Room	48 sq. ft.
6.	Gas Cyclinder Pad	160 sq. ft.

The Coal Preparation Room was attached to the laboratory, but there was no doorway between them. This was done to prevent the coal dust from entering the laboratory. In the laboratory area are two fume hoods, wall benches, and two island benches. They were arranged as shown in Figure III-9.

Figure 4 III-8 Laboratory Space

BY _____	DATE _____	THE LUMMUS COMPANY	E. OR J. NO. _____
CHKD. _____			
BY _____	DATE _____		SHEET _____ OF _____
SUBJECT _____			

BY _____	DATE _____	THE LUMMUS COMPANY	E. OR J. NO. _____
CHKD. _____	DATE _____		
SUBJECT _____		SHEET _____ OF _____	

figure 2 III g. Arrangement of laboratory

IV. TECHNICAL REPORT**H. Laboratory - cont'd****2. Staff**

The laboratory staff included: one Plant Chemist, one Assistant Plant Chemist, one Day Analyst, and eight Technicians.

IV. TECHNICAL REPORT

H. Laboratory - cont'd

3. Laboratory Equipment

Listed below is the major equipment used in the laboratory along with a description of the analysis performed.

<u>Equipment</u>	<u>Manufacturer</u>	<u>Use</u>
Rotovac	Brinkmann	Dewatering of tars
Spectronic 20	Bausch & Lomb	Utilities & water analyses
Combustion Tube Furnace	Lindberg	Caron-Hydrogen in coal
Adiabatic Calorimeter	Parr	Heat of combustion
Atomic Absorption	Varian	Trace analyses in ash
Electric Furnace	Hoskins	Volatiles in coal
Coulter Counter	Coulter Electronics	Particle size distribution of coal dust
Moisture Teller	H.W. Dietert	Quick determination of moisture
Muffle Furnace	Lindberg	Determination of ash
Kjeldahl Apparatus	Precision	Determination of Nitrogen
Moisture Oven	Bockel	Determination of Moisture
Dohrmann Sulfur Analyzer	Envirotech	Determination of trace, Sulphur in liquids, solids and gases
1400 Gas Chromatograph	Varian	Gas analyses
3700 Gas Chromatograph	Varian	Gas analyses
Pulverizer	Holmes	Coal preparation
Crusher	Braun	Coal preparation
C,H,S,N Analyzer	Carlo Erba	Determination of carbon Hydrogen, Sulfur and Nitrogen in coal

IV. TECHNICAL REPORT**H. Laboratory - cont'd****4. Permanent Sample Points**

The following is a list of sample point numbers and their location. The prefix letter was chosen to identify a particular area of the plant.

(a) Prefix "C" was used for all samples from Raw Coal Inlet to the Pretreater. See Drawing No. E6656-01005A.

"C1" coal from Raw Coal Automatic Sampler, PA-112.

"C2" (S-101) inert gas at the top of the Coal Bucket Elevator, JD-103.

"C3" (S-102) inert gas from the top of the Raw Coal Storage Bin, FE-102.

"C4" (S-103) inert gas from the top of the Raw Coal Weigh Feeder, JD-105.

"C5" (S-104) inert gas from Dust Collector, PA-104X.

"C6" (S-105) inert gas from Pulverized Coal Storage Bin, FE-103.

"C7" pulverized coal from Pulverized Coal Sample Cutter, PA-113.

"C8" coal dust from the hand operating Diverter, PA-110X.

(b) Prefix "P" was used for all samples from the Pretreater to the Gasifier. See Drawing No. E6656-02005A.

"P1" (S-201) coal and gas from the Pretreater, DC-209.

"P2" material from alternate Pretreater Dump Pot, FA-221.

IV. TECHNICAL REPORT**H. Laboratory****4. Permanent Sample Points - cont'd**

(c) Prefix "G" was used for all samples from the Gasifier to the Raw Gas Scrubber including char. See Drawings E6656-04005A and B.

"G1" char slurry (location to be defined)

"G2" char taken either from the Pile of the Slurry Filter Cake Conveyor, JD-401.

(d) Prefix "S" was used for all samples from the Raw Gas Scrubber to the Shift Converter. See Drawing No. E6656-02005C.

"S1" overhead from Raw Gas Scrubber, DA-201 taken from the line to Process Analyzer, AR-238-1 (not a routine laboratory sample).

"S2U" (SC-204) tar from Scrubber Surge Tank, FA-215 upstream of HCV-204.

"S2" (SC-204) tar from Scrubber Surge Tank, FA-215 downstream of HCV-204.

"S3" (SC-202) water to Venturi Scrubber, FE-201.

"S4" (SC-200) water to Raw Gas Scrubber, DA-201.

"S5" (SC-215) liquid effluent from Scrubber Surge Tank, FA-215.

"S6" (SC-203) blowdown from Steam Drum, FA-218.

"S7" (SC-214) oil from FA-215.

IV. TECHNICAL REPORT**H. Laboratory****4. Permanent Sample Points - cont'd**

(e) Prefix "SC" was used for all sample points from the Shift Converter to the Benfield Unit. See Drawing No. E6656-02005D.

"SC1" gas after Shift Converter, DC-208 taken from the line to Process Analyzer, AR-238-2 (not a routine laboratory sample).

"SC2" gas after Absorber Feed K.O. Drum, FA-203, taken from the line to Process Analyzer, AR-238-3 (not a routine laboratory sample).

(f) Prefix "B" was used for all sample points from the Benfield Unit up to the Stretford Unit. See Drawing E6656-02005E.

"B1" overhead from the Acid Gas Absorber, DA-202, taken from the line to Process Analyzer, AR-241 (not a routine laboratory sample).

"B2" (SC-205) liquor from a side draw off on the Acid Gas Absorber, DA-202 (not a routine laboratory sample).

"B3" (SC-206) bottoms liquor from the Acid Gas Absorber, DA-202.

"B4" (SC-207) regenerated liquor from the side draw off of the Absorbant Regenerator, DA-203.

"B5" (SC-208) regenerated liquor from the bottom of the Absorbant Regenerator, DA-203.

"B6" (SC-209) liquor from the top tray of the Absorbant Regenerator, DA-203 (not a routine laboratory sample).

IV. TECHNICAL REPORT**H. Laboratory****4. Permanent Sample Points - cont'd**

"B7" gas feed from the absorber effluent knock-out drum (FA-204) to the Carbon reactors (DC-204 A&B). Sample taken from the line to Process Analyzer AR-248-1 (not a routine laboratory sample).

"B8" gas feed from the acid gas knock-out drum (FA-205) to the Stretford Unit. Sample taken from the line to the Process analyzer AR-247-2 (not a routine laboratory sample).

(g) Prefix "ST" was used for all sample points from the Stretford Unit to the Carbon Reactors. See Drawing No. E7486-02005J (Ralph M. Parsons Drawing).

"ST1" gas overhead between the Absorbers, 10-1101 and 10-1102 (not a routine laboratory sample).

"ST2" liquor from the bottom of the Absorber, 10-1101.

"ST3" gas from the Separator, 10-1103 (not a routine laboratory sample).

"ST4" liquor to the Oxidizer, 10-1901.

(h) Prefix "CR" was used for all sample points from the Benfield Unit to the Methanators. See Drawing No. E6656-02005F.

"CR1" (S-210) gas from the Carbon Reactor, DC-203A taken from the line to the Process Analyzer, AR-213 (not a routine laboratory sample).

"CR2" (S-211) gas from the Carbon Reactor, DC-203B taken from the line to the Process Analyzer, AR-213 (not a routine laboratory sample).

IV. TECHNICAL REPORT**H. Laboratory****4. Permanent Sample Points - cont'd**

"CR3" (S-212) gas from the Carbon Reactors, DC-204A and B taken from the line to the Process Analyzer, AR-213 (not a routine laboratory sample).

"CR4" (SC-213) Dowtherm (not a routine laboratory sample).

(i) Prefix "M" was used for all sample points from the Methanators to Product Gas. See Drawing No. E6656-02005G & H.

"M1" effluent gas from the TWR Methanator, DC-205 taken from the line to Process Analyzer, AR-239-1 (not a routine laboratory sample).

"M2" effluent gas from the Final Methanator K.O. Drum, FA-209 taken from the line to Process Analyzer, AR-239-2 (not a routine laboratory sample).

"M3" feed gas to the HGR Methanator, DC-206 taken from the line to Process Analyzer, AR-239-3 (not a routine laboratory sample).

"M4" feed gas to the alternate Final Methanator DC-210, taken from the line to Process Analyzer, AR-239-4 (not a routine laboratory sample).

"M5" effluent gas from the alternate Final Methanator, DC-210 taken from the line to Process Analyzer, AR-239-5 (not a routine laboratory sample).

(j) Prefix "U" was used for all Utility sample points.

"U1" blowdown from High Pressure Boiler, BF-301.

IV. TECHNICAL REPORT

H. Laboratory

4. Permanent Sample Points - cont'd

"U2" blowdown from Low Pressure Boiler, BF-302.

"U3" blowdown from alternate Low Pressure Boiler, BF-302S.

"U4" Deionized Water (on a demand basis).

"U5" Boiler Feed Water (on a demand basis).

"U6" Cation Bed Effluent (on a demand basis).

"U7" Anion Bed Effluent (on a demand basis).

"U8" Cation Bed Acid Wash (sample cock A) (on a demand basis).

"U9" Anion Bed Caustic Wash (sample cock C) (on a demand basis).

"U10" Mixed Bed Caustic Wash (sample cock 2A) (on a demand basis).

"U11" Mixed Bed Acid Wash (sample cock E) (on a demand basis).

"U12" stack gas from High Pressure Boiler, BF-301 (on a demand basis).

"U13" stack gas from Low Pressure Boiler, BF-302 (on a demand basis).

"U14" stack gas from alternate Low Pressure Boiler, BF-302S (on a demand basis).

"U15" inert gas from Inert Gas Generator, BE-301 (on a demand basis).

"U16" inert gas from Inert Gas Generator, BE-301S (on a demand basis).

"U17" Cooling Tower Water Return Line.

IV. TECHNICAL REPORT**H. Laboratory****4. Permanent Sample Points - cont'd**

"U18" effluent from the Sewage Treatment Plant.

"U19" a fictitious sample point for presenting the data from regeneration.

"U20" Condensate Return Line to the Deaerator.

"U21" Demineralized Water Tank.

"U22" fast rinse of Mixed Bed.

"U23" City Water.

"U24" Neutralization Pit.

"U25" Condensate Return to Condensate Receiver, FA-312.

"U26" Propane feed to carbon beds.

"U27" Propane effluent from carbon beds to inert gas generators BE-301 & BE-301S.

(k) Prefix "TO" was used for all samples from the Thermal Oxidizer.

IV. TECHNICAL REPORT**H. Laboratory****5. Sample Schedule**

During a proposed 14 day gasifier run the laboratory would require 158 manhours per day to complete the analyses of all process, utility and environmental samples. This presents a sample overload of 70 manhours as shown by the following schedules (Tables III-2 and III-3). Because of this overload the sample schedule was revised to include the minimum number of samples needed for satisfactory plant operation using the laboratory personnel available. This was the final revision which seemed to work well during gasifier run 2-DB-0. However, even this final revision still presents an overload since no time has been allotted for reports, solution make-up or contingency and special analyses. Had the project continued, an increase in laboratory staff would have been necessary to handle the increasing sample load.

TABLE IV-4 SAMPLING SCHEDULE
COAL, CHAR, AND SCRUBBER WATER
(Revised with Cutbacks)

SAMPLE	SAMPLE FREQUENCY	ANALYSIS REQUIRED	ANALYST HRS. REQUIRED	ANALYST HRS. REQUIRED PER DAY
1. RAW COAL	Each Truck	+ 3/4"	0.50	1.50 (Assumed 3 trucks/day)
		+ 1/4"	0.50	
		Total Moisture	1.00	
	Composite of 3 trucks	Proximate	1.75	1.75
		Ultimate	5.50	5.50
2. GROUND COAL	Composite of 8 hrs.	Proximate	1.75	5.25
		Ultimate	5.50	16.50
3. CHAR	2-hr Filter Screen Samples	FSI and A.D. Moist.	1.00	12.00
		C-H and Ash	1.00	12.00
	8-hr. Dumpster Composite	Proximate	1.75	6.25
		Ultimate	5.50	16.50
	1 Filter Screen Sample/Shift	Proximate	1.75	5.25
		Ultimate	5.50	16.50
4. WATERS	Feed to Venturi Scrubber taken every 4 hrs.	pH 1	0.05	0.30
		TSS 1	0.25	1.50
	Feed to Raw Gas Scrubber taken every 4 hrs.	pH 1	0.05	0.15
		TSS 1	0.25	1.50
	Water from center section of FA-215	pH 1	0.05	0.15
		TSS 1	0.25	0.75
			TOTAL	108.00

TABLE IV-4 SAMPLING SCHEDULE - cont'd

GAS ANALYSIS

SAMPLE	SAMPLE FREQUENCY	ANALYSIS REQUIRED	ANALYST HRS. REQUIRED	ANALYST HRS. REQUIRED PER DAY
9. INERT GAS GENERATOR	1 per day	1 Orsat 1 G. C. analysis	0.50 0.50	0.50 0.50
10. GAS FROM H. P. CO ₂ SPHERE (FA-311)	1 per day	1 G. C. analysis	0.50	0.50
11. RAW PROPANE BEFORE CARBON REACTORS	1 per day	1 H ₂ S Mercaptan	2.00	2.00
12. PROPANE AFTER CARBON REACTORS	1 per day	1 H ₂ S Mercaptan	3.00	3.00
13. PROCESS GAS BEFORE BENFIELD SYSTEM	12 per day	2 G. C. per sample	1.50	18.00
15. PROCESS GAS AFTER STRETFORD SYSTEM	1 per day	2 G. C. analysis	1.50	1.50
16. PRETREATER GAS	3 per day	2 G. C. analysis	1.50	1.50
17. GAS FROM OVERHEAD OF FA-203 (AR-238-3)	Every 2 hrs.	2 G. C. analysis	1.50	1.50
			TOTAL	31.40

TABLE IV-4 SAMPLING SCHEDULE - cont'd

UTILITY ANALYSIS

SAMPLE	SAMPLE FREQUENCY	ANALYSIS REQUIRED	ANALYST HRS. REQUIRED	ANALYST HRS. REQUIRED PER DAY
5. U1, U2, U3, U5 U17, U18, U20 U21, U25	1 sample of each per day	3 o-phosphate 1 T-phosphate 9 pH 9 Silica 3 P-alk. 3 M-alk. 4 Hydrazine 7 Iron 8 Conductivity 1 calcium 1 Hardness 1 Chlorides 2 Residual Chlorine 2 Free Chlorine 1 Res. Cl (Chlorox)	0.15 0.25 0.45 0.45 0.45 0.45 0.20 0.35 0.40 0.15 0.15 0.15 0.15 0.10 0.10 0.15	0.15 0.25 0.45 0.45 0.45 0.45 0.20 0.35 0.40 0.15 0.15 0.15 0.10 0.10 0.15
6. U4, U6, U7 (1WT Unit)	1 sample/shift	3 pH 1 Acidity 3 Conductivity 2 Silica	0.15 0.15 0.15 0.10	0.45 0.15 0.45 0.30
7. U19 (Regeneration)	1 sample per shift	2 H ₂ SO ₄ titrations 1 Acidity 1 NaOH titration 1 Alkalinity 1 Conductivity	0.30 0.15 0.15 0.15 0.05	0.90 0.45 0.45 0.45 0.15
	Mixed Bed	1 H ₂ SO ₄ titration 1 NaOH titration 1 Fast Rinse 1 In-service Cond.	0.15 0.15 0.15 0.05	0.15 0.15 0.15 0.05
3. U24	Neutralization Pit	1 pH 1 TDS	0.05 0.25	0.15 0.75
		TOTAL		9.40 HRS./DAY

TABLE IV-4 SAMPLING SCHEDULE - cont'd

BENFIELD AND STRETFORD

SAMPLE	SAMPLE FREQUENCY	ANALYSIS REQUIRED	ANALYST HRS. REQUIRED	ANALYST HRS. REQUIRED PER DAY
BENFIELD SYSTEM				
18. LEAN LIQUOR	1 per day	1 Alkalinity	0.25	0.25
		1 Activator A	1.00	1.00
		1 Inhibitor B	1.00	1.00
		1 Iron	0.25	0.25
		Foam Height	0.25	0.25
19. RICH LIQUOR	1 per day	1 Alkalinity	0.25	0.25
		Foam Height	0.25	0.25
		1 Sulfur	0.50	0.50
STRETFORD SYSTEM				
20. LIQUID LEAN	1 per day	1 Alkalinity	0.25	0.25
		1 pH	0.05	0.05
		1 ADA	1.00	1.00
		1 Vanadium	0.50	0.50
		1 Entrained Sulfur	0.25	0.25
		1 H ₂ S	0.50	0.50
21. LEAN LIQUID	1 per week	1 percent oxidized	2.00	0.29
		1 Thiosulfate	1.00	0.14
		1 Total fixed carbon	1.00	0.14
		1 Free bisulfide	0.50	0.07
		1 Citric acid	1.00	0.14
			TOTAL	7.08

TABLE IV-4 SAMPLING SCHEDULE - cont'd

ENVIRONMENTAL SAMPLING
(Revised with increase in samples)

SAMPLE	SAMPLE FREQUENCY	ANALYSIS REQUIRED	ANALYST HRS. REQUIRED	ANALYST HRS. REQUIRED PER DAY
54" Plant Exit	1/day	1 COD	0.25	0.25
		1 Phenol	0.25	0.25
		1 N as NH ₃	0.25	0.25
		1 Color	0.10	0.10
		1 pH	0.05	0.05
		1 TSS	0.25	0.25
		1 TDS	0.50	0.50
			TOTAL	1.65
HOLDING TANK COMPOSITE	1/week	2 COD	0.50	0.07
CHAR FILTER SEPERATOR	1/week	2 Phenol	0.50	0.07
		2 N as NH ₃	0.50	0.07
		2 Color	0.20	0.03
		2 pH	0.10	0.01
		2 TSS	0.25	0.04
		2 TDS	0.50	0.07
			TOTAL	0.36
48" Plant Inlet	1/week	1 COD	0.25	0.04
		1 Phenol	0.25	0.04
		1 N as NH ₃	0.25	0.04
		1 Color	0.10	0.02
		1 pH	0.05	0.01
		1 TSS	0.25	0.04
		1 TDS	0.50	0.07
			TOTAL	0.26

TABLE IV-5 MINIMUM SAMPLING NEEDED TO KEEP PLANT RUNNING
(Final Revision)

SAMPLE	SAMPLE FREQUENCY	ANALYSIS REQUIRED	ANALYST HRS. REQUIRED	ANALYST HRS. REQUIRED PER DAY
1. RAW COAL	3 trucks per day Composite sample from each truck.	+3/4, +1/4, moisture, ash	3.0	3.0
2. GROUND COAL	Sample every 4 hrs. and prepare composite once/ day	Sieve, F.S.I., Proximate Ultimate	9.25	9.25
3. CHAR	Sample filters every prepare composite once/shift	<u>PRETREATER ON LINE</u> A.D. Moisture, Sieve, F.S.I. and Proximate	3.5	10.5
		<u>PRETREATER AND GASIFIER ON LINE</u> A.D. Moisture, Sieve F.S.I. Proximate and Ultimate	9.0	27.0
4. CHAK	Sample char dumpster once per shift and pre- pare daily composite.	A.D. Moisture, Sieve, Prox- imate and Ultimate	9.0	9.0
5. PRODUCT GAS	Sample twice/shift	Complete Analysis	1.5	9.0
6. SCRUBBER WATER	S-3 twice/shift S-4 twice/shift S-5 once/shift Composite daily for com- plete analysis at the end of the run.	pH, TSS pH, TSS PH, TSS	0.3 0.3 0.3	1.8 1.8 0.9

TABLE IV-5 MINIMUM SAMPLING NEEDED TO KEEP PLANT RUNNING - cont'd
(Final Revision)

SAMPLE	SAMPLE FREQUENCY	ANALYSIS REQUIRED	ANALYST HRS. REQUIRED	ANALYST HRS. REQUIRED PER DAY
7. BENFIELD	Lean and Rich solutions Exit gas from absorber and regenerator all once/day	Complete Analysis	6.75	6.75
8. STRETFORD	Lean Solution and exit gas from absorber once/day	Complete Analysis	4.85	4.85
9. UTILITY	One complete set of samples per day	Complete Analysis	3.95	3.95
10. I.W.T. REGENERATION	Cation & Anion beds 1/shift Mixed bed 1/day Neutralization Pit 1/shift	Wt.% H ₂ SO ₄ , Wt.% NaOH " " pH, TSS, TDS	3.65	3.65
11. MISC. GASES	Inert Gas Generator, H.P.CO ₂ , L.P.G. after carbon beds Sample once per day	Complete Analysis	4.0	4.0
12. ENVIRONMENTAL	54" PLANT EXIT 1/day 48" PLANT INLET 1/week Holding Tanks (2) 1/week Char Area Separator 1/week	Complete Analysis	3.0	3.0

IV. TECHNICAL REPORT

H. Laboratory

6. Outside Laboratories

We entered into several contracts with outside laboratories to perform environmental, biological and corrosion studies. These are listed below along with the type of work they were contracted to perform.

- Calgon Corporation - Water consultant for cooling tower. Also performed corrosion and biological studies on the cooling system.
- N.U.S. Corporation - Water consultant for boiler, cooling tower and sewage treatment systems. Also performed corrosion and biological studies on the cooling system and sewage treatment plant.
- Penn Environmental Consultants - Operated sewage treatment plant. Ran biological tests on the system and made the necessary adjustments.
- University of Pittsburgh - Ran N.P.D.E.S. permit samples

7. Data Reporting and Storage

The object of this system was to provide a permanent, continuous, and complete record of all laboratory samples and analyses in a convenient form.

a. Method

(1) All permanent sample points were to have an exclusive sample point number, i.e. G 1-25 (1330-1-7-75) Gasifier #1 sample point, twenty-fifth sample from that sample point from the start of the gasifier, taken at 1330 hours on January 1, 1975.

IV. TECHNICAL REPORT

H. Laboratory

7. Data Reporting and Storage

a. Method - cont'd

(2) Each sample submitted for analysis had a tag attached that had a complete identification number. The tag was to be initialled by the one who took the sample.

(3) The sample was logged in on an Analysis Work Sheet. The work sheet data included the sampling information, procedures used, all calculations and the analysis of the sample. The analysis work sheet was triple paged and produced two copies of the analysis.

(4) Upon completion of the analysis, one carbon copy of the work sheet was returned to the control room, the other carbon copy was sent to the Technical Superintendent. The original was retained by the laboratory. The original did not leave the laboratory control. Requests for copies were honored.

(5) The analysis was then entered on a Permanent Data Sheet. Each sample point had a permanent data sheet that contained all the laboratory analyses. A typed copy of the permanent data sheet was made and retained by the Technical Superintendent. The original by the laboratory.

(6) The Analysis Work was be retained for at least six months after completion of the run associated with the data.

(7) Special analysis on a sample from an assigned sample point was handled in the same manner as a routine sample, as far as data retention is concerned.

IV. TECHNICAL REPORT

H. Laboratory

7. Data Reporting and Storage

a. Method - cont'd

(8) All special analysis from unassigned sample points was recorded on a permanent data sheet that was in a separate section of the permanent data binder, and filed according to date.

(9) Assignment of permanent sample point numbers was by agreement between the Technical and Production Departments.

b. Discussion

(1) The one who took the sample will enter on the tag attached to the sample container a complete identification number and his initials. The identification number was composed of three parts; the first part identified the sample point location, the second part the cumulative number of samples from that point, the third the time and date of sampling. The cumulative number was available from the laboratory technicians.

(2) The sample was taken to the laboratory and the above information logged in on an Analysis Work Sheet together with the analyses to be done and the procedures to use. A master list of sample points and the required analyses was published. The sample and the Analysis Work Sheet remained together until the required were completed.

(3) Upon completion of the analyses, the data was transferred to a Permanent Data Sheet and the three paged Analysis Work Sheet divided. One copy of the Analysis Work Sheet was given to the Control Room, the other transferred to the Technical Superintendent and the original retained in a binder by the Laboratory for at least six months after the termination of the run on which the sample was taken.

IV. TECHNICAL REPORT

H. Laboratory

7. Data Reporting and Storage

b. Discussion

(4) Each month a permanent data sheet was prepared and proofread. All corrections were made before xeroxing. The original was retained by the computer group and the xeroxed copy retained by the laboratory.

(5) The computer group keypunched all laboratory data onto data cards for future use.

IV. TECHNICAL REPORT

I. Environmental Program

Synthane Pilot Plant was operated under the NPDES Permit issued by EPA. Under the new regulations established by the State of Pennsylvania, it was required of government facilities to file for a number of plans and permits and discharges to conform to State regulations. The following plans and permits were worked on and their status is as follows:

- (a) Pollution Incident Prevention Plan - Plan statement approved.
- (b) Spill Prevention Control & Counter Measures Plan - statement filed, approval pending.
- (c) Water permits (includes modifications to existing NPDES permit) - Permits approaching completion stage.
- (d) Air Permits - Permits approved.

There were a number of monitoring programs established to ensure conformance to various state and EPA permit requirements. The water discharge streams were monitored monthly by University of Pittsburgh for the parameters established in the NPDES permit. In addition, the effluent streams were monitored by both Lummus laboratory and outside laboratories such as Penn Environmental and NUS Corporation. This additional sampling and analysis ensured adequate control on the discharge of effluent streams.

The air quality was monitored by separate contracts established by DOE. The thermal oxidizer was monitored by RECON consultants and ambient air monitoring studies performed by ENVIRO-CONTROL.

IV. TECHNICAL REPORT**I. Environmental Program - cont'd**

At Synthane there was an ongoing program of establishment of operating practices that will result in minimal pollutant discharge. Efforts were made to minimize the impact of an unlikely oil spill or other disasters and our operators are familiar of the standard operating practices under such circumstances. It was the practice to report any pollutant discharge incident to proper authorities such as the Coast Guard, Pennsylvania Department of Environmental Resources and EPA.

A report covering the environmental activities of the Synthane Pilot Plant was issued in February 1979. The report contained the following information:

- 1) NPDES Survey Committee Report
- 2) Air and Water Permits
- 3) Solid Waste Permits
- 4) Pollution Incident Prevention Plan
- 5) Spill Prevention Control and Countermeasure Plan

A copy of this report is in the Synthane Pilot Plant Bruceton Library.

V. ENGINEERING REPORT

A. Program Objective

The Synthane Equipment and Materials Performance Evaluation Program (SEMPEP) was established at the Synthane Coal Gasification Pilot Plant to systematically record and analyze performance and failures of equipment and materials selected for the coal gasification process. Such mechanical evaluation of the components in the plant provided a sound basis for modifications and selection of alternates for reliable and safe operation of the plant. Also, the data gathered by the program can benefit other facilities in the coal conversion field facing similar equipment and material selection problems.

B. Changes and Achievements

The Synthane Coal Gasification Pilot Plant was designed by C.E. Lummus based on the data generated in the laboratory scale synthane unit in Pittsburgh Energy Technology Center. The plant was constructed by Rust Engineering Company and C.E. Lummus was responsible for startup and operations of the plant.

Prior to commissioning the plant, a mechanical audit was performed to check out the design and construction of the plant. As a result of the audit a list of changes was generated covering the process and mechanical modifications necessary for reliable and safe operation of the plant. No. LTBD-7936 "Mechanical Audit of Synthane Plant" (memo dated August 1, 1975). (The list of changes is included in the appendix).

V. ENGINEERING REPORT**B. Changes and Achievements - cont'd**

Several items on the list required extensive studies to solve the potential problems and detailed design packages were prepared to implement the required changes. The engineering for these changes was performed by the Pilot Plant project engineering department and the assistance of Lummus engineering specialists in Lummus Technical Center - Mechanical Engineering Department, Bloomfield, New Jersey. The study reports are included later in this section under the title "Special Reports".

During the period covering the startup and operating of the plant, several process and mechanical problems were encountered which required modifications of the existing equipment and the addition of several components and systems to the plant. The changes related to the Synthane Process Equipment are covered in the SEMPEP report included later in this section. Other changes are covered under the title "Miscellaneous Changes."

The Pilot Plant project engineering department prepared detailed engineering and design packages for these modifications and followed up procurement and construction activities.

Plant components having chronic failure problems were studied and special reports with recommended changes were prepared. The changes that were feasible within the constraints of operating schedule and budgets were implemented. In some cases alternate ways were designed to minimize the effects of the problems on plant operations.

V. ENGINEERING REPORT**C. Service Conditions and Operating Modes**

Coal preparation included raw coal unloading, storage, pulverizing and drying, and storage of pulverized coal. The system operated at near atmospheric pressure and at temperatures from ambient to approximately 900°F. The system was designed to handle five tons/hr. of coal and was operated continuously to build up inventory of pulverized coal prior to each gasification run and whenever required to replenish inventory during the run. The system was operated for about 1200 hours to give 2100 tons of Rosebud and 1600 tons of Illinois No. 6 coal in the period ending July 1976 through September 1978.

The high pressure coal feed system included weighed batching of pulverized coal, pressurizing lock hoppers (storage injectors) and continuous feeding from the injection hopper (primary injector) to either the pretreater or the gasifier. The system was designed to feed coal at 1 to 3 tons/hr, and pressurize coal at 1000 psig. It was operated at 600 psig and the operating temperature was approximately 150°F.

The pretreater and gasifier were designed for 1000 psig operation, but were operated at 600 psig. Operating temperature in the pretreater was around 800°F and in the gasifier was as high as 1700°F in the reaction zone.

The pretreater was bypassed during Montana Rosebud Coal runs, except for the last run when the pretreater was used to preheat this coal. It was operated for 520 hours for Illinois No. 6 Coal runs. The gasifier was operated for a total of 1200 hours.

V. ENGINEERING REPORT**C. Service Conditions and Operating Modes - cont'd**

The gas scrubbing operation included quenching of the overhead gas from the gasifier, scrubbing entrained solids and removal of liquid hydrocarbons from the gas. The system was designed for 1000 psig operation, but was operated at 600 psig. The operating temperature of the system was around 400°F. The water circulation in the gas scrubbing was started for 4300 hours in the period ending December 1978.

The char handling system included the transport of the 600°F char from the char cooler, the slurring of the char, depressurizing the slurry to atmospheric pressure, filtration of the char slurry and recycling the filtrate to the process. The high pressure part of the system was designed for 1000 psig operation, but was operated at 600 psig. Temperatures in the system ranged between 800°F and 120°F. The system was operated together with the gasifier and the char cooler.

FLOW CHART FOR DATA COLLECTION AND EVALUATION

----- FAILURE REPORT INFORMATION

FIGURE V - 1

V. ENGINEERING REPORT**D. Data Collection and Evaluation Program****1. Organization**

The data collection and evaluation system is shown on Figure V-1.

2. Procedures**a. Failure Reports**

In the event of failure of any plant component, the Operations Department notified Quality Control (Q.C.) Engineer. The Q.C. Engineer observed the failed component and initiated the Failure Report.

The Failure Report was filled out by the Q.C. Engineer with input from the Operations Department, the Technical Department and the Plant/Project Engineering Department, stating the following:

- (a) Time of Failure
- (b) Equipment Name and Number
- (c) Time the component was in service
- (d) Manufacturer, Model No., Material of Construction
- (e) Repair History
- (f) Service Conditions
- (g) Observations by Q.C. Engineer, including sketches and photographs detailing nature of failure

The report was reviewed by Failure Review Board in their periodic meetings to determine cause of the failures and corrective action. The failed components were sent to outside agencies if detailed analysis was required.

The completed failure reports were filed in the SEMPEP file and Q.C. file and copies were issued to DOE for external distribution.

V. ENGINEERING REPORT**D. Data Collection and Evaluation Program****2. Procedures - cont'd****b. Inspection Reports**

Critical process vessels were inspected prior to each plant run and an inspection report was issued along with the vessel closure permit.

The inspection report noted the condition of the internals in the vessel; it also noted the locations of process sensing elements. Mechanical condition of the components was compared with the previous observation and changes were reported.

Copies of Inspection Reports were filed by the Q.C. Engineer.

c. Piping Wall Thickness Monitoring

The piping wall thickness was monitored at predesignated points in the area of severe service. Periodic checks of wall thickness were made using ultrasonic measurements and points of abnormal wear were identified for corrective action to prevent the line failures.

d. Elapsed Time Meters

Elapsed time meters were installed in the electrical circuits to log the time in service of critical pumps and compressors. The time in service was noted on all failure reports related to these equipment items. The elapsed time meters were useful in evaluating service length of critical moving parts and those subject to wear, like bearings, pump seals, etc.

V. ENGINEERING REPORT**D. Data Collection and Evaluation Program****2. Procedures - cont'd****e. Test Coupons**

Under a special program sponsored by DOE, Metals Properties Council, Inc. (MPC) and Illinois Institute of Technology Research Institute (IITRI) test coupons of various alloys were installed in plant equipment subject to hostile conditions. The coupons were located in the pretreater, at various levels in the gasifier, and in vapor and liquid phases of the gas scrubbing vessels.

The coupons were removed and analyzed by MPC/IITRI at the end of a series of runs. The results were reported in their periodic progress reports.

Another set of test coupons was installed by the National Bureau of Standards (NBS) to study the effect of gasifier conditions on various refractory materials.

3. Arrangement of Collected Data**a. SEMPEP Files**

(SYNTHANE Equipment and Materials Performance Evaluation Program)

The equipment files are arranged in alpha-numerical order by the equipment numbers. The files contain failure reports related to each of the equipment items, along with special performance reports issued related to that item. The files are located in the Reference Library at the Synthane Plant.

V. ENGINEERING REPORT

D. Data Collection and Evaluation Program

3. Arrangement of Collected Data - cont'd

b. Quality Control Files

These files are arranged in the alpha-numerical order by the equipment numbers. Each file contains failure reports and inspection reports related to the equipment item. Also included are photographs showing the nature of the failures and appearance of the component during the inspection.

These files also have code certificates of repair and testing, along with the X-ray films showing the failures and the repaired components.

The transparencies (slides) are filed in chronological order. The files are located in the Reference Library at the Synthane Plant.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****1. Coal Preparation and Feed System****a. Equipment****(1) FE-101, Truck Hopper**

- The grating on the top of the hopper was revised by adding more crossbars. Spacing was changed from 6" x 6" to 2" x 3" to eliminate lumps of frozen coal which occasionally plugged the feed conveyor.

(2) JD-103, Raw Coal Bucket Elevator

- The discharge chute angle was changed to eliminate plugging problems.

(3) FE-102, Raw Coal Storage Bin

- Steam panel coils were added to the outside of the lower section to prevent freezing of the wet coal during storage.

(4) BC-101X, Drying Air Heater

- The pilot was changed from #2 fuel oil to propane firing to improve its starting reliability.

- A water spray quench nozzle was installed in the discharge duct to limit flue gas temperature below the 250°F limit of the system circulating fan by cooling the hot gas from the coal mill when the coal feed is interrupted.

- The main burner capacity was reduced by installing smaller nozzles.

- The angle of the inlet louvers was adjusted to minimize refractory erosion by entrained coal fines in the recycle flue gas.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****1. Coal Preparation and Feed System****a. Equipment - cont'd****(5) PA-102, Drying Mill**

- The mill is a modified hammer type pulverizer which simultaneously grinds and dries the coal. It produced the specified grind of 20 Mesh product during the Rosebud coal runs. The performance of the mill for Illinois No. 6 coal runs was less than satisfactory as it produced excessive fines. The mill speed, the hammer arrangement, and the types of hammers were changed to reduce the amount of fine coal produced in the mill.

- The main shaft bearings and mill seals were modified to prevent coal from leaking out of the mill seals and collecting in the main shaft bearings. The problem was reduced but not eliminated.

- The star feeder, PA-102A, was eliminated because it plugged and filled the weigh feeder above with coal. The weigh feeder was then used for coal feed control.

(6) PA-108X, Vibrating Screen Rotary Feeder

- After 3 years in service, the steel rotor blade edges were worn out. Teflon strips were added to the rotor edges to improve the gas seal and reduce the back-flow of gas through the solids leaving the bottom of the cyclone. This back-flow caused excessive solids carryover with the gas out the top of the cyclone.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****1. Coal Preparation and Feed System****a. Equipment - cont'd****(7) FD-101X, Vibrating Screen**

- The screen performance was satisfactory during the Rosebud run with 20 mesh product.

- During Illinois No. 6 coal runs, product in the range of 40 to 60 Mesh was required for pre-treater operation. The screen cloth was changed to get the desired product size and to improve the screen efficiency.

- The cover of the screen was modified to provide observation doors during the trial runs.

- The original rubber support wedges were replaced because of heat deterioration.

(8) GB-102X, Drying System Fan

- There was one major failure of the fan when fan blades were badly eroded by fine coal in the circulating gas. In addition, the blades were bent from water that collected in the casing. This resulted in excessive vibration and bearing failure. The fan rotor was rebuilt, balanced and installed. The casing drain was modified to prevent plugging. The rebuilt fan still has excessive vibration and a new fan rotor was purchased for installation.

(9) PA-104X, Dust Collector

- The explosion panels ruptured when the bags were backblown with the dust collector valves closed; the panels were replaced with panels supplied by Fike Metal Corporation. The snapblow sequence was revised to eliminate blowing when the valves are closed.

V. ENGINEERING REPORT

E. Equipment and Materials Performance Summary

1. Coal Preparation and Feed System

a. Equipment

(9) PA-104X, Dust Collector - cont'd

- Dust bag clamps and other pieces of metal fell into the discharge screw conveyor causing it to jam. A grating was installed over the screw conveyor trough to catch foreign material.

- Steam heating panels were installed at the bottom of the dust collector to prevent condensation at startup of a cold system.

(10) FE-103, Pulverized Coal Storage Bin

- Steam tracing was decommissioned since it vaporized the moisture from the coal. The mixture travelled up and condensed on the colder walls in the top section resulting in lumps of wet coal.

(11) FE-106, Weigh Hopper

- A screen (1/4" x 1/4" mesh) was installed in the hopper to catch lumps of wet or frozen coal and to prevent plugging of the feed system.

b. Instruments

(1) Pressure

- Pressure sensors tended to plug with coal fines. Inert gas purging was used but instrument readings were masked by the pressure drop of the purge gas flow. Instead of continuous purging, blast purging was used to clear the fines periodically.

- Inert gas purges were added to sensing lines of pressure switch installations.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****1. Coal Preparation and Feed System****b. Instruments - cont'd****(2) Level**

- The level probes (paddle and capacitance type) in the coal bins gave false indications because the probes were coated with wet coal.

- Nuclear level detectors were used successfully for the high pressure lock hoppers and primary injector.

(3) Weight

- The load cell readings used for the weigh hopper were erratic and inconsistent because of high sensitivity and the effect of external loads around the hopper. Adjustment of the load cell sensitivity and revision to the supports of piping and the hopper corrected the problem.

- The totalizer readings were erratic due to electrical interference. This was corrected by adding electronic noise suppressors.

c. Piping and Valves**(1) Power Operated Valves**

- The cylinder actuated ball valves made by Gulf and Western Company (EBV Division), had numerous failures and operating problems in solid and gas carrying solids service. Most of the failures were caused by excessive torque which broke the valve stems when the ball jammed in the seats. This problem was solved by significantly decreasing the actuator closure speed. The valves however still experienced leakage problems after a short number of cycles. The valve seats are held against the ball by small springs. The springs

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****1. Coal Preparation and Feed System****c. Piping and Valves****(1) Power Operated Valves - cont'd**

plugged up with solids so they would not retract, thus jamming the ball. In some cases, the springs stuck in the retracted position resulting in high gas leakage through the valve. A design modification was proposed but not yet implemented to solve this problem. The proposed modification incorporated an internal sleeve with packings to isolate spring cavity from the flow path of solids to keep the solids out of the spring area. Also, a controlled flow of inert gas to purge the isolated cavity was suggested for keeping the spring area clear of fine coal particles. (Ref. Project 106-7, "Valve Failure Analysis Report, and Lummus Memo No. LTBD-166.)

- One of the EB valves (XCV-15) in the vent line from the lock hopper was replaced by a Grove Flex Flow Valve. This valve has a flexible elastomer sleeve which seals openings of a metal cage where gas flows in one direction. This valve has performed satisfactorily after replacing the standard sleeve made of Hycar with a natural rubber sleeve. Similar valves were ordered to replace ball valves in lines with gas carrying fines in the high pressure coal feed system.

(2) Check Valves in Gas Lines Carrying Coal Fines

- The original horizontal piston type check valves plugged with coal fines and were unable to seal. They were replaced with check valves from Technocheck Company. This valve has two halves of a disc connected by elastomer hinge which folds to allow flow in one direction. These valves performed satisfactorily in the gas lines between the hoppers.

V. ENGINEERING REPORT

E. Equipment and Materials Performance Summary

1. Coal Preparation and Feed System

c. Piping and Valves - cont'd

(3) High Pressure Coal Feed Line

The high pressure coal feed line from the injection hopper to the pretreater and gasifier was revised to improve control of coal feed rate. The original design had a restriction in the coal line (Petrocarb Venturi) to generate pressure drop for feed rate control. The coal feed line was 1" Schedule 80, 304 SS. On several occasions, the restriction plugged resulting in coal feed interruptions. In the revised design, the restriction was eliminated and the desired pressure drop was generated by changing the feed line to 3/4" Schedule 160 and adding 60 feet to its length. In the first revision, the line had seven 90° turns made with tee pipe fittings which were later replaced with two long radius pipe bends to reduce plugging at the bends.

(4) The 1" high pressure coal transport line was equipped with a special 12" radius, 1", Schedule 80, 304 SS, jacketed pipe bend (elbow) with instrumentation to study erosion of the pipe at the bend in the solid-gas stream. The pipe bend, with instrumentation, was furnished by Argonne National Lab. During a 14-month period (2400 tons coal conveyed) thickness loss of up to 10 mils was detected. At that time, the elbow was replaced with another one with modified instrumentation. The jacket was eliminated as rupture of the elbow due to erosion was determined unlikely. During a 5 month period (146 tons coal conveyed) thickness loss of up to 24 mils was detected. Findings of this study are published in A.N.L. Report "Erosion Monitoring of Coal Feed Line Elbows at the Synthane Plant by Means of The A.N.L. Intensity Erosion Detection System," dated May 22, 1978.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****1. Coal Preparation and Feed System - cont'd****d. Material**

The carbon steel chain for the raw coal bucket elevator, JD-103, broke because of corrosion from the sour inert gas used for purging. The gas was generated from #2 fuel oil containing sulfur. The chain was replaced and the inert gas system was changed over to pure CO₂, then to inert gas from a propane fired inert gas generator. There were no further failures.

The carbon steel bodies of EBV ball valves in coal feed system were found corroded prior to the startup of the plant. Rust scale was found in the spring cavity of the valve. The corrosion was caused by trapped moisture in the system when it was idle. One of the valve bodies was electroplated with nickel to study its effect on the corrosion. No corrosion of the valve bodies was noticed after the startup of the plant.

The balls of the EBV valves in the coal feed system were of 440C stainless steel. The ball surface facing the solids flow was eroded. These balls were replaced with Type 316 stainless steel balls. Four types of coatings were tried on the ball surface for erosion resistance: LC-4 (Cr₂O₃), Stellite No. 6, Ceramic, and LW-IN40-WC (85% WC, 15% Cr₂O₃). Some of these coatings chipped but the tungsten carbide did not chip and performed the best.

The original expansion joints in the coal grinding system were wire-reinforced rubber bellows. All of these were destroyed during a fire in the coal grinding system. The rubber bellows were then replaced with stainless steel expansion joints which have performed satisfactorily.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary - cont'd****2. Pretreatment and Gasification****a. Equipment****(1) DC-209, Pretreater**

The pretreater was bypassed during all but the last of Montana Rosebud coal runs. Prior to its commissioning, the following changes were made:

- A distribution cone with nozzles was added to the bottom head for injecting oxygen and fluidizing steam.

- The coal feed location was changed from the bottom nozzle to one of the side entering nozzles with an internal pipe discharging downward.

- Additional thermowells and pressure taps were installed.

- The electric tracing on the outside of the pretreater was revised for higher temperature.

- Finally, the coal feed was introduced into the bottom nozzle and a diamond-shaped diverter was installed above the inlet piping in the pretreater cone.

(2) DC-202, Gasifier

- During the initial pressure test, the flanged joints on the gasifier shell leaked. The monel gasket ring plates were rewelded to the vessel halves at the inner edge and seal-welded together at the outer edge.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****2. Pretreatment and Gasification****a. Equipment****(2) DC202, Gasifier - cont'd**

- The internal head between the plenum chamber and char cooler buckled because of a high differential pressure during cold fluidization tests. The standpipe expansion joint between the gasifier and char cooler was also damaged. The head was reinforced with braces and the expansion joint was repaired by the vendor. Two rupture discs were installed to equalize high differential pressure between the gasifier, plenum chamber and char cooler.

At that time a fluidizing cone and intermediate head design suitable for 150 psig internal and external pressure was developed by LTC-MED (See memo LTBE-98, July 12, 1976). Drawings, installation schedule, and quotes were received but no orders were placed because of a long lead time and installation downtime.

- The gasifier shroud above the cone buckled after Run 1-M in October, 1976. The buckling resulted from thermal stresses at local hot spots generated by hot gas channeling which was caused by the presence of a clinker in the reaction zone. The buckled shroud pieces were removed and replaced with new-shroud pieces made of 1/8 inches thick Incoloy 800. For a long term fix it was recommended that a 1/2 inch thick shroud with a sliding attachment to the cone be used to resist buckling.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****2. Pretreatment and Gasification****a. Equipment****(2) DC202, Gasifier - cont'd**

The upper shroud section thermally buckled when the gasifier filled with agglomerated coal and gas channeling once again occurred. These buckles were not repaired since it was not deemed to be a sufficient detriment to fluidization.

- At one point investigations were made into the possibility of decreasing the reaction zone diameter to achieve better mixing there. Two schemes were investigated; pouring a cast refractory section of smaller inside diameter and adding an inner shroud. No resolution on which system to use was arrived at.

- Hastelloy flanges were added to the gasifier safety valve to allow easier servicing of the valve.

- During a run in January 1977, a steam eductor was installed in the cyclone dip leg to increase the pressure differential across the dipleg and return the collected solids to the gasifier. At the end of the run, the eductor throat was eroded and the internals were coated with a hard deposit. The eductor was removed. The effectiveness of the eductor was not determined.

- The 7th floor manway shroud was cracked in April 1977 due to local stresses caused by a hot spot. An attempt to weld the shroud produced more cracks so the repair was discontinued and 3/8" diameter holes were drilled at the end of the cracks to stop propagation.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****2. Pretreatment and Gasification****a. Equipment****(2) DC-202, Gasifier - cont'd**

- A hole eroded in the cyclone transition piece in June 1977. A new cyclone was fabricated and installed.

- The 2 inch deep bed injection pipe was replaced with a 3 inch pipe because of erosion in May 1978. The pipe was replaced with a 3 inch size to reduce the velocity of the coal feed stream and minimize erosion.

- The modifications made to the gasifier for process improvement are covered in the "Gasifier Mechanical Report" in this section.

b. Instruments**(1) Temperature**

- Thermocouples TE-265, installed in the reaction zone of the gasifier, and TE-268, in the plenum zone, to measure temperature of the distribution cone failed several times. The thermocouples in the plenum zone failed when their sheaths split. The cause was either sulfidization or improper fabrication. The bare thermocouples in the gasifier failed sometimes. In addition to mechanical failures they had a tendency to have clinkers grow on them and were later removed from the reaction zone.

- Thermocouples used in the pretreater and gasifier reaction zone gave erratic indications at times when the thermowells were coated with agglomerated coal. It is believed that the thermowells themselves sometimes acted as seeding points for agglomeration or clinker formation in the presence of critical bed conditions. Otherwise, the thermocouples in wells performed satisfactorily.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****2. Pretreatment and Gasification****b. Instruments - cont'd****(2) Pressure**

- Differential pressure sensing instruments were used in the pretreater and gasifier to measure fluidized bed height and bed density.

- The size, purge velocity, and configuration of the pressure instruments for the gasifier were revised to prevent coal and water from collecting in the sensing lines and instruments. (Ref. Lummus Report "Measurement Synthane Pilot Plant Coal Gasifier," dated July 1977). Performance of the pressure instruments was satisfactory after these modifications.

(3) Rupture Discs (RD-268, 263, 264)

Three rupture disc loops were installed to protect the three compartments of the gasifier and scrubber surge tank, after the gasifier internals were damaged because of high differential pressure.

The rupture discs for RD-263 were designed to burst at 30 psi differential pressure and others at 25 psi. Each of the discs had a water seal loop on each side to keep hot process gases away during normal operation. Each disc was also provided with isolation valves and a bypass for replacing a blown disc. The disc had a wire which broke on disc rupture and alarmed in the control room. The discs were designed by Fike Metal Products Company for this application.

The original discs were aluminum coated with teflon. Several premature ruptures occurred because the discs were cut by the sharp edges of the holder. The holders were modified to round off the corners and the discs were replaced by solid teflon discs.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****2. Pretreatment and Gasification - cont'd****c. Piping and Valves**

- Prior to commissioning of the pretreater, two 4-inch valves were installed between the pretreater and gasifier for isolation. Ceramic plug type valves originally designed for the char lock hopper service by Consolidated Controls Corp. were used for this purpose. The valves failed due to cracking of the ceramic plugs. Other valves tried in this service were EBV (Gulf & Western Energy Products) and Kamyr ball valves also originally designed for char lock hoppers. Finally, one EBV and one Kamyr valve were installed in this service and were designed to hold up to 150 psig pressure. These valves failed to hold against pressure and also the balls would bind in the seats.

- Control of solids flow in the standpipe between the gasifier and char cooler was difficult to achieve with differential pressure alone. A "slot valve" was developed to control solids flow. An actuator arm passed through one of the decommissioned boiler feedwater spray nozzles and activated the slot valve located at the end of the standpipe. Small actuator movements would open and close a slot for fine flow control, while a gross movement would open a large flap to open up the end of the pipe. Results were generally satisfactory with this arrangement.

- A special slide gate control valve supplied by Tapco Corp. (PDCV-204) was installed to control the char cooler bed height by controlling char flow. The valve bonnet flange leaked during hydrotesting after installation although it was designed for 600 psig operation. The

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****2. Pretreatment and Gasification****c. Piping and Valves - cont'd**

seat and gate eroded after 200 hours of service. The valve was then repaired by the vendor. The bonnet flange was re-designed for 1190 psig at 825°F and the gate and seat were rebuilt and recoated with Stellite #6. The seat opening was 2 x 2 inches. After 540 hours of service, the seat was eroded and the coating was cracked. The cracked metal was ground out and an SS304 insert was installed. The insert was revised so that the seat configuration was a 1/2 inch wide x 2 inch long opening with the gate traveling along the 2 inch side. This was done as a result of study to determine the required opening for char flow control. The 2 inch x 2 inch opening was judged oversized for the flow and pressure differential. The performance of the revised seat configuration was not evaluated because the mode of the char flow control was changed. The valve was left fully open and the flow was controlled by differential pressure between the char cooler and the high pressure slurry tank.

- The purpose of the control valve PDCV-226A was to let down excess steam from the char cooler to the vent header. The pressure drop through the valve was 600 psi and the steam carried entrained char fines. The control valve was an ITT Hammel Dahl, Conoflow "S" Angle Globe Valve, with Carbon Moly steel body and hard faced SS 316 trim. The valve had several failures due to erosion of the trim. The original coating on the trim was Stellite #6 which failed in a few days.

V. ENGINEERING REPORT

E. Equipment and Materials Performance Summary

2. Pretreatment and Gasification

c. Piping and Valves - cont'd

- Tungsten carbide coating was tried in place of Stellite #6 which improved service life of the valve. In earlier trials, the problem was with attachment of the plug to the stem, resulting in failures. This was solved by revised design of the plug, incorporating setscrews for positive attachment (Reference Lummus Report "Valve Applications at the Synthane Plant in Mixed Phase Erosive Service" the original dated November 1977 and updated in June 1978). The uncoated stem and the body inlet and outlet show a little erosion.

- Application of a choke type valve (rotating disc with orifice) was planned in this service and one modified 1 inch x 4 inch Willis Oil Tool Company Model M2 Valve was installed (PDCV-266B) in parallel to the ITT control valve (PDCV-266A).

- The piping downstream of PDCV-266A failed several times due to erosion. The original outlet piping eroded at the 1 inch inlet of 4 inch x 1 inch reducer and also at the 4 inch elbow. The piping was revised to have 1 inch extension of valve outlet discharging into 4 inch pipe. The valve was relocated to eliminate an elbow on the discharge side. There was no further erosive failure of the discharge piping.

- In July, 1978, a 1 inch elbow on the bypass line of the PDCV-266A failed due to erosion. The elbow was replaced with a capped tee.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****2. Pretreatment and Gasification****c. Piping and Valves - cont'd**

- The 2 inch line between the pretreater and gasifier developed a hole from erosion at an elbow 9 months after installation. Wall thinning was observed at points of change in direction. The line was changed to 3" in size and a capped extension was provided at the bend to act as a packed tee. No failures were observed in the 6 month period after the modification.

- The char lift line from the char cooler to the high pressure slurry tank was revised after cold fluidization tests from a Y-type mixing tee to a cross type because the former design did not function well. There were three failures due to erosion in the char lift line; twice in the pipe and once in the socket weld fitting next to the mixing cross. The mixing cross and downstream piping were replaced with type SS 304. At the time of plant deactivation, fittings were changed from socket weld to butt weld type to prevent erosion due to flow disturbance starting at the gap between the pipe and the fitting.

d. Material**(1) Internal**

- Various alloys were chosen for internal components. Incoloy 800 and SS 310 performed best in the gasifier. Following is a summary of their performance.

- Inconel 600 pipes failed because of severe sulfidation.

- Hastelloy C-276 failed because of corrosion in the thermowell reducing sulfur environment at high temperature.

V. ENGINEERING REPORT

E. Equipment and Materials Performance Summary

2. Pretreatment and Gasification

d. Material

(1) Internal - cont'd

- Incoloy 800 performed well in the high temperature zones, but when used below the dew point of process condensate, it failed because of stress corrosion cracking. The failure was caused by sensitization of the alloy during post weld heat treatment of the vessel followed by exposure to the process condensate containing sulfur and chlorides.

- Incoloy 825 components used to replace I-800 components have performed well in the gasifier environment.

- Stainless steel Types 304, 310 and 316 were used for thermowells and instrument tubings. They showed some corrosion in the gasifier environment but there were no failures.

(Reference paper by B.N. Greene, The Lummus Co., "Materials Experiences at the Synthane Coal Gasification Plant," dated March 1979).

- Twenty-two gasifier nozzles as originally designed had Incoloy 800 pressure bearing components. A leak was found in the Incoloy reducer of nozzle #50 in May 1977. Analysis of the failed component and radiographic examination of similar nozzles showed cracks. Metal chips were cut from the nozzles and analyzed to determine the cause. The conclusion was that the Incoloy 800 components had cracked due to stress corrosion. They were sensitized

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****2. Pretreatment and Gasification****d. Material****(1) Internal - cont'd**

during post weld heat treatment and then were exposed to process condensate in the gasifier containing H_2S , which caused intergranular stress corrosion cracking. All 22 nozzles were replaced with carbon steel overlayed with monel and/or Incoloy 825 components where required. (Reference Report by B.N. Greene, The Lummus Co., "Failure of Incoloy 800 Reducer at Synthane Plant" dated December, 1977).

- A thermowell made of Hastelloy C-276 was corroded at its lower end which is located in the reaction zone. The cause of the corrosion was overheating and sulfidation. The thermowell was shortened 20 inches. (Reference ANL Report "Synthane Gasifier Thermowell (TE-205) Failure" dated May 1978).

- Incoloy 800 thermocouple sheaths in the gasifier plenum chamber failed in July, 1976. Analysis of failed sheaths disclosed cracking and pitting starting from the outer surface. The cracks were further widened by expansion of insulation material MgO on conversion to $Mg(OH)$ with steam. (Reference ANL Report "Synthane Gasifier Distributor Cone Thermocouple Sheath (TE-268) Failure" dated October, 1976). Sheaths made of stainless steel were tested but failed in the same manner.

- An Inconel 600 steam purge line to the cyclone dip leg failed due to corrosion in June, 1978. The analysis confirmed severe sulfidation attack starting from the outer surface, i.e. gasifier environment and it was replaced with Incoloy 800 pipe.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****2. Pretreatment and Gasification****d. Material****(1) Internal - cont'd**

- The lower end of the cyclone dip leg made of Inconel 600 was found detached and lying in the gasifier cone in March, 1978. The analysis of the failed piece showed severe sulfidation of the Inconel 600.

(2) External

There were six failures in type SS304 lines connected to the gasifier caused by stress-corrosion cracking:

- A 4 inch SS304 flange in the heatup line to the gasifier cracked in September 1976. The failure was analyzed by Argonne National Laboratory and determined to be caused by stress corrosion cracking. A new SS304 flange was installed. (Reference ANL Report "Synthane Weld Neck Flange Failure" dated November 1976.)

- A 4 inch SS304 line in rupture disc piping cracked in February 1978. The crack was near a weld between a soc-o-let for the bypass line and the 4 inch pipe. The crack was weld repaired and the bypass line was rerouted to provide flexibility for thermal expansion.

- A crack was found in the 4 inch SS304 heatup line in May, 1978. The failed piece was analyzed by Argonne National Laboratories. The failure was determined to be caused by stress corrosion cracking. The line was replaced by SS316 piping which is more resistant to stress corrosion.

V. ENGINEERING REPORTE. Equipment and Materials Performance Summary2. Pretreatment and Gasificationd. Material

(2) External - cont'd

- Another crack was found in the 4 inch rupture disc line in July 1978. The failure was analyzed by Metallurgical Laboratories of C.E. Power Systems. The failure was determined to be stress corrosion cracking due to chlorides. (Reference C.E. Power Systems Report "Metallurgical Examination of Failed Tube Samples from Bruceton Gasification Plant" dated November 1978).

- Following this failure, all the rupture disc piping was checked for flexibility and was modified to eliminate excess stress conditions. All rupture disc piping was changed from SS304 to SS316 which is more resistant to stress corrosion cracking.

- A 1 1/2 inch SS304 oxygen line failed at two points by stress corrosion cracking caused by chlorides which may have migrated from the gasifier because of a leaking check valve. One failure was a reducer near the oxygen flow control valve. Another was near the junction of the oxygen line with a steam line. Some lines connected to the gasifier suffered corrosion. The failed piping was replaced with new SS304 components.

- An orifice run in the SS304 oxygen line was found severely pitted. The pitting was caused by corrosion due to contamination migrating from the gasifier via the steam line. The section of the line was replaced with new SS304 pipe.

- Purge gas lines carrying carbon dioxide or inert gas to the gasifier were carbon-1/2 moly steel material. These lines were pitted due to corrosion caused by carbonic acid which was formed by moisture in the inert gas and also by migration of steam from the gasifier. The lines were replaced with SS304 piping and tubing.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****2. Pretreatment and Gasification****d. Material - cont'd****(3) Testing**

- Under a program sponsored by the Department of Energy, Illinois Institute of Technology Research (IITRI) and Metal Properties Council, Inc. (MPC) metal coupon racks and refractory test coupons were installed in the pretreater and gasifier. One rack of coupons containing carbon steel, aluminized carbon steel, 304 SS, 316 SS, and 401 SS was attached to the handhole cover of the pretreater. Six other racks were located in various parts of the gasifier containing test coupons of 304 SS, 309 SS, 316 SS, 321 SS, 430 SS, Inconel 600, Inconel 601, Incoloy 800, Incoloy 825, Hastelloy X, Armco 21-6-9, Armco 22-13-5 and Rolled Alloys 333. Figure V-2 shows coupon location.

- The first set was removed in July 1977 after 781.8 hours of exposure. The findings of this corrosion study are reported in the MPC report, "A Program to Discover Materials Suitable for Service Under Hostile Conditions Obtained in Equipment for Gasification of Coal and Other Solid Fuels," dated February 1978. A copy of the report is in SEMPEP files under "Published Reports."

- Two sets of test coupons consisting of candidate refractory, brick and mortar materials were installed in the gasifier to study the effect of gasifier environment on various refractory materials. This study was conducted by National Bureau of Standards and was sponsored by the Department of Energy.

- A second set of test coupons from both IITRI/MPC and NBS was installed in July 1977 and removed in December 1978. The findings are to be published by MPC in mid-1979.

Pressures - 1000 psig
except as shown
*Refractories

FIGURE V-2
Corrosion Test Locations

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****3. Gas Scrubbing****a. Equipment****(1) EE-201, Venturi Scrubber**

- The original Venturi Scrubber was fabricated by Graham Manufacturing Company and consisted of 12" C.S. body with ceramic insulation in the nozzles. The unit was determined to be unsuitable during loss of cooling water due to its temperature limit of 600°F which is much lower than gasifier gas temperatures.

- A new Venturi Scrubber was fabricated by General Ionics Corp. It has a 12" C.S. shell with internal castible refractory insulation. The inside pipe is 5" ID SS310. The new unit was designed to handle 1800°F gas from the gasifier. This unit performed satisfactorily once its length was extended and periodic inspection showed no significant wear or deterioration.

(2) FA-215, Scrubber Surge Tank

- The tank internals and nozzle details were revised to solve problems created by excessive solids carryover from the gasifier.

- The funnel at the inlet nozzle was removed.

- The heights of baffles between the compartments were adjusted for effective solids settling and to have adequate surge capacities for the revised flow conditions in the venturi loop and the raw gas scrubber loop.

- There were no mechanical failures related to the scrubber surge tank.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****3. Gas Scrubbing****a. Equipment - cont'd****(3) EE-202, Second Stage Venturi Scrubber**

- The original Venturi Scrubber EE-201, fabricated by Graham Manufacturing Company, was installed in this service to scrub gases from scrubber surge tank to the raw gas scrubber. The unit performed satisfactorily in this service and minimized the problems of plugging of tower packing with entrained solids.

(4) DA-201 Raw Gas Scrubber

- The scrubber tower consists of a packed section for water wash and a tray section for oil wash of the gases. The oil wash section was never commissioned.

- The water wash section was originally packed with carbon steel pall rings. The packing was frequently plugged with solids and tar and also suffered corrosion. Packing was replaced with stainless steel pall rings which performed better but still had plugging problem. During the last runs, the packing was removed and the tower was used as a spray tower. The performance of the tower was satisfactory and saved cleanup time between the runs.

- The water inlet nozzle flange started to leak in March 1978 because an eccentric orifice used to restrict flow over the tower packing caused turbulence at the flange and as a result the water-char mixture eroded the flange surface. The flange was replaced and the orifice was changed to a concentric type.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****3. Gas Scrubbing****a. Equipment - cont'd**

- (5) GA-201, Scrubber Recycle Pump
and GA-207S, Venturi Scrubber
Recycle Pump

- These identical pumps circulated wash water in two high pressure loops for scrubbing the gas. The GA-207 pump was piped as a common spare for GA-201 and 207. The pumps were single stage centrifugal pumps with casing designed for high pressure. The original pump casings were cast steel and the impellers were 12% chrome steel.

- All three pumps had many seal, bearing and shaft failures in addition to severe corrosion and erosion.

- The original seals, Borg Warner Model U1500, failed within hours due to inadequate flow of seal flush water. Since high flow of seal flush water overtaxed the waste disposal system, a seal bushing was remachined with closer clearance and later a teflon-lip seal was added. This improved the performance but the wear on the seal increased clearances causing failures due to char fines wearing the seal faces.

- In May 1977, the shaft of GA-207 failed because of overstress. The shaft was replaced three times with successive failures. After the last failure, the shafts were replaced with larger, 1" diameter impeller connections.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****3. Gas Scrubbing****a. Equipment - cont'd**

- (5) GA-201, Scrubber Recycle Pump
and GA-207S, Venturi Scrubber
Recycle Pump - cont'd

- In December 1977, corrosion of GA-207 shafts was noticed and SS316 shafts were installed on all three pumps.

- The bearing problems were caused by higher than design char loading in the water. The thrust bearings in the pumps constructed of medium 300 series and the radial bearings of light 200 series. These should be replaced with heavier duty bearings but this is not possible with the present design of the bearing housing. Frequent vibration checks and rotor balancing were performed to minimize bearing failures.

- The pump casing failures were caused by low pH water during reactor startup when using CO₂ for heating and cavitation. Pump cavitation was caused by high water temperatures at low pressure and coal foam during gasifier operation.

- Several steps were taken to solve casing failures:

- SS316 liners were installed which eroded through in 50 hours.

V. ENGINEERING REPORT

E. Equipment and Materials Performance Summary

3. Gas Scrubbing

a. Equipment - cont'd

- (5) GA-201, Scrubber Recycle Pump
and GA-207S, Venturi Scrubber
Recycle Pump - cont'd

- The casings were overlaid with two passes. One was medium Coordinated Industries No. 101 rod, followed by hard Coordinated Industries Rod No. 204, Rockwell C-60. This resulted in cracking in the hard-facing.

- Weld overlay of medium Coordinated Industries Rod No. 101 which deposited 88% nickel resulting in casing life of approximately 400 hours during Run 2-DB-G.

- GA-207 casing was welded with a martensitic chrome steel with hardness of Rockwell C-52 to C-56. This gave service of approximately 200 hours.

- Hard facing of Nickle-Chrome-Boron was unsuccessful as it eroded quickly.

- In addition to the changes in the casings, pH of the water was controlled by caustic injection which extended time between pump failures.

- The GA-207 pump was modified to change speed from 3500 to 1750 rpm with a larger impeller to get adequate head. The trial was discontinued because the pump cavitated after coal fines accumulated in the system during gasifier operation.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****3. Gas Scrubbing****a. Equipment - cont'd**

- (5) GA-201, Scrubber Recycle Pump
and GA-207S, Venturi Scrubber
Recycle Pump - cont'd

- Several vendors were contacted to replace these pumps with suitable pumps for the actual service conditions but none had a design that would meet the combination standard of high casing pressure, high temperature and high solid concentration.

- See T. Munro's memo 7849-TFM-012-78 for the history of these pumps and its update by R. F. Sherrer's memo dated January 2, 1979.

- (6) EA-201&S Scrubber Recycle Coolers
and EA-218&S Venturi Circulating
Water Coolers

- These are multipass, shell and tube exchangers of carbon steel construction. The tubes were occasionally plugged up with solids during early runs due to high solid carryover from the gasifier. The major problem with these exchangers was tube and tubesheet deterioration due to low pH of the scrubbing water during gasification startup. The caustic injection to the scrubbing system slowed down the attack on tubes and tubesheets. It was planned to replace all four tube bundles with SS304 material.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****3. Gas Scrubbing****a. Equipment - cont'd****(7) FA-202 Decanter**

- This vessel had a boot designed to separate light oil, water and heavy tars from the scrubber loop blowdown stream. There was no significant amount of tars in the scrubbing water so no attempt was made to separate them. The vent from the tank was connected to the thermal oxidizer to stop discharge of unpleasant smelling vapors to the atmosphere.

(8) EA-213&S Waste Water Coolers

- These shell and tube exchangers cooled the scrubbing water blowdown flowing through the tubes. The tubes plugged frequently with solids and tars. The plugging problem was reduced by recirculating the blowdown water through the exchanger loop and thereby increasing the tube side velocity. Several tube failures occurred with these exchangers.

(9) EA-225A&B Waste Water Exchangers

- These are multipass shell and tube-type exchangers of carbon steel construction. They were added to meet the increased cooling load due to process revision. These exchangers plugged with char solids and were cleaned after each test.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****3. Gas Scrubbing****a. Equipment - cont'd****(10) GA-205&S Waste Water Pumps**

- These pumps had several seal failures due to concentration of solids higher than design. GA-205 motor windings burned out because of overload.

b. Instruments**(1) Temperature**

- All temperature instruments in the gas scrubbing system performed satisfactorily.

(2) Pressure

- Due to entrained solids, the sensing lines were flushed with boiler feed water.

(3) Level

- Plugging of the level taps with solids was a problem. In some cases, the taps were flushed with boiler feed water and in others the instruments were changed to bubbler type level sensors.

c. Piping and Valves

- A 1 inch carbon steel globe type bypass valve around the gasifier pressure control valve PCV-2205 was eroded through the bonnet in December 1976. The valve was replaced and piping of the upstream equipment was revised to use exchangers EA-203 and knockout pot FA-203 to condense and remove most of the water in the gas before letdown to flare.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****3. Gas Scrubbing****c. Piping and Valves - cont'd**

- The 4 inch gate valves in the suction piping of the gas scrubbing water circulating pumps GA-201, 207, and 207S were not closing tight due to plugging with solids. They were replaced with cylinder operated plug valves. Improved lubrication of the plug valves resulted in satisfactory performance.

- The control valve LCV-201 discharged the waste water from FA-215 at 600 psig to near atmospheric pressure. The valve was 1 inch ITT Hammel Dahl, unbalanced globe valve and the original trim was SS316 coated with Stellite #6. It failed due to erosion in few days. Replacement trim with Stellite #1016 improved life slightly. Next, the size of trim was increased from 1/4" to 3/8" because of increased flow due to process change. The trim material was replaced with tungsten carbide, and a flash flow cage of hardened stainless steel 440C was installed. These modifications achieved a 21-day run with no apparent wear. A trim with Borofused Molybdenum was tried which lasted approximately seven days. The trim with tungsten carbide and Stellite #1016 was reinstalled in the valve and it performed without a failure to date. (Ref.: Lummus Report "Valve Applications at the Synthane Plant in Mixed Phase Erosive Service" dated November 1977).

- In May 1977, the water flow control valve (FCV-206) to Venturi Scrubber EE-201 failed due to severe erosion of body and the valve was replaced.

V. ENGINEERING REPORT

E. Equipment and Materials Performance Summary

3. Gas Scrubbing

c. Piping and Valves - cont'd

- In August 1978, a 6 inch C.S. water line in the Venturi Scrubber loop failed at an elbow due to a combination of corrosion and erosion. The piping was replaced with SS304 material.

- The gas scrubbing area piping was studied to identify points of high velocity and change of direction and the piping wall thickness was checked at these points for potential erosion problems. No significant thickness loss was found other than at the points of failures. The caustic injection into the scrubbing water appeared to help minimize failures due to corrosion. (Ref.: Lummus Report "Piping System Analysis-Project 204-4" dated September 1978.)

- The 6 inch SS304 tail gas line from the Venturi Scrubber EE-201 to the surge tank FA-215 was of great concern because of its design temperature limit which has no allowance of extended high temperature upset condition caused by a quench water failure. For this reason, the line was equipped with several temperature monitoring points which could trip oxygen to the gasifier in case of quench water failure. There has been no upset subjecting the line to over-temperature. The movement of the line due to thermal expansion of the line and gasifier was studied and the spring hangers were revised. The routing of the line was revised during installation of siding on the structure to keep the line on the outside to insure convectional cooling in case of over-temperature.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****3. Gas Scrubbing****d. Material**

- The internal insulating refractory liner of the Venturi Scrubber EE-201 consisting of castible (C-E Refractories Light Weight Model #80), block (C-E Refractories Thermotect) and fiber cement performed without a major failure during the 30-month period since the installation.

- No failure was observed in stainless steel Type 310 components of the Venturi Scrubber and stainless steel Type 304 and 316 components of the tail gas line.

- The carbon steel piping and valves in the gas scrubbing water lines suffered metal loss due to a combination of corrosion and erosion. Corrosion was caused by dissolved CO_2 in the scrubbing water which was being neutralized with caustic injection. Replacement of carbon steel bodies of the control valves was underway.

- There are four locations in the gas scrubbing equipment where metal test coupons were installed under a special program by IITRI and Metal Properties Council to study corrosion of carbon steel, aluminized carbon steel, SS304, SS410, SS430, Monel 400, Inconel 600, Incoloy 800 and Titanium. The first set of coupons was removed in July 1977 after 591.8 hours exposure. The findings were reported in MPC report, "A Program to Discover Materials Suitable for Service under Hostile Conditions Obtained in Equipment for Gasification of Coal and other Solid Fuels", dated February 1978. See the Appendix for a copy of this report.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****3. Gas Scrubbing****d. Material - cont'd**

- A second set of test coupons was placed in the same location and removed in December 1978. The findings are to be published by Metal Properties Council.

4. Char Slurry System**a. Equipment****(1) FA-401 High Pressure Char Slurry Tank**

- The tank received dry char from the char cooler and recycled filtrate from the char slurry filter system. It was important that the line carrying the char be properly insulated to prevent condensation which led to plugging. The slurry flow from the tank was controlled as a function of the slurry level in the tank. The tank had inadequate surge capacity to allow fluctuations in the char flow and still maintain stable control of the discharge flow. Replacement with a larger tank is recommended.

(2) FA-403 Slurry Filter Feed Tank

- Five nozzles were added to the tank to install the letdown control valves and the bypass piping.

(3) GD-401 Agitator for Slurry Filter Feed Tanks

- The agitator blades were severely eroded and bent after one year of service. The turbine agitator was replaced with a new one and a second turbine was added to improve agitation. The performance was satisfactory after the modification.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****4. Char Slurry System****a. Equipment - cont'd****(4) GA-406&S Slurry Filter Feed
Pumps**

- In September 1975, the casing of pump GA-406 was severely eroded with 1/2" diameter hole in the casing after 1200 hours of service and the casing was replaced. The GA-406S casing was also found cracked in September 1975 and was replaced.

(5) PA-402X&S Slurry Filters

- The filters were EIMCO vacuum disc type with an atmospheric feed tank. The filter capacity was less than design because of higher slurry temperature which limited the vacuum due to the higher vapor pressure of water and different filter cake properties than design. The actual capacity was 30 gpm compared to 80 gpm design. There were several filter cloth failures. Heavier nylon cloth was used to resist tearing by the scrappers.

**(6) GB-401X&S Slurry Filter Vacuum
Pumps**

- These were Nash water ring type vacuum pumps. In January 1978, the casing of GB-401X was cracked because of freezing of water and was replaced.

**(7) GA-401 Char Slurry Recycle
Water Pump**

- The pump recycled filtrate from the receiver to the high pressure slurry tank. Originally a vertical multi-stage centrifugal pump was furnished.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****4. Char Slurry System****a. Equipment****(7) GA-401 Char Slurry Recycle****Water Pump - cont'd**

for this service. A booster pump GA-411 was installed to meet the required N.P.S.H. for the multi-stage pump. Many seal failures occurred with GA-401 because of the high solids concentration in the filtrate. The pump was designed to handle only trace amounts of solids whereas the actual solid concentration was as high as 20% at times when the filter cloth broke. This also plugged or eroded the impeller and pump casing. Liquid cyclones (FC-401A&B) and filters (FD-402&S) were installed to remove the solids upstream of the pump which reduced the number of failures. However, the multi-stage centrifugal pump was replaced with a reciprocating pump GA-401S to achieve satisfactory service.

(8) GA-411 Char Slurry Recycle**Water Booster Pump**

- Several mechanical seal failures occurred due to char fines in the filtrate and the seal was replaced with a packed stuffing box which has performed satisfactorily.

(9) GA-401S Char Slurry Recycle**Water Pump (Spare)**

- This was a triplex plunger-type reciprocating pump suitable for slurry service manufactured by Wilson Snyder, Oil Wells Division of U. S. Steel. The pump performed satisfactorily without a failure.

V. ENGINEERING REPORT

E. Equipment and Materials Performance Summary

4. Char Slurry System

a. Equipment - cont'd

(10) EA-401 Char Quench Water Cooler

- In March 1976, a tube leak was found and the tube was plugged.

- In December 1977, the exchanger shell ruptured because of freezing of water. The exchanger was taken out of service and was bypassed.

(11) FE-403A&B Char Lock Hoppers

- The char lock hoppers were intended to be the primary system of dry char letdown from the char cooler. They were never used because the ball valves between the char cooler and the lock hoppers would not seal against the pressure differential of 600 psi.

(12) FA-406 Low Pressure Char
Slurry Tank

- The tank was used to knock out entrained fines from the coal feed system vent line and to make a slurry for disposal. The tank and the agitator GD-402 performed satisfactorily.

(13) JD-401 Slurry Filter Cake Conveyor

- The conveyor had two failures both caused by overloading when the slurry froze in the conveyor. The conveyor housing was steam traced to prevent freezing.

V. ENGINEERING REPORT

E. Equipment and Materials Performance Summary

4. Char Slurry System - cont'd

b. Instruments

(a) Level

- The level instrument for the high pressure slurry tank malfunctioned because the sensing lines plugged with char. Purging with boiler feed water improved the performance but it had a masking effect on the level reading. A nuclear high level switch was installed which has performed satisfactorily.

(b) The pressure relief valve on the high pressure slurry tank failed to open when slurry froze in the inlet piping. The piping was revised to eliminate pockets.

The relief valve on the discharge of the reciprocating char slurry recycle water pump GA-401S was a shear pin type relief valve. The relief valve was replaced with a spring loaded type for more reliable opening and self-closing features.

(c) Flow

A sonic type flow meter supplied by Techsonic Corp. was installed on the discharge line of the high pressure char slurry tank. It failed because the line temperature exceeded the temperature limit of the electronic sensor. The sensor was replaced but was not used because of calibration problems.

(d) Density

Measurement of char slurry density was desired to calculate the mass flow rate of char in the slurry. A nuclear density gauge was purchased for installation.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****4. Char Slurry System****c. Piping and Valves**

Several piping failures occurred in the two 1 inch slurry transfer lines from high pressure slurry tank to the filter area. One of the lines had a "packed tee" configuration at each bend and the other one had long radius piping bends.

The failures in the line with packed tees were at the socket weld tees and were caused by a combination of erosion and corrosion. The erosion patterns had started at the socket gap between the piping and fittings. The piping at the outlet of the high pressure slurry tank was replaced with 1" SS304 material and butt weld fittings were used to eliminate the gap at socket weld fittings.

The long radius bends suffered erosion starting at the point of change in direction. The bends were replaced with new piping and the piping thickness was monitored by spot checks with ultrasonic measurements.

Plug valves in the slurry line were binding because solids settled in the lubricated cavities. The plugs were eroded on the upstream side because of their smaller opening compared to the pipe bore. Full-bore ball valves were used to replace the plug valves in the revised piping at the outlet of the high pressure slurry tank.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****4. Char Slurry System****c. Piping and Valves - cont'd**

The control valve LCV-405 reduced the char-water slurry pressure from 600 psig to atmospheric. Originally the globe valve was located near the high pressure slurry tank with a 2-1/2 inch discharge line to the filter area. This valve and the line were removed prior to plant startup because of the possibility of valve failure due to erosion. A Willis Oil Choke valve Type M-2 was installed to control the high pressure slurry. The valve controls by rotating one disc over a stationary disc. Each disc has at least one hole or orifice in it and when the holes line up the slurry will flow through the valve. Both discs are made of a hard material for the high pressure reduction. The valve is 90° angle type with a 1 inch inlet and a 4 inch outlet which discharges into the slurry tank. There are four valves, two connected to each of the two 1 inch slurry lines. (Initially the line experienced frequent plugging so a spare line was installed.) The valves were provided with boiler water flush.

The failures of these valves were caused by erosion of the discs at the orifice due to high pressure letdown of the erosive char slurry. Experiences with the different disc material is listed below.

- The original ceramic discs were eroded within one day.
- Tungsten carbide discs lasted six days of continuous service.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****4. Char Slurry System****c. Piping and Valves - cont'd**

- Borofused Molybdenum discs outlasted tungsten carbide.

- Hot pressed silicon carbide discs with vapor deposited silicon carbide were ordered for the valves but were not received at the time of the plant deactivation.

- Other types of failures were caused by erosion of downstream sleeves. Various sleeve materials were tested including ceramics from various firms, monel with vapor deposition of tungsten, Ni Resist, mild steel tubes lined with fused plasmaspray coating and Borofused Molybdenum. Most of these materials suffered extreme erosion within days. Sleeves that have shown best service were Coors ceramic AD-998 and Borofused Molybdenum.

- Variation in the valve trim were also tried. Different sizes of orifice were tried ranging from 1/4" to 1/2". Plugging of one of the two orifices was tried to reduce the flow area, but none of these resulted into satisfactory wear pattern. (Ref.: Lummus Report "Valve Applications at the Synthane Plant in Mixed Phase Erosive Service" dated June 1978.)

Other modifications considered to improve the valve performance were:

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****4. Char Slurry System****c. Piping and Valves - cont'd**

1. Cyclic operation (full open or closed activated by level switches) was not tried since it needed more surge volume in the high pressure slurry tank.

2. Series installation of two valves to reduce pressure drop through each one and to extend service life.

3. Installation of a discharge pot to impose a back pressure and thereby reduce erosion.

4. Split range operation of the valves to distribute wear and get longer service.

5. Operate the choke valves on flow control and fill the tank on level control.

5. Support Systems**a. BE-301&S Inert Gas Generators**

In the original installation, #2 fuel oil was used to generate inert gas. There were numerous failures of piping and equipment caused by the moist inert gas which contained SO_2 , SO_3 and NO_x . This acidic mixture was very corrosive to carbon steel equipment and piping where it condensed and accumulated. The use of the inert gas generator was discontinued and pure CO_2 was used for inert gas.

The inert gas generators were modified to burn propane. Sulfur from propane was removed in the modified propane system. Other modifications made to the inert gas systems were:

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****5. Support Systems****a. BE-301&S Inert Gas Generators - cont'd**

- Addition of catalytic converters to remove NO_x.
- Revision of cooling water piping to the gas coolers.
- Addition of a refrigeration type dryer to remove the moisture.

These modifications helped to reduce the failures but moisture content of inert gas was still high because when the gas was compressed from near atmospheric pressure to over 600 psig more moisture was condensed and was entrained in the high pressure inert gas. This resulted in some corrosion failures and operating problems in the connected CO₂ system.

Installation of a dessicant type dryer to further reduce the moisture of compressed inert gas was being considered at the time of plant deactivation. (Ref: Lummus Report "Historical Summary Inert Gas System" dated January 1979).

b. BE-302 Inline Burner

The burner was used to generate hot flue gas for heatup of the gasifier before startup. The original equipment used #2 fuel oil which has caused heatup line failures by intergranular stress corrosion cracking because of sulfur in the fuel oil. The burner was changed over to propane fuel after installation of a large propane facility with 30000 gallon storage capacity. The inline burner was not used in later runs since the gasifier was heated with superheated CO₂ and steam.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****5. Support Systems****b. BE-302 Inline Burner - cont'd**

The refractory at the discharge end of the firebox was found melted after 2 months of service. The failure was caused by flame impingement due to a deteriorated burner nozzle. The nozzle was replaced with a stainless steel one and the refractory was repaired by patching with Harbison Walker high temperature plastic over the original C-E Refractories Litewate-70. There were no refractory failures since the repair.

c. BF-301 High Pressure Boiler

The high pressure boiler supplied superheated steam for the pretreatment and gasification process.

The level gauge on the boiler drum leaked and was replaced after several repairs.

- The atomizing steam control valve was eroded because of moisture in the piping and throttling of the oversized valve. The valve was replaced with a smaller valve and the piping was revised to remove the condensate upstream of the valve. To reduce the failures a better valve is recommended for this service.

- The boiler tripped several times because the flame detector instrument malfunctioned. A second flame detector was purchased but was not installed yet.

- In September 1978 a boiler explosion occurred which severely damaged the unit. The unit was repaired and made ready for operation.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****5. Support Systems - cont'd****d. BF-302&S Low Pressure Boilers**

These boilers were used for steam tracing and space heating.

- The combustion air blower bearings and seals were replaced.

- BF-302S had leaks at the tubesheet joints after operation with untreated city water. The leaks were repaired by rerolling the tubes. In general, the performance of the boilers was satisfactory.

e. BF-303 Steam Superheater

The steam superheater was borrowed from the Institute of Gas Technology in Chicago for use in the Illinois No. 6 coal runs. Superheated steam was required for the pretreater operation and for pretreatment in the coal transport line. The unit was a fired heater with two burners. The burners were changed from natural gas firing to propane firing.

Pilots and a flame safeguard system were added to the heater for safe operation.

The superheater performed satisfactorily. The unit was returned to IGT after the plant deactivation.

Before the IGT superheater arrived a temporary superheater coil was installed in the coal dryer to generate steam. If the pilot plant will be reactivated it is recommended that a steam superheater be installed to meet the requirements of the operation.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****5. Support Systems - cont'd****f. CA-402X Flare**

The flare was used to burn the raw product gas from the plant.

The original flare was 6" in diameter to handle product gas that was free of steam and CO₂. The flare was very noisy because of larger than design flow when steam and CO₂ was not removed. The flare tip was changed from 6" to 14" which solved the noise problem.

g. BF-402 Thermal Oxidizer

The thermal oxidizer was used to burn liquid waste from the plant.

The original equipment had a 30 MM BTU/hour fuel oil burner and a gas burner which was to use product gas from the plant. The unit was designed to burn 32 gpm of liquid waste.

- In December 1976, the fuel oil burner was changed from 30 MM BTU/hour to 60 MM BTU/hour since the product gas from the plant was not available for use as fuel.

- The new burner was modified by changing the burner tip and the combustion air restriction details to make the flame shorter and steadier to solve problems of flame impingement on the wall and vibration.

- Water spray nozzles were changed from brass to stainless steel to withstand the corrosive atmosphere.

- Water spray nozzle holes that were spraying down were plugged to stop water collecting on the floor of the firebox.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****5. Support Systems****g. BF-402 Thermal Oxidizer - cont'd**

- The original refractory in the firebox (a C-E Lite Weight Castible-70) was eroded and spalled in January 1977. It was patched with Harbison-Walker super plastic. The refractory in the firebox failed four times since then requiring extensive repairs. Various refractory materials were tried to withstand high firebox temperature and chemical attack. The materials tried were C-E 90 Ram-HS, C-E Blu Ram-HS, Taylor Shamrock 888 and C-E Emerald Ram-HS. The last two are high chrome alumina refractory materials resistant to the chemical attack. They have performed better than others although the unit was not operated at full capacity for enough time to arrive at definitive conclusions. The main problem was coal slag attack at elevated temperatures. Some refractory spalling was also occurring. It is recommended that Emerald Ram be used as a refractory material and the wall temperature be kept as low as practical.

h. CO₂ System

The major operating problems and failures in the CO₂ system were caused by moisture content of recycled CO₂ and the inert gas used for makeup to the system. The acid liquid caused corrosion at low points and the entrained moisture caused erosion where high velocity occurred.

The components affected were CO₂ compressors, GB-301&S, vessels, exchangers, piping and valves.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****5. Support Systems****h. CO₂ System - cont'd**

The CO₂ compressors are four stage reciprocating type equipped with interstage coolers, knock-out pots and unloader valves for each stage.

- The gaskets of the 3rd and 4th stage unloader valve holders failed many times. The original soft steel-envelope asbestos gaskets were replaced by stainless steel envelope asbestos and then solid copper gaskets. Also, the diameter of jackbolts for the hold-down plates was increased to provide greater compressive force. Improved service resulted but the problem was not resolved completely.

- The pins of the unloader valves failed by a combination of erosion and corrosion. The erosion was caused by condensed moisture. The corrosion was caused by carbonic acid formed by CO₂ and water. Many of the carbon steel valve parts were replaced with stainless steel.

- The third stage knockout drum was replaced with a commercial entrainment separator for better disengagement of entrained moisture.

- Vents from the waterside of the intercoolers were piped to bleed off CO₂ leakage from the process and to provide adequate water circulation and cooling.

- Continuous drainers were added to the interstage knockout drums to remove condensed water.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****5. Support Systems****h. CO₂ System - cont'd**

- During initial operating period, the pistons were found worn to an egg-shape due to inert gas soot in the incoming gas.

- Filters were installed in the suction line to the compressor to retain dust from the incoming CO₂.

- Pistons were modified to include Teflon wear rings and cylinders were honed to accomodate the modified pistons.

The compressors were examined and the vibrations were monitored by Mechanical Technology, Inc. during their study of mechanical equipment in the plant. MTI report on the compressors will be available in mid-1979.

Use of the recycled CO₂ during startup was discontinued in April 1978 to reduce the compressor mechanical problem.

Other failures in the CO₂ system were:

(a) Carbon steel elbow in the nozzle of exchanger EA-308 failed because of corrosion from wet CO₂. Also, the carbon steel shell, heads and tubes were severely corroded. The exchanger was repaired and the exchanger EA-307 with stainless steel tubes was used as an aftercooler. Liquid was removed with a knockout pot with revised connections and EA-308 was used to reheat the CO₂ to 250°F with steam. Condensation in the CO₂ system was reduced during operation in the summer. An entrainment separator was ordered to dry the gas for winter operation.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****5. Support Systems****h. CO₂ System - cont'd**

(b) CO₂ pressure control valve PCV-345 failed due to combination of erosion and corrosion of the body. The control valve was replaced with a new stainless steel valve.

(c) There were failures of carbon steel CO₂ header piping because of wet CO₂ corrosion. The header was replaced with stainless steel piping and revised to make it free of moisture collecting pockets. Distribution lines for CO₂ were being changed to stainless steel at the time of plant deactivation.

j. Miscellaneous Changes

- Project 3-4: Chemical injection pumps and piping were added for boiler drum water pH control.

- Project 10-4: A new Liquified Propane Gas Storage tank with 30,000 gallon capacity and vaporizer were added. The larger tank and vaporizer were needed since the original 9500 gallon tank was inadequate for increased need because of conversion of Inert gas Generators and Inline burner from #2 fuel oil to propane firing. Activated carbon filters were added to remove sulfur from propane. The piping was revised to supply all users from the new propane facility and the smaller propane tank was decommissioned.

- Project 15-4: A condensate surge tank was added to return the condensate to the deaerator for the boilers.

V. ENGINEERING REPORT

E. Equipment and Materials Performance Summary

5. Support Systems

j. Miscellaneous Changes - cont'd

- Project 18-4: A heat exchanger was added to preheat the water entering the demineralizer to keep up the capacity of the resin beds in winter.

- Project 23-4: A concrete waste water storage tank (Char Pond) with 150,000 gallon capacity was constructed for interim storage of waste water. Transfer pumps and piping were installed to divert waste water to the tank during the plant runs and to the waste disposal system (Thermal Oxidizer) during the shutdown periods. The installation enabled longer plant runs in spite of limited capacity of the Thermal Oxidizer. In 1978 the stilling wall collapsed on the char pond due to freezing and improper wall length (the wall length was longer than originally designed when it was installed). Satisfactory system operation was being achieved without the stilling well before it collapsed.

- Project 44-4: A tank was added to the plant air system to provide additional surge capacity.

- Project 54-4: Section filters were added to the inert gas compressors (GB-303&S).

- Project 79-4: Two atmospheric carbon steel storage tanks were installed for storage of contaminated drainage from the paved process area.

- Project 101-4: Condensate Collection piping, surge tanks and condensate return pumps were installed to recover condensate from the steam tracing in the filter area, gas scrubbing area and the methanation area.

V. ENGINEERING REPORT

E. Equipment and Materials Performance Summary

5. Support Systems

j. Miscellaneous Changes - cont'd

- Project 158-4: The Thermal oxidizer burner was modified to make the flame stable and shorter. This was achieved by changing the burner tip and by adding restrictions to the combustion air path.

- Project 203-4: The knockout drum downstream of the CO₂ compressor aftercooler was modified by relocating the feed nozzle to provide better disengagement of entrained moisture.

- Project 2-7: The capacity of the neutralizing pit was increased by extending the acid brick lining to the top of the walls. These modifications provided enough volume to regenerate all three ion exchange beds at required intervals.

- Project 9-7: The inert gas generators were converted from #2 fuel oil to propane firing to product inert gas free of sulfur. Catalytic converters were added to remove NO_x from the inert gas. Also, a refrigerant dryer was installed to reduce the moisture down to +40°F dew point.

- Project 14-7: The inline burner which is used to produce hot flue gas for initial heat up of the gasifier was changed from #2 fuel oil to propane firing. This modification reduced the number of failures of the heat up piping caused by sulfur in the heat up gas.

V. ENGINEERING REPORT

E. Equipment and Materials Performance Summary

5. Support Systems

j. Miscellaneous Changes - cont'd

- Project 42-7: The flare stack size was changed from 6" to 14" to reduce the noise. The noise was created by high volumetric flow rate through the flare due to uncondensed steam and CO₂. The change in size eliminated the noise problem.

- Project 78-7: A sprinkler system was added to the cooling tower to protect it during shutdown periods.

- Project 90-7: Two large capacity filters were installed in the waste water line to the thermal oxidizer. The filters replaced a small duplex filter. The filters were installed to retain the solids in the waste water which caused uneven spray patterns by either eroding the spray nozzles or by plugging the spray ports.

- Project 119-7: A desuperheater was installed on the stream line to the thermal oxidizer to improve steam atomization of fuel oil and the waste water in the thermal oxidizer.

- Project : An extension was added to the administration building consisting of modified mobile trailers.

- Project 24-7: Maintenance department offices were added by modifying the mobile trailers.

- Project 26-7: Mobile trailers were installed to provide office and storage space for the New Construction Contractors.

- Project 47-7: A concrete pad and partition walls were constructed for storage of gas bottles and chemical drums in the maintenance area.

V. ENGINEERING REPORT**E. Equipment and Materials Performance Summary****5. Support Systems****j. Miscellaneous Changes - cont'd**

- Project 63-7: The foundation for the new Liquified Propane Gas storage tank was observed shifting. A new foundation was constructed which was anchored to the subsurface rock base.

- Project 64-7: Flush toilets were added in the engineering office trailers to replace chemical toilets. The new toilets were connected to the sewage treatment facility.

- Project 95-7: A prefabricated building was installed for storage of insulation material.

- Project -5: A prefabricated building was installed to house the Benfield chemical injection pumps and tanks.

- Project 17-5: A prefabricated building was installed to house the sulfur filter in the Stretford area.

- Project 134-4: Three sides of the process structure were enclosed with a translucent siding to protect the equipment and personnel from the winter winds. Circulation fans and CO monitors were installed in the enclosed area.

- Project 46-5: A prefabricated building was installed to house the sulfur analyzers which were relocated from the utility building. The building was equipped with H₂S sensing instrument and alarms for personnel safety.

V. ENGINEERING REPORT**F. Special Reports**

The following special reports from the Engineering Section are included in Appendix I.

- (a) Synthane Gasifier - Mechanical Report
- (b) GA-201, 207&S History
- (c) Thermal Oxidizer Repair History
- (d) Historical Summary - Inert Gas System
- (e) Project 109-7 Concrete Problems Status Report
- (f) Piping System Analysis (204-4)
- (g) Project 106-7 Valve Failure Analysis Summary Report

G. Project Status Reports

The following reports describe the status of engineering projects.

PROJECT STATUS REPORT

AS OF 12/29/78

PROJECT NUMBER & TITLE: 43-7 Installation of a rubbish chute
in the main structure.

SCOPE OF PROJECT: See attached status report.

STATUS OF PROJECT: See attached status report.

WORK ORDER REFERENCE NO: C-4106 dated July 7, 1978

BM & POR REFERENCE NO: BM: RFS-0062-78
POR: 7849-3714F

DRAWING REFERENCE NO: Drawings: E7849-02217
E7849-02218
E7849-02219

Sketches: SK-43-7-1
SK-43-7-2
SK-43-7-3

PROJECT STATUS REPORT

AS OF November 30, 1978

PROJECT NUMBER & TITLE: 222-4 Control Panel Modifications

SCOPE OF PROJECT: Revise panel for easier operation, by grouping of instruments and for future expansion.

STATUS OF PROJECT: Made front panel layout dwgs. and circulated for approval. Project placed on hold.

WORK ORDERS REFERENCE #

BM & REFERENCE #

DWG # REFERENCE: *SKE-DWM-222-41 and 42

PROJECT STATUS REPORT

AS OF November 30, 1978

PROJECT NUMBER & TITLE: 223-4 D/P for gasifier standpipe

SCOPE OF PROJECT: Add differential indication between 2
existing legs.

STATUS OF PROJECT: Engineering completed and approved.
Material not purchased.

WORK ORDERS REFERENCE #: C1656

BM & REFERENCE # BM# DWM-100-78

DWG # REFERENCE: LS-P2266

PROJECT STATUS REPORT

AS OF 12/29/78

PROJECT NUMBER & TITLE: 206-4 -- INSTALLATION OF A LUMPBREAKER
BETWEEN FE-106 & FE-103

SCOPE OF PROJECT: See attached status report

STATUS OF PROJECT: See attached status report

WORK ORDER REFERENCE No: None Issued

BM & POR REFERENCE No: None Issued

DRAWING REFERENCE No: No formal drawings were produced

PROJECT 206-4 INSTALLATION OF A LUMPBREAKER
BETWEEN FE-106 & FE-103

Status

The intent of Project 206-4 was to provide a means of breaking up lumps of coal that were forming due to material compression and compaction in the Pulverized Coal Storage Bin, FE-103. The lumps would pass undisturbed through the Petrocarb System and were plugging the coal feed system after the Primary Injector.

The following avenues were explored in an attempt to obtain a suitable lumpbreaker:

1. Information had been received that the Westinghouse Coal Gasification Facility had purchased, but had no intention of installing, a lumpbreaker similar to the one needed for our application. Letter 7849-RFS-013-78, see project file, was written requesting DoE's assistance in requisitioning this piece of equipment for our plant. Follow-up with Westinghouse, however, proved fruitless when they reversed their position and decided to incorporate the lumpbreaker into the Westinghouse process.
2. Inquiries were sent to lumpbreaker manufacturers to obtain this equipment. Five (5) companies were contacted with only two (2) responding favorably: Jacobson Co. and Franklin-Miller Co. Of these two (2), only the Franklin-Miller lumpbreaker was sufficiently compact to fit in the restricted area between FE-103 and FE-106. Even though the construction and capability of the Franklin-Miller unit greatly exceeded the requirements of our process, it was too expensive to justify.
3. The final approach was to design and fabricate, at the plant, a lumpbreaker that could economically fit our process needs.

At the time of plant close-out, the lumpbreaker design had not yet been completed and no materials for fabrication had been ordered.

PROJECT STATUS REPORT

AS OF 12/29/79

PROJECT NUMBER & TITLE: Argonne Solids Flow Meter 207-4

SCOPE OF PROJECT: Install spool piece meter element, conduit and cable. Sonic Instrument to be supplied by ANL to measure coal flow in 3" transport line.

STATUS OF PROJECT: No work done. W. O. issued to install spool piece. Direct purchase material received. ANL cable but not meter received.

WORK ORDERS REFERENCE #C-4216

BM & REFERENCE # P.O. #7849-3213F
No B.M.

DWG # REFERENCE: 7849-SK-JCO-85-78

PROJECT STATUS REPORT

AS OF November 30, 1978

PROJECT NUMBER & TITLE: 211-4 Grove valve to replace EBV's

SCOPE OF PROJECT: Replace petrocarb EBV's with Grove Valves to eliminate the problems of gas leakage and plugging of moving parts in EBV ball valves.

STATUS OF PROJECT: Parts ordered - solenoids received

WORK ORDERS REFERENCE # C4168

BM & REFERENCE # DWM-0073-78 - 7849-4067

DWG # REFERENCE: SKE-DWM-211-41, 42, 43
E 438-A-512, 513, 514, 515 and 514

PROJECT 212-4

CHAR LOCK HOPPER CONVERSION TO A SLURRY TANK

This project was to provide a larger surge capacity and better control of the high pressure char slurry pressure letdown system. A design was proposed but rejected due to the large filtrate circulation required which was more than proved capacity of the slurry filters.

A revised design with a reduced filtrate circulation was being worked on by the Technical Department but was not completed to date.

PROJECT 214-4 RELOCATE STEAM-OXYGEN LINE BEHIND SHROUD**Scope**

Clinkers formed around the steam-oxygen line to the oxygen distributor inside the gasifier and it was decided to place the line behind the shroud.

Drawings

E7849-02439

Relocation of O₂ Distributor
Piping behind Gasifier Shroud-
Sections & Details

SK 214-4 REL 1

O₂ Distributor in Gasifier
Internal Piping - Gasifier
Elev. Sections & Details

Purchase Orders

None

Bill of Material

REL-0084-78

Status

A work order package was prepared for approval. The package was approved and the job placed on hold. No material was purchased for this project.

PROJECT STATUS REPORT

AS OF 12/29/78

PROJECT NUMBER & TITLE: 2" EBV Valves in Petrocarb System 215-4

SCOPE OF PROJECT: Install 2" Ø EBV Ball Valves in one side of the Petrocarb System on either side of one to reduce the Gas Leakage. The existing EBV Valves in the Coal Dumplines do not seal tight.

STATUS OF PROJECT: Final package partially approved. Cancelled for plant shut-down.

WORK ORDERS REFERENCE #C-4214

BM & REFERENCE # BM # JCO-0082-78
No P.O.

DWG # REFERENCE: SKE-7849-771
SKA-7849-790

PROJECT 216-4 MODIFY LETDOWN CONTROL VALVE

Scope

The letdown control valves in the slurry service and in the gas service handling entrained coal fines had failed frequently terminating the gasifier runs. Various materials to resist erosion are being tried for the valve trims. The scope of this project was to modify the valve design to reduce the failures. The valves in consideration were:

LCV-405 A thru D - Char Slurry Letdown Valves on the discharge line from the high pressure slurry tank.

LCV-201 - Scrubber Surge Tank Blowdown Control Valve.

PDCV-2205 - Letdown Valve on the raw product gas line to flare.

PDCV-266 A & B - Char Cooler Steam Letdown Valves.

Status

The initial effort was to redesign the char slurry letdown valves. Two approaches were under consideration. The first one was to use the existing Willis Choke Valve and add a discharge pot between the valve outlet and the tank nozzle. The discharge pot will create a back pressure which will allow the operation of the Willis Choke Valves at near full open position and thereby reducing the wear on the rotating discs. The discharge jet from the valve will disperse its energy into the bulk of slurry in the discharge pot. The design of the discharge pot and piping was not started at the time of the plant deactivation.

The second approach was to direct two slurry jets at each other and thus disperse the energy of the jet streams. We have yet to develop correlation between the pressure drop through the nozzles and the distance between the nozzles. No hardware was designed for this modification at the time of plant deactivation.

PROJECT STATUS REPORT

AS OF November 30, 1978

PROJECT NUMBER & TITLE: 218-4 PDI's for cyclone dipleg

SCOPE OF PROJECT: Add and revise differential instrumentation on dipleg

STATUS OF PROJECT: Project on hold - need to finish nozzle details and installation BM dwg.

WORK ORDERS REFERENCE #: C1660

BM & REFERENCE #: DWM-0091-87

DWG # REFERENCE: D8530-02404
CS P2256 2265, 2267 and 2268

PROJECT STATUS REPORT

AS OF November 30, 1978

PROJECT NUMBER & TITLE: 220- Install sonic flow meter at LCV-201

SCOPE OF PROJECT: Provide a non-contact measurement of flow at letdown area's.

STATUS OF PROJECT: Recommended purchasing a portable meter. Evaluated 4 doppler types, the only one that met our criteria was the UN1/P-1 from flowmeter co. Submitted for approval. Project placed on hold.

WORK ORDERS REFERENCE #

BM & REFERENCE #: BM# DWM-0099-78

DWG # REFERENCE

PROJECT 172-4 GASIFIER SHROUD REPAIRScope

Replace the existing buckled shroud in the gasifier with a new shroud designed to withstand the thermal stresses and movements caused by temperature gradients and cyclic operation.

Drawings

E7849-02617	New Gasifier Shroud Assembly
B7849-02606	37" ID Shroud Pl. Lower Sect.
B7849-02607	37" ID Shroud Pl. Center Sect.
B7849-02608	Shroud Pl. Reducer Ring
B7849-02609	40 1/2" Shroud Pl.
B7849-02610	39" ID Trap Ring
B7849-02611	Lower Shroud Seal Pl. Ring
B7849-02612	Shroud Supt. Ring
B7849-02613	Friction Ring
B7849-02614	Upper Shroud Stiff Ring
B7849-02615	Flexible Tabs for Solids Trap
B7849-02616	37" ID Shroud Pl. Top Sect.
B7849-02618	42" Shroud Flange
SK 172-4 REL 1	Refractory Shroud Design

Purchase Orders

7849-3054	Shroud Fabrication
7849-3098	Shroud Material
7849-3111	Shroud Material
7849-3112	Shroud Material
7849-3113	Shroud Material

Status

The new 37 inch diameter shroud was designed to allow thermal expansion and temperature variations. The shroud design had a special sliding joint arrangement where it would rest on the cone. The shroud would ride up and down on the cone surface as it expands and contracts in radial direction.

The shroud was fabricated out of 1/2 inch thick Incoloy 800 plant in sections for assembly inside the gasifier. The fabricated shroud pieces are stored in the Warehouse.

PROJECT 176-4 COAL FEED CONTROLLER (ROTARY FEEDER)

Drawings

Beaumont Birch CR45368-1 - 4" SST Mark II Periphery
Seal Rotary Feeder

E784901911	Rotary Coal Feeder Cen. Assy.
E7849-01912	Rotary Coal Feeder Sects. & Det.
E7849-01913	Rotary Coal Feeder Motor Sup. & Det.
E7849-01914	Rotary Coal Feeder Sect. & Det.
B7849-01435	Rotary Coal Feeder Vent Line
D7849-01433	Rotary Coal Feeder Piping & Support Det.
1407-25-205-10 MDD 2C	Data Sheet
B7849-04111	Rotary Coal Feeder Elect. Schematic
1407-25-501-5	Cable Schedule Area 100 Sht. 1
1407-25-521-4	Raceway Schedule - Area 100 Sht. 1

Purchase Orders

7849-3199	Feeder Assembly Parts
7849-3202	Electrical Items
7849-3203	Feeder Assembly Parts
7849-3206	Feeder Fab. P.O.
7849-3210	Additional Assy. Parts
7849-3221	Additional Assy. Parts
7849-3247	Installation Material

Bills of Material

REL-0059-78	Feeder Assembly
REL-0054-78	Feeder Installation

Status

Feeder fabrication was completed (P.O. 3206) and feeder was delivered to the site. All feeder installation drawings are complete, and installation material was received. Additional work required: Shim motor, hook up feeder purge connections, fully test and calibrate feeder, design new seals for rotary feeder hold down bolt to casing seal. The feeder is stored in the warehouse.

Note: The feeder shaft was bent while transporting to the offsite warehouse. The shaft has to be straightened and realigned.

Project 130-4
W/O B-12801

GASIFIER SAMPLING SYSTEM

DRAWINGS: C7848-02030
C7849-02605
C7849-02603
C7849-02604
E7849-02619
D7849-02231
E7849-02423
E7849-02424
E7849-02425, 27, 28, 29
E7849-02907

B/N	BNM-00	-78	
P.O.'s	7849-3136	7849-3157	7849-3208
	3137	3159	3216
	3138	3116	
	3150	3173	
	3150	3178	
	3155	3185	

SCOPE:

Scope of this project was to install a sampling system at the outlet of the gasifier upstream of the venturi scrubber to analyze:

1. The offgas from the gasifier for process evaluation;
2. Condensibles in the gas for environmental studies;
3. Amount and characteristics of the solids carried over with the gas.

STATUS:

To filter, condensers and condensate received were installed. The majority of piping spools were fabricated and 30% of the piping was installed.

The fabricated piping and equipment were tagged and stored in the Warehouse.

PROJECT STATUS REPORT

AS OF November 30, 1978

PROJECT NUMBER & TITLE: 130-4 Gas Sampling (Instr.)

SCOPE OF PROJECT: Provide instrumentation specifications for system.

STATUS OF PROJECT: Material has been purchased, but not installed.

WORK ORDERS REFERENCE #: See B. McSkimming file.

BM & REFERENCE #: 7849-3116

DWG # REFERENCE: E7848-02030-1

NOTE: Conduit layout sketch needed for dp switch.

PROJECT 183-4 RUPTURE DISC STRESS ANALYSIS

Scope

Project was initiated to check stress in RD piping following a series of failures of the SS 304 pipes by stress corrosion cracking.

Drawings

SKB-7849-737	7th Floor RD Piping
SKB-7849-738	12th Floor RD Piping
SKB-7849-739	6th Floor RD Piping
SK-RMD-11	Continuation 6th Floor RD Piping

Purchase Orders

None

Bills of Material

None

Status

Drawings were sent to Bloomfield for analysis. Piping stress analysis was performed on the computer. The analysis showed no high stress area in the piping. The computer printout is in the project file 183-4.

Later the 6th floor rupture disc and piping were taken out of service. The block valve from the 12th floor rupture disc piping was removed and the heatup line was blinded to reduce the bending of the piping and also because the heatup line was no longer used.

The material of the rupture disc piping was changed from stainless steel type 303 to stainless steel type 376 which is more resistant to stress corrosion cracking.

PROJECT 189-4 COOLING WATER REVISIONS FOR CO₂ COMPRESSORS

SCOPE:

This project was to revise the cooling water distribution to the CO₂ compressor liner jackets and intercooler to minimize compressor valve problems caused by condensation of moisture in the cylinder. The increased flow of cooling water to intercoolers and use of tempered water to cool the cylinder would shift the water condensation from the cylinders to the intercoolers which will allow its separation in the knockout drums.

STATUS:

The project was placed on hold for further process studies and for recommendation from the compressor vendor.

PROJECT STATUS REPORT

AS OF 12/29/78

PROJECT NUMBER & TITLE: 10" Pretreater 181-4

SCOPE OF PROJECT: Install new 3" vertical coal transport line & 10" Ø Pretreater. Insulate and steam trace both. Install T/C's, at Pcells, and flow control switch.

STATUS OF PROJECT: Final Engineering Approved 9/20/78. Mechanical material received. Instrumentation not ordered. No fabrication done. The material will be placed on surplus. Cancelled for plant shutdown.

WORK ORDERS REFERENCE #C-4203

BM & REFERENCE # B.M. #JCO-0077-78
P.O. #7849-3083
7849-3232, 7849-3250

DWG # REFERENCE: SK-REL-072878
SKE-7849-757
SKE-7849-758
SKB-7849-768
D-7849-02623

PROJECT STATUS REPORT

AS OF November 30, 1978

PROJECT NUMBER & TITLE: 10" Pretreater (Instru.)

SCOPE OF PROJECT: Spec. Instrumentation for new 10" pretreater and issue dwgs., loop sheets.

STATUS OF PROJECT: Engineering complete - Equipment not purchased.

WORK ORDERS REFERENCE #:

BM & REFERENCE #: DWM-0093-78

DWG # REFERENCE: SKB-7849-768 and LSP2259, 60, 61, 63, 63, 64 and LST2234

PROJECT STATUS REPORT

AS OF November 30, 1978

PROJECT NUMBER & TITLE: 190-4 Density meter for Char Slurry

SCOPE OF PROJECT: Provide mass flow indication from FA-401
for material balance.

STATUS OF PROJECT: Equipment received but not installed.

WORK ORDERS REFERENCE #: C4152

BM & REFERENCE #: 7849-3179 and BM DWM 0051-78

DWG # REFERENCE: LS D400

R. F. Scherrer

PROJECT STATUS REPORT

AS OF 12/29/78

PROJECT NUMBER & TITLE: 192-4 INSTALLATION OF A NEW WILSON-SNYDER PUMP TO REPLACE THE EXISTING GA-401 PUMP.

SCOPE OF PROJECT: See Status Report

STATUS OF PROJECT: See Status Report

WORK ORDER REFERENCE NO: C-4103, C-4104, C-4107, C-4109
New Construction Task; Z-164-T42377

BM & POR REFERENCE NO: BM: RFS-0063-78, RFS-0070-78
POR: 7849-4627, 7849-4628, 7849-4629,
7849-4643, 7849-4644

DRAWING REFERENCE NO: Drawings: E7849-04434
E7849-04221
D7849-04216
1407-25-525
1407-25-508
1407-25-202
B7849-0110
Sketches: 7849-SK-JCO-84-78
SK-4104-1

PROJECT 192-4 INSTALLATION OF A WILSON-SNYDER PUMP
TO REPLACE THE EXISTING GA-401 PUMP

Status

The intent of Project 192-4 was to provide a back-up pump for the Char Slurry Recycle System.

Due to internal erosion, the original centrifugal pump servicing this system provided poor service. To insure uninterrupted service, a Wilson-Snyder reciprocating pump was installed as a spare. However, due to continual deterioration and subsequent failure of the centrifugal pump, the reciprocating pump was used as the primary unit.

Since the char slurry recycle system is a critical element of the total process and any interruption of the water flow would result in the termination of a run, management decided to remove the original centrifugal pump and replace it with another Wilson-Snyder reciprocating pump to provide a back-up pump for the system. The second Wilson-Snyder pump was originally purchased for potential needs in the gas scrubbing area.

The project installation had been divided into two phases; 1) construction of the foundation and minor concrete modifications to the filter area was to be done by new construction, and 2) the pump installation and required piping and electrical connection was to be performed by the Maintenance Department. At the time of plant closeout, no work by new construction had been completed and the contract for the work was subsequently cancelled. Maintenance had completed the site preparations as requested on Work Orders Nos. C-4103 & C-4104 and had installed some conduit in the pipe rack leading to the filter area. All material ordered by Maintenance for their part of the project had been received.

PROJECT STATUS REPORT

AS OF 12/29/78

PROJECT NUMBER & TITLE: 195-4 Installation of a Brick Wall
in the Thermal Oxidizer

SCOPE OF PROJECT: See attached status report

STATUS OF PROJECT: See attached status report

WORK ORDER REFERENCE No: None Issued

BM & POR REFERENCE No: None Issued

DRAWING REFERENCE No: Preliminary Sketch: SK-195-4-1

PROJECT 195-4 INSTALLATION OF A BRICK WALL
IN THE THERMAL OXIDIZER

Status

Due to numerous failures, an investigation was undertaken to find a suitable replacement for the firebox refractory in the Thermal Oxidizer. A refractory state-of-the-art information search was conducted along with a feasibility study for relining the Thermal Oxidizer with brick. The results of these investigations were presented in the form of a preliminary report and was circulated for approval, see the project file. After preliminary approval, the project was placed on hold until the Thermal Oxidizer again required a complete new lining.

For an indepth understanding of this project and related problems, refer to the correspondence in the project file paying particular attention to the Repair History Report, written by J. Olson and updated by R. Scherrer, and the Summary Report, written by G. Crosslands of Lummus LTC-MED Division.

Since this project never progressed past the preliminary stages, no materials had been ordered.

PROJECT STATUS REPORT

AS OF 12/29/78

PROJECT NUMBER & TITLE: 118-7 Waste Water Unloading Arms

SCOPE OF PROJECT: See attached status report.

STATUS OF PROJECT: See attached status report.

WORK ORDER REFERENCE # C-4101, C-4108

BM & POR REFERENCE # BM: RFS-0048-78, RFS-0068-78
POR: 7849-3217F

DRAWING REFERENCE # E7849-04432
D7849-04437

PROJECT 118-7 WASTE WATER UNLOADING ARMS

Status

The intent of Project 118-7 was to provide a safe means of transferring waste water from the Char Pond and Oily Water Sump to disposal trucks for removal from the plant. All work on this project has been completed except for installation of the loading arms which had long deliveries. The loading arms were delivered to the plant, but were not installed prior to closing.

An unused loading arm from the Stretford Area had been transferred to the Waste Water Removal system servicing the Char Pond. It was intended to return this loading arm to its original location after receipt and installation of the new loading arms.

The new loading arms were received and stored in the warehouse.

PROJECT STATUS REPORT

AS OF 12/29/78

PROJECT NUMBER & TITLE: (124-7) Spill containment pad
@ Caustic/Acid unloading area.

SCOPE OF PROJECT: To install a concrete spill pad with a
sump & drain to neutralizing pit to
contain acid and caustic spills @ the
truck unloading station.

STATUS OF PROJECT: Prel. & Final packages have been routed
and approved. Package was issued for a
ceiling price on 10/28/78. No material
has been purchased, project was cancelled.

WORK ORDERS REFERENCE # Task Order No. Z-171

BM & REFERENCE # BM = RMD-0087-78 (Sheet 1 of 1)
POR = (None)

DWG # REFERENCE E 7849-03223

PROJECT STATUS REPORT

AS OF 12/29/78

PROJECT NUMBER & TITLE: 125-7 Steam Tracing Review

SCOPE OF PROJECT: See attached status report.

STATUS OF PROJECT: See attached status report.

WORK ORDER REFERENCE # C-4110, C-4113, C-4114, C-4115

BM & POR REFERENCE # None required.

DRAWING REFERENCE # Sketches: SKB-7849-784
SKA-7849-786
SKA-7849-787
SKA-7849-788
SKA-7849-801
SKA-8530-604
SKA-8530-605
SKA-8530-606

PROJECT 125-7 STEAM TRACING REVIEW**Status**

The intent of Project 125-7 was to inspect all steam tracing and condensate return systems to identify and correct potential freezing problems. At the time of plant closeout, three (3) work orders, C-4110, C-4113, and C-4114 had been sent to Maintenance requesting changes to the systems; one work order, C-4115, was in circulation for approval, and an additional work order was being prepared. Of the three (3) work orders sent to Maintenance only one, C-4110, had been completed.

Work remaining to complete this project included: 1) inspection of the main steam header, 3" MS 3102, and branch connections from the 4 x 3 reducer on the east end of the plant to the filter area, 2) inspect the main steam supply header and branch connections from the boilers to the junction in the pipe rack with header 8" MS 3102, 3) sonically and visually inspect all steam traps to insure proper operation and installation.

PROJECT STATUS REPORT

AS OF 12/29/78

PROJECT NUMBER & TITLE: (129-7) Security Fence

SCOPE OF PROJECT: To install a security fence between the employee parking lot and the plant. This would improve plant security and reduce property loss by making employees pass thru a guard station to leave the plant.

STATUS OF PROJECT: The preliminary package was routed and returned with comments - the project was cancelled.

WORK ORDERS REFERENCE # None

BM & REFERENCE # None

DWG # REFERENCE SKE-8530-601

PRETREATER ALIGNMENT**Scope**

Breaking of flanged joint between Pretreater and Gasifier cause flanges to spring apart. Check of Pretreater indicated misalignment.

Purchase Orders

None

Bill of Material

REL-0096-78

Drawings

SKD-7840-783 - Alignment and Spring Hanger Settings for Pretreater and Associated Piping.

SK-REL 102578 - New Spring Hanger For Pretreater Overflow Line.

Status

Engineering complete. Maintenance proceeded to step 5 of SKD-7845-783 and it was discovered that a larger spring hanger was required in place of hanger - P.O. 7848-3218F. Hanger from P.O. 7849-3250F Item 1 was located and proposed for installation via memo 8530-PEL-054-78, dated 10/24/78. Last known condition; piping disconnected.

PROJECT STATUS REPORT

AS OF 12/29/78

PROJECT NUMBER & TITLE: Replace char slurry line to A & B
Willis choke valves (no project no.)

SCOPE OF PROJECT: Replace existing 1" 4201-D3A Char Slurry
line with new stainless stl. line. The
existing line was showing signs of erosion.

STATUS OF PROJECT: Drawing and bill of mat'l. were sent to
main't. dept. on 11/14/78. The project
was cancelled and no material was purchased.

WORK ORDERS REFERENCE # C-1752

BM & REFERENCE # BM # RMD-0095-78 (Sheets 1 & 2)
POR - (None)

DWG # REFERENCE D8530-02402

Project 90-7
W/O C-4126

DUPLEX FILTERS TO T.O. WATERGUNS

Drawings - SK-BNM-90-7-1-78

B/M BNM-0045-78

P.O.'s 7849-3149 - Simplex Filters

This project was to provide a large capacity filter for the thermal oxidizer waterguns. Filters and piping were installed, but equipment was never used.

Project 104-7
W/O C-4127

K.O. DRUM RECYCLE CO₂

Drawings - SK-BNM-104-7-1-78
SK-BNM-104-7-2-78
SK-BNM-104-7-3-78
SK-BNM-10278-1
TB-552E-Wright Austin

B/M BNM-0047-78

P.O.'s 7849-3151F

This Project was to replace an undersized K.O. Drum downstream of the after cooler of CO₂ compressors with a larger commercially available entrainment separator. Piping and entrainment separator were purchased and received but were not installed.

PROJECT STATUS REPORT

AS OF 12/29/78

PROJECT NUMBER & TITLE: Pretreater Sample Bomb

SCOPE OF PROJECT: Install Sample collection bomb near bottom of pretreater. To permit collection of hot coal samples from Pretreater Bed.

STATUS OF PROJECT: The high pressure ball valve received, not installed.

WORK ORDERS REFERENCE # B10786

BM & REFERENCE # B.M. #JCO-0014-77
P.O. #7849-3058

DWG # REFERENCE 7849-SK-JCO-65-77 Rev. 1 4/7/78

Project 61-7
Z-142, T-423F6
W/O C-4130

SHOWER AND LOCKER FACILITY FOR MEN

Drawings - E 7849-02214
E 7849-02215
E 6656-05135-2
SKE-7849-F15
P-1244-1
1405-25-F04
E7426-09901

B/M BNM-0060-78

P.O.'s 7849-2646 - Piping
7849-2648 - Shower Columns
7849-2647 - Propane Unit Heaters

Scope

This Project was to provide a separate "Clean" (Street Clothes) and "Dirty" (Company Clothes) areas for plant personnel to contain hazardous chemicals from coal processing area. It was designed in accordance with the latest "NIOSH" and DOE Regulations.

Status

Engineering and design completed and approved. New Construction Subcontracts for building fabrication, erection, and foundation construction were awarded.

Building was received in crates and stored on the plant site. Shower fixtures were received and stored in the warehouse. The building erection and foundation construction subcontract was cancelled.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

CONTENTS

- A. Introduction
 - 1. Purpose
 - 2. Scope
- B. General Conditions for Deactivation and Standby
 - 1. Work Needed for Standby Condition
 - 2. Equipment to be Operated during Standby
 - 3. Status of Major Open Projects
 - 4. Utilities, Commodities, and Service Contracts
 - 5. Fire Prevention and Protection
 - 6. Safety and Security
 - 7. Documentation
 - 8. Protection of Files and Records
- C. Preservation Procedures
 - 1. Equipment Cleaning and Preparation
 - 2. Rust Prevention
 - 3. Protection of Openings
- D. General Procedures to Protect Property
 - 1. Reciprocating Compressors
 - 2. Centrifugal Pumps
 - 3. Exchangers, Vessels, Tanks and Bins
 - 4. Conveyors and Bucket Elevator
 - 5. Instrumentation
 - 6. Fired Heaters
 - 7. Shop Machines and Tools
 - 8. Vehicles
 - 9. Special Valves
 - 10. Piping System
 - 11. Electrical Facilities

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

CONTENTS - cont'd

- D. General Procedures to Protect Property - cont'd
 - 12. Air Conditioning and Ventilation Units
 - 13. Warehouse Items
 - 14. Grounds
 - 15. Pest Control
 - 16. Elevator
 - 17. Buildings and Structures
 - 18. Laboratory
 - 19. Computer
 - 20. Equipment never Commissioned
- E. Additional Specific Procedures to Protect Deactivated Systems
 - 1. Coal Handling
 - 2. Petrocarb
 - 3. Pretreater
 - 4. Gasifier
 - 5. Gas Scrubbing
 - 6. Char Filter System
 - 7. Benfield Unit
 - 8. Stretford Unit
 - 9. Thermal Oxidizer
 - 10. Carbon Dioxide System
 - 11. Inert Gas System
 - 12. Liquid Carbon Dioxide Plant
 - 13. Liquid Oxygen Plant
 - 14. Cooling Water System
 - 15. Demineralizer
 - 16. High Pressure Boiler
 - 17. Propane System
 - 18. Field Piping

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

CONTENTS - cont'd

- F. Emergency and Safety Equipment
- G. Equipment List
- H. Specific Procedures to Reactivate Systems
- I. Schedule

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

A. Introduction

1. Purpose

(a) This specification provides procedures for deactivating and reactivating the Synthane Pilot Plant in Bruceton, Pennsylvania, and putting the plant in standby for up to two (2) years.

(b) The deactivation work is to be done between December 1, 1978 and January 31, 1979.

(c) The plant equipment will be maintained in standby between February 1, 1979 and September 31, 1980.

2. Scope

(a) The specifications contain detailed technical instructions which are necessary for deactivating and protecting all types of in-place equipment, piping systems, electrical, instruments, warehouse items, buildings, grounds, shop machines, power tools, vehicles, and hand tools.

(b) Computerized inventories will be available for warehoused equipment, materials and spare parts. A complete listing of all tagged capital equipment including sensitive items will be provided.

(c) A work schedule and manpower requirements are included.

(d) Reactivation of the equipment will take three to six months.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

B. General Conditions for Deactivation and Standby

1. Work Needed for Standby Condition

- (a) Heat the buildings occupied or used for storage.
- (b) Bar over rotating equipment and lubricate periodically. Reciprocating equipment will be disassembled for storage.
- (c) Clean, dry, install desiccant and seal vessels.
- (d) Control valves stored in place.
- (e) Store instrument transmitters and controller in place.
- (f) Leave vessels not commissioned as is.
- (g) Drain and blow lines clear
- (h) 110V electric power will remain in service and higher voltage power will be disconnected to standby equipment.
- (i) Store equipment in the insulation building, warehouse and bonded warehouses.
- (j) Seal control panels located outside, add desiccant, and heat panel to keep dry.
- (k) Treat carbon steel heat exchanger surfaces.
- (l) Remove flanged relief valves and store in the warehouse.
- (m) Surplus mobile equipment

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

B. General Conditions for Deactivation and Standby - cont'd

2. Equipment to be Operated During Standby

- (a) Emergency generators - generators will continue to be test run weekly.
- (b) Low pressure boilers to supply building heat.
- (c) Packaged air compressors to maintain instrument air.
- (d) A Zeolite water softener will be rented to provide softened boiler feed water to enable us to shut down the demineralizer system.
- (e) Boiler feed water system - deaerator and low pressure boiler feed water system.
- (f) Fire water system.
- (g) Domestic water to shop, warehouse, utilities and administration buildings.
- (h) Sanitary sewage treatment plant.
- (i) Plant fuel oil system.
- (j) Heat will be supplied to the following buildings:
 - (1) Control, switchgear, and laboratory building.
 - (2) Utility building
 - (3) Maintenance and warehouse building
 - (4) Administration building
 - (5) Guard house
 - (6) Compressor building

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

B. General Conditions for Deactivation and Standby - cont'd

3. Status of Major Open Projects

(a) The high pressure boiler repair will be completed and the boiler pressure parts will be hydrotested. The instruments will be mounted but not connected and the electrical wiring will not be connected.

(b) Store gasifier sampling system equipment and piping.

(c) Finish char pond and salt storage projects.

(d) Store building for shower-locker facility.

(e) Cancel filter building enclosure.

(f) Cancel spill containment pad for caustic and acid unloading area.

4. Utilities, Commodities and Service Contracts

(a) The contractors furnishing utilities, commodities or services will be informed to arrange for reduced demands during the standby period.

(b) All contracts for utilities, commodities and services will be reviewed to revise rates based on reduced demands. Particular attention will be directed toward obligations arising out of clauses relating to termination charges, capital credits and reconnecting charges.

(c) All unnecessary contracts for in-plant sales and services will be terminated.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

B. General Conditions for Deactivation and Standby - cont'd

5. Fire Prevention and Protection

(a) Portable fire fighting equipment will be kept in the plant. These units will be inspected and serviced as required during December, 1978, and will require periodic inspections by maintenance personnel.

(b) The quantity required, type and location of all portable fire fighting units will be coordinated through our plant Safety Supervisor.

(c) All coal stockpiles will be removed from the plant site. Scrap lumber, trash and other debris will be removed from around buildings.

(d) Each floor of the main structure will be hosed down after equipment cleaning and preservation is completed. All fire hoses located in the main structures will be left in place. The five gallon drums of foam will be resealed and stored.

6. Safety and Security

a. Deactivation Period

(1) All the plant safety, health, and fire protection procedures that were established for operations will be followed during the deactivation period; i.e., fire permit procedures, lock out procedures, vessel entry procedures, personnel protection program, respiratory protection program, etc.

(2) The plant safety and health administrator shall determine the degree of hazard involved in major deactivation operations where toxic, flammable and/or combustible compounds will be used. He will specify any special precautions that are required for personnel and plant safety.

(3) Guard service will be retained 24 hours per day.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

B. General Conditions for Deactivation and Standby - cont'd

6. Safety and Security - cont'd

b. Standby Period

(1) The operation supervisor will be appointed safety and security responsibilities.

(2) Personnel protection equipment will be furnished to all individuals, i.e. safety glasses, hard hats, goggles, gloves, respirators, etc.

(3) A First Aid Station will be established.

(4) A security guard will be on duty during day shift.

(5) The operators on duty will check the security guard stops when a guard is not on duty.

7. Documentation

(a) Project files will be summarized.

(b) This procedure manual will serve as the primary reference to describe work performed for deactivation. At the completion of this period, a master copy will be filed with verification that each activity was completed as specified with completion dates. If the actual work differs from the procedure, a detailed explanation will be provided.

(c) A logbook will be maintained by the work leakers to provide a record of the work performed. Any problems encountered during the work performance will be recorded along with recommendations for special action during either the maintenance or reactivation periods.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

B. General Conditions for Deactivation and Standby - cont'd

7. Documentation - cont'd

The logbook will be maintained by the work leaders to provide a record of the work performed. Any problems encountered during the work performance will be recorded along with recommendations for special action during either the maintenance or reactivation periods.

(d) All equipment will be marked to provide easy identification. Additional information will be marked on the equipment to provide safety precautions or special instructions regarding that item.

- All equipment being disassembled or relocated for storage will be tagged identifying all mating parts, their storage location and the original location.
- Identification tags will be water and sun resistant and shall remain readable. Any tags that show deterioration will be replaced.
- A typical identification tag attached to equipment will include the following information:

Equipment name and number
Manufacturer's name, part and serial number.
Location for installation.
Special instructions.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

B. General Conditions for Deactivation and Standby - cont'd

7. Documentation - cont'd

- Identification tags on instrumentation equipment will also include:

- Calibration information.

- "AIR TO OPEN" or "AIR TO CLOSE"

- Companion orifice size and meter factor.

(e) During the standby period, a routine monthly checklist will be prepared and used to document all work performed. This will insure that each activity is recognized and completed on a regular basis and will serve as input to the monthly status reports.

(f) Additional records will be used to provide information concerning storage locations for equipment and inventory sheets.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

B. General Conditions for Deactivation and Standby - cont'd

8. Protection of Files & Records

(a) The following list of files and records was generated on this project. All files and records remaining on site shall be stored in lockable rooms in the Administration Building.

<u>Files & Records</u>	<u>Location</u>
Raw Data (Charts, Tapes, Etc.)	On Site
Process	On Site
Engineering	On Site
Operation	On Site
Maintenance	On Site
Safety	C.E. Lummus-Bloomfield
Accounting	C.E. Lummus-Bloomfield
Drawings	Reproducible On Site
Data Books	On Site (3 Sets)
Warehouse	On Site
Laboratory	On Site
Inventories	On Site

(b) There are additional sets of data books distributed as follows:

1974-1977 Files and Records - GSA Retention
Center Mechanicsburg, PA

(c) An inventory report of all government property will be prepared by C.E. Lummus, and submitted to the Government Property Administrator upon completion.

Final disposition of files will be as directed by The DOE Contract Administrator, in Chicago.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

C. Preservation Procedures

1. Equipment Cleaning and Preparation

(a) All equipment and material should be thoroughly cleaned, insofar as may be practical, internally and externally.

(b) All fluids, i.e., fuels, water, etc., shall be completely drained from all tanks, vessels, jacketing, piping and rotating equipment.

2. Rust Prevention

(a) Coatings

For unpainted external machined surfaces the rust preventative will be a heavy application of grease or liquid film which dries to a tough coating and which conforms with the performance requirements of the U. S. Defense Department Specifications for Preservatives as listed below:

Spec Designation	- MIL-C-11796 Class 1.
Application Method	- Hot application brush or maximum temperature of application, 200°F.
Description	- Thick hard drying, greasy film. For protection of highly finished parts of simple design for long periods.
Material Used	- TECTYL 435

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

C. Preservation Procedures

2. Rust Prevention

(a) Coatings - cont'd

For internal lubrication systems of assembled equipment, the rust preventative will be of a type which does not require removal before operation of the equipment and which conforms to the performance requirements of the U. S. Defense Department Specification for Preservatives as listed below:

Spec Designation	- MIL-L-21260, Type 1, Grade 30
Application Method	- Brush, dip or spray, 60°F to 120°F.
Description	- Engine lube oil with corrosion inhibitors, including hydro- bromic acid neutralizers.
Material Used	- SUNFILL 2630

For inside of equipment pump cases, heat exchanger surfaces, which conforms with the performance requirements of the U. S. Defense Department Specifications for Preservatives as listed below:

Spec Designation	- MIL-C-16173D, Grade 5
Application Method	- Brush, dip or spray at ordinary room temperatures. (Approximately 70°F) Stir before using.
Description	- This compound is a " <u>Solvent Cut- Back Cold-Application Corrosion Preventative.</u> " It is liquid at ordinary room temperature. At lower temperatures it tends to become viscous.
Material Used	- TECTYL 511M

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

C. Preservation Procedures

2. Rust Prevention - cont'd

(b) Procedure

Acceptable methods of applying MIL-L-21260 rust preventative are spraying, brushing, filling, flushing, etc., through all available openings, or by disassembly if necessary to completely coat and protect all unpainted internal surfaces. Particular attention should be paid to journal surfaces of sleeve bearings and antifriction bearings so they are completely covered. For machines this shall be done while the unit is being slow rolled.

Wire a large RED weatherproof tag to each piece of equipment treated with a rust preventative that states: "Caution - This Equipment has been treated with a Rust Preventative and shall not be disturbed by Unauthorized Personnel." The brand name of the preservative must be on this tag.

Any piping disassembled from equipment shall have internal surfaces cleaned and coated with a rust preventative, where necessary, which conforms with MIL-C-16173D, Grade 5.

After application of rust preventative, exposed machined surfaces shall be wrapped with a heavy Vapor Phase Inhibitor (VPI) treated paper or other heavy waterproof paper (or plastic) enclosing VCI (Vapor Corrosion Inhibitor) crystals. In all cases, pH of wrapping shall be neutral. The wrapping shall be secured tightly with tape. Sharp edges shall be cushioned to prevent puncture of wrapping.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

C. Preservation Procedures

2. Rust Prevention

(b) Procedure - cont'd

Spare and replacement parts shall be treated with a rust preventative, wrapped in heavy plastic enclosing VCI crystals, tape sealed and stored carefully indoors.

Oil reservoirs and bearing cavities on rotating equipment shall be filled with a preservative oil which conforms with MIL-L-2160 Type 1, Grade. The items shall be tagged with instructions for draining, periodic rotation, and refilling.

Where possible, non-critical items such as steel plates and shapes will be stored in a vertical position or in a sloped position to provide gravity run-off for rain and snow.

3. Protection of Openings

Flanged openings shall be protected with bolted-on steel covers using at least four bolts. A gasket shall be used between the flange and the metal cover. After openings have been covered, the joint shall be wrapped with waterproof tape. Beveled or screwed pipe ends shall be protected with plastic closures or thread protectors and sealed with waterproof tape. Screwed holes shall be protected with screwed plastic plugs.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

C. Preservation Procedures

3. Protection of Openings - cont'd

Porous bags filled with desiccant shall be hung on the inside of metal bolt-on covers on all major connections of rotating equipment unless physical size is restrictive. No loose bags permitted inside machinery.

Desiccant used in all rotating equipment shall be nondelequescing, nondusting, chemically inert, dehydrating agents. The quantity of dehydrating agent to be used shall be determined by the volume of the enclosed space as follows:

Silica Gel - used at a rate of eight (8) pounds per 100 cubic feet of volume.

Activated Alumina - used at a rate of eight (8) pounds per 100 cubic feet of volume.

All closures that are part of the original equipment shall be tight fitting.

Plastic plugs and caps should be highly colored so they are visible and preclude their loss in the system.

Sealing tape shall be impervious to water and not subject to cracking or drying out if exposed to sunlight, heat or cold.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

1. Reciprocating Compressors (Lubricated and Non-Lubricated)

A. Protection

(a) Drain all lubricating oil, water from the cylinder jackets, separators, intercoolers, after-coolers, and any moisture from pulsation dampeners or volume bottles, and the compressor piping. Disconnect all piping and appurtenances.

(b) Remove filter elements and strainers.

(c) Open compressor and remove all cylinder valves, seals and rings. These items will be cleaned (apply rust preservative oil to valves), wrapped, boxed, tagged with the equipment number and stored indoors. A RED tag on the compressor shall read, "CYLINDER VALVES, SEALS AND RINGS MUST BE INSERTED BEFORE RUNNING THIS COMPRESSOR." The tag should also state where the seals, rings and valves are stored.

(d) Fill the water cylinder jackets, separators, intercoolers, aftercoolers (shell and tube sides), pulsation dampeners, volume bottles, and compressor piping with rust preventative, TECTYL 511M.

(e) Drain the excess compound from all system components, paying particular attention to low spots, pockets and exposed piping in which the compound could collect. Save drainings for future use.

(f) Fill the lubrication system to full capacity with rust preventative. Use engine lube oil with corrosion inhibitors, including hydrobromic acid neutralizers, SUNFILL 2630.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

1. Reciprocating Compressors (Lubricated and Non-Lubricated)

A. Protection - cont'd

(g) Turn the compressor at a speed sufficient to circulate the oil throughout the internal compressor systems. Several minutes should be adequate, but visual checks should be made to see that the oil is reaching all points.

(h) Look for areas which did not receive a coating during the compressor turning. It will be necessary to spray these areas with the preservative while slow rolling the compressor manually. DO NOT DRAIN THIS COMPOUND FROM THE COMPRESSOR.

(i) Install desiccant and replace all inspection, hand hole and valve covers.

(j) All unpainted external machined surfaces shall be cleaned and coated with rust preventative, TECTYL 435.

(k) Wire a large RED weatherproof tag to each piece of equipment treated with a rust preventative that states: "CAUTION - THIS EQUIPMENT HAS BEEN TREATED WITH A RUST PREVENTATIVE AND SHALL NOT BE DISTURBED BY UNAUTHORIZED PERSONNEL." The brand name of the preservative must be on this tag.

(l) Any piping disassembled from equipment shall have internal surfaces cleaned and coated with a rust preventative, TECTYL 511M.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

1. Reciprocating Compressors (Lubricated and Non-Lubricated)

A. Protection - cont'd

(m) After application of rust preventative, exposed machined surfaces shall be wrapped with a heavy Vapor Phase Inhibitor (VPI) treated paper or other heavy waterproof paper (or plastic) enclosing VCI (Vapor Corrosion Inhibitor) crystals. In all cases, pH of wrapping shall be neutral. The wrapping shall be secured tightly with tape. Sharp edges shall be cushioned to prevent puncture of wrapping.

(n) Spare and replacement parts shall be treated with a rust preventative, wrapped in heavy plastic enclosing VCI crystals, tape sealed and stored carefully indoors.

B. "V" Belts and Shafts

(a) All "V" belts will be removed and wiped clean, tied together and attached in a convenient location on the driven equipment.

(b) Driving and driven shafts will be cleaned and receive a heavy application of rust preventative which conforms with MIL-C-11796, Class 1.

C. Preventative Maintenance

The following preventative maintenance will be performed on all compressors and appurtenances. Log sheets showing work scheduled and completed will be maintained.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

1. Reciprocating Compressors (Lubricated and Non-Lubricated)

C. Preventative Maintenance - cont'd

(a) Prime and check compressor lubricator system using SUNFILL 2630 at least once every three months. All exposed unpainted metal surfaces will be inspected every three months and recoated as required.

(b) Bar over the compressor crank shaft at least once every two weeks during storage. Operate the oil pump (when available) to insure the rust inhibiting oil is flushed onto all internal barring surfaces. Do not allow the crank shaft to come to rest at the same position it did prior to the barring.

(c) At least once every three months, operate the lubricator so that the rust inhibiting oil is pumped into the lubricator lines and main bores at the same time the unit is being barred over. In the case of crank shaft driven lubricators, this must be done by operation of the individual priming pumps.

(d) Inspect the internal surfaces of the frames and the cylinder bores at least once every three months.

(e) Inspect the cylinder valves that are boxed and stored indoors by removing the protective wrapping and checking for rust. If there is any rust problem, clean and recoat with rust preventative oil, SUNFILL 2630, and replace any desiccant.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

1. Reciprocating Compressors (Lubricated and Non-Lubricated)

C. Preventative Maintenance - cont'd

(f) Inspect pressure vessels and piping for internal rusting at least once every three months. If there is any rust present, clean and recoat with rust preventative compound, TECTYL 511M.

(g) Inspect desiccant bags hung on the inside of the metal bolt-on covers every three months and replace as necessary.

D. Reactivating the Compressors

(a) Install all cylinder valves, seals and rings in the compressors. Remove all desiccant from compressor and appurtenances. Flush cylinder water jackets, separators, intercoolers, aftercoolers, pulsation dampeners or volume bottles and all compressor piping thoroughly with hot water or low pressure steam, and air dry. Reconnect all piping and compressor appurtenances. Although the compressor may be started with the inhibited oil in the lubricating system, it is advisable to drain this oil and replace it with the manufacturer's recommended lubricant.

(b) Install couplings, "V" belts and all protective guards before starting the machine.

(c) Install filters and strainers.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

2. Centrifugal Pumps

A. Protection

Centrifugal pumps shall be cleaned and protected using the following steps:

- (a) Disconnect all pump piping.
- (b) Drain pump case, piping, seal and all bearing cavities.
- (c) All mechanical seals are to be removed, cleaned, wrapped, tagged with the equipment number and stored indoors. A RED tag on the pump shall read, "MECHANICAL SEALS MUST BE REPLACED BEFORE RUNNING THIS PUMP." The tag should also state where the seal is stored. On packed pumps, it will be necessary to remove the seal packing.
- (d) Fill all bearing cavities with rust preventative. Use engine lube oil with corrosion inhibitors, including hydrobromic acid neutralizers, SUNFILL 2630.
- (e) Fill pump case, seal cavity and bearing cooling cavities with TECTYL 511M.
- (f) Drain excess compound from pump case, seal cavity and bearing cooling cavities.
- (g) Install desiccant and close all pump openings.
- (h) All unpainted external machined surfaces shall be cleaned and coated with rust preventative, TECTYL 435.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

2. Centrifugal Pumps

A. Protection - cont'd

(i) Acceptable methods of applying SUNFILL 2630 rust preventative are spraying, brushing, filling, flushing, etc., through all available openings, or by disassembly if necessary to completely coat and protect all unpainted internal surfaces. Particular attention should be paid to journal surfaces of sleeve bearings and anti-friction bearings so they are completely covered. For machines this shall be done while the unit is being slow rolled.

(j) Wire a large RED weatherproof tag to each piece of equipment treated with a rust preventative that states: "CAUTION THIS EQUIPMENT HAS BEEN TREATED WITH A RUST PREVENTATIVE AND SHALL NOT BE DISTURBED BY UNAUTHORIZED PERSONNEL." The brand name of the preservative must be on this tag.

(k) Any piping disassembled from equipment will have internal surfaces cleaned and coated with a rust preventative, TECTYL 511M where necessary.

(l) After application of rust preventative, exposed machined surfaces will be wrapped with a heavy Vapor Phase Inhibitor (VPI) treated paper or other heavy waterproof paper (or plastic) enclosing VCI (Vapor Corrosion Inhibitor) crystals. In all cases, pH of wrapping shall be neutral. The wrapping shall be secured tightly with tape. Sharp edges shall be cushioned to prevent puncture of wrapping.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

2. Centrifugal Pumps

A. Protection - cont'd

(m) Spare and replacement parts will be treated with a rust preventative, wrapped in heavy plastic enclosing VCI crystals, tape sealed and stored carefully indoors.

(n) Oil reservoirs and bearing cavities on rotating equipment will be filled with a preservative oil, SUNFILL 2630, above. The items will be tagged with instructions for draining, refilling and periodic rotation.

B. "V" Belts and Shafts

(a) All "V" belts shall be removed and wiped clean, tied together and attached in a convenient location on the driven equipment.

(b) Drive shafts shall be cleaned and receive a heavy application of rust preventative, TECTYL 435.

C. Preventative Maintenance

The following preventative maintenance will be performed on all pumps. Log sheets showing work scheduled and completed shall be maintained on each pump.

(a) External Surfaces - Inspect external machined surfaces every three months and recoat as required.

(b) Internal Surfaces - Units fitted with bearing oil reservoirs shall be filled full with rust inhibiting oil, SUNFILL 2630. Flush bearings with rust inhibiting oil, SUNFILL 2630, every three months. Internal pump case and cooling cavities will be coated with rust preventative TECTYL 435. Every month, the rotors shall be turned per schedule. Strap wrenches must be used for this purpose.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

2. Centrifugal Pumps - cont'd

D. Reactivating the Pump

(a) Remove heavy coating of rust preventative from all external machined surfaces by peeling or with solvent.

(b) Drain all rust inhibiting oil from bearings, oil reservoirs, and add manufacturer's recommended lubricant.

(c) Install mechanical seals and packing where required.

(d) Flush internal pump case and all cooling cavities with hot water or low pressure steam, and air dry.

(e) Reconnect all pump piping.

(f) Install "V" belts and all protective guards before starting the pump.

3. Exchangers, Vessels, Tanks and Bins

A. Protection

(a) Shell and Tube Exchangers

. Drain all exchanger shell side and tubeside liquids.

. Disconnect all piping.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

3. Exchangers, Vessels, Tanks and Bins

A. Protection

(a) Shell and Tube Exchangers - cont'd

. On fixed tubesheet units, remove front and rear heads or covers. Clean all tubes, shell, heads or covers, steam clean if required. Apply corrosion preventative to the shell and tube side surfaces, TECTYL 511M, then replace front and rear heads or covers.

. All exchanger openings shall be sealed and protected.

. Add desiccant.

. Removable bundle units will be prepared the same as above, however, the tube bundle will be pulled on these units for a more thorough cleaning and for better application of the corrosion preventative to the shell and tube sides.

. Double pipe exchangers shall be prepared the same as above.

(b) Pressure Vessels (Unlined)

. Drain or empty all vessel liquids and compounds. Clean vessel and internals.

. Seal and protect vessel openings.

. Add dessicant.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

3. Exchangers, Vessels, Tanks and Bins

A. Protection - cont'd

(c) Pressure Vessels (Refractory Lined)

. Empty and air clean all internal surfaces of refractory lined vessels. Hand clean flanges and apply rust preventative, TECTYL 435, to the flange faces.

. Install top and bottom heads and all openings.

. Add desiccant.

(d) Tanks and Bins

. Empty contents and clean all internal surfaces.

. Air dry the interior, and seal the tank or bin openings with polyethylene that will protect the interior against direct rain or snow.

. Add desiccant.

B. Preventative Maintenance

The following preventative maintenance will be performed on exchangers and pressure vessels only. Log sheets showing work scheduled and completed shall be maintained.

(a) External Surfaces -- All exposed unpainted metal surfaces should be inspected every three (3) months and recoated as required.

(b) Inspect desiccant bags hung on the inside of metal bolt-on covers every three (3) months and replace as necessary.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

3. Exchangers, Vessels, Tanks and Bins - cont'd

C. Reactivating

(a) All internal surfaces protected with the corrosion preventative should be cleaned by flushing with hot water or low pressure steam and then air dried. The rust preservative applied to flanges and machined surfaces may be peeled off. Any residual greasy film may be removed by rag wiping with a safety solvent.

(b) Reconnect all piping.

(c) Remove desiccant.

(d) Remove temporary covers over openings.

4. Conveyors and Bucket Elevator

A. Protection

(a) Clean belt conveyor components and lubricate all bearings. Remove belts, roll-up, tag and store indoors. Tag the conveyor to indicate where the belt is stored. Remove chain drives, clean, lubricate, tag, wrap and store indoors.

(b) Clean screw conveyors and lubricate bearings. Drain gear boxes and refill with rust inhibiting oil, SUNFILL 2630. Make sure bolt-on covers and access covers are tightly in place. Remove "V" belts, clean and attach securely to a part of the conveyor out of the weather.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

4. Conveyors and Bucket Elevator

A. Protection - cont'd

(c) Clean Bucket Elevator and lubricate bearings with grease that conforms to NLGI No. 2 consistency while the shaft is revolving. Drain gear box and refill full with rust inhibiting oil, SUNFILL 2630. Remove "V" belts, clean and attach securely to a part of the conveyor

B. Preventative Maintenance

None required.

C. Reactivating the Conveyors

(a) Install belts, chain drives, lubricate all bearings, chains and motors.

(b) Drain gear boxes and refill to operating level with the manufacturer's recommended lubricant.

(c) Install "V" belts.

(d) Check conveyor belts and replace, if necessary.

5. Instrumentation

A. General

(a) Clean and store transmitters, controllers and analyzer components that are located outside.

(b) All thermocouples, flow elements, dial thermometers, glass rotameters, thermowells, level glasses and pressure gauges will be left in place.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

5. Instrumentation

A. General - cont'd

(c) Stored instrumentation will be tagged by Loop Component Number and logged with a description of manufacturer, model number, serial number, range, DOE tag number and installed location.

(d) Control valves and actuators will be left in place and stroked per schedule.

B. Main Control Panel Instrumentation

Controllers, recorders, switches, I/P transducers located on or behind the panel will be left installed with a purge of instrument air.

C. Field Instruments

(a) All instruments are to be tagged with the instrument number for storage.

(b) Field connections will be sealed against moisture and dust.

D. Analytical Instruments

(a) All field analyzers are to be cleaned and stored with desiccant. Each component shall be tagged by function and stored in the warehouse.

(b) Chromatographs and analyzers will be disconnected from process lines and power sources and all openings sealed. Chromatographs are to be purged with dry helium and analyzers purged with nitrogen before sealing.

(c) All area monitors will be left in place.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

5. Instrumentation - cont'd

E. Controllers, Recorders and Displacers in Field

(a) Strip chart recorders and recording controllers will be removed and stored. Remove chart and clean ink systems. Recorder pens will be taped, tagged by loop number and stored. Add desiccant to case.

(b) Seal pneumatic openings with tape. Tag sensing lines and signal lines.

(c) Cover glass view ports with tape.

(d) Fisher level-trol type displacer assemblies will be removed, drained, inspected, cleaned and stored with stilling well.

(e) Level-trol, pressure, differential pressure and temperature controllers will be cleaned, purged with clean dry air and bagged desiccant placed inside the case.

F. Control Valves and Regulators

Control Valves and regulators will remain installed with air supply on.

G. Relief Valves

Flanged Relief Valves will be removed and stored. Threaded relief valves will be left in place.

H. Flow Elements

All flow elements, i.e., orifice plates, annubar and restriction orifices will be left in place.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

5. Instrumentation - cont'd

I. Switches

(a) Flow

. Flow switches including paddle type will be removed from their respective lines, cleaned, inspected and tagged.

. Open lines will be taped and tagged by loop component number.

. Add desiccant inside the switch housing before storage.

(b) Level

. Displacer type level switches, with their chambers, will be removed from the field for inspection, repairs, and storage. Connections are to be taped and tagged by loop component number.

. Add desiccants inside the switch housing before storage.

. All diaphragm indicators, etc. remain in place.

. LAH-109 indicator will be removed, cleaned and stored. Opening shall be taped and tagged LAH-109.

. Disconnect nuclear source level switches from their power sources and their electrical cables preserved.

. Lock the source unit shutter closed. The source will be stored in a locked box in the warehouse with warning signs on the box.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

5. Instrumentation

I. Switches - cont'd

(c) Pressure Differential Pressure

. Pressure and differential pressure switches will be disconnected from their process lines, inspected, cleaned, tagged and stored. Their connections will be tagged by loop component number and taped.

. Seal open electrical or process connections as required.

. Add desiccant to the housing of electronic circuits.

(d) Temperature

Bulb or thermocouple type temperature and transmitters exposed to the weather will be removed from the field, inspected, cleaned, repaired, tagged and stored. Thermowell will be left in place.

J. Indicators

(a) Glass tube rotameters will be left in place.

(b) Remove metal tube transmitting type rotameters from the field for inspection, cleaning, repair and storage.

(c) All threaded ends shall be sealed with plastic pipe caps and tagged by loop component number.

(d) Seal flanged ends and tag by loop component number.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

5. Instrumentation

J. Indicators - cont'd

(e) Glass level indicators will be left in place.

(f) Pressure gauges, including magnahelics will remain in place.

K. Thermal Elements and Thermometers

(a) All thermocouples and dial thermometers will remain in place.

(b) All thermowells will remain in place.

(c) The weather station instruments will remain in service.

L. Control Panels

(a) All outside control panels will be left electrically energized with 110V supply to maintain heat in the inside panel.

(b) Air supply will remain ON to the main control panel and remain OFF to the local control panels.

(c) Switches will be placed in the OFF position.

(d) Clean panels and cable trays without disassembly of the panels.

(e) Clean ink from the recorders.

(f) The control panel will be de-energized electrically.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

6. Fired Heaters

A. Protection

(a) Drain any liquid from heater coils. Disconnect gas supply and all piping. Blow clean the inside of heater coils and air dry. Remove the burner assembly clean, preserve, wrap, tag and store indoors. All coil openings will be sealed and protected. The top of the heater stacks will be sealed with a weather cap tack welded in place.

(b) Plug openings where burners are removed. Lubricate damper linkages. Internal stack refractory will not be cleaned.

B. Preventative Maintenance

(a) The following preventative maintenance will be performed on fired heaters. Log sheets showing work scheduled and completed shall be maintained.

(b) External Surfaces - Dampers should be moved manually every three (3) months to assure continued free movement. No lubrication is required.

(c) Internal Surfaces - Inspect desiccant bags hung on the inside of the coil metal bolt-on flange covers every three (3) months, and replace as necessary.

(d) The stack is self-draining and no maintenance is required.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

6. Fired Heaters

C. Reactivating

(a) Flush heater coils with hot water or low pressure steam and air dry.

(b) Install burner assembly and reconnect all piping.

(c) Remove desiccant.

7. Shop Machines and Tools

A. Machine Protection

Clean each machine and repair worn or scratched surfaces. Unprotected surfaces must be covered with corrosion preventative lubricant MIL-C-11796. Belts must be removed and tied securely to the driving pulleys. Component parts must be cleaned and protected and packaged in individual boxes. These boxes will be labeled to identify contents, and the machine from which the parts were removed. The complete tool is then to be wrapped or enclosed with a protective covering.

B. Tool Protection

Portable power tools and hand tools must be inventoried, cleaned and packed in boxes suitable for storage. Contents of each box must be clearly identified.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

8. Vehicles

A. Mobile Equipment

(a) Six government owned pieces of mobile equipment will be inactivated consisting of the following units:

- One Pick-Up Truck
- One W-20 Case Front-Loader
- One Gasoline Fork Lift
- One Sweeper
- One Cherry Picker
- One Diesel Air Compressor

(b) Drain all lubrication oil from crank cases and gear boxes. Drain cooling systems and flush to remove sediments.

(c) Remove any filter elements and strainers.

(d) Clean all machinery exterior surfaces. Heavy contaminations of dirt, oil and grease may be removed by use of a grease cleaning compound.

(e) Grease all units per manufacturer specifications.

(f) Fill lubrication systems to normal capacity with rust preventative, SUNFILL 2630.

(g) Start engine and run at speed sufficient to circulate the rust preventative throughout the lubrication system. Shut down engine.

(h) Remove spark plugs. Pour one pint of SUNFILL 2630 into each cylinder and replace plugs.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

8. Vehicles

A. Mobile Equipment - cont'd

- (i) Remove battery and store.
- (j) Seal carburetor air inlets and engine exhaust outlets.
- (k) Clean exterior surface of vehicle.
- (l) Store vehicles and remove weight from tires.

9. Special Valves

Procedure for deactivating Rockwell Plug Valves, EBV Valves, Kaymer Valves, Slide Gate Valve under Gasifier, Overflow Valves Pretreater to Gasifier, and Flanged Relief Valves.

- (a) Remove valves from pipe lines and clean pipe flanges and install blind flanges on pipe opening.
- (b) Clean all valves internally and externally to remove all loose rust and scale. Steam clean if required.
- (c) Coat with rust preventative, TECTYL 435.
- (d) Cap all openings, crate in wooden boxes, tag and store.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

10. Piping System

A. Protection

All piping systems that will not be used during the plant standby period, will be drained and cleaned. Any removed spool pieces shall be cleaned and protected in the same way as the other piping. Tag spool pieces to indicate where they are to be reinstalled. Store the spool piece as close as practical to the point of removal. The diagrams and lists will be stored in the plant operations files.

B. Reactivating Piping Systems

Inspect piping, chemically clean where needed and hydrotest system.

11. Electrical Facilities

A. Requirements for Standby State

(a) Lighting

. Building lighting will be limited to the administration building, guard house, utilities, control room, lab, switch room and maintenance building.

. Roadway and parking lot lighting will be retained as is.

. Process structure lighting will be reduced to emergency system. Pipe bridge lighting will remain on except in the filter area, which will be lit by floodlights on char dump roof.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

11. Electrical Facilities

A. Requirements for Standby State - cont'd

(b) Power

. Substation transformer TR1 will be de-energized. Essential equipment supplied from this substation will be relocated. Maintenance building feeder will be supplied from transformer TR2.

. Essential equipment will be re-located to MCC1A, MCC1D, MCC1B and maintenance building. All other motor control centers will be de-energized. The breakers or fuses feeding these MCC's will be removed.

. Lighting power and instrument transformers that are not used will be disconnected. Primary and secondary leads will be taped.

(c) Drivers

. Drivers will be stored in place with couplings connected.

. Chains and belts are to be removed.

. Installed motor heaters will be activated with 110 volt electrical.

B. Distribution Systems

All components of the system that serve the inactive areas will be de-energized. Distribution transformers not required for essential loads will be de-energized, cleaned and painted.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

11. Electrical Facilities - cont'd

C. Security and Protective Lighting

On lighting systems that can be completely de-energized the transformers will have both the primary and secondary leads disconnected from the system. Where conditions will not permit complete de-energizing of those systems, they should be reduced to a minimum consistent with safety and security requirements. Obstruction lights to air navigation should be maintained in service, if necessary. Any structure extending 200 feet above ground elevation will have obstruction lights installed and maintained.

D. Interior Electrical Systems

(a) Interior electrical systems in all inactive buildings will be de-energized by opening service entrance switches and locking service entrance equipment in the open position, if possible.

(b) Feeder Circuits - All feeder branch circuits and local switches must be left in the open position. The building service entrance equipment must be left in the open position regardless of whether the distribution system is energized or de-energized. Electric lamps are left in place.

(c) Switches - All switches and controllers not required to be closed for lighting for supply to power outlets for use in emergencies or for operation of equipment must be left in the open position. Install tags on those switches which are required to be closed in the inactive status. The tags shall indicate the purpose of the switch which is closed. Warning tags of a different color or design must be installed on those switches if closed would result in damage to equipment.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

11. Electrical Facilities

D. Interior Electrical Systems - cont'd

Since solvent cutback corrosion preventative is injurious to most forms of electrical insulation, careful supervision must be exercised so that it does not come in contact with any electrical insulation. Corrodible surfaces adjacent to electrical insulation may be preserved by use of clear drying insulation varnish.

E. Switchboards, Power and Lighting Distribution Panels

(a) Clean the equipment, including bus work and appurtenances, insofar as practical without disassembly of the switchboards or panels of their component parts.

(b) Make necessary repairs and clean; then, repaint any surfaces on which existing paint is chipped, cracked or show signs of corrosion.

(c) Oil and grease all linkages and fittings that normally require lubrication.

(d) Open all switches not required for use during plant inactivation.

(e) Place porous bags filled with activated alumina in each compartment of the lighting and motor control centers, panels, starter control panels, distribution panels, etc. Tag the outside of each panel door with RED tag reading: CAUTION - CONTAINS DESICCANTS - REMOVE BEFORE OPERATING.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

11. Electrical Facilities - cont'd

F. Electrical Cables

(a) Electric cables and wire ends for removed outside equipment will have the individual conductor terminals adequately insulated from each other and from ground.

(b) Where cables and wires do not terminate in a watertight enclosure, the end will be sealed. The individual conductors are to be insulated from each other. The conductors are then to be taped together with self-fusing rubber tape, then dipped in insulating varnish.

(c) The conduit terminal end with cables or wires extending out of the conduit is to be sealed with an electrical insulating putty wrapped with rubber tape then coated with insulating varnish to keep dirt, water, moisture, etc. from entering the conduit.

NOTE: Excessively long leads extending out of conduit should be pulled back into the conduit, if possible, and the short ends then protected and insulated as above. If it is impossible to pull them back into the conduit, cable or wire ends shall be insulated and sealed. The conduit is to be sealed. The long leads are then to be coiled, tied in place and secured to the conduit and mechanically protected.

(d) When cables or wires are disconnected, they are to be marked and tagged with the equipment tag number or name of the piece of equipment they supplied power to. They will also be identified as to the terminal or the wire or wires that they were disconnected from.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

11. Electrical Facilities - cont'd

G. Inspections and Test

(a) Inspect and test as necessary to determine the condition of equipment and circuits. Repair if feasible or list equipment inoperable.

(b) Insofar as practical, those items of electrical equipment outside the plant structure and buildings that are susceptible to deterioration due to water, moisture and corrosion must be removed, properly tagged and stowed inside in a dry area. The tags must include the tag number and the name of the equipment and its normal installed location. A complete set of mounting bolts and associated hardware and equipment required for reinstallation is to be placed in a cloth bag and physically attached to each unit removed.

(c) Attach suitable tags of noncorrodible materials at the normal installed location of removed items. The tags indicate the name of the item, the normal location, the tag number of equipment and the storage location.

(d) The following records will be prepared incident to inactivation.

. A list of all items removed from their normal location to a more secure or inside storage area. Include the tag number and name of each such item, its normal location and its storage location.

. A list of the location of all pertinent records, drawings, machinery history, etc., shall be made.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

11. Electrical Facilities - cont'd

H. Batteries

(a) Rechargeable nickel-cadmium batteries that will not be used are to be filled with distilled water, then fully charged. Primary battery leads must be disconnected and taped. Battery terminals protected with an industrial grade of battery terminal preservative.

(b) Primary (dry) batteries shall be removed from all dry battery powered equipment, including testing instruments and all equipment and instruments so tagged.

(c) All lead acid storage batteries installed in the plant and in rolling stock will be removed and stored.

I. Electrical Motors

Motors and their controllers outside enclosed structures, in wet or damp locations and exposed to the weather, except those of the totally enclosed and explosion proof type, must be removed to dry storage. All cable ends are to be sealed, cleaned, and preserved. Direction of rotation of the motor is to be indicated on the motor.

12. Air Conditioning and Ventilation Units

Existing heating, ventilation, and air conditioning will be retained. Portable air conditioning units not used will be stored in a heated warehouse.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

13. Warehouse Items

(a) Most warehouse items will generally withstand indefinite storage in their present condition and location.

(b) Unpainted machined surfaces with a minimum protective coating should be treated with rust preventative.

(c) Any boxed or crated items should be opened and inspected to determine if the rust preventative provided by the manufacturer is adequate for extended storage. If not, these items should be cleaned and protected with an appropriate rust preventative.

(d) Every three months, the materials and equipment stored in the warehouse area should be inspected. If there is any rusting, they should be cleaned and protected with a rust preventative.

14. Grounds

a. General

An inspection must be made to ensure proper drainage and erosion control and corrective measures taken where required to ensure protection of buildings, pavement and other facilities. Weed, brush and other vegetation control measures will be done for fire protection and proper function of drainage systems.

b. Paved Areas

An inspection must be made to facilities to determine if drainage is adequate; if not, corrective action must be taken. Bituminous pavements that are highly oxidized or showing deterioration should be given a Bituminous seal. Cracks and joints in pavement surfaces will be maintained to a degree necessary to keep excess moisture and debris from joints or cracks.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

14. Grounds - cont'd

c. Ground Maintenance

(a) Improved and semi-improved grounds should be mowed frequently enough to provide an orderly appearance. Areas adjacent to buildings and roadways may require more frequent mowing than large open areas.

(b) Unimproved ground should be maintained at a height consistent with fire prevention measures and to control poisonous and nauseous plant growth according to local and state laws and regulations.

(c) Inspection of grounds must be accomplished on a frequency that assures a neat appearance at all times. This includes areas along fence lines that parallel public roads.

(d) Shoulders adjacent to paved areas must be maintained on a scheduled basis to preclude ponding of water undermining edges of pavement and to ensure positive drainage run-off. Also, maintenance schedule must be developed to control weed growth on all shoulders.

(e) Joints and cracks in concrete must be maintained on a scheduled basis to preclude excessive infiltration of water and dirt. Likewise, joints and cracks must be regularly inspected and treated with soil sterilants to preclude vegetation growth. Damaged areas of pavement which are causing drainage impairment should be given high priority for timely repair.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

14. Grounds - cont'd

(f) Surface of Bituminous pavements must be maintained by scheduled application of fog spray of Bituminous material or by rolling. Vegetation growth in cracks must be controlled by scheduled inspection and application of soil sterilants. Damaged areas which are hazardous to traffic or causing drainage impairment should be given high priority for timely repair.

(g) Parking and storage areas should be maintained to the minimum standards specified for a comparable class of road pavements with principle emphasis on the preservation of drainage.

(h) Sidewalk maintenance generally should be discontinued except in the case of walks used by personnel engaged in maintenance services. Drainage along walks should be kept functioning, and edges of high-type sidewalks should be protected from undermining of backfillings, riprap, or sodding by washes. Curbs and gutters should be similarly protected.

(i) Inspection of the fences must be accomplished on a frequency that assures security and neat appearance at all times. This includes areas along the fence lines that parallel public roads. The post foundations and supports shall be inspected, the condition of the fence checked and repaired as required, and check the condition of the surrounding area (weeds and grass cut, proper grading and fill, and all trash removed) to maintain a neat appearance.

(j) Appropriate "WARNING" signs shall be placed on all fences indicating that this is federal property. An emergency telephone number shall also be included on each sign.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

14. Grounds - cont'd

d. Winter Maintenance

(a) Snow removal should be accomplished on roads, streets, walks and other paved areas only to the extent necessary to provide access for maintenance, fire protection and similar activities.

(b) Normal functioning of drainage is essential to dispose of surface run-off. It may be necessary to remove snow and ice to provide connections to the established drainage system and to maintain drainage openings to their full capacity.

15. Pest Control

(a) General - Routine operation and seasonal schedules for the application of control measures should be concluded as rapidly as possible, except as may be required to protect buildings and structures from wood destroying pests, and to protect stored items such as files, etc., susceptible to pest and rodent damage.

(b) Equipment - Power driven and hand operated sprayers and dusters must be cleaned, greased and placed in dry storage.

(c) Pesticides - Pesticides retained for pest and rodent control must be plainly labeled with disposal date, based on manufacturer's recommended shelf life, and placed in dry storage under lock and key. Deteriorated pesticides must be destroyed.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

15. Pest Control - cont'd

(d) Maintenance - Individual rather than community methods of protection should be applied, including the use of bed nets, repellants, and insecticides applied by sprayers.

(e) Breeding Places - Breeding places for flies, other insects and rodents must be sought out and destroyed. Water ditches conducive to mosquito growth should be treated or filled to prevent formation of breeding areas.

(f) Structural Protection - Buildings and structures susceptible to damage by termites, wood borers, powder post beetles and other wood destroying pests, must be inspected every six (6) months and appropriate measures taken to control the infestations discovered during the inspection.

(g) Stored Commodities - Surveillance, inspections and control measures should be conducted to the extent necessary for the protection of stored commodities and files.

(h) Control Measures - Additional control measures may be needed where health problems are involved; that is, mosquitoes, flies, rodents and various pests of medical significance.

16. Elevator

The plant elevator shall be kept in operation during the standby period. This is the best method of keeping the elevator from deteriorating and its operation will assist significantly with plant inspection and equipment maintenance. The present service contract on the elevator would be renegotiated to provide the minimum safe service for a reduced usage.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

17. Buildings and Structures

a. Protection

(a) Windows - All windows that are readily accessible from the outside of the building will be securely fastened. They are also to be boarded up to prevent breakage from storm or flying debris and vandalism. Storm sashes are to be left in place.

(b) Doors - With the exception of doors that will be used for frequent entry, all doors must be secured by a board placed across the door opening and secured to the door frame. Doors used for frequent opening are secured by a board placed across the door opening. However, these boards must be hinged at one side of the door frame and secured to the other side by a clasp and padlock. Large glassed areas and doors are to be boarded up to prevent breakage from storm, flying debris and vandalism. All doors secured by being boarded up, or boards hinged across the frame of the door for access to the building, must have the words "OFF LIMITS" conspicuously painted on them.

(c) Metal Surfaces - Exposed metal surfaces subject to rust and not properly protected must be painted or otherwise treated with suitable preservative.

(d) Keys - The keys for doors, cabinets, storage areas and similar openings must be checked for proper lock operation and identified by tags or other suitable means. Keys should be stored at a central location in a locked cabinet.

(e) Cleanup - Scrap lumber, trash and other debris must be removed from around and under the building and platforms. Interior furnishings and floors will be left clean.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

17. Buildings and Structures

a. Protection - cont'd

(f) Protection - An inspection must be made to ensure proper drainage and erosion control, and corrective measures taken where required to ensure protection of buildings.

(g) Mechanical Equipment - All equipment must be cleaned, inactivated, preserved and protected, when applicable, as prescribed for plant equipment.

(h) Electrical Equipment and Instruments - Refer to the electrical instrument sections.

(i) Propane Gas - If propane is required in the buildings, inactive areas should be cut off from the remainder of the installation by closing all valves. If equipment is disconnected from gas service lines, the pipe openings must be capped or blocked off and properly tagged. Make sure the tag cannot be accidentally destroyed or removed.

(j) Water Heating Equipment - If water heaters are not required for maintenance in the buildings, heaters must be flushed out, water lines must be drained and openings capped off.

(k) Plumbing - If not required during the inactive period of the building, water must be removed from traps in the drainage system and plumbing fixtures if it is not necessary to maintain a seal to prevent back flow of sewer gases. If it is necessary to retain a trap seal or if the drain cannot be readily drained or evacuated, antifreeze should be added to prevent freezing. Reverse trap and siphon jet type commodes should be winterized with antifreeze. A small quantity of oil may be poured into floor drains and similar drains to retard evaporation.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

17. Buildings and Structures

a. Protection - cont'd

(1) Heating levels for all buildings must be determined individually. Unoccupied buildings should be maintained at 45-50°F; occupied buildings should be maintained at 65 to 70°F.

b. Preventative Maintenance

(a) General - Where specific procedures are not given, the necessary corrective measures and preservation should be applied as a matter of good judgment to meet local conditions. Where common deficiencies or failures are found, they should be noted in the log with details and recommended action to be taken. It may also be advisable and/or necessary to maintain some heat in some building or isolated part of a building.

(b) Exterior Maintenance - Standards of maintenance for exterior of buildings must insure structural soundness and weather tightness and elimination of fire hazards.

(c) Windows and Doors - Glass in windows and doors must be replaced as long as the frames remain in sound condition. If frames become so deteriorated that they no longer will retain the glass, the openings should be closed with boards or waterproof paper, or made weathertight by other means.

(d) Roofs - Roofs generally must be kept weathertight by patching. Maximum use should be made of asphalt roof coating material to extend the life of asphalt roof coverings. Reroofing should be accomplished only when the above procedure will no longer provide weathertight protection.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

17. Buildings and Structures

b. Preventative Maintenance - cont'd

(e) Gutters and Downspouts - Gutters and downspouts, if required to prevent roof drainage down exterior walls, and other roof drainage systems must be kept operable.

(f) Side Walls - Side walls must be kept weather tight by patching with materials similar to that provided in the original construction so far as is practicable. If large areas require replacement, lower grade materials such as asphalt saturated felt covered with battens may be used.

(g) Surface Painting - Surfaces of doors, sashes, trim and metal must be painted to the extent necessary to prevent deterioration.

(h) Interior Maintenance - Standards of maintenance for interior of buildings should be confined mainly to that necessary to insure soundness of floors and trusses and to eliminate fire hazards. Metal surfaces must be painted if necessary to prevent deterioration.

(i) Visual Inspections - Make visual inspections of buildings and structures once every three (3) months during the inactive status. If the extent of maintenance requirements depend on factors such as local climate and weather conditions, the nature of the building, etc. the visual inspection can be regulated to a more frequent or longer duration. However, they must be made at least once every six (6) months. A report of the inspection is to be made and filed. When corrective

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

17. Buildings and Structures

b. Preventative Maintenance

(i) Visual Inspections - cont'd

maintenance is required, the description of work performed and the date completed should be logged. The inspection on buildings and structures shall include:

- Foundations
- Floors and floor coverings
- Walls, external and internal
- Partitions
- Ceilings
- Roofs, gutters, flashing and vents
- Windows and doors
- Building utilities (water, gas power, air conditioning units, sanitation, heating)
- Condition of paint
- Condition of surrounding grounds - cleanliness, weeds cut, proper grading and fill
- Degree of corrosion on structural members
- Concrete foundations for cracking

(j) Water lines - Water supply lines to interior of buildings required for maintenance must be ready for use.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

18. Laboratory

- (a) Inventory all chemicals and apparatus.
- (b) Update all analytical procedures, calculation methods and reporting procedures.
- (c) Index all laboratory data and transfer to computer tapes.
- (d) Package apparatus and leave in laboratory.
- (e) Return all gas cylinders.
- (f) Gas Chromatographs
 - . Disconnect carrier gases
 - . Cover chromatographs with plastic and seal with tape
- (g) Atomic Absorption Spectrometer
 - . Disassemble into individual components
 - . Cover and seal
- (h) CHNS Analyzer
 - . Disconnect carrier and combustion gases
 - . Cover and seal
- (i) Sulfur Analyzer
 - . Disassemble into separate components
 - . Cover and seal
- (j) Volatiles Furnace Assembly
 - . Disassemble into separate components
 - . Cover and seal

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

19. Computer

- (a) Deenergize the MODCOMP II/26 and its peripherals.
- (b) Deenergize the equipment, clean tube bundles and cable trays without disassembly.
- (c) Remove paper from all hard copy printers.
- (d) Wrap the processor, peripherals and scanivalve in plastic with desiccant placed in each unit.
- (e) Store tape decks in the main control room with data acquisition system in plastic with desiccant added before sealing.
- (f) Key HVAC in service.

20. Equipment Never Commissioned

The following equipment was never commissioned and no decommissioning activities will be done.

Checks will be made to insure that all vessels are closed.

FD-202 A&B	Steam Filters
	"A" steam filters were in service for a short while.
DC-208	Shift Converter
DC-204 A&B	Carbon Reactors
DC-203 A&B	Sponge Iron Reactors
FA-208	Dowtherm Head Tank
EA-223	Dowtherm Cooler
FB-202	Caustic Circulation Tank
GA-215	Caustic Circulation Pump
GA-214	Caustic Circulation Pump

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

D. General Procedures to Protect Property

20. Equipment Never Commissioned - cont'd

DC-205	TWR Methanator
EA-208	Methanation Heat Exchanger
EA-211	Methanation Heat Exchanger
EA-209	Methanation Heat Exchanger
FA-206	Methanation Effluent K.O. Drum
DC-207	Final Methanator
EA-215	Methanation Heat Exchanger
FA-209	Final Methanator Effluent K.O. Drum
EA-216	Methanation Heat Exchanger
DC-206	HGR Methanator
FA-225	Condensate Pot
EA-217	Methanation Heat Exchanger
EA-214	Methanation Heat Exchanger
FA-207	Alt. Methanation Effluent K.O. Drum
EA-219	Methanation Heat Exchanger
DC-210	Alt. Fine Methanator
EA-220	Methanation Heat Exchanger
FA-212	Alt. Fine K.O. Drum

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

E. Additional Specific Procedures to Protect Deactivated Systems

1. Coal Handling

a. Raw Coal Bucket Elevator (JD-103)

- (a) Open bottom of JD-103
- (b) Clean all coal from elevator pit.
- (c) Run bucket elevator with bottom open.
- (d) Run JD-102 raw coal conveyor with elevator pit open.
- (e) Close bottom of JD-103.

b. Raw Coal Bin (FE-102)

- (a) Pull spool under PA-103X. Clean before removing.
- (b) Fab chute to divert coal to bin on road.
- (c) Line bin door with plastic.
- (d) Empty coal bin and coal will be sold.
- (e) After bin is empty, water wash.
- (f) Air dry bin.
- (g) Close vessel and replace spool.

c. Gravimetric Feeder (JD-105)

- (a) Open JD-105 East & West doors.
- (b) Clean all coal from belt.
- (c) Water wash and air dry.
- (d) Release tension on weigh belt.
- (e) Close with drying agent in electrical boxes and on the belt.

d. Flash Drying Mill (PA-102)

- (a) Open and water wash.
- (b) Close.
- (c) Remove belts from motor and leave pulley cover off.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

E. Additional Specific Procedures to Protect Deactivated Systems

1. Coal Handling

d. Flash Drying Mill (PA-102) - cont'd

- (d) Mill and motor will be rotated per schedule.
- (e) Put electric heater in service for motor.
- (f) Drain cooling water from bearing coolers.

e. Cyclone (FC-101X)

- (a) Open inspection door.
- (b) Water wash with PA-108X running.
- (c) Air dry.

f. Dust Collector

- (a) Connect dust collector outlet to the rubber chute and pull spool going to FE-103 to clean the vessel.
- (b) Blind inert gas going to dust collector.
- (c) Open dust collector door and wash inside of vessel.
- (d) Open dust collector explosion panels.
- (e) Pull cloth bags out of dust collector and leave out.
- (f) Wash dust collector again and air dry.
- (g) Close dust collector explosion door.
- (h) Close door on dust collector.
- (i) Replace spool to FE-103.
- (j) Remove rubber chute.

g. Drying System Fan (GB-102X)

- (a) Pull belts connecting motor to fan.
- (b) Fan will be turned per schedule.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

E. Additional Specific Procedures to Protect Deactivated Systems

1. Coal Handling

h. Drying Air Heater (BC-101X)

- (a) Pull fuel oil rotameters.
- (b) Pull burner gun assembly and cover opening left on burner.
- (c) Open firebox and install drying agent.
- (d) Cover vent stacks on 14th floor.
- (e) Seal electrical panel.

i. Dry Coal Storage Bin (FE-103)

- (a) Pull valve 26 and venturi for storage.
- (b) Remove coal from FE-103 and Petrocarb.
- (c) Open manway on top of FE-103.
- (d) Wash inside of PA-113, coal sample feeder and air dry.
- (e) Water wash FE-103 and air dry.
- (f) Close FE-103 & PA-113.

j. Control Panels

- (a) Clean chart inking assemblies.
- (b) Leave panel heater in service.
- (c) Close and seal.

k. Circulating Gas Control Valves

- (a) Remove XV-130 and 131 system control valves.
- (b) Pull diaphragm and pack for storage. Leave valve in place.

1. Oversize Screen FD-101

- (a) Remove screen cover.
- (b) Screen will be washed when the cyclone FE-101X is cleaned.
- (c) Air dry and install cover.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

E. Additional Specific Procedures to Protect Deactivated Systems

2. Petrocarb

- (a) Store all large ball valves in place.
- (b) Open manways on all vessels, FE-106, FE-105, and FE-104 A & B. Wash clean, blow dry, install drying agent, and close.
- (c) Blind all open flanges on all vessels.
- (d) Pull all instruments, transmitters, DP cells, and pressure switches, and store.
- (e) Remove all nuclear level indicators.
- (f) Maintain all control valves in place. Stroke on schedule basis.
- (g) XV-23, -24, -27 stored in warehouse.

3. Pretreater

- (a) Open wash and blow dry.
- (b) Pull ball valves on pretreater overflow line.
- (c) Blind close all openings.
- (d) Pull instruments and store.
- (e) Maintain all control valves in place. Stroke on scheduled basis.
- (f) Prepare high pressure steam superheater.

4. Gasifier

- (a) Open, inspect, and wash clean.
- (b) Remove all instruments and store.
- (c) Maintain all control valves in place. Stroke on schedule basis.
- (d) Close all block valves around rupture disc piping and open seal loop water drains.
- (e) Close vessel and blind. Close all open nozzles.
- (f) Pull and store PDCV-204 (slide valve).

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

E. Additional Specific Procedures to Protect Deactivated Systems

5. Scrubbing

a. Vessels

- (a) FA-215, Scrubber Surge Tank
- (b) DA-201, Raw Gas Scrubber
- (c) FA-218, Steam Drum
- (d) FA-213, Startup Drum
- (e) FA-202, Decanter
- (f) FA-224, Waste Water Receiver

b. Procedures

- (a) Pull all Rockwell plug valves and pack
for storage.
- (b) Open all vessels and inspect.
- (c) Wash if needed.
- (d) Air dry and close.
- (e) Pull all transmitters and store.
- (f) Prepare all pumps.
- (g) Prepare heat exchangers.
- (h) Close, cap or blind all open ended piping.
- (i) All control valves will be stroked.
- (j) All rotating equipment will be turned.

c. Gas Scrubbing Equipment

(a) Heat Exchangers

- EA-218 & S Venturi Circulating Water
Cooler and Spare
- EA-201 & S Scrubber Recycle Cooler and Spare
- EA-225 & S Waste Water Cooler and Spare
- EA-213 & S Waste Water Cooler and Spare

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

E. Additional Specific Procedures to Protect Deactivated Systems

5. Scrubbing

c. Gas Scrubbing Equipment - cont'd

(b) Pumps

GA-207 & S	Venturi Scrubber Pump and Spare
GA-201	Scrubber Tower Pump
GA-205 & S	Waste Water Pump and Spare
GA-210	Recycle Water Pump
GA-211	Recycle tar pump
GA-206 & S	Tar Pump and Spare
GA-208 & S	Wash Oil Pump and Spare
GA-209	Oil make-up pump

6. Char Filter System

a. Filter Area

(a) Flush and clean FA-403, and FA-406 slurry tanks. Blow dry, apply rust prevent on agitator shaft. Cap atmospheric vent pipe.

(b) Remove LT-407 and 413 level transmitters.

(c) The following pumps will be rotated on a scheduled basis:

GA-406 & S	Slurry filter feed pumps
GA-409 & S	Slurry tank pumps
GA-404 & S	Waste water pumps
GA-403	Effluent holding tank pump
GA-410	Char pond pump

(d) Prepare EA-401 heat exchanger.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

E. Additional Specific Procedures to Protect Deactivated Systems

6. Char Filter System

a. Filter Area - cont'd

(e) HP slurry tank FA-401:

- . Remove nuclear level indicator (LSH-414)
- . Remove LIC-415 level chamber.
- . Open manway on vessel, wash, clean and blow dry.

(f) Oily water sump:

- . Remove waste from sump.
- . Add 50 lbs of trisodium phosphate to clean water in the sump and boil for 8 hours with steam.
- . Remove cleaning solution and flush with water.

b. Filter Building

(a) Block in all domestic water to Filter Bldg. Drain lines and blow dry.

(b) Remove top covers on JD-401 char conveyor. Wash out, blow dry and replace covers.

(c) Remove filter elements from PA-402X and 402SX char slurry filters. Strip cloth off elements and put the elements in a box to prevent warping. Store in Filter Bldg.

(d) Open FD-402 & S filters. Remove filter elements and discard. Clean vessels and close.

(e) Grease plug valves in vacuum lines between char filter and filtrate receiver. Leave in closed position.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

E. Additional Specific Procedures to Protect Deactivated Systems

6. Char Filter System

b. Filter Building - cont'd

- (f) Open handway on FA-404 filtrate receiver. Flush and clean vessel and blow dry.
- (g) Open drains on GB-401Z & SX vacuum pumps and blow dry. Disconnect seal water piping. Remove pulley guards and belts so that motor and pumps can be turned on a scheduled basis.
- (h) Install air jumpers on the following solenoid operated control valves so that valves can be stroked on a scheduled basis.
- (i) Install air jumper on solenoid operated switches on char slurry filter dump gates so that gates can be stroked on scheduled basis.
- (j) Install 100 watt light in electrical and instrument panels. Add drying agent and close.
- (k) The following pumps will be rotated on a scheduled basis.

GA-411

Char Slurry Recycle Water Booster Pump

GA-408 & S

LP Filtrate Pumps

- (m) Prepare GA-401, Char Slurry Recycle Pump.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

E. Additional Specific Procedures to Protect Deactivated Systems

7. Benfield Unit

a. System

- (a) Water wash and air dry all vessels and piping
- (b) Pull all transmitters and store
- (c) Pull filters out of HPC filter FD-201
- (d) Stroke all control valves per schedule
- (e) Prepare all pumps
- (f) Prepare heat exchangers
- (g) Cover cap or blind all open ended piping on vessel side
- (h) Keep motor heaters in service on pump motors

b. Vessels

(a)	Solution Storage Tank	FB-201
(b)	Absorber Knockout Drum	FA-204
(c)	HPC Mix Tank	FA-201
(d)	Absorber	DA-202
(e)	HPC Filter	FD-201
(f)	Regenerator	DA-203
(g)	Acid Gas Knockout Drum	FA-205

c. Pumps

(a)	Major Solution Circulating Pump	GA-202
(b)	Spare	GA-202S
(c)	Minor Solution Circulating Pump	GA-212
(d)	Spare	GA-204
(e)	Regenerator Reflux Pump	GA-204
(f)	Spare	GA-204S

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

E. Additional Specific Procedures to Protect Deactivated Systems

7. Benfield Unit

d. Heat Exchangers

(a) Acid Gas Cooler	EA-207
(b) HPC Trim Cooler	EA-205
(c) Shift Effluent Cooler	EA-203A
(d) Shift Effluent Cooler	EA-203B

8. Stretford Unit

a. System

- (a) vaporize water from Stretford solution.
- (b) Dispose of Stretford solution.
- (c) Stroke all control valves per schedule.
- (d) Pull all instruments transmitters.
- (e) Air dry all vessels and piping.
- (f) Rotate blowers and pumps.
- (g) Stroke all control valves.
- (h) Open closed vessels.

b. Vessels

(a) Absorber	DA-501
(b) Absorber	DA-502
(c) Separator	FA-502
(d) Reactor	DC-501
(e) Slurry Tank	FB-501
(f) Oxidizer	DC-503
(g) Cooling Tower	EF-501
(h) Oxidizer	DC-503
(i) Solution Surge Tank	FA-501
(j) Slurry Filter	PA-522
(k) Vapor Water Separator	FA-526
(l) Vacuum Receiver	FA-528

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

E. Additional Specific Procedures to Protect Deactivated Systems

8. Stretford Unit

c. Pumps

(a)	Solution Surge Tank Pump	GA-501
(b)	Spare	GA-502
(c)	Absorber 1 Pump	GA-503
(d)	Absorber 2 Pump	GA-504
(e)	Slurry Tank Pump	GA-505
(f)	Cooling Tower Bottom Pump	GA-506
(g)	Filtrate Pump	GA-526
(h)	No. 1 Oxidizer Air Blower	GB-501
(i)	No. 2 Oxidizer Air Blower	GB-502
(j)	Filtrate Vacuum Pump	GB-503

d. Heat Exchangers

(a)	Solution Heater	EA-501
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9. Thermal Oxidizer - BF-402

- (a) Pull waste water guns clean guns, and store.
- (b) Pull oil burner and pilot tip. Clean and store.
- (c) Remove guards and belts on quench air blower and combustion air blower so that motors and blowers can be rotated by hand.
- (d) Close up all openings.
- (e) Open duplex filters in waste water line, clean and close.
- (f) Pull Brooks rotometer and oil totalizer on fuel oil supply. Clean and store.
- (g) Install drying agent and 100 watt light bulb in the panel.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

E. Additional Specific Procedures to Protect Deactivated Systems

9. Thermal Oxidizer - BF-402

(h) Maintain all control valves in place and stroke on scheduled basis.

(i) Install air jumper around solenoid operated control valves so that valves can be stroked.

10. Carbon Dioxide System

a. System

(a) CO₂ Compressors - GB-301 &S, will be deactivated as per procedure.

(b) After cooler - EA-307, will be deactivated as per procedure.

(c) Preheaters - EA-308, will be deactivated as per procedure.

(d) High Pressure CO₂ Receiver - FA-311:

a) Open vessel, wash out, and blow dry.

b) Close up vessel.

(e) All pressure and flow transmitters will be pulled, cleaned and stored.

b. Low Pressure CO₂ Receiver - FB-311

(a) Empty vessel of all CO₂

(b) Purge with plant air

(c) Raise dome with plant air

(d) Hang dome from top of vessel with six chokers or as many as needed to support the weight for an extended amount of time.

(e) Vent plant air.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

E. Additional Specific Procedures to Protect Deactivated Systems

11. Inert Gas System

a. Inert Gas Generators - BE-301 & S

- (a) Shut generators down.
- (b) Block in and drain cooling water.
- (c) Open firebox and inspect. Close with desiccant inside.
- (d) Rotate refrigeration compressor per schedule.
- (e) Prepare refrigeration compressor.
- (f) Prepare heat exchangers.
- (g) Rotate GB-310X and 310SX air blowers per schedule.

b. LP Inert Gas Receiver FB-302

- (a) Empty vessel of all inert gas.
- (b) Purge with plant air.
- (c) Raise dome with plant air.
- (d) Hand down from top of vessel with six chokers or as many as needed to support the weight for an extended amount of time.

- (e) Vent plant air.

c. Inert Gas Blowers - GB-302 & S

- (a) Shut down and prepare for standby.
- (b) Rotate compressor shaft per schedule.

d. Inert Gas Compressors - GB-303 & S

- (a) Prepare intercooler.
- (b) Prepare compressors.
- (c) Rotate compressor shafts per schedule.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

E. Additional Specific Procedures to Protect Deactivated Systems

12. Liquid Carbon Dioxide Plant

- (a) Remove CO₂ liquid.
- (b) Disconnect CO₂ supply headers from plant header.
- (c) Disconnect all electrical power.
- (d) Vendor to remove the CO₂ package from the plant site.

13. Liquid Oxygen Plant

- (a) Close all block valves on liquid O₂ header.
- (b) Open vents on liquid O₂ storage tanks and cylinders.
- (c) After O₂ has slowly been vented off, shut electricity off and disconnect wiring.
- (d) Vendor to remove the Liquid O₂ package from the plant site.

14. Cooling Water

- (a) Drain cooling tower water basin. EF-301.
- (b) Prepare cooling tower supply pumps GA-306 & S.
- (c) Control valves to be stroked.
- (d) Prepare fire water system for manual operation. System will be put in service per schedule to wet all wood work.
- (e) Set up a portable sump pump to discharge water collected in the basin to storm sewer.
- (f) Cooling water supply and return headers will be blocked in drained and air dried.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

E. Additional Specific Procedures to Protect Deactivated Systems

15. Demineralizer

(a) Expand the anion, cation and mixed beds and shut down without regenerating. All three tanks will be drained and blocked in.

(b) Empty acid tank, FB-309.

(c) Empty caustic tank, FB-310.

(d) Water wash and drain all tanks, piping, pumps to neutralizing pit.

(e) Prepare demineralized water pumps, GA-302 & S, and demineralized water regeneration pump, GA-318. Rotate pump shafts per schedule.

(f) Prepare heat exchangers.

(g) Drain demineralized water tank, FB-301.

16. High Pressure Boiler - BE-301

(a) Cover stack on high pressure boiler.

(b) Disconnect fuel oil piping and cap.

(c) Put drying agent in firebox.

(d) Close header discharge valves.

(e) Fill water drains with water and hydrazene.

(f) Maintain nitrogen pressure inside drums.

(g) Prepare GA-303 & S, high pressure boiler feed water pumps.

17. Propane System

(a) Stop using propane on plant site.

(b) Convert both low pressure boiler pilots to bottled propane.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

E. Additional Specific Procedures to Protect Deactivated Systems

17. Propane System - cont'd

- (c) Block in and air dry 1-1/2" steam header to LPG vaporizer.
- (d) Block in propane header at FQI-2303 totalizer.
- (e) Pull check valve internals downstream of FQI-2303 and blind all nozzles at tank isolation valves.
- (f) Line propane gas header up to flare pilot on thermal oxidizer.
- (g) Make temporary connection for CO₂ to purge the header from LP boilers, inline burner, inert gas generators, and drying air heater to flare pilot and thermal oxidizer header.
- (h) When header is purged free of propane break union at water heater on propane supply header in men's shower room and purge this header to atmosphere.
- (i) After all propane headers are purged, remove all temporary CO₂ connections and cover or cap all openings in propane header.
- (j) The liquid propane storage tanks will be left with liquid inventory still in them.
- (k) The old 10,000 propane storage tank has already been prepared as per above procedure.

18. Field Piping

- (a) Domestic water headers not being used while plant is on standby will be blocked in where it comes out of the ground on plant site and must be air dried.
- (b) Steam tracing supply headers not in service will be blocked in and air dried.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

E. Additional Specific Procedures to Protect Deactivated Systems

18. Field Piping - cont'd

(c) Condensate header not in service will be blocked in and air dried.

(d) Medium steam supply headers not in service will be blocked in and air dried.

(e) HS header will be blocked in and air dried. All control valves will be stroked per schedule.

(f) CO₂ header will be blocked in and air dried. All control valves will be stroked per schedule.

(g) All process piping in coal service will be water washed and air dried.

(h) LP inert gas headers will be air dried and blocked in.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

F. Emergency and Safety Equipment

All fire fighting equipment will be kept as is during the entire standby period because there is still a possibility of property damage and personal injury due to fire as long as equipment is running.

One stretcher and two self-contained breathing units will be placed in close proximity to the control room. The attached drawing shows the locations of all emergency and safety equipment.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

G. Equipment List

The equipment list is included as Appendix B.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

H. Specific Procedures to Reactivate Systems

a. Coal Handling

1. Raw Coal Bucket Elevator (JD-103)

- a) Open manways and inspection doors.
- b) Inspect elevator for complete integrity and cleanliness.
- c) Hook up all alarms and shutdowns.
- d) Run bucket elevator and check for proper operation.
- e) Close up manways and install new explosion panel.

2. Raw Coal Bin (FE-102)

- a) Open vessel manway.
- b) Inspect vessel for cleanliness.
- c) Install level indicators and all alarms.
- d) Close up vessel manway.
- e) Purge vessel with inert gas and have inert atmosphere (below 9% oxygen) in vessel before loading with coal.

3. Gravimetric Feeder (JD-105)

- a) Open all doors on feeder.
- b) Inspect for mechanical and electrical integrity.
- c) Adjust belt tension.
- d) Check all alarms and shutdowns.
- e) Close up feeder.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

H. Specific Procedures to Reactivate Systems

a. Coal Handling - cont'd

4. Flash Drying Mill (PA-102)

- a) Open mill.
- b) Inspect for mechanical integrity.
- c) Rotate mills and motors.
- d) Connect motor and mill.
- e) Commission cooling water to bearings.
- f) Close up mill.

5. Cyclone (FC-101X)

- a) Open inspection door.
- b) Check for cleanliness and integrity.
- c) Close door.

6. Dust Collector (PA-10)

- a) Open dust collector door.
- b) Inspect for cleanliness.
- c) Install new bags.
- d) Rotate PA-109 rotary air lock.
- e) Close up dust collector.
- f) Check all alarms and shutdowns.
- g) Insert dust collector before starting coal through system.

7. System Air Fan (GB-102X)

- a) Inspect fan for mechanical integrity.
- b) Balance fan.
- c) Connect fan to motor.
- d) Test run fan. Install guards.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

H. Specific Procedures to Reactivate Systems

a. Coal Handling - cont'd

8. Dry Coal Bin (FE-103)

- a) Open and inspect vessel for cleanliness.
- b) Install level indicators and alarms.
- c) Inspect PA-113 coal sample cutter for proper operation.
- d) Inspect explosion panel for leaks.
- e) Close up vessel and inert before grinding coal.

9. Drying Air Heater (BC-101X)

- a) Open burner. Inspect refractory repair if required.
- b) Remove covers on vent stacks.
- c) Install all instruments and rotameters.
- d) Install burner gun assembly.
- e) Commission combustion air blower.
- f) Check all alarms and shutdowns.
- g) Reconnect fuel oil and propane supply lines.
- h) Fire burner on minimum fire per refractory dryout procedure before grinding coal.

10. Circulating Gas Control Valves

- a) Reinstall XV-103 & 131 system control valves.
- b) Check for proper stroke and operation of valves.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

H. Specific Procedures to Reactivate Systems

a. Coal Handling - cont'd

11. Oversize Screen (FD-101)

- a) Remove screen cover.
- b) Inspect screen for rips or tears.
Replace if required.
- c) Start screen and inspect for proper operation and excess vibration.

12. Control Panels

- a) Control panels will be opened and inspected for electrical integrity.
- b) All charts and recorders will be function checked.
- c) Function check all alarms and shutdowns.

b. Petrocarb

1. Replace all large ball valves.
2. Open manways on vessels and inspect.
Remove drying agent.
3. Remove or open all blinds.
4. Replace all instrumentation.
5. Replace all nuclear indicators.
6. Replace all manways.
7. Pressure test system for leak check.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

H. Specific Procedures to Reactivate Systems - cont'd

c. Pretreater

1. Reinstall all instruments.
2. Reinstall ball valves on pretreater overflow line.
3. Pull head of pretreater and check gaskets and internals.
4. Air blow all piping (instrument and process).
5. Pressure test equipment for leak check.
6. Put blinds in open position.

d. Gasifier

1. Open vessel and inspect all internals.
2. Inspect manway gaskets. Replace if required.
3. Air blow all piping (instrument and process).
4. Replace all instruments.
5. Replace PDCV-204.
6. Put rupture disc piping back in service.
7. Close all manways.
8. Remove all blinds required for standby operation or swing to open position.
9. Pressure test vessel leak check.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

H. Specific Procedures to Reactivate Systems - cont'd

e. Gas Scrubbing

1. Open all vessels and inspect.
2. Air blow all piping (process and instrumentation).
3. Remove all blinds or put in open position.
4. Install Rockwell plug valves.
5. Commission all pumps as per Maintenance.
6. Commission all heat exchangers as per Maintenance.
7. Reinstall all manways.
8. Pressure test system for leak check.

f. Char Filter System

1. Filter Area

- a) Open all atmospheric vents.
- b) Prepare all pumps as per procedure.
- c) Prepare all pumps as per procedures.
- d) Reinstall all instrumentation.
- e) Open FA-401, HP Char Slurry Tank.
Inspect and install manway with new gasket.
- f) Put oily water sump in service.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

H. Specific Procedures to Reactivate Systems

f. Char Filter System - cont'd

2. Filter Building

- a) Put domestic water piping back in service.
- b) Replace filter elements on PA-402S and SX, Char Slurry Filters.
- c) Replace filter elements in FD-402 & S filters.
- d) Open and inspect FA-404 filtrate receiver and close and pressure test.
- e) Remove all air jumpers on instruments.
- f) Prepare all pumps as per Maintenance.
- g) Prepare all heat exchangers as per Maintenance.
- h) Install all instrumentation.

g. Benfield Unit

1. Prepare all pumps as per Maintenance.
2. Prepare all heat exchangers as per Maintenance.
3. Install all instruments.
4. Install filters in FD-201 HPC filter.
5. Open all blinds.
6. Air blow all piping instruments and process.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

H. Specific Procedures to Reactivate Systems - cont'd

h. Stretford Unit

1. Install all instruments.
2. Prepare all pumps as per Maintenance.
3. Prepare all heat exchangers as per Maintenance.
4. Recharge all units with Stretford solution.
5. Air blow all piping instruments and process.
6. Recharge unit with HPC solution.
7. Pressure test unit where required.

i. Thermal Oxidizer (BF-402)

1. Replace waste water guns.
2. Replace oil burner and pilot tip.
3. Replace belts and guards on motors and blowers.
4. Open all closed openings and stacks.
5. Replace all instruments.
6. Put all instruments back in service.
7. Commission all pumps as per Maintenance.

j. Carbon Dioxide System

1. Commission GB-301&S CO₂ compressors as per Maintenance.
2. Commission heat exchangers as per Maintenance.
3. Open and inspect FA-311 high pressure sphere. Close and pressure test.
4. Install all instruments.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

H. Specific Procedures to Reactivate Systems

j. Carbon Dioxide System - cont'd

1. Low Pressure CO₂ Receiver (FB-311)

- a) Pressure FB-311 with plant air and raise dome.
- b) Remove chokers hanging dome.
- c) Do a bladder leak check with plant air.
- d) Purge with CO₂.

k. Inert Gas System

1. Inert Gas Generators

- a) Open firebox and inspect. Remove dessicant.
- b) Prepare heat exchangers as per Maintenance and put in service.
- c) Put GB-310X and 310SX in service as per Maintenance.
- d) Put refrigeration unit in service.

2. LP Inert Gas Receiver (FB-302)

- a) Raise dome with plant air and remove chokers.
- b) Do a bladder leak check.
- c) Purge vessel with inert gas.

3. Inert Gas Blower (GB-302&S)

- a) Have Maintenance check for startup.

4. Inert Gas Compressors (GB-303&S)

- a) Start equipment up as per Maintenance.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

H. Specific Procedures to Reactivate Systems - cont'd

1. Liquid Carbon Dioxide Plant

1. Re-rent package unit.
2. Do electrical and mechanical hookup.
3. Charge unit as per vendor.

m. Liquid Oxygen Plant

1. Re-rent package unit.
2. Do electrical and mechanical hookup.
3. Charge unit as per vendor.

n. Cooling Water

1. Put fire system back on auto.
2. Chemically clean piping and tower basin.
3. Prepare pumps as per Maintenance.
4. Put all instruments back in service.

o. Demineralizer

1. Prepare heat exchangers as per Maintenance.
2. Inspect and charge caustic and acid tank.
3. Do a three bed regeneration.

p. High Pressure Boiler (BE-301)

1. Remove covering on boiler stack.
2. Remove drying agent from firebox.
3. Remove hydrazine from tubes and flush.
4. Prepare pumps as per Maintenance.
5. Connect fuel oil piping.
6. Do a hydrotest on boiler.
7. Check all instruments.
8. Do electrical check.
9. Service test boiler.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

H. Specific Procedures to Reactivate Systems - cont'd

q. Propane System

1. Put steam header back in service.
2. Open block valves around FQI-2303 and remove blinds at tank.
3. Reinstall check valve internals.
4. Purge header with propane.
5. Connect headers to equipment.
6. Test fire all equipment.

r. Field Piping

1. Domestic Water Headers

- a. Will be visually inspected.
- b. Pressure tested.
- c. Chemically cleaned and passivated.
- d. Flushed and put in service.

2. Steam Tracing Supply Headers

- a. Will be visually inspected.
- b. Pressure tested.
- c. Piping will be blown clean.
- d. Steam traps will be open cleaned or replaced as required.
- e. Headers will be put in service as required.

3. Condensate Header

- a. Will be visually inspected.
- b. Pressure tested.
- c. Flushed and drained.
- d. Condensate will be dumped to sewer until it meets specs.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

H. Specific Procedures to Reactivate Systems

r. Field Piping - cont'd

4. Medium Steam Headers

- a. Will be visually inspected.
- b. Pressure tested.
- c. Flushed and blown clean.

5. HS Header

- a. Will be visually inspected.
- b. Pressure tested.
- c. Dirt legs will be opened.
- d. Piping will be blown clean.
- e. High pressure traps will be cleaned or replaced as required.

6. CO₂ Headers

- a. Will be visually inspected.
- b. Pressure tested.
- c. Blown clean.

7. Process Piping

- a. Will be visually inspected.
- b. Pressure tested.
- c. Flushed and blown dry.

8. L.P. Inert Gas Headers

- a. Will be visually inspected.
- b. Pressure tested.
- c. Cleaned as required.
- d. Piping will be purged clear of oxygen when put in service.

VI. DEACTIVATION AND REACTIVATION OF PLANT EQUIPMENT

I. Schedule

	December '78 4 11 18 25	January '79 1 8 15 22 29	February '79 5 12 19 26	March '79 5 12 19 26
A. <u>Project Completion</u>				
High Pressure Boiler	→			
Char Pond	→			
Salt Storage	→			
B. <u>Documentation</u>				
Deactivation Procedure	→			
Technical & Engineering Update		→		
Environmental Report			→	
Final Report				→
C. <u>Deactivate Equipment</u>				
Thermal Oxidizer & Filter Bldg.	→			
Coal Grinding, Handling, & Storage Systems	→			
Petrocarb System		→		
Gasifier, Pretreater, & Structure		→		
Gas Scrubbing Systems		→		
Stretford Systems		→		
Benfield Systems		→		
CO ₂ & O ₂ Systems		→		
Utilities		→		
Mobile Equipment			→	
Warehouse, Grounds, Cleanup, Misc.			→	
Instruments			→	
D. <u>Inventory and Cleanup</u>				→

VII. ENVIRONMENTAL REPORT

A. History

The SYNTHANE Pilot Plant is located at the Pittsburgh Energy Technology Center (PETC) on U.S. Bureau of Mines' property in Bruceton, Township of South Park, Allegheny County, Pennsylvania. The Bureau-owned property comprises some 260 acres of hilly, wooded terrain. The plant is bordered on the south and west by horse-riding stables and on the north and east by other PETC facilities.

In August of 1972, a Final Environmental Statement was prepared by the Department of Interior. This statement identification no. is INT FES 72-28 and a copy of the above material will be retained in the Library of the Bruceton Pilot Plant.

The landsite for the plant covers approximately 15 acres, 11 of which were cleared and graded. The plant was constructed in a natural gully which was backfilled approximately 30 feet from its lowest point. In its original state, this natural gully carried rain water runoff from the site and surrounding areas to Lick Run Creek. The site covered about 1000 feet of this gully, which was replaced with a bell-and-spigot concrete drainage line 48 inches in diameter. Parallel to the 48-inch line is a 12-inch perforated line used to drain miscellaneous underground streams and mine seepage to the 48-inch drainline discharge (buried box) located at the east end of the plant site. The plant effluent then discharges by gravity through an additional 1100 feet of 54-inch diameter line, installed at a later date, to Lick Run.

VII. ENVIRONMENTAL REPORT

A. History - cont'd

During the site preparation phase of the project, a number of mine drainage lines were discovered. Discharges from these lines were diverted into the 48-inch interceptor at various points. In addition, surface drainage, septic tank effluent and live stock excretia from the surrounding area all drained into the 48-inch line at its inlet. It was apparent that the impact of liquid wastes from plant operations could not be determined by a single effluent sample since so much contaminated water was flowing into the plant drainage system. To overcome this problem, it was decided, with the concurrence of the Environmental Protection Agency (EPA), to monitor five discrete plant discharge streams before their entry into the 48-inch drain line. The NPDES permit application filed in December 1975 listed the following five sampling points:

- 001 Sanitary Sewage Treatment Plant
- 002 Cooling Tower Blowdown
- 003 Neutralization Pit
- 004 High-Pressure Boiler Blowdown
- 005 Low-Pressure Boiler Blowdowns

During the initial periods of plant operation, it was discovered that several drain lines in the process area discharged directly to the storm sewer system rather than the oily water sewer. (The oily water sewer system was designed to collect objectionable wastes and direct them to a large catch basin so that they could be incinerated in the thermal oxidizer.) A program to determine the number of such connections that existed and a method to correct them was undertaken. Several other connections were found and it was

VII. ENVIRONMENTAL REPORT

A. History - cont'd

also determined that objectionable discharges from process operations could be spilled on the ground and eventually find their way into the plant discharge through the 12-inch perforated line. As a corrective measure, all affected portions of the process area were paved with curbed concrete pads which drained through trenches to two new 15,000 gallon holding tanks. Effluent collected in these tanks could then be burned in the thermal oxidizer.

To advise and assist Plant Management in environmental matters, the SYNTHANE Environmental Steering Committee (SESC) was formed. The Committee was comprised of representatives of the Environment and Conservation Division of PERC, the DOE SYNTHANE Project Staff and representatives of the Lummus Company. Dr. M. A. Shapiro of the University of Pittsburgh served as a consultant. The Committee met monthly, or as required, and was charged with the responsibility of recommending to Management courses of action in all plant environmental matters.

When all process streams within the plant were under proper control, it was decided to institute a plant outfall monitoring program. The plant outfall was unaccessable due to the fact that during construction of the SYNTHOIL Pilot Plant (Bruceton Coal Liquefaction PDU) the outfall headwall was converted into a closed concrete box and buried approximately 20+ feet below grade. A plan was finally developed to install a manhole from grade into the existing box for access to the box and installation of sample pump suction lines.

VII. ENVIRONMENTAL REPORT

A. History - cont'd

The project was completed and four ISCO automatic samplers were installed at the outfall in a small sampling building. An ISCO flow monitor was also installed to record flow patterns. A daily sample was withdrawn for each of the following lines:

1. 12-inch perforated line
2. 15-inch sanitary sewer
3. 48-inch line
4. 54-inch discharge line

In addition, an ISCO sampler and flow recorder were installed at the 48-inch inlet to the plant to monitor the inlet stream. This monitoring program was ongoing at the time of the plant shutdown.

VII. ENVIRONMENTAL REPORT

B. Major Environmental Events

Following is a brief chronological history of major environmental activities at the SYNTHANE Pilot Plant:

- Aug. 22, 1972 Department of Interior Final Environmental Statement (INT FES 72-28) submitted for review.
- Oct. 13, 1972 Lummus issued Final Report, coal to gas prototype, including Environmental Impact Statement (Contract No. HO 110989)
- March, 1974 Started correspondence with the Environmental Protection Agency (EPA) on effluent (NPDES) permits.
- Sept. 3, 1974 Submitted application to EPA for permit to discharge effluents.
- July 23, 1975 Review of NPDES permit application made by the Pennsylvania Department of Environmental Resources (PA DER) - specified certification subject to conditions contained in letter.
- Aug. 1, 1975 Copy of original NPDES permit application which was submitted to EPA by the U.S. Bureau of Mines (USBM) was sent to the U.S. Energy Research & Development Administration (ERDA). It was at about this time that correspondence was begun to revise the original permit to the present five (5) NPDES discharge points because of the contaminated inflow from horse farm and acid mine drainage.
- Aug. 7, 1975 ERDA Pittsburgh Energy Research Center (PERC) requested a delay in the issuance of the NPDES permit to perform a more complete survey of the site.

VII. ENVIRONMENTAL REPORT

B. Major Environmental Events - cont'd

- Aug. 13, 1975 EPA allowed for the extension and indicated they would not take any further action until they received the revised permit application.
- Nov. 1975 Two independent consultant firms conducted site surveys and submitted reports on ground water problems at SYNTHANE.
- Dec. 4, 1975 Submitted revised NPDES application to EPA requesting permitting of five (5) sample points: sanitary treatment plant, high-pressure blowdown, low-pressure blowdown, neutralization pit and the cooling tower.
- Feb/Mar. 1976 Air monitoring program instituted with DeNardo-McFarland. Initial background study to define sensitivity of air basin to a small point source such as the SYNTHANE Pilot Plant.
- April 1976 Installed air monitoring station on top of the SYNTHANE structure.
- July 28, 1976 Final EPA NPDES permit obtained.
- SYNTHANE Environmental Steering Committee (SESC) was formed.
- Aug. 1976/
Feb. 1977 Air monitoring program continued with six-month study.
- August 1976 Problem with obtaining and categorizing discrete effluent samples arose. In construction of the SYNTHOIL Plant (Bruceton Coal Liquefaction PDU), the SYNTHANE Plant outfall headwall was converted into a large concrete catch basin and was buried 20 feet beneath the SYNTHOIL entrance road. SYNTHANE personnel had protested this action before SYNTHOIL construction but protests were overruled.

VII. ENVIRONMENTAL REPORT

B. Major Environmental Events - cont'd

Sept. 14, 1976 Lummus prepared and submitted a three-phase environmental package which included such things as paving and trenching the process area, effluent sampling box, drainage holding basin and process vent control. Estimate for this work was \$90,000.

September 1976 Completed and submitted Air Pollution Emissions Report to EPA. It included low-pressure boilers, high-pressure boiler, drying air heater, inline burner, thermal oxidizer and flare stack.

Apr. 4, 1977 First thermal oxidizer stack sampling by RECON.

Apr. 19, 1977 Letter sent from R. Lewis, SYNTHANE Program Manager to A. L. Julian, Chief-DOI/PBAO discussing Wallace Road drainage and its effect upon the SYNTHANE effluent sampling program.

Sept. 1977 Institution of weekly environmental report by Lummus to the Environment and Conservation Div. of PERC.

Oct. 14, 1977 Meeting between Department of Energy (DOE) SYNTHANE Pilot Plant personnel and representatives of the EAC Div. of PERC and the U. S. Army Corps. of Engineers (COE) to discuss means of correcting drainage from Wallace Road and PERC sites north of Wallace Road.

Dec. 26, 1977 Oil spill - overflow of underground tank (approximately 200 fals). This incident triggered a series of meetings and letters amongst Lummus, PA DER, DOE SYNTHANE, PERC and other government agencies.

VII. ENVIRONMENTAL REPORT

B. Major Environmental Events - cont'd

- Jan. 6, 1978 Survey of SYNTHANE Plant to determine if there were additional operations subject to oil spills. Mr. S. Harper of PA DER accompanied the group for part of the survey.
- Jan. 24, 1978 Meeting between PERC and SYNTHANE personnel to discuss Bruceton site effluent problems.
- Jan. 24, 1978 Meeting of various government agencies at Bruceton site to discuss environmental problems.
- Jan. 26, 1978 Letter from PA DER to DOE regarding oil spills of 12-26-77 and 1-6-78 stating new law for federal agency compliance and requesting proper notification of oil spills.
- Jan. 26, 1978 SYNTHANE Plant survey by R. Feldman and B. Fogman of Lummus-Bloomfield regarding oil spills.
- March 9, 1978 Special plant survey to determine if there were any effluent discharge points to be added to the NPDES permit.
- March 23, 1978 Special meeting of SESC. Formulated and recommended an outfall sampling program.
- March 23, 1978 Received directive for new benzene standard compliance.
- March 1978 Final draft of Lummus Spill Prevention Control & Countermeasure (SPCC) Plan submitted to PA DER for review and comments.
- Apr. 3, 1978 First meeting of the Bruceton Site Environmental Assurance Committee (BSEAC) Technical Sub-Committee.

VII. ENVIRONMENTAL REPORT

B. Major Environmental Events - cont'd

- Apr. 4, 1978 Meeting to discuss sampling and testing required to comply with benzene standards. Lummus to do sampling and testing.
- Apr. 6-7, 1978 Sampling being done for compliance with benzene standard. All samples were found to be below set limits of 0.5%.
- Apr. 19, 1978 Pollution Incident Prevention (PIP) Plan submitted by Lummus to PA DER.
- May 1, 1978 Spill Prevention Control & Countermeasures (SPCC) Plan submitted to PA DER.
- May 30, 1978 Char pond stilling well collapsed. Approximate discharge of 4000 gallons of 1% oil in contaminated water.
- June 5, 1978 Oil spill occurred in the gas scrubbing area. Approximate spill 50 to 100 gallons. Found one sewer hub in gas scrubbing connected directly to storm sewer. This was immediately corrected and all other storm sewer connections in the process area were checked.
- June 8, 1978 Air Permit Application filed with Allegheny County Health Dept.
- June 15, 1978 Penn Environmental hired as consultant to assist with environmental studies and to operate sanitary sewage plant.
- July 29, 1978 Fuel oil spill occurred in the utility area. Accidental discharge of fuel oil through an open pipe which was disconnected from the boilers which were being inspected.

VII. ENVIRONMENTAL REPORT

B. Major Environmental Events - cont'd

Oct. 18, 1978 Received approval of PIP Plan from EPA.

Oct. 23, 1978 Air permits approved by the Department of Health for Allegheny County.

Jan. 17, 1979 Water permit application submitted. Modification of NPDES permit and State water permit application.

APPENDICES

- A. Test Directives and Design Basis
- B. Summaries of Run Data and Steady State Criteria
 - 1. Run 1 (Free Fall)
 - 2. Run 1-DB (Deep bed injection, pretreater only)
 - 3. Run 2-DB (Deep bed injection, pretreater and gasifier)
- C. Analyses of Coals
 - 1. Rosebud
 - 2. Illinois No. 6
- D. Index and Inventory of Documents in the Synthane Pilot Plant Library
- E. Equipment List
- F. Inventory of Computer Programs, Documentation and Historical Data
- G. Report: "A Program to Discover Materials Suitable for Service under Hostile Conditions Obtaining in Equipment for the Gasification of Coal and Other Solid Fuels"
- H. List of Engineering Changes
- I. Special Engineering Department Reports

APPENDIX A

Test Directive No. 1

Test Directive No. 1-DB

Test Directive No. 2-DB

Design Basis

E.R.D.A.

SYNTHANE PILOT PLANT

TEST DIRECTIVE: NO. 1

DATE: 6/9/76

Objective: To gasify Montana Rosebud sub-bituminous coal at 600 psig for a steady state period of 12 to 14 days at a carbon conversion of about 67% to test the gasifier system operability and reliability, to determine product compositions and yields, and gasifier throughput. The run should be terminated by a voluntary shutdown and then the gasifier should be inspected for signs of slag, erosion, corrosion, and refractory deterioration.

Test Conditions:

1. Coal handling: Rosebud coal should be ground to 20x0 mesh with not more than 30% through 200 mesh. Ground coal should be dried to below 14% moisture (ASTM method).
2. Pretreatment: The pretreater is not needed and should be bypassed.
3. Petrocarb: Ground coal should be transported from the Storage Injector to the gasifier with CO₂. Initial estimates are that the transport line velocity should be 11 ft/sec. The CO₂ carried with the coal will add about 9 ft/sec to the velocity in the transport line, so the total velocity is estimated to be 20 ft/sec.

The CO₂ will be provided from the CO₂ storage system since the Benfield system will not be operated to recover CO₂ from the product gas. The coal feed rate should be 2 tons/hr.

4. Gasification: Bed height will be controlled at 10 ft. Fluidizing velocity (steam + O₂) will be 0.3 ft/sec. Bed temperature is 1550°F.
5. Char cooler: Fluidizing velocity (base of char cooler) should be 0.3 ft/sec. Temperature should be held at 525°-600°F.
6. Char removal: The alternate high pressure slurry system should be used since the lock hopper system is not available.
7. Raw Gas Scrubbing: The venturi and water wash section of the raw gas scrubber should be operated at design conditions.
8. Downstream Processing: After the water wash, product gas will be sent directly to the thermal oxidizer and the normal shift, Benfield, and methanation will not be used.
9. Analytical: Coal and char analysis to be done each 8 hours to establish carbon conversion. Condensate should also be sampled from the venturi scrubber line to determine suspended solids. Samples of wastewater from the scrubber surge tank should be taken every 8 hours and saved for analysis of pollutants. Tar samples should also be obtained every 8 hours and saved for possible analysis.

10. Parameters to be reported: The attached list of Gasifier Calculations should be done and reported as much as possible. CO₂ flow from the Petrocarb system will be estimated since tracer studies will not be done this run.
11. Operating Procedure: This should follow the detailed Operating Manual.
12. Alteration of Conditions: Carbon conversion should be determined as soon as possible through at least two determinations and then a meeting should be held with the ERDA Operating Committee to determine changes to be made to achieve the desired carbon conversion of 67%.

Calculations for Hourly Log

Feed Rates

Coal Feed Rate	#/hr ft ² #/hr ft ³
Oxygen to Coal Ratio	## raw coal SCF/# raw coal
Steam to Coal Ratio	## raw coal SCF/# raw coal

Gasifier Fluid Bed Properties

Gas superficial velocity (bottom of bed)	ft/sec
Fluid bed density	lb/ft ³
Fluid bed height	ft
Pressure drop	in H ₂ O/ft of bed
Solids inventory	lbs
Residence Time	

Char Cooler Fluid Bed Properties

Fluidizing steam superficial velocity	ft/sec
Vaporized water superficial velocity	ft/sec
Total steam superficial velocity	ft/sec
Fluid bed density	lb/ft ³
Pressure drop	in H ₂ O/ft of bed
Solids inventory	lb
P (gasifier - char cooler)	in H ₂ O
P Maximum	in H ₂ O
P Minimum	in H ₂ O
Residence Time	

Product Rates

Tar	lb/lb coal
Condensate	lb/lb coal
Gas composition	scf/# raw coal
(H ₂ , CO, CO ₂ , CH ₄ , C ₂ H ₆ , NH ₃)	
Equivalent CH ₄ , N ₂ , H ₂ S, H ₂ O	scf/# maf coal

Entrainment Line

Superficial velocity	ft/sec
Steam-coal ratio	lb/lb raw coal SCF/lb raw coal
O ₂ -coal ratio (bottom)	lb/lb raw coal SCF/lb raw coal
O ₂ -coal (total)	lb/lb raw coal SCF/lb raw coal

Calculations for Hourly Log

(cont'd)

Pretreater

Bed ht (actual)	ft
Bed ht (calculated)	ft
Superficial velocity	ft/sec
Pressure drop	in H ₂ O/ft of bed
Solids inventory	lbs
Residence Time	
Bed Density	

Pretreater, Gasifier and Char Cooler Calculations

Run Identification Number: _____

Reporting Period

Begin: _____

End: _____

Coal:

Feed System and Pretreater Calculations

Coal Feed System

Temperatures:

CO ₂ supply TR 1-7	_____ °C	_____ °F
Primary injector temp. TR 1-9	_____ °C	_____ °F
Steam temp. TR 1-8	_____ °C	_____ °F
Entrainment line temp. TR 1-1	_____ °C	_____ °F
TR 1-3	_____ °C	_____ °F
TR 1-4	_____ °C	_____ °F
Entrainment line (bottom of pretreater) TE 1-5	_____ °C	_____ °F
Not presently in computer		

Pressures:

Entrained line P PDIC-15	_____ psi
Pressure in Primary injector PI-16	_____ psi
P - Petrocarb orifice (add to computer)	_____ psi

Flows:

Steam flow	_____ lb/hr
	_____ lb/lb coal, raw
	_____ SCF/lb coal

Feed System and Pretreater Calculations

(cont'd)

O ₂ flow (base of line)	_____ lb/hr
	_____ lb/lb coal
	_____ SCF/lb coal
O ₂ flow - Total	_____ lb/hr
	_____ lb/lb coal
	_____ SCF/lb coal
CO ₂ flow (by tracer)	_____ SCF/hr
	_____ lb/hr
Coal flow (weigh hopper)	_____ lb/hr
	_____ ton/hr
Coal flow (orifice)	_____ lb/hr
	_____ ton/hr
Line velocity	_____ ft/sec

Pretreater

Pretreater temp. (TR 265 - 1)	_____ °C	_____ °F
(TRC - 203)	_____ °C	_____ °F
Pretreater pres. (PI - 267)	_____ atm,	_____ psig
Bed height calc.	_____ ft	
Bed height (actual)	_____ ft	
Bed Density	_____ lb/ft ³	
P	_____ in	

Feed System and Pretreater Calculations

(cont'd)

Gas Composition

CO	_____ %
CO ₂	_____ %
H ₂	_____ %
O ₂	_____ %
N ₂	_____ %
CH ₄	_____ %
C ₂ H ₆	_____ %
H ₂ O	_____ %
Residence time	_____ min
Inventory	_____ lb
Superficial velocity (bottom)	_____ ft/sec

Operating Conditions - Gasifier

1) Temperatures

a. gasifier - upper bed (TR 205-3)	_____ °C	_____ °F
b. gasifier - middle (TR 265-4)	_____ °C	_____ °F
c. gasifier - lower (TI-200-2)	_____ °C	_____ °F
d. gasifier distributor cone		
minimum: location _____	_____ °C	_____ °F
average	_____ °C	_____ °F
maximum: location _____	_____ °C	_____ °F
e. gasifier steam and O ₂ mixture	_____ °C	_____ °F
f. gasifier - raw gas (TR 265-2)	_____ °C	_____ °F
g. char cooler - upper (TI 200-4)	_____ °C	_____ °F
h. char cooler - middle (TI 200-3)	_____ °C	_____ °F
i. char cooler - lower (TR 265-5)	_____ °C	_____ °F

2) Pressures

a. gasifier PI 256	_____ atm	_____ psig
PR 295	_____ atm	_____ psig
b. char cooler	_____ atm	_____ psig

3) Feed Rates

a. Gasifier	_____ #/hr
1. specific raw coal feed rate	_____ #/hr ft ²
	_____ #/hr ft ³
2. oxygen to coal ratio	_____ #/# raw coal
	_____ SCF/# raw coal
	_____ #/# maf coal
3. steam to coal ratio	_____ #/# raw coal
	_____ SCF/# raw coal
	_____ #/# maf coal
b. Char Cooler	
1. specific char (moisture free)	
feed rate	_____ #/hr ft ²
	_____ #/hr ft ³

2. char (moisture free) to raw coal ratio _____ #/#
3. fluidizing steam to char (moisture free) ratio _____ #/#
4. fluidizing steam to raw coal ratio _____ #/#
5. spray H₂O to char (moisture free) ratio _____ #/#
6. spray H₂O to raw coal ratio _____ #/#

Fluid Bed Properties

1. Gasifier

- a. gas superficial velocity _____ ft/sec
 - bottom of fluid bed _____ ft/sec
 - mean bed _____ ft/sec
 - top of fluid bed _____ ft/sec
 - outlet of gasifier _____ ft/sec
- b. fluid bed density _____ lb/ft³
- c. fluid bed height _____ ft
- d. pressure drop _____ in H₂O/ft of bed
- e. solids residence time _____ min
- f. solids inventory _____ lb
- g. gasifier diameter _____ ft

2. Char Cooler

- a. fluidizing steam superficial velocity purge steam superficial velocity _____ ft/sec
- b. vaporized water superficial velocity _____ ft/sec
- c. total steam superficial velocity _____ ft/sec
- d. fluid bed density _____ #/ft³
- e. calculated bed height pressure drop _____ in H₂O/ft of bed
- f. solids residence time _____ min
- g. solids inventory _____ #
- h. P - gasifier-char cooler _____ in H₂O

Gasifier Kinetic Rates

1. Carbon inventory _____ lb
2. Gasification rate _____ lb C/hr ft³
_____ lb C/hr lb C in bed
3. Methane format in rate ft³ of CH₄/hr ft³ of bed
lb C/hr lb C in bed

Conversions

1. steam decomposition (water balance) %
2. steam decomposition (H balance) %
3. % C gasified %
4. % C converted %

Solids, Feeds and Effluents

1. Raw coal
a. feed rate #/hr
b. chemical analysis (weight percent)

	<u>As Rec'd</u>	<u>Moisture free</u>	<u>MAF</u>
Moisture			
Ash			
Volatile matter			
Fixed Carbon			
Carbon			
Hydrogen			
Oxygen			
Nitrogen			
Sulfur			

c. Size distribution

<u>Mesh</u>	<u>Wt. % on</u>
--	--
--	--
--	--
--	--
--	--

d. HHV Btu/lb

e. Free swelling index

2. Char

a. production rate #/# raw coal
#C/#C in coal

b. Chemical analysis
(same as above)

c. Size distribution
(same as above)

d. Moisture free HHV Btu/lb

3. Fines

a.

b.

c. same as above

d.

Gas Effluent (Raw Gas Scrubber Effluent)

	SCF/# raw coal	SCF/# maf coal	Vol. %
Total Gas			
H ₂ O	-	-	-
CO	-	-	-

SCF/# raw coal SCF/# MAF coal Vol. %

Total Gas

CO ₂	-	-	-
CH ₄	-	-	-
C ₂ H ₆	-	-	-
Equivalent CH ₄	-	-	-
N ₂	-	-	-
NH ₃	-	-	-
H ₂ S	-	-	-
H ₂ O	-	-	-

Liquid Effluents

1. Condensate

- a. production rate _____ #/# raw coal
- b. composition : pH, suspended solids,
phenol, COD, thiocyanate, cyanide,
NH₃, Cl, carbonate, bicarbonate,
Total S.

2. Tar

- a. production rate _____ #/lb raw coal
_____ #/maf coal

b. composition (wt. percent)

C	_____
H	_____
O	_____
N	_____
S	_____

c. HHV

Btu/lb

Material Balance

<u>Inputs</u>	<u>lb/hr</u>	<u>%H</u>	<u>lb/hr</u>	<u>%O</u>	<u>lb/hr</u>	<u>%C</u>	<u>lb/hr</u>	<u>%N</u>	<u>lb/hr</u>	<u>%S</u>	<u>lb/hr</u>
oxygen	--			--	--						
coal	--	--	--	--	--	--	--	--	--	--	--
steam	--	--	--	--	--						
CO ₂	--			--	--	--	--				
Total	--		--		--		--		--		--
<u>Outputs</u>	<u>lb/hr</u>	<u>%H</u>	<u>lb/hr</u>	<u>%O</u>	<u>lb/hr</u>	<u>%C</u>	<u>lb/hr</u>	<u>%N</u>	<u>lb/hr</u>	<u>%S</u>	<u>lb/hr</u>
condensate	--	--	--	--	--	--	--	--	--	--	--
char	--	--	--	--	--	--	--	--	--	--	--
tar	--	--	--	--	--	--	--	--	--	--	--
fines	--	--	--	--	--	--	--	--	--	--	--
gas	--	--	--	--	--	--	--	--	--	--	--
total	--		--		--		--		--		--
% closure (recovery)	--		--		--		--		--		--

E.R.D.A. SYNTHANE PILOT PLANT

TEST DIRECTIVE: RUN NO. 1-DB

DATE: 1/14/77

Objective: To gasify Montana Rosebud subbituminous coal at 600 psig for a steady state period of a minimum of 24 hours at a carbon conversion of about 67% to test the gasifier system operability and reliability, to determine product compositions and yields and gasifier throughput. During this run, coal will be injected below the bed surface through a dip tube to reduce tar production and fines carryover. A process feasibility test of five to seven days should be attempted on this run and each subsequent run. The run should be terminated by a voluntary shutdown and then the gasifier should be inspected for signs of slag, erosion, corrosion, refractory deterioration and cyclone plugs.

Test Conditions:

1. Coal Handling. Rosebud coal should be ground to 20 by 0 mesh with not more than 30% through 200 mesh. Ground coal should be dried to below 10% moisture (ASTM method) and preferably as low a moisture content as possible to reduce oxygen consumption.
2. Pretreatment. The pretreater is not needed and should be bypassed.
3. Coal Injection. During this run, coal should be injected below the bed surface with a dip tube. The dip tube should be located 4" to 6" off the gasifier shroud and terminate about 6' above the cone line, pointing vertically downwards. The velocity should be kept in the range of 20 to 40 ft/sec to prevent short circuiting of fresh coal to the char withdrawal line.

Test Conditions: (cont'd)

4. Petrocarb. Ground coal should be transported from the storage injector to the gasifier with CO₂. Total transport velocity in the lift line should be below 40 ft/sec. The CO₂ will be provided from the CO₂ storage system since the Benfield system will not be operated to recover the CO₂ from the product gas. The coal feed rate should be three tons/hour.
5. Gasification. Bed height will be controlled at 10 ft. Every effort should be made to maintain a stable bed height (+ 1 ft) to allow kinetic analyses of gasifier performance to be made. Fluidizing steam velocity will be 0.4 ft/sec. Bed temperature should initially be brought to 1450°F, until carbon conversion is determined, and raised in 25°F increments until the desired conversion is obtained. Final temperatures should not exceed 1550°F.
6. Char Cooler. Fluidizing velocity (base of char cooler) should be 0.3 ft/sec. Temperature should be held at 525° to 600°F.
7. Char Removal. The alternate high pressure slurry system should be used since the lock hopper system is not available.
8. Raw Gas Scrubbing. The venturi and water wash section of the raw gas scrubber should be operated as revised.
9. Downstream Processing. After the water wash, product gas will be sent directly to the flare without the use of gas cleanup equipment.
10. Analytical. After reaching 1450°F coal, char and gas samples are to be taken every two hours and analyzed to establish carbon conversion. Condensate should also be

Test Conditions: (cont'd)

sampled to determine suspended solids. Samples of waste water from the scrubber surge tank should be taken every four hours and saved for analysis of pollutants. If possible, tar samples should also be obtained every four hours and saved for analysis.

11. Parameters to be Reported. The list of gasifier calculations transmitted with Test Directive #1 should be made and reported to the extent possible. CO₂ flow from the Petrocarb system will be estimated for the run since flow measurement devices are not yet installed.
12. Operating Procedure. This should follow the detailed Operating Manual.
13. Alteration of Conditions. Carbon conversion should be determined as soon as possible through at least two samples and then a meeting should be held with the ERDA SYNTHANE Operating Committee to determine changes to be made to achieve the desired carbon conversion of 67%.

E.R.D.A. SYNTHANE PILOT PLANT

TEST DIRECTIVE: RUN NO. 2-DB

DATE: 8/29/77

OBJECTIVE

- A. Conduct a gasification feasibility run of five (5) to seven (7) days operation at 600 psig and at least 67% carbon conversion with Illinois No. 6 bituminous coal at a feed rate of 1.8 tons per hour. The run should be terminated by a voluntary shutdown and then the gasifier should be inspected for signs of slag, erosion, corrosion, refractory deterioration and cyclone plugs.
- B. Obtain steady state data at the desired operating conditions to determine product compositions and yields, gasifier throughput and heat and material balances. Steady state duration preferably should be several days; 24 hours is the minimum. During this run, coal will be injected below the bed surface through a dip tube to reduce tar production and fines carryover.

TEST CONDITIONS

1. Coal Handling

Illinois No. 6 coal should be ground to 20 by 0 mesh with not more than 30% through 200 mesh. Ground coal should be dried to below 8% moisture (ASTM Method) and preferably as low a moisture content as possible to reduce oxygen consumption.

TEST CONDITIONS - cont'd

2. Pretreatment

The pretreater is needed to eliminate the caking properties of the Illinois No. 6 coal. The pretreater temperature should be held at 800°F. It is expected that oxygen usage will be 0.8 to 1.0 cu. ft. O₂/lb. of coal. The allowable range for the pretreater temperature is from 770°F to 840°F. Fluidizing velocity, using steam or a mixture of steam and CO₂, should be 0.25 to 0.4 ft/sec. Satisfactory pretreater operation should be established before a char bed is built in the gasifier. A maximum free-swelling index of one (1) is recommended (ASTM-D-720).

3. Coal Injection in Gasifier

During this run, coal should be injected below the gasifier bed surface with a dip tube using the latest configuration.

4. Petrocarb

Ground coal should be transported from the storage injector to the gasifier using CO₂. However, if separate tests with steam transport of coal prove successful, steam will be substituted for the CO₂ transport gas. Induced transport velocity in the lift line should be below 20 ft/sec. The coal feed rate should be 1.8 tons per hour.

5. Gasification

Bed height should be controlled at approximately 20 ft. Every effort should be made to maintain a stable bed height (+ 1 ft) to allow kinetic analysis of the gasifier performance to be made. Fluidizing steam velocity should be 0.5 ft/sec. Due to the relatively lower

TEST CONDITIONS - cont'd

reactivity of Illinois No. 6 coal, the bed temperature should initially be brought to 1600°F and maintained until carbon conversion is determined. The temperature should then be raised in reasonable increments until the desired conversion is obtained. Final temperature should not exceed 1800°F.

6. Char Removal

The char removal system should be operated as in Run 1-DB.

7. Raw Gas Scrubbing

The venturi and water wash section of the raw gas scrubber should be operated as revised.

8. Downstream Processing

During this run, the Benfield and Stretford units will be brought on line as soon as possible. When these units have been operated satisfactorily, product gas should be burned either in the thermal oxidizer or the boilers, as appropriate.

9. Analytical

After reaching 1600°F, coal, char and gas samples are to be taken every two (2) hours and analyzed to establish carbon conversion. Condensate should also be sampled to determine suspended solids. Samples of waste water from the scrubber surge tank should be taken every four (4) hours and saved for analysis of pollutants. If possible tar samples should also be obtained every four (4) hours and saved for analysis.

TEST CONDITIONS - cont'd

10. Parameters to be Reported

The list of gasifier calculations transmitted with Test Directive No. 1 should be made and reported to the extent possible. Normal operating data should be collected to establish satisfactory operation of the Benfield and Stretford units.

11. Operating Procedure

This should follow the detailed Operating Manual.

12. Alteration of Conditions

Carbon conversion should be determined as soon as possible through at least two (2) samples and then a meeting should be held with representatives of the ERDA SYNTHANE Operating Committee to determine changes to be made to achieve the desired carbon conversion of +67%.

DESIGN BASIS

Feedstocks

	<u>Pittsburgh Seam</u>	<u>Illinois No. 6</u>
Carbon	73.8%	67.1%
Hydrogen	5.2	4.5
Nitrogen	1.5	1.2
Oxygen	8.0	8.6
Sulfur	1.6	2.9
Ash	7.4	7.0
Moisture	<u>2.5</u>	<u>8.7</u>
	100.0%	100.0%
Free Moisture	10% wt. max.	
Sulfur	5% wt. max.	
Size	3/4" max.	
Operating Pressure	100 psig	
Coal Feed Rate	3 tons/hr	
Carbon Conversion	70%	
Purified Gas after Acid Gas Removal	89480 SCFH	
Purified Gas to Methanation	26,790 SCFH	
Purified Gas to Fuel or Flare	62,690 SCFH	
SNG per Methanator	7,480 SCFH	

Operating Deviations from Design Basis

- A. 600 PSIG operation - Government request
- B. Rosebud Coal - Government request
- C. Bypass Pretreater with Rosebud Coal - Government request Rosebud non-caking
- D. Use alternate char letdown - Bad Valves
- E. Purchased CO₂ for inert gas - High sulphur fuel oil
- F. Coal feed to deep bed from free fall injection - Experience gained from Run No. 1
- G. Propane fuel for inert gas - High sulphur fuel oil
- H. Pretreater in service - Illinois No. 6 Coal

SYNTHANE PILOT PLANT
RUN REPORT NO. 1

The gasifier program for Test Directive No. 1 began on July 7, 1976, and was concluded on December 20, 1976. During this period, the Plant produced gas for a period of 228 hours, processing 709 tons of coal. A summary of the Plant operation through this period, is provided below:

<u>Date</u>	<u>Run No.</u>	<u>Hours Duration</u>	<u>Reason For Curtailment</u>
7/7/76	1-A	1.8 hours	Instrument problems
7/8/76	1-B	6.5 hours	Low CO ₂ capacity
7/19/76	1-C	10.5 hours	Plugged line FA-403
7/20/76	1-D	14.5 hours	Overgasified bed
8/11/76	1-E	2.5 hours	Poor pressure control
8/12/76	1-F	8 hours	No coal in primary injector
8/13/76	1-G	5 hours	Plugged line FA-403
8/14/76	1-H	2 hours	Plugged standpipe to char cooler
8/15/76	1-I	5 hours	Plugged line FA-403
8/16/76	1-J	7 hours	Boiler outage
9/15/76	1-K	4 hours	Plugged standpipe to char cooler
9/30/76	1-L	4.5 hours	Plugged standpipe to char cooler
10/10/76	1-M	17 hours	No char removal, clinker in gasifier
10/29/76	1-N	11 hours	Plugged line to filter area
10/30/76	1-O	19 hours	No coal feed, wet coal
10/31/76	1-P	22 hours	O ₂ pump shutdown
11/19/76	1-Q	16.7 hours	Plugged standpipe to char cooler
11/20/76	1-R	6.6 hours	PCV-338 failure, blown RD
11/21/76	1-R	7.7 hours	Low CO ₂ capacity
11/22/76	1-S	19.5 hours	Gasifier outlet plugged
12/20/76	1-T	37 hours	PCV-2205, bypass leak
TOTAL		227.8 hours	

As shown in the summary, the Plant achieved a continuous operating period of 37 hours with coal and oxygen feed during Run 1-T in December of 1976.

APPENDIX R
OPERATIONS SUMMARY RUN REPORT NO. 1

RUNS A TO J

Run Number Date	A 7/7/76	B 7/8/76	C 7/19/76	D 7/20/76	E 8/11/76	F 8/12/76	G 8/13/76	H 8/14/76	I 8/15/76	J 8/16/76
Raw Coal, tons/hr	1.12	0.67	1.68	1.42	2.0	2.6	2.5		2.3	2.5
Steam, lbs/hr	6725	4628	4320	4536	4976	4300	3688		3608	4332
Oxygen, SCFH	6935	9504	10306	9563	7990	10989	6399		9876	10432
Steam/Coal, lbs/lb	2.99	3.47	1.30	1.59	1.24	0.83	0.74	(3)	0.78	0.87
O ₂ /Coal, lbs/lb	0.26	0.60	0.26	0.28	0.16	0.18	0.11		0.18	0.18
Carbon Conversion, %	21	21	57	94	(2)	22.9	29		25	58
H ₂ /CO, vols/vol.	2.05	12.7	6.93	6.44	(2)	(2)	(2)		3.8	4.7
Bed Temp., °F	1200	1400	1500	1650	1175	1153	1257		1550	1535
CH ₄ Scrubber Ohd, mol %	(2)	(2)	(2)	(2)	(2)	(2)	(2)		(2)	(2)
Run Time, hrs (1)	1.75	6.5	10.5	14.5	2.5	(4)	5		5	3
Run Number Date	K 9/15/76	L 9/30/76	M 10/10/76	N 10/29/76	O 10/30/76	P 10/31/76	Q 11/19/76	R 11/20/76	S 11/22/76	T 12/15/76
Raw Coal, tons/hr	1.9	1.3/3.0	2.05	3.29	2.0	3.27	2.6	2.1	2.3	2.52
Steam, lbs/hr	4721	4548	4500	6227	6597	6634	6933	6736	7008	5630
Oxygen, SCFH	11128	(3) 9737	12400	9776	7738	10312	10650	9950	10700	11670
Steam/Coal, lbs/lb	1.22	2.3/0.76	1.10	0.95	1.64	1.01	1.34	1.64	1.54	1.12
O ₂ /Coal, lbs/lb	0.24	0.41/0.14	0.26	0.13	0.16	0.13	0.17	0.20	0.20	0.19
Carbon Conversion, %	52.3	74.3	65.4	47.5	45.9	29.9	49.5	46.9	52.4	57.4
H ₂ /CO, vols/vol	4.6	2.45	2.60	5.17	7.28	5.17	4.37	5.53	5.17	5.17
Bed Temp., °F	1479	1575	1530	1420	1400	1400	1400	1400	1400	1440
CH ₄ Scrubber Ohd, mol %	(2)	9.3	(4) 11.7	9.1	5.8	8.2	11.3	(4) 6.3	(4) 8.0	7.5
Run Time, hrs (1)	4	4.5	13	11.1	19.5	22.4	16.7	(4) 14.3	(4) 19.5	36.8

Notes:

- (1) Time starts at start of O₂ feed
- (2) No samples taken
- (3) Rate after reaching 1500°F
- (4) Interruption or interruptions occurred during the run and are not included in the run time

Summary of Synthane Pilot Plant Operations

<u>Run Duration</u>			<u>Periods of Continuous Operation</u>		
<u>Run No.</u> <u>1-DB</u>	<u>Operation</u> <u>(Hours)</u>	<u>Elapsed*</u> <u>Time</u> <u>(Hours)</u>	<u>Date</u> <u>1977</u>	<u>Duration</u> <u>(Hours)</u>	<u>Reason for Curtailment</u>
A	13	↑	Feb. 23/24	13	Hole in char cooler steam vent line
B	48	74	Feb. 24/25	23	Char slurry line plugged
		↓	Feb. 25/26	25	Leaking of skimming valves in scrubber surge drum
C	23	↑	Feb. 27	4	Plug in char cooler standpipe
C/D		53	Feb. 27/ March 1	41	Circuit breaker trip
D	28	↓	March 1	6	Plug in char cooler standpipe, clinker
E	18	↑	March 15/16	8	Char slurry circulating pump problems
		27	March 16	7	Low bed density
		↓	March 16	3	Low bed density, clinker, H.P. steam line failure
F	13	↑	March 22	3	Char slurry recycle water pump down
		15	March 22	10	Plug in char cooler standpipe, clinker
G	7.5	↑	March 31	7.5	Char slurry line plugged
H	35.5	126	April 1/2	35.5	Plug in char cooler standpipe
		(cont'd)			

*Operation plus outages

Summary of Synthane Pilot Plant Operations - cont'd

<u>Run Duration</u>		<u>Periods of Continuous Operation</u>			
<u>Run No.</u> <u>1-DB</u>	<u>Operation</u> <u>(Hours)</u>	<u>Elapsed</u> <u>Time</u> <u>(Hours)</u>	<u>Date</u> <u>1977</u>	<u>Duration</u> <u>(Hours)</u>	<u>Reason for Curtailment</u>
I	13	↓	April 2/3	13	Plug in char cooler standpipe
J	17		April 3/4	8.5	Char slurry line plugged
			April 4	5	Erratic temperature readings, instrument problems
			April 5	3.5	Plug in char cooler standpipe, clinker
K	15	18	April 15/16	15	Plug in char cooler standpipe, clinker
L	16	↑	April 27/28	9	Char slurry recycle water pump down
		19			
		↓	April 28	7	Plug in char cooler standpipe, clinker
M	26.5	31	May 16/17	26.5	Char slurry line plugged
N	85.5	↑	May 20	6	Coal transport line plugged
			May 21/22	10	Char slurry recycle water pump down
			May 22/23	7.5	Char slurry line plugged
			May 23	6.5	External power failure
		174	May 24/25	16.5	Char slurry recycle water pump problems
			May 25/26	17	Low CO ₂ header pressure
		(cont'd)			

Summary of Synthane Pilot Plant Operations - cont'd

<u>Run Duration</u>			<u>Periods of Continuous Operation</u>		
<u>Run No.</u> <u>1-DB</u>	<u>Operation</u> <u>(Hours)</u>	<u>Elapsed</u> <u>Time</u> <u>(Hours)</u>	<u>Date</u> <u>1977</u>	<u>Duration</u> <u>(Hours)</u>	<u>Reason for Curtailment</u>
			May 26	5	Nut in Petrocarb primary outlet valve
			May 27	6.5	Plug in char cooler standpipe
			May 27	4	Petrocarb problems
			May 27	6.5	Gasifier nozzle leak
	197.5		Aug. 5	2.5	Pretreater temperature trip
			Aug. 6-9	46*	Rupture disc failure
		266	Aug. 9-13	97	Low CO ₂ header pressure
			Aug. 14	5	Char slurry recycle water pump down
			Aug. 14-16	47	Plug in char cooler standpipe, clinker
	556.5	803		556.5	

*Ten outages occurred during this period due to repeated rupture disc failure. In some instances the outages were longer than the maximum 30 minutes allowed by the definition of a continuous operation period.

STEADY STATE PERIODS OF RUN SERIES 1-DB

<u>Steady State Period No.</u>	<u>Run No. 1-DB</u>	<u>Steady State Duration (Hours)</u>	<u>Coal Feed (Lb/Hr)</u>	<u>Fluidizing Steam (Lb/Hr)</u>	<u>Oxygen Feed (SCFH)</u>	<u>Gasifier Bed Temperature (°F)</u>	<u>Steam/Coal (Lb/Lb)</u>	<u>O₂/Coal (Lb/Lb)</u>	<u>Carbon Conversion (Wt. %)</u>	<u>H₂/CO (Vol/Vol)</u>	<u>CH₄ Make Scrubber Ohd (Mol. %)</u>
1	A	5.7	4,580	7,621	17,939	1,414	1.66	0.33	75.80	3.91	8.86
2	B	4.4	4,860	6,884	19,053	1,481	1.42	0.33	74.48	3.33	9.30
3	B	4.4	4,880	7,018	19,499	1,503	1.44	0.34	75.84	3.31	9.54
4	B	12.9	4,820	6,888	19,104	1,499	1.43	0.33	69.27	3.20	9.43
5	C	5.2	6,600	6,369	19,367	1,497	0.96	0.25	56.43	2.86	9.19
6	C	3.2	5,640	6,399	17,979	1,498	1.13	0.27	62.57	3.39	9.52
7	D	5.4	4,400	6,479	18,125	1,502	1.47	0.35	72.98	3.67	9.15
8	D	4.4	4,400	6,454	17,852	1,500	1.47	0.34	72.24	3.81	9.32
9	G	3.0	5,450	6,170	19,582	1,496	1.13	0.30	58.34	3.07	10.03
10	H	1.5	5,550	6,060	18,579	1,485	1.09	0.28	59.37	3.04	9.99
11	H	4.0	5,550	5,959	18,926	1,490	1.07	0.28	58.56	2.68	10.03
12	H	5.2	4,070	5,863	16,140	1,495	1.44	0.33	58.40	3.07	8.45
13	I	2.1	5,640	5,333	17,459	1,491	0.94	0.26	52.93	2.66	9.56
14	M	1.9	4,000	6,881	14,410	1,322	1.72	0.30	50.18	5.24	8.06
15	N	1.9	4,050	7,184	14,010	1,294	1.77	0.29	51.19	7.99	7.44
16	N	3.8	4,050	6,785	13,183	1,283	1.67	0.27	47.26	7.30	7.77
17	N	1.9	4,050	6,797	13,255	1,297	1.68	0.27	48.16	6.86	6.55

STEADY STATE PERIODS OF RUN SERIES 1-DB

<u>Steady State Period No.</u>	<u>Run No. 1-DB</u>	<u>Steady State Duration (Hours)</u>	<u>Coal Feed (Lb/Hr)</u>	<u>Fluidizing Steam (Lb/Hr)</u>	<u>Oxygen Feed (SCFH)</u>	<u>Gasifier Bed Temperature (°F)</u>	<u>Steam/Coal (Lb/Lb)</u>	<u>O₂/Coal (Lb/Lb)</u>	<u>Carbon Conversion (Wt. %)</u>	<u>H₂/CO (Vol/Vol)</u>	<u>CH₄ Make Scrubber Ohd (Mol. %)</u>
18	N	1.7	3,650	6,783	12,660	1,295	1.86	0.29	54.40	6.76	7.21
19	N	1.7	4,300	6,828	12,510	1,289	1.59	0.25	46.14	6.79	7.96
20	O	2.8	3,010	6,611	12,661 *	1,300	2.20	0.35	50.96	8.51	6.95
21	O	5.5	3,900	6,603	11,647 *	1,309	1.69	0.25	40.61	7.61	7.76
22	O	3.6	4,590	6,255	13,358 *	1,400	1.36	0.25	39.93	5.64	8.48
23	O	2.4	3,840	7,226	15,688 *	1,518	1.88	0.34	53.91	4.53	6.05
24	O	5.9	4,100	7,297	16,585 *	1,508	1.78	0.34	61.58	4.11	6.05
25	O	14.9	5,040	7,110	17,435 *	1,503	1.41	0.29	55.42	3.65	7.09
26	O	5.9	4,290	6,368	16,976 *	1,505	1.48	0.33	62.78	3.31	8.15
27	O	4.4	5,000	7,166	19,789 *	1,540	1.43	0.33	70.87	3.00	7.22
28	O	3.4	5,170	7,160	19,519 *	1,544	1.38	0.32	65.86	2.94	6.57
29	O	2.4	5,270	7,240	19,448 *	1,541	1.37	0.31	58.74	3.32	6.66

*Although the pretreater was in operation during these steady state periods, the flow rates shown are gasifier feed rates only.

SUMMARY OF SYNTHANE PILOT PLANT OPERATIONS

Run No. 2-DB	Operation (Hours)	Elapsed* Time (Hours)	Sub-Run No. 2-DB	Date 1977	Duration (Hours)		Reason for Curtailment
					Pretreater	Gasifier	
A	2.3	408.8	A-1	9/13	.25		Agglomeration in Pretreater
			A-2	9/26	.5		Agglomeration in Pretreater
			A-3	9/28	.3		Agglomeration in Pretreater
			A-4	9/30	1.2		Agglomeration in Pretreater
B	4.3	152.5	B-1	10/25	1.5		Agglomeration in Pretreater
			B-2	10/29	1.25		Agglomeration in Pretreater
			B-3	10/31	1.5		Petrocarb outlet Plugged
C	2.2	79.1	C-1	11/9	.2		Lost CO ₂ Compressor
			C-2	11/11	2		Agglomeration in Pretreater
D	46.5	293.6	D-1	12/3	8		Agglomeration in Pretreater
			D-2	12/9	2.5		Agglomeration in Pretreater Due to Loss On O ₂ Header Pressure
			D-3	12/13	36		Agglomerated Gasifier
E	6.8	543.2	E-1	12/30	6		Char Cooler Standpipe Plugged
				<u>1978</u>			
			E-1	1/20	.8		Char Cooler Standpipe Plugged

*Operation plus outages.

SUMMARY OF SYNTHANE PILOT PLANT OPERATIONS - cont'd

Run No. 2-DB	Operation (Hours)	Elapsed* Time (Hours)	Sub-Run No. 2-DB	Date 1977	Duration (Hours)		Reason for Curtailment
					Pretreater	Gasifier	
F	17.5	60.4	F-1	2/3	2.9		Coal Feed Venturi Plugged
			F-2	2/4	1		Coal Feed Venturi Plugged
			F-3	2/5	13.6		Leak in line on Gasifier RD Piping
G	42	315.1	G-1	3/26	5.5		Petrocarb Vessel Empty
			G-2	3/26	4.5		Flange Leak In Gas Scrubbing
			G-3	3/27	3		Flange Leak In Gas Scrubbing
			G-4	4/2	3		Coal Feed Line Plugged
			G-5	4/6	17.5	5.5	Char Slurry Lines Plugged
			G-6	4/8	8.5	5.5	Char Cooler Standpipe Plugged
H	16.5	151.8	H-1	4/20	5.0	1.0	Leak in Pretreater Overflow Line
I	22.3	452.1	I-1	5/9	.5		Agglomerated Pretreater
			I-2	5/17	5.1		Leak in Char Mix Tee
			I-3	5/19	5.3		Agglomerated Pretreater
			I-4	5/21	1.3		Plugged Coal Feed Venturi
			I-5	5/23	2.3		Agglomerated Pretreater and Coal Transport Line
			I-6	5/28	7.8	1.8	Agglomerated Pretreater and Gasifier

*Operation plus outages

SUMMARY OF SYNTHANE PILOT PLANT OPERATIONS - cont'd

Run No. 2-DB	Operation (Hours)	Elapsed* Time (Hours)	Sub-Run No. 2-DB	Date 1977	Duration (Hours)		Reason for Curtailment
					Pretreater	Gasifier	
J	25.1	184.6	J-1	6/12	3.5		Plugged Coal Feed Venturi
			J-2	6/17	9.2		Agglomerated Pretreater
			J-3	6/19	12.4	7.6	Plugged Char Cooler Standpipe
K	16.8	169.2	K-1	7/4	2.5		Wet Coal in Petrocarb
			K-2	7/11	14.25	11.25	Poor Coal Feed and Pressure Upset in Petrocarb System
L	14.1	78.9	L-1	7/20	.7		Low CO ₂ Supply
			L-2	7/21	6.7		Agglomerated Pretreater
			L-3	7/23	6.7		Agglomerated Pretreater
M	25.0	116.3	M-1	7/27	11.75	10.6	Plugged Coal Feed Line
			M-2	7/31	13.25	11.25	Loss of Gas Scrubbing Circulation
N	45.2	131.4	N-1	8/9	11.2		Agglomerated Pretreater
			N-2	8/12	26.0		Agglomerated Pretreater
			N-3	8/15	8.0		Agglomerated Pretreater
O	134.1	202.4	O-1	8/22	55.8	50.4	Leak In 3" Coal Lift Line
			O-2A	8/25	7.6	6.9	Loss of Coal Feed
			O-2B	8/26	28.6	25.5	Loss of Coal Feed

* Operation plus outages

SUMMARY OF SYNTHANE PILOT PLANT OPERATIONS - concluded

<u>Run No.</u> <u>2-DB</u>	<u>Operation</u> <u>(Hours)</u>	<u>Elapsed*</u> <u>Time</u> <u>(Hours)</u>	<u>Sub-Run No.</u> <u>2-DB</u>	<u>Date</u> <u>1977</u>	<u>Duration (Hours)</u>		<u>Reason for Curtailment</u>
					<u>Pretreater</u>	<u>Gasifier</u>	
			0-2C	8/27	30.45	30.45	Loss of Coal Feed
			0-3	8/29	<u>11.6</u>	<u>11.6</u>	Hole in Char Lift Line
					420.25 Total	181.85	
	<u>420.7</u>	<u>3339.4</u>					

*Operation plus outages

OPERATIONS SUMMARY RUN REPORT NO. 2-DB

FOR PRETREATER

Run Number	A (1-14)	B (1-2)	B-3	C (1-2)	D (1-3)	E-1	E-2	F (1-3)
Date	9/13/77	10/25/77	10/31/77	11/9/77	12/3/77	12/30/77	1/20/78	2/3/78
Raw Coal, tons/hr	(3)	1.10	0.93	(4)	0.6-1.8	(4)	(4)	1.0-1.5
Steam, lbs/hr	(3)	300	1700	533	1900	2200	4950	5700
Oxygen, SCFH	(3)	575	800	960	960-2880	(3)	(3)	900-2900
Inert Gas, SCFH (2)	(3)	36000	25000	31610	12000	16470	16500	14230
Superficial Vel., ft/sec	(3)	0.45	0.61	0.42	0.43	0.50	1.00	1.20
Bed Temp. Range, °F	660-940	430-1200	600-935	620-960	600-900	460-830	680-800	600-870
F.S.I.	0-1.5	0-1.5	0.5-1.0	0-1.0	0.0-2.0	0.0	(4)	0.0
Volatile Content, wt.%	32.0	32.5	33.0	28.5	27.5	23.8	(4)	24.6
Run Time, hrs (1)	2.3	2.8	1.5	2.2	46.5	6.0	0.8	17.5
Run Number	G (1-4)	G-5	G-6	H-1	H-2	I-1	I (2-5)	I-6
Date	3/26/78	4/6/78	4/8/78	4/20/78	4/26/78	5/9/78	5/17/78	5/28/78
Raw Coal, tons/hr	1.3-3.1	2.5	1.9	2.1-2.5	1.3-2.2	2.20	2.1-2.5	2.8
Steam, lbs/hr	5900	7250	6000	5705	4220-5490	2560	5340	5350
Oxygen, SCFH	1830-4960	3620	2830	1800-4250	3000-4000	2760	3160-3880	4680
Inert Gas, SCFH (2)	24000	26100	20400	22590	16270-22000	23620	30400	28920
Superficial Vel. ft/sec.	1.35	1.62	1.53	1.22	0.88-1.16	0.70	1.28	1.25
Bed Temp., °F	450-920	730-850	680-830	720-900	600-950	420-810	670-920	640-860
F.S.I.	0.0-0.5	0.0-1.0	0.5	(3)	0.0-1.5	(3)	0.5-1.0	0.5-1.0
Volatile Content, wt.%	27.4	26.6	24.8	(3)	24.7	(3)	26.6	28.4
Run Time, hrs. (1)	16.0	17.5	8.5	5.0	11.5	0.5	14.0	7.8

Notes:

- (1) Time starts at start of O₂ feed to the pretreater
- (2) Inert gas can be either pure CO₂ or a mixture of CO₂ and N₂
- (3) No samples taken
- (4) No data taken

OPERATIONS SUMMARY RUN REPORT NO. 2-DB

FOR PRETREATER

(continued)

Run Number	J (1-2)	J-3	K-1	K-2	L-1	L (2-3)	M-1	M-2
Date	6/12/78	6/19/78	7/4/78	7/11/78	7/20/78	7/21/78	7/27/78	7/31/78
Raw Coal, tons/hr	1.6	1.6	(3)	1.6	1.8	1.9	1.7	1.8
Steam, lbs/hr	5340	5440	5335	5340	5880	6000	5530	5730
Oxygen, SCFH	2425	2410	(3)	2617	2802	2950	2427	2617
Inert Gas, SCFH (2)	21800	19100	24000	24200	16860	19400	15360	15510
Superficial Vel., ft/sec	1.15	1.15	1.2	1.2	1.3	1.33	1.2	1.2
Bed Temp., °F	650-980	780-820	(3)	800-850	780-820	790-830	790-815	800-820
F.S.I.	0.0-0.5	0.0-0.5	(4)	0.0	(4)	0.0-1.0	0.0-0.5	0.0
Volatile Content, wt.%	24.5	23.5	(4)	21.9	(4)	28.1	21.2	21.4
Run Time, hrs (1)	12.7	12.4	2.9	14.2	0.7	13.4	11.8	13.3
Run Number	N-1	N-2	N-3	0-1	0-1-A	0-2-B	0-2-C	0-3
Date	8/9/78	8/12/78	8/15/78	8/22/78	8/25/78	8/26/78	8/27/78	8/29/78
Raw Coal, tons/hr	1.8	1.3-1.5	1.3	1.91	1.95	1.45	1.93	1.66
Steam, lbs/hr	6120	3820-5750	6100	5390	4670	4510	4920	4690
Oxygen, SCFH	2759	2197-2385	1980	2707	2818	2542	3081	2910
Inert Gas, SCFH (2)	16100	16000	15570	26710	18910	7230	11668	20272
Superficial Vel., ft/sec	1.33	0.9-1.3	1.3	1.2	1.0	0.9	1.0	1.0
Bed Temp., °F	790-820	720-840	730-850	830-850	835-850	850-870	830-860	830-855
F.S.I.	0.0-0.5	0.5-1.0	1.0	0.0	(3)	0.0	(3)	(3)
Volatile Content, wt.%	25.1	27.7	30.3	20.0	(3)	18.0	(3)	(3)
Run Time, hrs (1)	11.2	26.0	8.0	55.8	7.6	28.6	30.5	11.7

Notes:

- (1) Time starts at start of O₂ feed to the pretreater
- (2) Inert gas can be either pure CO₂ or a mixture of CO₂ and N₂
- (3) No samples taken
- (4) No samples taken

GASIFIER STEADY PERIODS OF RUN SERIES 2-DB

<u>Steady State Period No.</u>	<u>Run No. 2-DB</u>	<u>Steady State Duration (Hours)</u>	<u>Coal Feed PPH</u>	<u>Fluidizing Steam PPH</u>	<u>Oxygen Feed SCFH</u>	<u>Gasifier Bed Temperature °F</u>	<u>Steam/Coal (Lb/Lb)</u>	<u>O₂/Coal (Lb/Lb)</u>	<u>Carbon Conversion (wt.%)</u>	<u>H₂/CO (Vol/Vol)</u>	<u>CH₄ Make Dry Basis (mol.%)</u>
1	M-1	1.7	3200	7410	12500	1484	2.32	0.33	53.08	3.83	10.98
2	M-2	1.8	3500	6640	13000	1473	1.90	0.31	57.51	3.47	10.84
3	M-2	2.7	3500	6620	10670	1480	1.89	0.26	57.55	3.96	11.61
4	O-1	7.6	4100	7130	11710	1471	1.74	0.24	47.46	4.24	10.87
5	O-1	2.0	4450	7160	11260	1455	1.61	0.21	40.70	4.59	11.59
6	O-2C	8.9	4160	6400	9390	1413	1.54	0.19	47.89	3.80	10.65
7	O-3	2.5	3740	5900	9230	1483	1.58	0.21	41.16	3.63	11.02

COMPARISON OF SYNTHANE PILOT PLANT GASIFICATION DATA

FREE FALL VS DEEP BED INJECTION

<u>Run No.</u>	<u>1-T</u> ⁽¹⁾	<u>1-DB</u> ⁽²⁾	<u>1-DB</u> ⁽³⁾	<u>2-DB</u> ⁽⁴⁾	<u>2-DB</u> ⁽⁵⁾
Ground coal feed, ton/hr	2.52	2.00 - 2.03	2.73 - 2.82	1.60 - 1.75	1.87 - 2.23
Gasifier O ₂ /ground coal, SCF/lb	2.32	3.25 - 3.60	3.32 - 3.85	3.05 - 3.91	2.26 - 2.86
Gasifier steam/ground coal, lb/lb	1.12	1.60 - 1.75	0.99 - 1.18	1.89 - 2.32	1.54 - 1.74
Gasifier bed height, ft	15.0	14.0 - 24.1	12.1 - 19.7	23.6 - 38.6	16.2 - 21.4
Gasifier bed density, lb/ft ³	19.3	7.0 - 20.3	14.7 - 20.2	3.7 - 6.2	8.1 - 9.2
Gasifier bed temperatures, °F	1,437	1,280 - 1,320	1,485 - 1,505	1,473 - 1,484	1,413 - 1,483
Gasifier top temperature, °F	608	1,145 - 1,174	1,048 - 1,226	510 - 612	1,176 - 1,270
Equivalent CH ₄ /MAF coal, SCF/lb	2.52	2.31 - 2.81	2.63 - 3.77	2.35 - 2.57	1.84 - 2.37
Carbon Conversion (char analyses), %	57.4	43.4 - 48.2	52.7 - 61.7	53.1 - 57.6	40.7 - 47.9
Carbon Conversion (gas analysis), %	--	47.3 - 51.2	52.9 - 62.6	37.8 - 45.0	21.9 - 31.6
Raw gas production, dry, SCFD	102,000	92,100-99,330	123,500-136,500	54,300 - 65,030	52,450 - 68,760
Dry Gas analysis, mole %					
CO ₂	51.5	63.7 - 64.8	50.4 - 56.5	45.64 - 52.85	37.47 - 48.06
CO	6.0	2.8 - 4.3	7.4 - 9.6	5.91 - 7.26	4.38 - 6.10
H ₂	31.0	22.5 - 23.7	24.7 - 27.9	23.42 - 25.21	16.63 - 25.85
CH ₄	10.0	7.1 - 8.7	10.1 - 10.8	10.84 - 11.61	10.65 - 11.59
C ₂ H ₆	0.9	0.7 - 1.0	0.2 - 1.3	0.41 - 0.67	0.49 - 0.88

COMPARISON OF SYNTHANE PILOT PLANT GASIFICATION DATA

FREE FALL VS DEEP BED INJECTION

<u>Run No.</u>	<u>1-T</u> ⁽¹⁾	<u>1-DB</u> ⁽²⁾	<u>1-DB</u> ⁽³⁾	<u>1-DB</u> ⁽⁴⁾	<u>2-DB</u> ⁽⁵⁾
H ₂ S	0.3	0.1 - 0.8	0.0 - 0.3	1.19 - 1.44	1.00 - 1.66
N ₂	0.3	0.0	0.0 - 0.3	4.59 - 9.45	13.58 - 18.94

(1) Data from Run No. 1

(2) Data from steady state periods 14-17 Run No. 1-DB-N

(3) Data from steady state periods 6, 9-11, 13 Run No. 1-DB-C, G, H, & I

(4) Data from steady state periods 1-3 Run No. 2-DB-M-1 M-2

(5) Data from steady state periods 4-7 Run No. 2-DB-O-1, O-2C, & O-3

APPENDIX B

Steady State Criteria for Run 1-DB

For the purposes of data reporting a definition of a steady state was made. The criteria used for defining steady state periods were that the following variables remain steady within the limits of their average values shown:

Coal feed rate	$\pm 15\%$
Fluidizing steam flow	$\pm 5\%$
Oxygen flow to gasifier	$\pm 2\%$
Gasifier bed temperature	$\pm 15\%$

Bed height and bed density were excluded in the definition of steady state periods in order to achieve a unified definition of steady state for all runs.

APPENDIX B

Steady-State Criteria for Run 2-DB

For the purpose of data reporting a definition of a steady state was made. The criteria used for defining steady state periods was that the gasifier temperature remains steady within $\pm 30^{\circ}\text{F}$. The following was the range of other variables during the selected steady state periods.

Fluidizing steam flow $\pm 5\%$

Oxygen flow to gasifier $\pm 7\%$

Even though the temperature criterion for the selection of steady state periods was set to be $\pm 30^{\circ}\text{F}$, some temperature spikes beyond the specified limit were accepted to increase the length of the steady state period. These spikes occurred due to a momentary variation in some other process variable. Their durations were short and their values were eliminated from the steady state calculations.

Bed height and bed density were excluded in the definition of steady state periods in order to achieve a unified definition of steady state for all runs.

APPENDIX B

Steady State Criteria for Run 2-DB - cont'd

Illinois No. 6 Coal

Reports

1. Reports for each individual run A through O may be found in the Bruceton Synthane Pilot Plant Library.
2. Run Report No. 2-DB (COO-003-40 Dist. Category UC-90C) covering the operating period September 1977 through September 1978 may be found in the Bruceton Synthane Pilot Plant Library.

Statistical Analysis of Ground Rosebud Coal

As per ASTM D-3176, the hydrogen and oxygen, on an as received basis, contain hydrogen and oxygen present in moisture. On a moisture free basis, the hydrogen and oxygen have been adjusted to eliminate the hydrogen and oxygen present in moisture.

A. Ground Rosebud Coal - As Received

<u>Component</u>	<u># of Samples</u>	<u>Mean</u>	<u>Standard Deviation</u>
Moisture	107	6.76 wt. %	± 1.85
Volatiles	107	34.83 wt. %	± 1.00
Ash	107	10.57 wt. %	± 0.67
Hydrogen	44	4.87 wt. %	± 0.15
Carbon	44	62.20 wt. %	± 1.04
Nitrogen	44	0.95 wt. %	± 0.10
Sulfur	44	0.81 wt. %	± 0.09
BTU/lb	44	10,545	± 201

B. Ground Rosebud Coal - Moisture Free

<u>Component</u>	<u># of Samples</u>	<u>Mean</u>	<u>Standard Deviation</u>
Volatiles	107	37.32 wt. %	± 0.89
Ash	107	11.32 wt. %	± 0.69
Hydrogen	44	4.45 wt. %	± 0.11
Carbon	44	66.2 wt. %	± 0.75
Nitrogen	44	0.99 wt. %	± 0.12
Sulfur	44	0.85 wt. %	± 0.12
BTU/lb	44	11,213	± 231

APPENDIX C

Statistical Analysis of Ground Illinois No. 6 Coal

As per ASTM D-3176, the hydrogen and oxygen, on an as received basis, contain hydrogen and oxygen present in moisture. On a moisture free basis, the hydrogen and oxygen have been adjusted to eliminate the hydrogen and oxygen present in moisture.

A. As Received Basis - 18 samples

<u>Component</u>	<u>Mean</u>	<u>Standard Deviation</u>
Moisture	1.4	± 0.28
Volatile	35.5	± 1.29
Ash	13.0	± 0.66
Hydrogen	5.0	± 0.09
Carbon	67.1	± 0.60
Nitrogen	1.2	± 0.07
Sulfur	3.9	± 0.10
Heat of Combustion (BTU/#)	12180	± 140
F.S.I.	4.5	± 0.5

B. Moisture Free Basis - 18 samples

<u>Component</u>	<u>Mean</u>	<u>Standard Deviation</u>
Volatiles	35.9	± 1.33
Ash	13.2	± 0.66
Hydrogen	4.9	± 0.09
Carbon	68.1	± 0.60
Nitrogen	1.2	± 0.07
Sulfur	4.0	± 0.10
Heat of Combustion (BTU/#)	12350	± 155

APPENDIX D

INDEX OF THE LIBRARY AT THE SYNTHANE PILOT PLANT

A library has been established at the Synthane pilot plant which is located in the maintenance building. The contents of the library have been stored in a combination of bookcases, filing cabinets and a series of boxes. A layout of the library and an index of all the material stored in it are shown on the following pages.

APPENDIX D

INDEX OF THE LIBRARY AT THE SYNTHANE PILOT PLANT

A library has been established at the Synthane pilot plant which is located in the maintenance building. The contents of the library have been stored in a combination of bookcases, filing cabinets and a series of boxes. A layout of the library and an index of all the material stored in it are shown on the following pages.

F1 THRU F8	EQUIPMENT DATA FILES	B4	PUBLISHED REPORTS AND PHOTOS
F9	COMPUTER PROGRAM DECKS	B5	VENDORS CATALOGUES
F10	TECHNICAL DEPT. FILES	B6	COMPUTER MANUALS
F11	LABORATORY FILES	B7	SAFETY
F12	COMPUTER GROUP FILES	B8	PURCHASING
*	BOXES 1 THRU 16 (DUPLICATES)	B9	PURCHASING AND ADMINISTRATION
**	BOXES 16 THRU (DUPLICATES)	B10	PERSONNEL, ACCOUNTING AND CONTRACTING
B1	TECHNICAL AND OPERATIONS	B11	PERSONNEL, ACCOUNTING AND CONTRACTING
B2	ENGINEERING AND EQUIPMENT OPERATING MANUALS	DF1	DRAWING FILE, STICK
B3	RUN REPORTS	DF2	DRAWING FILE, FLAT

LIBRARY INDEX

<u>Bookcase Number</u>	<u>Shelf Number</u>	<u>Contents</u>
B1	1	(7) Technical Dept. Operating Log Books (2) Instrument Shop Log Books Job Instructions #B-7426 Notes on Technical Audit Committee, 1975 & 1976 Laboratory Procedures Commercial Evaluation of Synthane Process Original Project Specifications - U.S. - B.O.M. for Synthane Pilot Plant (5 volumes) Evaluation of Bureau of Mines Synthane Process C. F. Braun Review of Equipment C. F. Braun Technical Evaluation - 1978 Soil and Foundation Investigation dtd. 1973 by Woodward-Moorhouse Engineering Evaluation and Study of Synthane Process by W. M. Kellogg and Company Economic Evaluation of Fluid Bed Gasification dtd. 1971 by M.E.R.C. Charlock Hopper Problems Miscellaneous Correspondence on Gasifier Gasifier Insulation Studies
B1	2	Start-Up Calculations 600# Operation with Rosebud Coal Calculations for Inert Gas Systems, CO ₂ Compressors, Heat Transfer, Gasifier, Shift Convertor Calculations on Cyclone, Char Cooler Spray Nozzles, Warehouse Inventory, Petrocarb, Charlock Hopper, Venturi Scrubber

LIBRARY INDEX

<u>Bookcase Number</u>	<u>Shelf Number</u>	<u>Contents</u>
B1	2 (cont'd)	Calculations on Benfield, Cold Coal Fluidization, Gasifier Pressure Traps, CO2 Compressor, Gasifier Calcs., Stretford System, Gas Scrubbing Calculations for Coal Fluidization Tests, Coal Feed Rate Determinations Flow Transmitter Control Valve Sizing Original Design Calculations 600# Pretreater Operation Calculations for 600# Rosebud Coal Start-Up Operation Manual Standard Operating Procedure Technical Manual
B1	3	Operators Manual for Utilities Combustion Calculations by Graphical Methods Coal and Char Handling Systems Gasifier Design Process Design Calculations, Vol. I & II 1000# Operation Original Calculations Material and Heat Balances for 600# Operation Gasifier Light-Off Design Calculations for 600# Operation Design Calculations for 600# & 1000# Operation - Petrocarb, Pretreater, Gasifier, Gas Scrubbing Calculations for Transport Line, Char Cooler, Cold Fluidization Tests, Coal Feed Rate, Char Cooler Spray Nozzle and Sieve Analysis Calculations on Gasifier Pressure Drop, Instrument Purges, Sampling Train, H.P. Char Slurry Tank (FA-401) Circulation and Misc. Info.

LIBRARY INDEX

<u>Bookcase Number</u>	<u>Shelf Number</u>	<u>Contents</u>
B1	3 (cont'd)	Original Job Calculations Calculations on Char Handling, Flare System, Utilities, 600 psig Hot Gas Test, O ₂ Plant, Coal Handling, Instrument Analyzers Calculations for Reranging of DP Transmitters for 600 psig Tests Hot Gas Test Redesign of Inert Gas Generating System Cold Coal Fluidization Test
B1	4	Original Run Reports for Gasifier Run 2-DB-A through 2-DB-F " through 2-DB-G through 2-DB-I " through 2-DB-J through 2-DB-N " through 2-DB-N through 2-DB-O " 2-DB-O " 1-A through 1-S " 1-Q through 1-T and 1-DB-A through 1-DB-F " 1-DB-G through 1-DB-N " 1-DB-G through 1-DB-O Reports on Coal Feed System Reports on Inert Gas Drying System Reports on Laboratory Final Report Reports on H.P. Pretreatment of Illinois #6 Coal Reports on Gasifier Sampling System Pretreater Report (Interim) Test Directives Coal Grinding Tests

LIBRARY INDEX

<u>Bookcase Number</u>	<u>Shelf Number</u>	<u>Contents</u>
B1	4 (cont'd)	Redesign of Inert Gas Generation System Operating and Manufacturers Instructions for Inert Gas Generator
B1	5	Test Directives for All Gasifier & Pretreater Runs Sample Analyses of All Gasifier Runs
B1	6	<u>Hot Char Let Down System</u> Phase I Final Report (2 copies) Execution Proposal Phase II Report (2 copies) Phase III Report <u>Process Data Acquisition Computer System</u> Installation & Hardware Manual, Vol. I Software & Operating Manual, Vol. II Instruction Manual - Multiple Scanivalve System Computer System Scope Report Operating Procedure Manual Monthly Inventory and Production Report Final Environmental Report (3 copies) Air and Water Pollution Laws Synthane Start-Up Manual (2 copies) Operating Manual (2 copies) Instrument Index Pipeline Index Drawing Index Lummus Technical Proposal, Vol. I Schneider Hydrostatic Test Records Invitation to Bid for the Construction of the Synthane Pilot Plant, Vol. I thru VI Purchase Orders for Relief and Control Valves Rust Purchase Orders

LIBRARY INDEX

<u>Bookcase Number</u>	<u>Shelf Number</u>	<u>Contents</u>
B2	1 (cont'd)	Price Quotations for Spare Parts (2 Volumes) Transcript Proceedings of the General Technical Advisory Committee of ERDA Listing of Vendor Drawing Numbers
B2	2	Coal Gasification Technical Related Papers Engineering Specifications A-211 through GA-202 Engineering Specifications GB-201 through L-213 Engineering Specifications L-214 through YF-231 Test Reports and Authorizations for Concrete and Piping X-Ray Log Plant Change Log Engineering Specifications Lummus Bid & Design Documents, Vol. I thru III
B2	3	Lummus Bid & Design Documents, Vol. IV & V Gasifier Nozzle Replacement & Certification Orifice Data Sheets Recommended Spare Parts Lists (2 Volumes) <u>Lummus Engineering Procedures Manuals</u> Project Execution Technical Project Welder Qualification Procedures Performance Assurance Plan Q.A. Summary Report H.P. Boiler Repair Notes Boiler Explosion Investigating Committee Notes

LIBRARY INDEX

<u>Bookcase Number</u>	<u>Shelf Number</u>	<u>Contents</u>
B2	4	Plant Deactivating Procedure (Stand-By) Maintenance Checks (Stand-By) Maintenance Guidelines (Stand-By) Security Procedure (Stand-By) S.O.P. Manual (Stand-By) Equipment Control Sheets, Book I & II (Stand-By) Instrumentation Storage Location, Book III (Stand-By) Instrumentation Index, Book IV (Stand-By) Instrument Index with Location, Book V (Stand-By) Equipment Stored in Warehouse, Book VI (Stand-By) <u>Equipment Operating Manuals</u> Plant Utilities and General Services Gravimetric Feeder Elevator (2 copies) Zink Sulfur Removal (PA-202) Zink Sulfur Removal (PA-202) Zink Air Heater (BE-302) Zink Flare System (CA-402X) Zink Thermal Oxidizer (CA-401X) <u>Equipment Operating Manuals</u> Illinois Water Treatment System (BG-301) (3 copies) H.P. Boiler Instrumentation Specifications H.P. Boiler Foxboro Equipment Original CE H.P. Boiler (BF-301) Repaired CE H.P. Boiler (BF-301) Inert Gas Generator (BE-301) O2 System Cooper Penjax Inert Gas Compressor (GB-303) Cooper Penjax Methanator Recycle Compressor (GB-202) Cooper Penjax Methanator Recycle Compressor (GB-201) Cooper Penjax CO2 Compressor (GB-301) (2 copies) Cooper Penjax CO2 Compressors Material Certs. Ingersol Rand Stand-By Air Compressor (GB-314) Ruthrauff HVAC Northern Propane Storage System (PA-304) (2 copies) Eimco Filters (PA-403) (2 copies)

LIBRARY INDEX

<u>Bookcase Number</u>	<u>Shelf Number</u>	<u>Contents</u>
B2	6	Text and Reference Hand Books
B3	TOP	Empty Carousel Slide Trays
B3	1	Run Report No. 1 (9 copies) Run Report No. 1-DB (2 copies) Supplement to Run Report No. 1-DB (2 copies)
B3	2	Run Report No. 1-DB (9 copies) Supplement to Run Report No. 1-DB (2 copies)
B3	3	Run Report No. 2-DB (9 copies)
B4	TOP	Various Slides and Official Presentation of Synthane Pilot Plant Photograph Album of Final Plant Status in Stand-By Condition Photographs of Synthane Plant in Various Stages from Construction to Shut-Down
B4	1	<u>Publications</u> Synthane Coal Gasification Brochure - Non Tech. Synthane Coal Gasification Brochure - Technical Energy Crisis Failure of Incoloy 800 Reducer @ Synthane Plant
B4	2	<u>Publications</u> Up-Date of Synthane Pilot Plant Status-10/77-10/78 Measurement of Pressure Fluidized Bed Level and Density in the Synthane Pilot Plant Coal Gasifier A Pictorial Tour of the Synthane Pilot Plant Engineering Aspects of the Synthane Coal Gasification Process Valve Applications at the Synthane Pilot Plant in Mixed Phase Erosive Service - 11/77 The Synthane Process - A technical and Economic Assessment - 12/77 Eighth Synthetic Pipeline Gas Symposium (AGA) Ninth Synthetic Pipeline Gas Symposium (AGA)
B4	3	<u>Publications</u> Valve Applications at the Synthane Plant in Mixed Phase Erosive Service - 6/78 Synthane Up-Date Mid '78 Synthane Project Review Lummus Presentation - 9/76 G.P.R.T. Review Report 11/78 DOE

LIBRARY INDEX

<u>Bookcase Number</u>	<u>Shelf Number</u>	<u>Contents</u>
B5	TOP	Property Lists and Flow Diagrams
B5	1	Various Vendor Catalogs
B5	2	Various Vendor Catalogs
B6	ALL	Computer System Operating Manuals and Records
B7	ALL	<u>Safety Related Materials</u> OSHA National Safety Council Safety Procedures Manual Related Safety Manual

LIBRARY INDEX

<u>File Cabinet Number</u>	<u>Drawer Number</u>	<u>Contents</u>
F-1	1	Vendor Equipment Files, BC-101X - BF-301
F-1	2	Vendor Equipment Files, BF-301 - BG-304
F-1	3	Vendor Equipment Files, BG-305 - DA-211B
F-1	4	Vendor Equipment Files, DC-202
F-2	1	Vendor Equipment Files, DC-202 (continued)
F-2	2	Vendor Equipment Files, DC-203 - EA-215
F-2	3	Vendor Equipment Files, EA-216 - FA-205
F-2	4	Vendor Equipment Files, FA-206 - FA-511
F-3	1	Vendor Equipment Files, FB-201 - FD-404
F-3	2	Vendor Equipment Files, FE-101 - GA-209
F-3	3	Vendor Equipment Files, GA-210 - GA-402
F-3	4	Vendor Equipment Files, GA-404 - GB-301
F-4	1	Vendor Equipment Files, GB-302 - JD-401
F-4	2	Vendor Equipment Files, PA-102
F-4	3	Vendor Equipment Files, PA-102 (cont.) - PA-202
F-4	4	Vendor Equipment Files, PA-301 - PA-522
F-5	1	Valves (Gen. Info.) EBV - PDCU-2205

NOTE: For detailed descriptions of above, see "Combined Real Property & Equipment List" located on top of file cabinet #F-1.

F-5	2	General Engineering Information of Plant Revisions and Changes
F-5	3	General Engineering Information of Plant Revisions and Changes
F-5	4	General Engineering Information on Plant Revisions and Changes
F-6	1	Rust P.O.'s - #1407-1, 21, 11, 43, 65, 75, 79, 80, 81, 82, 88, 89, 90, 91, 95, 97, 98, 99, 100, 101, 108, 117 and 119

LIBRARY INDEX

<u>File Cabinet Number</u>	<u>Drawer Number</u>	<u>Contents</u>
F-6	2	Rust P.O.'s - #1407-182, 6, 91, 108, 117, 122, 125, 126, 127, 128, 132, 133, 135, 136, 138, 139, 165, 177, 182, 183, 187, 211, 241, 246, 252, 254, 268, 290, 297, 320, 321, 332 and 338
F-6	3	Vendor Catalogs/Manuals - A to I
F-6	4	Vendor Catalogs/Manuals - I to M
F-7	1	Vendor Catalogs/Manuals - M to Z
F-7	2	Instrument Information - Data Sheets, Change Orders, Taylor Instrument Books
F-7	3	Process Analyzer's Operating and Maintenance Manuals
F-7	4	<u>Gasification Research Papers</u> "Suitable Materials" dtd. 7/12/76 for U.S.-E.R.D.A. "Metallurgical Exam" dtd. 11/17/78 by C.E. Power Systems "Failure of Incoloy 800 Reducer" dtd. 12/77 by B.N. Greene, The Lummus Co. "Measurement of Pressure, Fluidized Bed Level and Density" dtd. 7/77 by D.M. Bailey & O.D. Runnels, The Lummus Co. "Valve Applications in Mixed Phase Erosive Service" dtd. 11/77 by D.M. Bailey, A.W. Massa, O.D. Runnels and P.C. Strebinger, The Lummus Co. "Valve Applications in Mixed Phase Erosive Service" dtd. 6/78 by S.E. Carson & O.D. Runnels, The Lummus Co. "Mechanical Audit of Synthane Plant" under Job No. 7426 dtd. 8/1/75, The Lummus Co. "Materials Problems Experienced at Synthane Plant" by S. Danyluk, G.M. Dragel & D. Dubis, DOE "Coal Pressurization and Feeding Use of a Lock Hopper System" dtd. 2/77 by R. Lewis, R. Santore & D. Dubis, DOE

LIBRARY INDEX

<u>File Cabinet Number</u>	<u>Drawer Number</u>	<u>Contents</u>
F-7	4 (cont'd)	"Metallurgical Exam of Gasifier Dipley" dtd. 1/16/79 by M.H. Rafiee, C.E. Power Systems "Materials Experience" dtd. 12/15/78 by B.N. Greene, The Lummus Co. "Suitable Materials" dtd. 2/27/79 - supplement to Annual Progress Report from 1/78 to 12/78 by The Metal Properties Council "Gasifier Distributor Cone Thermocouple Sheath (TE-268) Failures" dtd. 10/76 by S. Danyluk & G. Dragel, Argonne National Laboratory "Analysis of Pump Shaft (GA-207) Failures" dtd. 4/78 by same authors as above "Thermowell (TE-205) Failure" dtd. 5/78 by same authors as above "Weld Neck Flange Failure" dtd. 11/76 by same authors as above "Stress-Corrosion Cracking in 316SS Tubes" dtd. 12/77 by same authors as above "Analysis of Rabble Arm Cracks" dtd. 7/77 by same authors as above "Materials Technology for Coal-Conversion Processes" dtd. April-June 1977 by Argonne National Lab
F-8	1	D.O.E. Contract 1978-1980 Start-Up Plan Monthly Activity Reports, #1 dtd. 10/74 through #53 dtd. 1/79 Quarterly Operations Reports, #1 dtd. Aug.-Oct. 1974 through #16 dtd. 4th qtr. or 1978 Annual Operations Reports, #1 dtd. 1975 through #4 dtd. 1978

LIBRARY INDEX

<u>File Cabinet Number</u>	<u>Drawer Number</u>	<u>Contents</u>
F-8	2	Monthly Financial and Administrative Report #51 dtd. 2/5/79
		Analysis of Contract Cost EY-76-C2-0003. *000
F-8	3	EMPTY
F-8	4	EMPTY
F-9	ALL	Computer Program Decks

LIBRARY INDEX

(Technical Department Files)

<u>File Cabinet Number</u>	<u>Drawer Number</u>	<u>Contents</u>
F-10	1	Weekly Reports dtd. 1/4/76 through 2/4/79 Monthly Reports dtd. 2/76 through 12/78 Gasifier Reports dtd. 1976 through 1978 Braun Report dtd. 1975
F-10	2	Technical Support Committee Petrocarb Unit, 1975 through 1978 Pretreater, 1976 through 1978 D.O.E. Memoranda and Test Directives Coal and Coal Grinding Laboratory Reports Benfield Unit Sulphur Recovery Unit Methanation Oxygen Plant Gasifier Sampling System Sampling Gasifier Cyclone LPG and Fuel Oil Flare and Thermal Oxidizer
F-10	3	Gas Scrubber Venturi Scrubber Char Filtration and Pond Inert Gas and CO ₂

LIBRARY INDEX

(Technical Department Files)

<u>File Cabinet Number</u>	<u>Drawer Number</u>	<u>Contents</u>
F-10	3 (cont'd)	Steam and Boiler Water Cooling Water Boiler Water Softener Char Cooler Cooling Coils Gasifier O ₂ Distribution Petrocarb Rotary Feeder 250 psig Operation Gasifier 14 Day Run IGT Drawings
F-10	4	Air Monitoring Reports Air Pollution Control Regulations Synthane Environmental Steering Committee Meeting Reports Air Permits NPDES Monitoring Results Other Environmental Reports NPDES Permit - Correspondence with E.P.A. Allegheny County Air Permit Forms Water Softener NPDES Permits - State Permits & Correspondence Water Permit Applications Neutralization Pit Additions Inlet Water Treatments

LIBRARY INDEX

(Technical Department Files)

<u>File Cabinet Number</u>	<u>Drawer Number</u>	<u>Contents</u>
F-10	4 (cont'd)	Oil Spill Reports Environmental Reports - 1977 through 1978 Sewage Treatment Plant Operation Plant Operating Summary Solids Disposal Analytical Results for Effluent Discharges Plant Effluent Sampling Oil Pads and Booms Information Plant Sewer Systems Testing Benzene Study Sanitary Treatment Plant Operating Manual Environmental Impact Statement Toxic Substance Control Act Photographs of Synthane Discharge Site Sampling SPCC Plan Environmental and EPA, 1979

LIBRARY INDEX

(Laboratory Files)

<u>File Cabinet Number</u>	<u>Drawer Number</u>	<u>Contents</u>
F-11	1	Run Reports, Test Directives, Lab Log Books 1975-1979, Lab Data Computer Sheets 1975-1978
F-11	2	Lab Inter-Office Memos & Correspondence, A to P (see file index in front of drawer for detailed contents)
F-11	3	Lab Inter-Office Memos & Correspondence, Q to W (see file index in front of drawer for detailed contents)
F-11	4	Lab Data Computer Sheets 1978-1979 and Vendor Catalogs on Laboratory Equipment
F-12	1	Computer Program Documentation, AAI thru STATS
F-12	2	Computer Program Documentation, STM thru WRTAPE
F-12	3	Weekly Reports, General Information, Computer Information and Instrument Change Orders
F-12	4	FLIC Documentation

LIBRARY INDEX

Material stored in boxes (almost all this material is a duplicate of what is in files or bookcases).

Box #1

C.E. Synthane Operations Manual
C.E. Synthane Technical Manual
C.E. Synthane Safety Procedures Manual
C.E. Technical Task Force Audit Report - January 1976
Process Design Calculations
Invitation for Bid - Original Contract
Start-up Plan (2)
Gasifier - Redesign for 150 psi operation
Gasifier - Nozzle Replacement Report
Notes and Calculations - Dr. I. Gjerle
Rockwell Valve Study
Lummus Operating Manual
Gasifier - Specifications & Drawings
DOE/GPRT Report - November 1978
Lummus/GPRT Report - November 1978
Lummus Presentation - September 1976

Box #2

Dedication Information (3)
Instrumentation Manual - Type VU Boiler
ASTM Standards - seven volumes
Procurement Policies - Cost Type Contractors

Box #3

Hot/Dry Char Letdown System, PH. I, II, & III
1407-7 Operation, Maintenance & Repair - Elevator
1407-7 Parts Manual - Pittsburgh Elevator Company
BE-302 In-line Burner
1407-87 Zink Thermal Oxidizer
Operations Manual - Utilities and General Services for USBM

Box #4

Instruction Manual - Computer, 5 volumes
Installation and Hardware Manual - Computer, volume 1
Software and Operations Manual - Computer, volume 2
GTAC Meeting - Fossil Energy
Operating Manual - Coal Gas Prototype Plant
Job Instructions - 7426
Appendix - Lummus Presentation - September 1976

LIBRARY INDEX

Box #5

Synthane Project Review - November 1978
Analysis of Contract Cost
Procedures for Deactivation

Box #6

ASTM Standards - 1976, 17 volumes

Box #7

Lummus Standard Operations Procedures
Lummus Technical Manual
Instrument Data Book
Summary - Coal Grinding Tests
Test Directives
Report - Pretreatment of Illinois #6 Coal

Box #8

Miscellaneous Drawings
IWT Operations Manual
HVAC - Operations Manual
Eimco - Operations Manual
H.P. Boiler - Operations Manual
Run Reports, 1-DB - G, H, I, J

Box #9

Run Reports 1-DB Supplements - 15 copies
Test Procedures & Reports

Box #10

Operations Manual - Zink Air Heater (1407-84)
Operational Manual - Zink Thermal Oxidizer
Run Report #2-DB, September 1977 to August 1978
Equipment List
Diagrams - H.P. Boiler

Box #11

Technical Operations Manual
Run Report #1-DB, 1977
Run Report #1-DB, Supplement
Instruction Manual, H.P. Boiler, BF-301
Appendix GPRT Presentation, November 1978 (2 volumes)

LIBRARY INDEX

Box #12

Gasifier - Nozzle Replacement & Certification (2)

Process Data Acquisition - Computer

National Fire Codes - 15 volumes

C.E. Contract 87272

Box #13

Miscellaneous Vendor Catalogs

Box #14

Operations Manual - J. Zink, Sulphur Removal System

Operations Manual - J. Zink, Thermal Oxidizer

Computer Manuals - Installation and Hardware

DAVCO - Sewage Treatment Operations Manual

Project Review Contract - #E-36-2003

Box #15

Government Contracts Reporter - 5 volumes

Procurement Regulations - Volume #1

Box #16

Government Contracts Reporter - Volumes 6, 7, 8

Volume I - Technical Proposal

Box #17

ASTM Standards - 1973, 12 volumes

Box #18

ASTM Standards - 1973, 1974, 1975

Box #19

Spare Parts - Quotations - Rust

Technical Manual - 2 volumes

Standard Operating Procedures - 3 volumes

Operations Manual

Synthane - Technical Economic Assessment

Foxboro - Instrumentation H.P. Boiler

LIBRARY INDEX

Box #20

Misc. Reports (duplicates) and correspondence - D.M. Bailey

Box #21

Misc. Reports, Drawings, correspondence - G. Cliff

Box #22

Operations Manuals
Standard Operating Procedures
Willis Valve Catalogs

Box #23

Equipment Operating Manuals

Box #24

Equipment Operating Manuals

Box #25

Equipment Operating Manuals

Box #26

Equipment Operating Manuals

Box #27

GPRT Presentation & Appendix

Box #28

Computer Manuals - seven volumes

Box #29

PATH
Operations Manuals
Systems Manual
IWT Manual
Cost Codes
Procurement Policies

LIBRARY INDEX

Box #30

Job Instructions #B7426
Environmental Report
OSHA Standards - 4 copies
Safety Procedures - 4 volumes
Computer Manuals

Box #31

GPRT Presentation - Appendix, November 1978

Box #32

Misc. Computer Manuals
FLIC System

Box #33

Misc. Reports and Manuals - D.M. Bailey

Box #34

Eyetone Glucose Tester and Manuals
Misc. Medical Equipment

Box #35

Run Report #1-DB - 3 copies

Box #36

Run Report #1-DB - 3 copies

LIBRARY INDEX

Plant Drawings

The Library also contains two (2) Drawing Files. The original copies of all Plant related drawings are stored in these two (2) files. Drawing references are kept in file cards on the top of each cabinet. An Instrument index file is also available.

APPENDIX D

DOCUMENTS STORED IN THE SYNTHANE PILOT PLANT LIBRARY

GENERAL

1. Test Directives
2. Run Reports No. 1 and No. 1-DB
3. Individual Run Reports A-A thru -T and 1-DB-A thru -O
4. Lummus Design Books
5. Published Reports
6. Inventory of Equipment

OPERATIONS

1. Standard Operating Procedures
2. Operations Manual

TECHNICAL

1. Technical Manual
2. Technical Project Reports
3. Technical File
4. SEMPEP File
5. Quality Control File
6. Lab File
7. Computer Books
8. Report, "High Pressure Pretreatment of Illinois No. 6 Coal"
9. Report: "Coal Feed System"
10. Report: "Coal Grinding Tests"
11. Report: "Inert Gas Drying"
12. Report: "Gasifier Sampling"
13. Report: "Valve Failure Analysis"

APPENDIX D

DOCUMENTS STORED IN THE SYNTHANE PILOT PLANT LIBRARY

(continued)

ENGINEERING

1. Engineering Drawing Sepia Flat Files
2. Engineering Drawing Standard Files
3. Engineering File
4. Maintenance File
5. Equipment Control Index
6. Instrument Index
7. Vendor Books for Equipment Items

ENVIRONMENTAL

1. Environmental Report
2. Environmental Statement
3. Air and Water Permits

DEACTIVATION AND REACTIVATION

1. Deactivation and Reactivation Procedures

APPENDIX D

LIBRARY

Technical Manual Updated
SOP Manual Updated
Operations Manual
Deactivation and Plant Equipment Condition
Environmental Report
Run Reports with Data
Test Directive Updated
Lummus Design Books
Technical Project Reports
Computer Books
Engineering Drawing Sepia Flat File
Engineering Drawing Standard File
Lab File
Engineering File
Technical File
Maintenance File
Published Reports
Safety Audit Braun and Lummus
SEMPEP Files
Quality Control Files

APPENDIX D

TECHNICAL ENGINEERING DEPARTMENT

ADDITIONAL REPORTS

The originals of these reports may be found in the Synthane Pilot Plant Bruceton Library.

1. Test Directive

This report contains the start-up and operating procedures which would have been used for the next plant start-up following Run 2-DB-O. It does not recognize procedural changes that would have to be made if the recommended pretreater/gasifier mechanical changes were effected.

2. High Pressure Pretreatment of Illinois No. 6 Coal

This report details the plant experience when feeding the pretreater with Illinois No. 6 coal. The contents of this report leads to the recommendation that experimentation with in-line coal pretreatment should be done.

3. Coal Feed System

This report contains the plant experience with the Petrocarb Unit from a process aspect only. It discusses the process changes made resulting in Run 2-DB-O coal feed line configuration.

4. Coal Grinding Tests

This report discusses the changes made to the vibrating screen and the hammers in the impact mill to reduce the fines production and limit the coarse end of the ground coal to less than 20 to 30 U.S. Mesh.

APPENDIX D

TECHNICAL ENGINEERING DEPARTMENT

ADDITIONAL REPORTS

(continued)

5. Inert Gas Drying

This report recommends and provides a solution to the wet inert gas problem in the Petrocarb Unit and the main inert gas piping. Water condensation in the inert gas liner gave problems in coal feeding and Petrocarb Unit pressurization.

6. Gasifier Sampling

This report outlines the recommended operating procedures and equipment necessary to sample the gasifier overhead directly. It also provides a means of sampling downstream of the gas scrubbing tower.

APPENDIX D

REPORTS

Reports for each individual run A through T may be found in the Bruceton Synthane Pilot Plant Library.

Run Report No. 1 (COO-0003-20 Dist. Category UC-90C) covering the operating period July through December 1976 may be found in the Bruceton Synthane Pilot Plant Library.

Reports for each individual run 1-DB-A through O may be found in the Bruceton Synthane Pilot Plant Library.

Run Report No. 1-DB (COO-003-26 Dist. Category UC-90C) covering the operating period February through August 1977 may be found in the Bruceton Synthane Pilot Plant Library.

APPENDIX E

EQUIPMENT LIST

PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
LOCATION: BRUCETON, PENNSYLVANIA

DATE _____

PAGE 1 OF 26

EQUIP.	DESCRIPTION	P.O.	REF. P&I	SUPPLIER	REMARKS
DC-101X	DRYING AIR HEATER	1407-40	01005A	COMB.ENG.RAYMOND	PART OF PA-102 SPEC. 32
BE-301	INERT GAS GENERATOR	1407-64	03027	GAS. ATMOS.	PART OF BE-102 SPEC. 32
BE-301S	INERT GAS GENERATOR	1407-64	03027	GAS. ATMOS.	PART OF BE-102 SPEC. 32
BE-302	IN-LINE BURNER	1407-84	02005A2	JOHN ZINK	PART OF BE-103 SPEC. 16
BF-301	HI PRESSURE BOILER	6656-100	03012A	COMB.ENG.	PART OF BF-103 SPEC. 50
BF-302	LOW PRESSURE BOILER (PM)	1407-61	03012B	CLEVER BROOKS	PART OF BF-104 SPEC.
BF-302S	LOW PRESSURE BOILER (PM)	1407-61	03012B	CLEVER BROOKS	PART OF BF-104 SPEC.
BF-303	STEAM SUPERHEATER		01005A1	F.WHEELER/IGT	40
BF-402	THERMAL OXIDIZER	1407-87	03020	JOHN ZINK	PART OF BF-105 SPEC. 120
BH-201	DE-SUPERHEATER FOR CHAR COOLER		02005A2		8
					360

402

PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
LOCATION: BRUCETON, PENNSYLVANIA

JOB NO. 30

DATE _____

PAGE 2 OF 26

192.

JOB NO. 330
DATE _____
PAGE 3 OF 26

[illegible]

EQUIPMENT CONTROL INDEX
PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
LOCATION: BRUCETON, PENNSYLVANIA

JOB NO. 6530
 DATE _____
 PAGE 4 OF 26

EQUIP.	DESCRIPTION	P.O.	REF. P&I	SUPPLIER	REMARKS
DC-201	DELETED				
DC-202	GASIFIER	6588-	02005A2	F. W. GLITSCHE	76
DC-203A	SPONGE IRON REACTOR	407-57	02005F	VALCAN MFG.	16
DC-203B	SPONGE IRON REACTOR	407-57	02005F	VALCAN MFG.	16
DC-204A	CARBON REACTOR	407-52	02005F	NATIONAL ANN BOX	16
DC-204B	CARBON REACTOR	407-52	02005F	NATIONAL ANN BOX	16
DC-205	TWR METHANATOR	4-7-50	02005G	FOSTER WHEELER	16
DC-206	HGR METHANATOR	407-50	02005H	BOARMAN	16
DC-207	FINAL METHANATOR	407-50	02005G	BOARMAN	16
DC-208	SHIFT CONVERTER	407-50	02005D	BOARMAN	16
DC-209	20" Ø PRETREATER	407-50	02005A	BOARMAN	32
DC-210	ALT. FINAL METHANATOR	407-50	02005H	BOARMAN	16
DC-211	DELETED				
DC-501	REACTOR TANK	407-44	02005J	JOHN ZINK	24
DC-502	OXIDIZER NO. 1	407-44	02005J	JOHN ZINK	32
DC-503	OXIDIZER NO. 2	407-44	02005J	JOHN ZINK	32
					360

EQUIPMENT CONTROL INDEX
PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
LOCATION: BRUCETON, PENNSYLVANIA

JOB NO. 30
DATE
PAGE 5 OF 26

EQUIP.	DESCRIPTION	P.O.	REF. P&I	SUPPLIER	REMARKS
EA-201	SCRUBBER RECYCLE CLR	1407-35	02005C1	HEATLAN, INC.	24
EA-201S	SPARE	1407-35	02005C1	HEATLAN, INC.	24
EA-202	SHIFT FEED/EFFLUENT EX. (2ND STAGE)	1407-47	02005D	SMITHCO ENG.	24
EA-203A	SHIFT EFFLUENT COOLER	1407-35	02005D	HEATLAN, INC.	24
EA-203B	SHIFT EFFLUENT COOLER	1407-35	02005D	HEATLAN, INC.	24
EA-204	REGENERATOR REBOILER	1407-35	02005E	HEATLAN, INC.	24
EA-205	HRC TRIM COOLER	1407-35	02005E	HEATLAN, INC.	24
EA-206	ABSORBER EFFLUENT CIR	1407-47	02005E	SMITHCO ENG.	24
EA-207	ACID GAS COOLER	1407-35	02005E	HEATLAN, INC.	24
EA-208	METHANATOR FEED EFFLUENT EXCH.	1407-47	02005G	SMITHCO ENG.	24
EA-209	METHANATOR EFFLUENT EX.	1407-47	02005G	SMITHCO ENG.	24
EA-211	METHANATOR START-UP HEATER	1407-47	02005G	SMITHCO ENG.	24
EA-213	WASTE WATER COOLER	1407-35	02005C1	HEATLAN, INC.	24
EA-213S	SPARE	1407-35	02005C1	HEATLAN, INC.	24
EA-214	COLD RECYCLE COOLER	1407-47	02005H	SMITHCO ENG.	24
EA-215	FINAL METHANATOR HEATER	1407-47	02005G	SMITHCO ENG.	24
EA-216	FINAL METHANATOR COOLER	1407-47	02005G	SMITHCO ENG.	24
EA-217	ALTERNATE METH. START-UP HEATER	1407-47	02005H	SMITHCO ENG.	24
EA-218	VENTURI CIRCULATING WATER COOLER	1407-35	02005C1	HEATLAN, INC.	24
EA-218S	SPARE	1407-35	02005C1	HEATLAN, INC.	24
EA-219	ALTERNATE FINAL METHANATOR HEATER	1407-47	02005H	SMITHCO ENG.	24
EA-220	ALTERNATE FINAL METHANATOR COOLER	1407-47	02005H	SMITHCO ENG.	24
EA-222	SHIFT FEED/EFFLUENT EXCH (1st STAGE)	1407-47	02005D	SMITHCO ENG.	24
EA-223	DOWTHERM COOLER STEAM BOILER	1407-35	02005F	HEATLAN, INC.	24
EA-224	DELETED				
EA-225A&B	WASTE WATER HEAT EXCHANGER		02005C1		46
EA-226A&B	CONDENSERS (GAS SAMPLING SYSTEM)		02030		626 48

EQUIPMENT CONTROLL INDEX
PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
LOCATION: BRUCETON, PENNSYLVANIA

JOB NO. 8530
DATE
PAGE 6 OF 26

EQUIP.	DESCRIPTION	P.O.	REF. P&I	SUPPLIER	REMARKS
EA-301X	LIQUID OXYGEN VAPORIZER	USBM			PART OF PA-301 BY OTHERS
EA-302X	1ST STAGE INTERCOOLER	1407-43	03027	COOPER-PENJAX	PART OF GB-303 24
EA-302SX	SPARE	1407-43	03027	COOPER-PENJAX	PART OF GB-303S 24
EA-303X	2ND STAGE INTERCOOLER	1407-43	03027	COOPER-PENJAX	PART OF GB-303 24
EA-303SX	SPARE	1407-43	03027	COOPER-PENJAX	PART OF GB-303S 24
EA-304	AFTER COOLER	1407-43	03027	COOPER-PENJAX	PART OF GB-303 24
EA-304SX	SPARE	1407-43	03027	COOPER-PENJAX	PART OF GB-303S 24
EA-305X	1ST STAGE INTERCOOLER	1407-43	03024	COOPER-PENJAX	PART OF BG-301 16
EA-305SX	SPARE	1407-43	03024	COOPER-PENJAX	PART OF GB-301S 16
EA-306X	2ND STAGE INTERCOOLER	1407-43	03024	COOPER-PENJAX	PART OF GE-301 16
EA-306SX	SPARE	1407-43	03024	COOPER-PENJAX	PART OF GB-301S 16
EA-307	CO2 COOLER		03024	SMITHCO	24
EA-308	CO2 LEATER	1407-47	03024	HEATLAN, INC.	24
EA-309	MELTANATOR EFFLUENT EX.	1407-47	03024	SMITHCO	24
EA-310X	INTERCOOLER	1407-34	03019	JOY MFG.	PART OF GE-304 16
EA-310SX	SPARE	1407-34	03019	JOY MFG.	PART OF GB-304 16
EA-311	STEAM CONDENSED	1407-35	03012C	HEATLAN, INC.	24
EA-312X	AFTER COOLER	1407-34	03019	JOY MFG.	PART OF GE-304 24
EA-312SX	SPARE	1407-34	03019	JOY MFG.	PART OF GB-304S 24
EA-313X	3RD STAGE INTERCOOLER	1407-43	03019	COOPER-PENJAX	PART OF GB-301 16
EA-313SX	SPARE	1407-43	03019	COOPER-PENJAX	PART OF GB-301S 16
EA-314X	DEMIN. WATER REGEN. HTR.	1407-79	03026	ILL.WATER.TREAT.	16
EA-315X	A&F PRESSURE BUILD-UP COIL 1 & 2	1407-		AIR PRODUCTS	PART OF PA-301 BY OTHERS
EA-316X	STEAM TRIM HEATER			AIR PRODUCTS	PART OF PA-301 BY OTHERS
EA-350	FEED WATER HEATER FOR IWT UNIT		03026		16
					448

PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
LOCATION: BRUCETON, PENNSYLVANIA

PAGE 7 OF 26

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407

PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
LOCATION: BRUCETON, PENNSYLVANIA

DATE _____

PAGE 8 OF 26

[illegible]

607

EQUIPMENT CONTR L INDEX
PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
LOCATION: BRUCETON, PENNSYLVANIA

JOB NO. 8530
DATE _____
PAGE 9 OF 262

EQUIP.	DESCRIPTION	P.O.	REF. P&I	SUPPLIER	REMARKS
EE-101	STEAM EDUCTOR FOR COAL PIT DRAIN		01005A		
EE-201	VENTURI SCRUBBER	1407-62	02005C1	GRAM MFG. CO.	16
EE-202	VENTURI SCRUBBER		02005C1		16
EE-401&S	STEAM EDUCTOR FOR GA-404 & S		03020		
EE-533	STEAM EDUCTOR FOR SULFUR STORAGE TANK	1407-44	02005J--	JOHN ZINK	
EF-202	DELETED				
EF-301	COOLING TOWER	1407-9	03017	PRITCHARD	40
EF-501	COOLING TOWER	1407-44	02005J	JOHN ZINK	24
EG-201	RECYCLE EDUCTOR	1407-55	02005H	SCHUTTE KOERTING	16
EG-301	DEAERATOR	1407-81	03012C	CHICAGO HEATER	
					112

410

EQUIPMENT CONTROLL INDEX
PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
LOCATION: BRUCETON, PENNSYLVANIA

JOB NO. 0330
DATE
PAGE 10 OF 26

EQUIP.	DESCRIPTION	P.O.	REF. P&I	SUPPLIER	REMARKS
FA-201	CARBONATE SOL. MIX TANK	1407-46	02005E	SOUTHERN TANK	24
FA-202	DECANTER	1407-51	02005C2	METAL EQUIP. CO.	24
FA-203	ABSORBER FEED K.O. DRUM	1407-60	02005D	BUFFALO TANK	24
FA-204	ABSORBER EFFLUENT K.O. DRUM	1407-46	02005E	SOUTHERN TANK	24
FA-205	ACID GAS K.O. DRUM	1407-46	02005E	SOUTHERN TANK	24
FA-206	METH. EFFLUENT K.O. DRUM	1407-46	02005G	SOUTHERN TANK	24
FA-207	ALT. METH. EFFLUENT K.O. DRUM	1407-46	02005H	SOUTHERN TANK	24
FA-208	DOWTHERM HEAD TANK	1407-46	02005F	SOUTHERN TANK	24
FA-209	FINAL METH. EFFLUENT K.O. DRUM	1407-46	02005G	SOUTHERN TANK	24
FA-211	DELETED	1407-46	02005C2	SOUTHERN TANK	-
FA-212	ALT. FINAL METH. EFFLUENT K.O. DRUM	1407-46	02005H	SOUTHERN TANK	24
FA-213	VENTURI SCRUBBER START-UP DRUM	1407-46	02005C1	SOUTHERN TANK	24
FA-215	SCRUBBER SURGE TANK	1407-52	02005C1	NATIONAL BOX	24
FA-217	DELETED	1407-46	02005C2	SOUTHERN TANK	-
FA-218	WASTE HEAT DRUM	1407-46	02005C1	SOUTHERN TANK	24
FA-219	CHAR COOLER HEAD TANK	1407-46	02005A2	SOUTHERN TANK	24
FA-220	CHAR FINES DRUM	1407-52	02005D	NATIONAL BOX	24
FA-221	ALTERNATE PREPREATER DUMP POT	1407-52	02005A1	NATIONAL BOX	24
FA-222	CHAR COOLER DUMP POT	1407-52	02005A2	NATIONAL BOX	24
FA-223	DELETED				-
FA-224	WASTE WATER SURGE TANK	1407-60	02005C2	BUFFALO TANK	24
FA-225	CONDENSATE POT		02005H		
FA-226	DELETED				-
FA-227	CONDENSATE FLASH TANK		03013		
FA-230	CONDENSATE RECEIVER		02030		432

EQUIPMENT CONT. INDEX
PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
LOCATION: BRUCETON, PENNSYLVANIA

JOB NO. 8530

DATE

PAGE 11 OF 26

EQUIP.	DESCRIPTION	P.O.	REF. P&I	SUPPLIER	REMARKS
FA-301X	I. G. GENERATOR K.O. POT	1407-64	03027	GAS ATMOS.	PART OF BE-301 8
FA-301SX	SPARE	1407-64	03027	GAS ATMOS.	PART OF BE-301S 8
FA-302	CO2 K.O. DRUM	1407-46	03024	SOUTHERN B. TANK	100
FA-303X	1ST STAGE K.O. POT	1407-43	03027	COOPER-PENJAX	PART OF GB-303 16
FA-303SX	SPARE	1407-43	03027	COOPER-PENJAX	PART OF GB-303S 16
FA-304X	2ND STAGE K.O. POT	1407-43	03027	COOPER-PENJAX	PART OF GB-303 16
FA-304SX	SPARE	1407-43	03027	COOPER-PENJAX	PART OF GB-303S 16
FA-306X	1ST STAGE K.O. POT	1407-43	03024	COOPER-PENJAX	PART OF GE-301 16
FA-306SX	SPARE	1407-43	03024	COOPER-PENJAX	PART OF GE-301S 16
FA-307X	2ND STAGE K.O. POT	1407-43	03024	COOPER-PENJAX	PART OF GE-301 16
FA-307SX	SPARE	1407-43	03024	COOPER-PENJAX	PART OF GE-301S 16
FA-308	4TH STAGE K.O. POT	1407-46	03024	SOUTHERN T.B.	16
FA-309	H.P. INERT GAS RECEIVER	1407-46	03027	SOUTHERN T.B.	40
FA-310X	LIQ. OXYGEN STRG. TK.	USBM		SOUTHERN T.B.	PART OF GE-304 16
FA-311	H.P. CO2 RECEIVER	1407-52	03024	NATIONAL BOX	PART OF GE-301 40
FA-312	CONDENSATE RECEIVER	1407-46	03012C	SOUTHERN B. TANK	PART OF GB-301S 8
FA-313X&SX	INST./PLANT AIR RECEIVER	1407-34	03019	JOY MFG.	PART OF GB-303 8
FA-314X	3RD STAGE K.O. POT	1407-43	03024	COOPER-PENJAX	PART OF GB-303S 16
FA-314SX	SPARE	1407-43	03024	COOPER-PENJAX	16
FA-315X	I.G. COMP. SUCTION POT	1407-34	03027	COOPER-PENJAX	8
FA-315SX	SPARE	1407-34	03027	COOPER-PENJAX	8
FA-316X&SX	VAPOR ELIMINATOR	USBM		AIR PRODUCTS	PART OF PA-301 BY OTHER
FA-317X	A THRU F GASEOUS OXYGEN	USBM		AIR PRODUCTS	PART OF PA-301
FA-320	CONDENSATE POT		03012C		
FA-327	CONDENSATE FLASH TANK		03013		
FA-328	CONDENSATE FLASH TANK		03013		420

EQUIPMENT CONTINUED INDEX
PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
LOCATION: BRUCETON, PENNSYLVANIA

JOB NO. 8530
DATE _____
PAGE 12 OF 26

EQUIP.	DESCRIPTION	P.O.	REF. P&I	SUPPLIER	REMARKS
FA-329	PLANT AIR RECEIVER		03019		-
FA-330	LPG TANK		09901		-
FA-401	CHAR SLURRY TANK	1407-52	04005B	NATIONAL BOX	16
FA-402	FLARE K.O. TANK	1407-46	03020	SOUTHERN	16
FA-403	SLURRY FILTER FEED TANK	1407-46	04005B	SOUTHERN	24
FA-404X	FILTRATE RECEIVER	1407-56	04005B	EIMCO	PART OF PA-402 16
FA-405X	VACUUM PUMP K.O. POT	1407-56	04005B	EIMCO	PART OF PA-402 16
FA-406	L.P. CHAR SLURRY TANK	1407-51	04005A	METAL EQUIP.CO.	24
FA-470	DELETED				-
FA-408	K.O. DRUM (THERMAL OXIDIZER)		03020		16
FA-409A	NORTH EFFLUENT HOLDING TANK		03025		-
FA-409R	SOUTH EFFLUENT HOLDING TANK		03025		-
FA-414	CONDENSATE FLASH TANK		03013		-
FA-501	SOLUTION SURGE TANK	1407-44	02005J	JOHN ZINK	24
FA-502	SEPARATOR TANK FOR ABSORBER	1407-44	02005J	JOHN ZINK	24
FA-511	SUMP TANK	1407-44	02005J	JOHN ZINK	16
FA-524	DELETED	1407-44	02005J	JOHN ZINK	-
FA-526	PART OF COND. RETURN UNIT PA-501	1407-44	02005J	JOHN ZINK	-
FA-528	VACUUM RECEIVER	1407-44	02005J	JOHN ZINK	16
					208

EQUIPMENT CONTROL INDEX
PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
LOCATION: BRUCETON, PENNSYLVANIA

JOB NO. 8530

DATE

PAGE 13 OF 26

EQUIP.	DESCRIPTION	P.O.	REF. P&I	SUPPLIER	REMARKS
FB-201	H.P.C. SOL STORAGE TANK	51	02005E	METAL EQUIP.	16
FB-202	CAUSTIC CIRC. TANK	46	02005F	SOUTHERN BOILER	16
FB-203	PURGE BREAK TANK				8
FB-301	DEMINERALIZED WATER STORAGE TANK	8	03026	PITT-DESMOINES	24
FB-302	L.P. INERT GAS RECEIVER	8	03027	PITT-DESMOINES	100
FB-305	FUEL OIL TANK	46	03020	SOUTHERN	-
FB-306X	PHOSPHATE TANK	63	03020 03012C	BETZ	PART OF BG-303 8
FB-307X	HYDRAZINE TANK	63	03012C	BETZ	PART OF BG-303 8
FB-309	ACID TANK	51	03026	METAL EQUIP.	32
FB-310	CAUSTIC TANK	60	03026	BUFFALO TANK	32
FB-311	L.P. CO2 RECEIVER	8	03024	PITT-DESMOINES	100
FB-312X	PHOSPHATE SOLUTION TANK	63	03012C	BETZ LAB	PART OF BG-309 8
FB-313	STEAM BLOWOFF TANK	86	03012C	THOMPSON TRACTOR	PART OF GE-301
FB-314X	EMERG. GEN. F.O. TANK	46	03020	SOUTHERN BOILER	
FB-315	FUEL OIL STORAGE TANK	407-19	03020	RICHMOND ENG.	
FB-316AX	EAST LIQUID CO2 STORAGE TANK		04005J		PART OF PA-314
FB-316BX	WEST LIQUID CO2 STORAGE TANK		04005J		PART OF PA-314
FB-401X	TAR TANK	407-87	03020	JOHN ZINK	PART OF BF-402 8
FB-402	LPG STORAGE TANK	USBM			OLD PROPANE TANK
FB-403	CHAR SLURRY HOLDING TANK				WILL GO INSIDE CHAR POND 24
					314

EQUIPMENT CONTROL INDEX
 PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
 LOCATION: BRUCETON, PENNSYLVANIA

JOB NO. 8530
 DATE _____
 PAGE 14A OF 262

EQUIP.	DESCRIPTION	P.O.	REF. P&I	SUPPLIER	REMARKS
FR-501	SLURRY TANK	1407-44	02005J		24
FR-531	SULFUR STORAGE TANK	1407-44	02005J	JOHN ZINK	24
FC-101X	CYCLONE SEPARATOR	1407-40	01005A	RAYMOND DIV.	PART OF PA-102 SPEC. 16
FC-401 A/B	CYCLONE		04005B		16
FD-101X	DRIED COAL VIBRATING SCREEN	1407-40	01005A	RAYMOND DIV.	16
FD-102X	RAW COAL STORAGE TANK VENT STORAGE	1407-33	01005A	CONVEYOR ENG.	16
FD-206A/B	FILTER SETTLERS		02030		16
FD-201	HOT CARBONATE FILTER	1407-99	02005E	CUNO	-
FD-202A	STEAM FILTER	1407-57	02005D	VULCAN MG. CO.	-
FD-202B	STEAM FILTER	1407-57	02005D	VULCAN MG. CO.	-
FD-203A	DELETED	1407-99	02005A-2	CUNO	-
FD-203B	DELETED	1407-99	02005A-2	CUNO	-
FD-204A&B	DELETED	1407-98	02005A-2	PALL TRINITY	-
FD-205	DELETED	1407-44	02005A-2	JOHN ZINK	-
FD-301X	AIR COMP. INTAKE FILTER	1407-34	03019	GAS DRYING	-
FD-301SX	SPARE	1407-34	03019	GAS DRYING	-
FD-302X	AIR DRIER PRE-FILTER	1407-41	03019	GAS DRYING	-
FD-303X	AIR DRIER PRE-FILTER	1407-41	03019	GAS DRYING	128

EQUIPMENT CONT'L INDEX
PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
LOCATION: BRUCETON, PENNSYLVANIA

JOB NO. 8530
DATE _____
PAGE 142 OF 26

EQUIP.	DESCRIPTION	P.O.	REF. P&I	SUPPLIER	REMARKS
FD-304SS	IN-LINE FILTERS PART INERT GAS		03027		PART OF DE-301
FD-305	IN-LINE FILTERS FOR CO ₂ COMPRESS.		03024		PART OF GB-301
FD-306	IN-LINE FILTERS FOR CO ₂ COMPRESS.		03024		PART OF GB-301
FD-307	IN-LINE FILTERS FOR CO ₂ COMPRESS.		03024		PART OF GB-301
FD-401A	CHAR LOCK HOPPER FILTER	1407-68	04005A	NATIONAL BOX	
FD-401B	CHAR LOCK HOPPER FILTER	1407-68	04005A	NATIONAL BOX	
FD-402	THERMAL OXIDIZER WATER FILTER		03020	ZURN IND.	8
FD-403/C	FILTER		04005B		16
FE-101	TRUCK HOPPER	1407-32	01005A	CONVEYOR ENG.	150
FE-102	RAW COAL STORAGE BIN	1407-32	01005A	CONVEYOR ENG.	
FE-103	PULV. COAL STORAGE BIN	1407-32	01005A	CARMEN IND.	
FE-104A	STORAGE INJECTION HOPPER	6656-1611	01005A1	NOOTER	
FE-104B	STORAGE INJECTION HOPPER	6656-1611	01005A1	NOOTER	
FE-105	PRIMARY INJECTOR	6656-1611	01005A1	NOOTER	
FE-106	WEIGH HOPPER	6656-1611	01005A1		
FE-402A	CHAR LOCK HOPPER	1407-68	04005A	NATIONAL BOX	-
FE-402B	CHAR LOCK HOPPER	1407-68	04005A	NATIONAL BOX	-
					174

EQUIPMENT CONTROL INDEX
PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
LOCATION: BRUCETON, PENNSYLVANIA

JOB NO. 8530
DATE
PAGE 15 OF 26

EQUIP.	DESCRIPTION	P.O.	REF. P&I	SUPPLIER	REMARKS
GA-201	SCRUBBER TWO. RECYCLE	1407-54	02005C1	BYRON JACKSON	16
GA-202	MAJOR SOLUTION CIRC. PUMP	1407-67	02005E	BINGHAM	32
GA-202S	SPARE	1407-67	02005E	BINGHAM	32
GA-203	CARBONATE SOL. MAKE-UP PUMP	1407-58	02005E	LAWRENCE PUMP	16
GA-204	REGEN. REFLUX PUMP	1407-67	02005E	BINGHAM	16
GA-204S	SPARE	1407-67	02005E	BINGHAM	16
GA-205	WASTE WATER PUMP	1407-67	02005C2	BINGHAM	16
GA-205S	SPARE	1407-67	02005C2	BINGHAM	16
GA-206	DELETED	1407-197	02005C2	MOYNO	
GA-206S	DELETED	1407-197	02005C2	MOYNO	
GA-207	VENTURI SCRUBBER PUMP	1407-54	02005C1	BYRON JACKSON	16
GA-207S	SPARE	1407-54	02005C1	BYRON JACKSON	16
GA-208	WASH OIL PUMP	1407-54	02005C2	BYRON JACKSON	16
GA-208S	SPARE	1407-54	02005C2	BYRON JACKSON	16
GA-209	DELETED	1407-45	02005C2	BYRON JACKSON	} 16
GA-210	DELETED	1407-45	02005C2	BYRON JACKSON	
GA-211	DELETED	1407-45	02005C2	BYRON JACKSON	
GA-212	MINOR SOL. CIRCULATION PUMP	1407-67	02005E	BINGHAM	32
GA-212S	SPARE	1407-67	02005E	BINGHAM	32
GA-214	CAUSTIC CIRCULATION PUMP	1407-67	02005F	BINGHAM	16
GA-215	DOWTHERM FILLING	1407-66	02005F	GROVER MFG.	—
GA-216A&B	DELETED				
GA-216S	DELETED				
GA-217	DELETED				
GA-218	DELETED				320

EQUIPMENT CONTROL INDEX
PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
LOCATION: BRUCETON, PENNSYLVANIA

JOB NO. 8530
 DATE _____
 PAGE 16 OF 26

EQUIP.	DESCRIPTION	P.O.	REF. P&I	SUPPLIER	REMARKS
GA-219	DELETED				
GA-220	DELETED				
GA-221	DELETED				
GA-222	DELETED				
GA-223&S	INST. PURGE PUMP FOR DA-203 CAUSTIC PUMPS		02005E		24
GA-224&S	INST. PURGE PUMP FOR DA-203				16
GA-227	CONDENSATE RETURN PUMP		03013		PART OF FA-227
GA-302	DIMINERALIZED WATER	1407-73	03026	DURIRON CO.	16
GA-302S	SPARE	1407-73	03026	DURIRON CO.	16
GA-303	H.P. BFW PUMP		03012C		24
GA-303S	SPARE		03012C		-
GA-304	L.P. BFW PUMP		03012C	WORTHINGTON	-
GA-304S	SPARE		03012C	WORTHINGTON	-
GA-305X	LIQUID OXYGEN FEED	USBM		WORTHINGTON	PART OF PA-301
GA-305SX	SPARE	USBM		WORTHINGTON	PART OF PA-301
GA-306	COOLING TOWER PUMP	1407-54	03017	BYRON JACKSON	32
GA-306S	SPARE	1407-54	03017	BYRON JACKSON	32
GA-307AX	PHOSPHATE PUMP	1407-63	03012C	BETZ LAB	8
GA-307BX	PHOSPHATE PUMP	1407-63	03012C	BETZ LAB.	8
GA-308X	HYDRAZINE PUMP	1407-63	03012C	BETZ LAB.	8
					184

EQUIPMENT CONTROL INDEX

PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT

LOCATION: BRUCETON, PENNSYLVANIA

JOB NO. 8530

DATE

PAGE 17 OF 26

EQUIP.	DESCRIPTION	P.O.	REF. P&I	SUPPLIER	REMARKS
GA-308SX	SPARE	1407-63	03012C	BETZ LAB.	8
GA-309AX	CORROSION INHIBITOR	1407-63	03017	BETZ LAB.	PART OF BG-305 8
GA-309FX	SPARE	1407-63	03017	BETZ LAB.	PART OF BG-305 8
GA-310X	CATION ACID PUMP	1407-79	03026	ILLINOIS WATER	8
GA-310SX	SPARE	1407-79	03026	ILLINOIS WATER	8
GA-311X	ANION CAUSTIC PUMP	1407-79	03026	ILLINOIS	8
GA-311SX	SPARE	1407-79	03026	ILLINOIS	8
GA-312X	MIXED BED ACID PUMP	1407-79	03026	ILLINOIS	8
GA-312SX	MIXED BED CAUSTIC PUMP	1407-79	03026	ILLINOIS	8
GA-313X&S	MIXED BED CAUSTIC PUMPS & SPARE	1407-79	03026		8
GA-314ES	CONDENSATE PUMP	1407-63	03012C	BINGHAM	24
GA-315X	FUEL OIL PUMP	1407-63	03012B	CLEVER BROOKS	
GA-315SX	SPARE	1407-63	03012B	CLEVER BROOKS	
GA-316X	PHOSPHATE PUMP	1407-63	03012C	BETZ LAB.	8
GA-316CX	SPARE	1407-63	03012C	BETZ LAB	8
GA-316AX			03012C		8
GA-317	FUEL OIL PUMP	1407-102	03020	COEN DUPLEX	
GA-317S	SPARE	1407-102	03020	COEN DUPLEX	
GA-318	DEMIN WATER REGEN PUMP	7353	03026	DURIRON CO.	8
GA-319X	TRUCK UNLOADING PUMP	USBM	03020	AIR PRODUCTS	
GA-320	CONDENSATE RETURN PUMP	5092	03012C	HARRIS PUMP	
GA-321	DELETED		03012C		PART OF BG-309 8
GA-322	CHEMICAL INJECTION PUMP		02005F		PART OF BG-310 8
GA-323	CHEMICAL INJECTION PUMP		02005E		PART OF BG-310 8
GA-324	CHEMICAL INJECTION PUMP		02005F		PART OF BG-311 8
					168

PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
LOCATION: BRUCETON, PENNSYLVANIA

PAGE 18 OF 26

[illegible]

JOB NO. 8530
DATE _____
PAGE 19 OF 26

[illegible]

PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
LOCATION: BRUCETON, PENNSYLVANIA

PAGE 20 OF 26

[illegible]

PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
LOCATION: BRUCETON, PENNSYLVANIA

PAGE 21 OF 26

[illegible]

423

PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
LOCATION: BRUCETON, PENNSYLVANIA

PAGE 22 OF 26

[illegible]

EQUIPMENT CONTROL INDEX
 PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
 LOCATION: BRUCETON, PENNSYLVANIA

JOB NO. 8530
 DATE _____
 PAGE 23 OF 26

EQUIP.	DESCRIPTION	P.O.	REF. P&I	SUPPLIER	REMARKS
GB-401X	CHAR FILT. VACUUM PUMP	56	04005B	EIMCO	16
GB-401SX	SPARE	56	04005B	EIMCO	16
GB-501	AIR BLOWER FOR OXIDIZE NO. 1		02005J		16
GB-502	AIR BLOWER FOR OXIDIZE NO. 2		02005J		16
GB-503	VACUUM PUMP FOR FILTER		02005J		24
GD-301X	PHOSPHATE TANK AGIT.	63	03012C	BETZ LABS	
GD-302X	PHOSPHATE TANK AGIT.	63	03012C	BETZ LABS	
GD-303	NEUTRALIZING PIT. AGIT.		03026		
GD-304	FOR BG-310		02005E		PART OF BG-310
GD-305	FOR BG-311		02005F		PART OF BG-311
GD-306	FOR BG-312		03012C		PART OF BG-312
GD-401	L.P. CHAR SLURRY AGIT.	31	04005B	CHEMINEER	16
GD-402	SLURRY FILTER FEED TANK AGIT.	31	04005A	CHEMINEER	16
GE-301	EMERGENCY GEN.	86	03020	THOMPSON TRACT.	
GE-302	375 KW EMERGENCY GEN.	5046	03020	KEYSTONE DIESEL	136

JOB NO. 8530
DATE _____
PAGE 24 OF 26

EQUIP.	DESCRIPTION	P.O.	REF. P&I	SUPPLIER	REMARKS
GE-303	UNINTERRUPTIBLE POWER SUPPLY.	4009	UTILITY BLDG.		16
JC-201	ELEVATOR	7	IN PROCESS AREA	ERSHAM	
JD-102	RAW COAL FEED CONVEYOR	33	01005A	CONVEYOR ENG.	24
JD-103	RAW COAL BUCKET ELEV.	33	01005A	CONVEYOR ENG.	24
JD-105	RAW COAL WEIGH FEEDER	33	01005A	CONVEYOR ENG.	24
JD-401	WET CHAR CONVEYOR	42	04005B	BORG WARNER	24
					112

426

EQUIPMENT CONTROL INDEX
PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
LOCATION: BRUCETON, PENNSYLVANIA

JOB. NO. 8530
DATE
PAGE 25 OF 26

EQUIP.	DESCRIPTION	P.O.	REF. P&I	SUPPLIER	REMARKS
PA-102	FLASH DRYING MILL	40	01005A		16
PA-103X	COAL VALVE W/DOWN SPOUT	33	01005A		16
PA-104X	DRIED COAL DUST COLLECTOR	40	01005A		16
PA-105X	VIBRATOR FOR FE-102	33	01005A		
PA-106X	SLIDE GATE ON JD-103	33	01005A		
PA-108X	ROTARY FEEDER ON FD-101	40	01005A		
PA-109X	ROTARY FEEDER ON PA-104	40	01005A		
PA-110X	DRIED COAL DIVERTER VALVE	40	01005A		
PA-111	PETROCARB	6656 1611			
PA-112	RAW COAL SAMPLE CUTTER	33	01005A		
PA-113	FULV. COAL SAMPLE CUTTER	33	01005A		
PA-114X	VIBRATING BIN DISCHARGES OF FE-103	38	01005A		
PA-115	DELETED				
PA-116	L.P.G. STATION		03020		
FA-200	DATA ACQUISITION SYSTEM				
PA-200A	SCANIVALVE				
PA-102A	MILL STAR FEEDER	40	01005A		
PA-117	PETROCARB ROTARY FEEDER				NOT INSTALLED YET
PA-107X	ROTARY VALVE		01005A		
					48

EQUIPMENT CONTROL INDEX
PROJECT: COAL TO GAS PROTOTYPE PILOT PLANT
LOCATION: BRUCETON, PENNSYLVANIA

JOB NO. 8530
DATE _____
PAGE 26 OF 26

EQUIP.	DESCRIPTION	P.O.	REF. P&I	SUPPLIER	REMARKS
PA-301	OXYGEN FACILITY	USBM	02005A2		
PA-302	INSTRUMENT AIR DRYER	41	03019	GAS DRYING, INC.	
PA-303	SHOP MCH. RADIAL DRILL (2) LATHES.				
	MILLING MACHINE & HACKSAWS	69	SHOP		
PA-305	FULVERIZER	7426F 275F		PRECISE MINING CO.	
PA-306	CRUSHER	353F		CURTIN-MATHESON	
PA-313	CONDENSATE RETURN UNIT	5092		HARRIS PUMP	
PA-314	LIQUID CO2 SYSTEM		04005J	LIQUID CARBONICS	
PA-315	INERT GAS DRYER				NOT INSTALLED YET
PA-304	REFRIGERANT DRYER		03027		PART OF BE-301 16
PA-307	SULFUR REMOVAL TOWERS		03027		PART OF BE-301 16
PA-402X	CHAR SLURRY FILTER	56	04005B	EIMCO	} 100
PA-402SX	SPARE	56	04005B	EIMCO	
PA-403	SANITARY SEWER PLANT	37	DAVIS WASTE &	WATER	
PA-500	ABRAGIVE BLASTING EQUIP.			CLEMCO	
PA-501	TWR METH. FLAME SPRAY EQUIP.			CLEMCO	
PA-522	SLURRY FILTER		02005J		132
PA-101	LUMPBREAKER				NOT INSTALLED YET

APPENDIX E
GENERAL PLANT EQUIPMENT

A. Raw Coal Handling and Storage

- 1) Use of local coal storage terminal for handling and receiving coal shipments from mines.
- 2) Raw Coal Storage on site - 250 tons
- 3) Truck Hopper - 20 tons
- 4) Belt Feeder - 30 tons/hr.
- 5) Bucket Elevator - 30 tons/hr.
- 6) Sample Cutter

B. Coal Grinding, Drying, and Storage

- 1) Impact Mill Feeder - 11,800 lbs/hr.
- 2) Impact Mill - Feed Size 3/4" x 0
- 3) Drying Air Heater - 3,600 MBtu/hr.
- 4) Dust Collector
- 5) Vibrating Screen
- 6) Circulating Fan - 4750 SCFM
- 7) Dry Coal Storage - 100 tons
 - a) Vibrating Bin Discharge Equipment - discharge rate - 1700 lbs/min.
- 8) Coal Out
 - a) Less than 20 U.S. Mesh.
 - b) 70% greater than 200 mesh.
 - c) Less than 14% moisture.

APPENDIX E
GENERAL PLANT EQUIPMENT
(continued)

C. Coal Pressurization and Gasifier Feeding

- 1) Transportation by CO₂ or inert gas and superheated steam.
- 2) Cyclic Pressurization via CO₂ or inert gas into Feed Injection Hopper from Dry Coal Storage.
- 3) Capacity - 5 tons/hr. at 1000 PSIG
 - a) Normal Rate - 3 tons/hr.
 - b) Minimum Rate - 1 ton/hr.
- 4) Hopper Capacities
 - a) Weigh Hopper - 2 tons
 - b) Storage Injectors (2) - 2 tons each
 - c) Primary Injector - 6 tons

D. Pretreating

- 1) Steam/O₂ treatment in fluidizing bed.
- 2) Necessary for caking type of coals, optional for non-caking coals.
- 3) Capacity - 3 tons/hr. at 1000 PSIG

E. Gasifier

- 1) Steam/O₂ fluidized bed.
- 2) Coal oxidation to provide heat for endothermic gasification.
- 3) Coal feed injected directly into fluidized bed to minimize tar/phenol formation.

APPENDIX E

GENERAL PLANT EQUIPMENT

(continued)

E. Gasifier - cont'd

4) Controlled Variables

a) Pressure

a) 1000 psig design

b) 600 psig present operation

b) ~~Temperature via O₂ flow (1500° to 1800°F)~~

c) Fluidization velocities via steam flow

d) Bed height controlled via differential pressure and valve

e) Residence time via feed rate and bed height

5) Capacity - 3 tons/hr.

F. Char Handling

1) Primary cooling from gasifier temperature to 600°F via steam in char cooling section of Gasifier.

2) Char Removal from Gasifier

a) Lock Hopper system followed by steam transport to final quench to prepare for filtration not commissioned.

b) Steam conveying to high pressure water slurry system for cooling at Gasifier pressure, subsequent depressuring for filtration.

3) Char filtration and dewatering

a) Rotary vacuum filtration

b) Filtered char disposal via truck transport

c) Filtrate recirculated to high pressure slurry system

4) Char Output - 1,850 lbs/hr.

APPENDIX E
GENERAL PLANT EQUIPMENT
(continued)

G. Gas Clean Up

- 1) Preliminary gas wash and quench in two water operated Venturi Scrubbers.
- 2) Water Wash Scrubber using circulating water
 - a) Provisions for oil wash not in service.
- 3) Low Pressure steam generation for heat recovery.
- 4) Accumulators for fines separation from Gasifier plus oil, water and tar separation.
- 5) Accumulated water, tars, and oil disposed of in thermal oxidizer or hauled away by truck.
- 6) Input - 15,060 lbs/hr. (wet basis) at 1000 PSIG and 1400°F. Mol. wt. equals 21.5.

H. Shift Converters (Not Commissioned)

- 1) Catalysts beds to control CO/H₂ ratio for later methanation. Cobalt molybdate catalyst.
- 2) Fixed bed reactors.

I. CO₂ and H₂S Removal (Not Commissioned)

- 1) Benfield Process (145,000 SCFH at 965 psig and 125°F)
 - a) Washing gas with hot K₂CO₃ for CO₂ and H₂S removal.
 - b) Regenerated K₂CO₃ solution releases CO₂ and H₂S.

APPENDIX E
GENERAL PLANT EQUIPMENT
(continued)

I. CO₂ and H₂S Removal (Not Commissioned) - cont'd

- 2) H₂S removed from CO₂ in b), above, via Stretford Process (61,970 SCFH at 3 psig & 120°F, 5.0 Vol.% H₂S Max).
 - a) Process converts H₂S to elemental sulphur.
 - b) CO₂ recycled to process.
 - c) CO₂ excess disposed of in thermal oxidizer.
 - d) Sulphur melted and disposed of via truck transport.
- 3) Tail Gas - less than 200 ppm by volume sulphur.

J. Carbon Bed Clean Up (Not Commissioned)

- 1) To remove final traces of sulphur from Benfield washed gas via fixed bed carbon reactors.
- 2) Capacity - 26,760 SCFH at 960 psig and 95°F.

K. Methanation (Not Commissioned)

- 1) Approximately 25% of Benfield Process treated gas methanated. Un-methanated gas to plant fuel system.
- 2) Objective to produce 900 BTU/SCF Gross Heat Value with a 90 Vol.% CH₄.
- 3) Methanation to be accomplished over Raney Nickel Catalyst.
 - a) Tube wall type reactor (50% of Carbon Bed treated gas)
 - 1) steam generation

APPENDIX E

GENERAL PLANT EQUIPMENT

(continued)

- K. Methanation (Not Commissioned) - cont'd
- b) Plate type reactor (50% of Carbon Bed treated gas)
 - 1) hot gas recycle
 - 4) Both Methanators can operate simultaneously.
 - 5) Fixed Bed Catalytic Methanator to insure complete CO conversion after 3a and 3b above.
 - 6) Capacity - 26,790 SCFH @ 950 psig and 95°F.
- L. Utility Support Facilities
- 1) Electric Power
 - 2) Raw and Cooling Water
 - 3) Instrument and Plant Air
 - 4) Fuel Oil and LPG
 - 5) Water Treating
 - 6) Steam Generation and Condensate Handling
 - 7) Sewers - Sanitary and Storm
 - 8) Gas, Liquid and Solids Waste Disposal
 - 9) Oxygen Storage and Feeding
 - 10) Inert Gas Generation and Compression
 - 11) CO₂ Storage and Compression
 - 12) Flare System
 - 13) Dowtherm System

APPENDIX E

GENERAL PLANT EQUIPMENT

(continued)

L. Utility Support Facilities - cont'd

- 14) A Utility and General Service Manual, which may be found in the Synthane Pilot Plant Bruceton library, describes the capacity and function of the above Utility Systems.

APPENDIX F

INVENTORY OF COMPUTER PROGRAMS, DOCUMENTATION AND HISTORICAL DATA

A. Programs and program documentation

The following programs and subroutines have been written by the Computer Group. Program decks and documentation are located in the library. A sample of the documentation form is also attached.

1. Data Retrieval Functions

APT - plots historical data versus time
ATORPT - automatically produces report of historical data
CAL - performs process calculations on historical data
C1 - copies 10-second data to new tape
FIGURE - draws a graphic display of the gasifier
GP6 - plots 10-second data versus time
HBG - draws a gasifier heat balance graphic
INSERT - updates raw or averaged historical data tape
MBP - performs material balance calculations
MST - produces monthly summary table for plant operation
MTREAD - prints data from one historical data file
MTSLCT - prints data for up to five points over a time period
PC1 - prints calculation logs for last 24 hours on tape
PC2 - prints pretreater data for last 24 hours on tape
PC3 - prints gasifier data for last 24 hours on tape
PRT - draws pretreater graphic
PXY - plots X versus Y and curve fits the data
OSRT - sorts historical data into chronological order
STEADY - determines steady-state periods from tape
TCOPY - copies or condenses averaged data tapes
UCP - reads tape in preparation for process calculations
UPDATE - calculates average values for a steady-state
W1 - prints 10-second data

APPENDIX F

(continued)

INVENTORY OF COMPUTER PROGRAMS, DOCUMENTATION AND HISTORICAL DATA

- cont'd

A. Programs and program documentation - cont'd

2. CRT Functions

ATOPLT - plots historical data versus time
BOI - calculates boiler efficiency
CCF - changes coal feed rate in the EU table
CET - changes specific EU table values
CO2 - performs a CO2 balance around the gasifier
DIR - displays instrument type and range
GRAPHIC - draws pretreater and gasifier graphics on CRT
LAB - prints data sheets for coal and char analysis
MSR - positions tape and activates MTSLECT
O2C - computes oxygen consumption in the pretreater and transport line
PCL - activates program PCL
PCP - calculator function
RDC - prints data for more than one run period
RRT - activates programs to print test directive tables
STM - performs a steam balance around the pretreater/gasifier
TREND - records 10-second data on tape
TTT - inputs floating point numbers through the CRT

3. Laboratory Data Handling Functions

CLTR - prints Coulter analysis results for any sample
CSP - prints a char sample data report
C1 - prints analyses for C1 samples
C1A - prints analyses for C1A samples
C7 - prints chemical analyses for C7 samples
C7A - prints analyses for C7A samples
C7S - prints analyses for C7S samples
C8A - prints chemical analyses for C8A samples
C8AS - prints screen analyses for C8A samples
GSS - prints screen analyses for GS samples
GSU - prints chemical analyses for GS samples
G1 - prints analyses for G1 samples
G2 - prints chemical analyses for G2 samples
G2S - prints screen analyses for G2 samples
IG - prints analyses for IG samples
PT - prints analyses for PT samples
PUNCH - punches laboratory data cards
P1 - prints analyses for P1 samples
SA - prints analyses for SA samples

APPENDIX F
(continued)

INVENTORY OF COMPUTER PROGRAMS, DOCUMENTATIONS AND HISTORICAL DATA

- cont'd

A. Programs and program documentation - cont'd

3. Laboratory Data Handling Functions - cont'd

SC2 - prints analyses for SC2 samples

SSP - performs a statistical analysis on any sample cards

STATS - performs a statistical analysis on coal samples

SV - prints chemical analyses for SV samples

SV1 - prints screen analyses for SV samples

S1 - prints analyses for S1 samples

S2 - prints water analyses for S2 samples

S2U - prints water analyses for S2U samples

S2UL - prints chemical analyses for S2 samples

S2US - prints screen analyses for S2U samples

S2UUL - prints chemical analyses for S2U samples

S3 - prints water analyses for S3 samples

S3U - prints chemical analyses for S3 samples

S4 - prints water analyses for S4 samples

S4S - prints screen analyses for S4 samples

S4U - prints chemical analyses for S4 samples

S5 - prints water analyses for S5 samples

S5S - prints screen analyses for S5 samples

S5U - prints chemical analyses for S5 samples

S7 - prints analyses for S7 samples

4. System Programs

AA1 - prints a message when a digital input changes state

ABC - activates program TIMER

ACTIVATE - activates scanned points

AUX DUMP - determines if historical data has been written to tape

CHKTP - prints dates and times from historical data tapes

COALFD - prints a message when XCV-26 changes state

COPY - copies historical data tapes on-line

CUBIC - calculates specific volume of steam

CVP - prints control valve specification table

IHL - prints instrument specification sheet

INACTIVE - checks active/inactive status of all analog inputs

INV - produces plant raw material inventory reports

ITS - writes daily plant inventory data to tape

APPENDIX F
(continued)

INVENTORY OF COMPUTER PROGRAM, DOCUMENTATION AND HISTORICAL DATA

- cont'd

A. Programs and program documentation - cont'd

4. System Programs - cont'd

MERGE - prints computer hookup list
PITS - punches daily plant inventory data cards
 from tape
PTROFD - prints condition of the Petrocarb valving
 system
PVP - prints instrument purge flow table
PVTAP - updates data on historical data tape
PWC - punches weekly plant inventory cards from tape
SCANOFF - checks the status of the Scanivalve
TABLE - prints Table 5-4 of the test directive
TIMER - determines changes of state for plant
 instruments
TITLZR - maintains value for total coal fed to the
 gasifier
U79 - updates RAD file 79, plant instrument data
VAP - determines valve actions throughout the plant
VSS - prints valve change table
WITS - writes weekly plant inventory data to tape
WO2 - calls subroutine OUTTAB
WTDATA - orders data to be written to edited data
 tapes
WTNAM - transfers PTID names to edited data tapes

5. Transient Programs

CH1 - inserts 0.001 in all blank spaces of lab data
 cards (one card samples)
CH2 - inserts 0.001 in all blank spaces of lab data
 cards (two card samples)
CIR - changes instrument range
CONVERT - converts hexadecimal numbers to decimal
 values
DP1 - calculates pressure drops in the 1-inch transport
 line
DP2 - calculates pressure drop in the horizontal and
 vertical sections of the transport line
DRAW - reads information from RAD file 180 for program
 GRAPHIC
FOR - converts gas analysis to a moisture-free basis
INITIAL - initializes RAD file 81, plant inventory
 values

APPENDIX F
(continued)

INVENTORY OF COMPUTER PROGRAM, DOCUMENTATION AND HISTORICAL DATA

- cont'd

A. Programs and program documentation - cont'd

5. Transient Programs - cont'd

INITIAL SAT - initializes RAD file 70, saturated
 steam enthalpies
INITIAL SUPER - initializes RAD file 71, super heated
 steam enthalpies
LABDTA - updates values in the EU table
LOOK - prints PTID names and descriptions
LMT - determines range for variables read from tape
NEW FILE - writes instrument hookup data to RAD file 79
SWITCH - sets columns 3 and 4 on data cards to blanks
TEMPORARY - extracts information from RAD file 45
U4 - updates purge flow values in RAD file 400
WRITE - prints reports of instrument hookup data

6. Test Programs

PLOT1 - tests X/Y plotter functions
PLOT2 - tests X/Y plotter functions
PLOT3 - tests X/Y plotter functions
TEMP - tests thermocouple conversions
TERM - tests Terminet carriage control characters
TEST - tests Terminet on/off control characters
WRITE - tests printing of elongated characters

7. Subroutines

ANSWERS - calculates values for 02C
AVERAGE - averages values from historical data tapes
AVETAP - reads data from averaged tape
AVEVAL - prints average EU tape values
AVG - prints a report of averaged data
BOLEFF - computes boiler efficiency
BOX - draws a square box on X/Y plotter
CALCS - computes process calculations
CALCXY - performs decimal operations for CRT calculator
CIRCLE - draws circle on X/Y plotter
CLEAR - outputs clear screen and home characters to CRT
CMPTM - compares two times and dates
CONSTANTS - sets constants for 02C

APPENDIX F
(continued)

INVENTORY OF COMPUTER PROGRAM, DOCUMENTATION AND HISTORICAL DATA

- cont'd

A. Programs and program documentation - cont'd

7. Subroutines - cont'd

CONVERSION - compensates raw gas analysis for gasifier conditions
COPY - copies historical data to a new table
CORE - transfers EU table data from core
CORRINV - moves inventory data in RAD file 81
DIAMOND - writes diamond-shaped box on X/Y plotter
FIND - finds a particular time and date on a data tape
GASIFIER - inserts the gasifier graphic data into RAD file 180
GRAPH1 - plots data generated by program DP1
GRAPH2 - plots data generated by program DP2
GTDESC - retrieves PTID descriptor without units
GTNAME - obtains PTID descriptor
HEAD - writes data for program 02C
HEADER - prints headings for updated calculated values
HEADING - prints heading for program RDC
HEADR1 - prints headings for updated average gas compositions
HEAT - performs heat balance calculation
HEX - draws a hexagonal box on the X/Y plotter
HXN - performs hexadecimal conversion for CRT calculator
INT - prints a table listing EU table values read from tape
LABDATA - reads laboratory data from data cards
LAST - determines last time and date in a data file
LIMIT - checks limits of all values in a data file
LISTTP - lists run names on an averaged data tape
LMTCHK - prints report of historical data outside range
LOOK - prints calculated values for steady-states
LOOK1 - prints undated average gas compositions
LOOK2 - calculates average molecular weight for raw gas
MSR - prints a report for up to five PTIDs over a period of time
NORMALIZE - normalizes gas compositions
NUMB - converts a real number into 10 ASCII characters
OUTPTR - writes pretreater data to the X/Y plotter
OUTPUT (MST) - prints monthly summary table
OUTPUT (02C) - outputs data for program 02C
OUTTAB - prints data table for program 02C
PLTDTA - plots historical data versus time
PRETREAT - writes pretreater data to RAD file 180

APPENDIX F
(continued)

INVENTORY OF COMPUTER PROGRAM, DOCUMENTATION AND HISTORICAL DATA

- cont'd

A. Programs and program documentation - cont'd

7. Subroutines - cont'd

PRINT - prints laboratory data sheets for solid samples
PRINTING - prints process data on a gasifier graphic
PRINTING DATA - prints data sheet for heat balance
PRINTWK - prints weekly plant inventory report
PRINT2 - prints laboratory sieve analysis data sheets
PRNTDATA - prints PTID numbers and associated values
PRNTOT - prints averaged historical data
PRTGRP - writes pretreater graphic to the X/Y plotter
PUNWK - punches weekly plant inventory data cards
RAWTP - reads data from raw data tape
RECTANGLE - draws a rectangle on the X/Y plotter
ROUND - rounds a positive real number to three
 significant figures
SAS - reads historical data from tape and prepares for
 plotting
SEARCH - positions the data tape
SORT - locates a particular data file within a data set
SRCSRT - searches data tape and sorts files into
 chronological order
STORE - stores PTID values for drawing gasifier graphics
TLP - plots historical data on the X/Y plotter
WEEKINV - reads data for weekly plant inventory
WEEKLY - calculates weekly inventory totals
WKTOTAL - calculates weekly inventory totals
WORK1 - converts coal and char analysis to as-received,
 moisture and ash-free bases
WORK2 - converts as-received analyses to moisture and
 ash-free bases
WORK3 - reads sieve analysis data
WRITE - prints steady-state time number and time period
WRTAPE - writes O₂ consumption data to tape

In addition to the above user-written programs, changes to the following Modcompe and Metromation programs were also made:

CTR
EUD
LPPLLOT
SCU
SVS
TALLY
USI

APPENDIX F
(continued)

INVENTORY OF COMPUTER PROGRAM, DOCUMENTATION AND HISTORICAL DATA
- cont'd

A. Programs and program documentation - cont'd

Description of these programs may be found in the FLIC or MAX III documentation. The altered program decks are located in the program libraries.

B. Historical Data Tapes

The following list shows the times and dates of all historical plant data which is available on tape. Copies and edited versions are indicated where they exist.

APPENDIX F

(continued)

HISTORICAL DATA TAPES

<u>#</u>	<u>Starting Time/Date</u>	<u>Ending Time/Date</u>	<u>Copy</u>	<u>Edited</u>
H01	040276	050976	X	
H02	050976 1300 060276 1615 061076	052876 1350 060276 1030 061176	X	
H03	052876 1550 060276 1030 061176	1245 060276 1415 061076 1635 061176	X	
H04	1335 061176	0800 62476	X	
H05	1245 070276	0193 071276	X	
H06	0919 071276 0738 071676 1420 071776	1415 071576 1554 071676 0914 072176	X	
H07	0920 072176 0800 072676	1800 072376 1600 072776	X	
H08	1545 080676	1420 081376	X	
H09	1402 081376	1345 081776	X	
H10	1345 081776	1000 091076	X	
H11	091076	092376	X	
H12	2037 092576	1531 100376	X	
H13	2301 100376	1511 100876	X	X
H14	1517 100876	0257 101776	X	X
H15	1611 100876 0916 101876	2400 100876 1600 102676	X	X
H16	1600 102676	0900 102876	X	X
H17	0900 102876	0800 102976	X	
H18	0900 102976	1400 110176		

APPENDIX F
(continued)

HISTORICAL DATA TAPES

<u>#</u>	<u>Starting Time/Date</u>	<u>Ending Time/Date</u>	<u>Copy</u>	<u>Edited</u>
H19	1400 110176 1600 110276	0900 110276 1300 111076	X	
H20	1400 111076	1600 111676	X	
H21	1600 111676	1600 112276	X	
H22	1600 112276 1400 112676	0900 112676 1600 112976	X	
H23	1600 112976	1600 120576	X	
H24	1600 120476	1600 121076	X	
H25	1600 121076	1600 121776	X	
H26	1600 121776	122376	X	
H27	0800 122376	0800 123076	X	
H28	0800 123076	1600 010677	X	
H29	1600 021977	0800 022777	X	X
H30	0823 022777	0800 030577	X	X
H31	0800 031177	0800 031777	X	X
H32	2200 032277 1600 031777	0900 032377 1700 032277	X	X
H33	0830 032977	1600 040477	X	X
H34	0800 041277	0800 041977	X	X
H35	1600 042777	1600 050177	X	X
H36	0800 051577	1600 052377	X	X
H37	1645 052377	1600 053177	X	X
H38	1600 053177	0800 062277	X	X
H39	0800 073077	1600 080477	X	X
H40	1600 080477	0800 081177	X	X

APPENDIX F
(continued)

HISTORICAL DATA TAPES

<u>#</u>	<u>Starting Time/Date</u>	<u>Ending Time/Date</u>	<u>Copy</u>	<u>Edited</u>
H41	0800 081177	1600 081877	X	X
H42	1600 091277	1600 092377	X	X
H43	1600 092377	1600 093077	X	X
H44	1600 102177	1600 102877	X	X
H45	1600 102877	1600 110477	X	X
H46	1600 110477	0800 111177	X	X
H47	0800 111177	0800 111677	X	X
H48	0800 111677	0800 112377	X	X
H49	0800 112377	1600 120177	X	X
H50	1600 120177	1600 120877	X	X
H51	1600 120877	1600 121577	X	X
H52	1600 121577	0800 122377	X	X
H53	0800 122377	0800 123077	X	X
H54	0800 123077	0400 010678	X	X
H55	0400 010678	1600 011378	X	X
H56	1600 011378	2100 012278	X	X
H57	0000 012378	1600 013178	X	X
H58	1600 013178	1600 020778	X	X
H59	1600 020778	1600 021478	X	X
H60	0800 032378	0800 033078	X	X
H61	0800 033078	1000 040678	X	X
H62	1600 040678	1600 041378	X	X
H63	1600 041378	1600 142078	X	X
H64	1600 042078	1600 042778	X	X

APPENDIX F
(continued)

HISTORICAL DATA TAPES

<u>#</u>	<u>Starting Time/Date</u>	<u>Ending Time/Date</u>	<u>Copy</u>	<u>Edited</u>
H65	1600 042778	0800 050578	X	X
H66	0800 050578	0800 051278	X	X
H67	0800 051278	0800 051978	X	X
H68	0800 051978	0800 052678	X	X
H69	0800 053178	0800 060778	X	X
H70	0800 060778	0800 061478	X	X
H71	0800 061478	0800 062178	X	X
H72	0800 062178	0800 063078	X	X
H73	0800 063078	1600 070478	X	X
H74	1600 070478	0800 071178	X	X
H75	0800 071178	0000 072078	X	X
H76	0000 072078	0000 072778	X	X
H77	0000 072778	0800 080378	X	X
H78	0800 080378	0800 081178	X	X
H79	0800 081178	1000 081778	X	X
H80	1000 081778	1600 082578	X	X
H81	1600 082578	0800 083178	X	X
H82	0800 083178	0800 090778	X	X
H83	0800 090778	0800 091678	X	X
H84	0800 091678	0800 092978	X	X

APPENDIX F

(continued)

Copies of the computer operating system are also maintained on tape. Other programming systems such as hardware diagnostics and vendor written programs may also be found on system tapes. The following system tapes are available:

APPENDIX F
(continued)

SYSTEM TAPES

#S01	1 Binary File -- SYS
#S02	Scratch
#S03	Blank Tape
#S04	Blank Tape
#S05	Executive Process I/O Library
#S06	Fillable Diagnostics -- 092775
#S07	Scratch
#S08	Relocatable Diagnostics -- 121875 -- MC II/IV
#S09	ERDA FLIC System -- no USL contents -- 012576
#S10	Final ERDA FLIC System -- includes USL contents -- 012676
#S11	FLIC System -- 013076
#S12	FLIC System -- 013076
#S13	ERDA FLIC System -- ERDA data base DDB
#S14	One File SOP Disc Cataloger -- 052476
#S15	Copy of Original System -- lower disc -- 070276
#S16	FLIC -- Upper and Lower discs -- 032376
#S17	MC II/IV Fillable Diagnostics and Utility Software -- 102076
#S18	Tape Copy RESYSGENED SYSTEM -- Upper and Lower discs -- 110476
#S19	Original System -- Upper and Lower discs -- copy made 112676
#S20	X/Y Plotter Package -- six files -- Revision A -- Source files 1-3 -- Object files 4-6 -- 081376

APPENDIX F
(continued)

SYSTEM TAPES - cont'd

#S21 Disc/Tape copy -- New System -- 121076 --
 Resysgened with X/Y Plotter -- 012077

#S22 Disc copy -- Revision M for tran made -- 060777
 11:45

#S23A Disc Save Diablo -- OS -- 060177 -- before H System
 Process

#S23B System Image (disc save) -- Upper and Lower discs --
 062377 1100

#S24 System disc -- MAX III version F.3 Sysgened for 4
 disc drives and 2 tapes -- Copy made 100377

#S25 Core Dump -- 071477 1410 -- 110277

#S26 Core Dump -- 072077 0400 -- 110277

#S27 Old System: H.Ø System Processors; 2 disc drives,
 1 tape drive -- Updated for DA 052478

#S28 Source 062477

#S29 MUSE User's Library (Source) -- Scientific Sub (3
 files) -- Linear Prog (20 files LPPNEWJC -1) --
 copy made 082278

#S30 MUSE User's Library (Object) -- Scientific Subroutines
 (3 files) -- Linear Programming Routines (20 files
 LPPNEWJC -1)

#S31 #D1, #D2, #D3, #D4 -- copied 013078 -- 101378

#S32 Disc #1, 2, 3, 4 -- copied 092778

#S33 Drive MØ, M1, System with XYP (8-hour dump) --
 Drive MØ, M1, Original 2 disc system 062276 --
 record retention 101378

#S34 MAX II/III Source, Rev F.3

#S35 Copy of M2 disc, 6/28/78

#S36 USBM Final Source - 9/12/77

APPENDIX F
(continued)

Several tapes were also generated which contain user written programs. These program tapes are:

- #P1 - APT, ATO, FIGURE, LAB, UCP, CALCS and HBG
- #P2 - Laboratory data handling routines
- #P3 - ABC, CVP, IHL, MST, O2C, PUNCH, PVP, PXY, RRT, SAP, SSP, STATS, STEADY, TIMER, VAP, VSS, HEAT (subroutine)
- #P4 - all user-written programs, FLIC source, Modcomp Scientific Subroutine Package, Linear Programming Package and X/Y Plotter Package
- #P5 - FLIC source, Scientific Subroutine Package, Linear Programming Package and X/Y Plotter Package

C. Discs

The computer operating system resides completely on disc and is loaded into memory from there whenever the system is brought on-line. Four disc packs are required to operate the system in its current configuration. There are:

- M0 - contains system elements and FLIC libraries
- M1 - contains output files, source library and scratch space
- M2 - contains user library and RAD files
- M3 - contains RAD files and scratch files

The last three disc packs may be generated using information which is stored elsewhere, usually on cards, so that no additional copies of the packs are kept. Two extra copies of M0 are kept on spare disc packs. An additional operating system which will run on only two disc packs is also kept available in case of a hardware problem with any of the disc drives. These discs are numbered M0A and M1A.

APPENDIX F
(continued)

D. Data Cards

Laboratory data cards for the following samples have been cataloged and retained:

C1	1 - 259	013076 - 092278	
C1A	1 - 53	022676 - 092378	
C2	1 - 82	032875 - 060475	
C3	1 - 423	032075 - 080875	
C4	1 - 67	042375 - 053175	
C5	1 - 310	040875 - 063078	
C6	1 - 341	032075 - 080875	
C7	1 - 300	110575 - 112178	
C7	1 - 300	110575 - 112178	screen
C7	1 - 300	110575 - 112178	Coulter
C7A	1 - 68	120175 - 092078	
C8	1 - 30	110675 - 062978	
C8	1 - 30	110675 - 062978	screen
C8A	1 - 6	030176 - 061578	
C8A	1 - 6	030176 - 061578	screen
G1	1 - 225	101075 - 030177	
G2	1 - 465	020776 - 083178	
G2	1 - 465	020776 - 083178	screen
G2	1 - 465	020776 - 083178	Coulter
GS	1 - 94	071276 - 081678	
GS	1 - 94	071276 - 081678	screen
GS	1 - 94	071276 - 081678	Coulter

APPENDIX F
(continued)

D. Data Cards - cont'd

HT	1 - 5	030378 - 032778	
IG	1 - 36	080178 - 091578	
Pl	1 - 9	082478 - 082978	
PE	9 - 640	072876 - 122978	
PI	1 - 144	072575 - 121778	
PT	1 - 53	081877 - 092278	
PT	1 - 53	081877 - 092278	screen
SA	1 - 227	052778 - 112178	
SA	1 - 227	052778 - 112178	Coulter
SC2	1 - 231	022477 - 083178	
SV	1 - 73	071276 - 090178	
SV	1 - 73	071276 - 090178	screen
SV	1 - 73	071276 - 090178	Coulter
S1	1 - 103	070676 - 081277	
S2	1 - 13	081276 - 121676	
S2U	1 - 27	022477 - 040177	
S3	1 - 284	022676 - 082978	
S3	1 - 284	022676 - 082978	screen
S3	1 - 284	022676 - 082978	chemical
S3	1 - 284	022676 - 082978	Coulter
S4	1 - 289	012676 - 082978	
S4	1 - 289	012676 - 082978	screen
S4	1 - 289	012676 - 082978	chemical
S4	1 - 289	012676 - 082978	Coulter

APPENDIX F
(continued)

D. Data Cards - cont'd

S5	1 - 220	012876 - 083178	
S5	1 - 220	012876 - 083178	screen
S5	1 - 220	012876 - 083178	chemical
S5	1 - 220	012876 - 083178	Coulter
S6	1 - 86	072076 - 123077	
S7	1 - 10	070976 - 103176	
TO1	1 - 3	070776 - 071776	
TP	1 - 11	071276 - 042878	
U1	1 - 1583	022475 - 092178	
U2	1 - 2084	021475 - 123178	
U3	1 - 1662	122374 - 123178	
U4	1 - 756	013075 - 122878	
U5	1 - 3468	010375 - 123178	
U6	1 - 603	020575 - 121778	
U7	1 - 694	020575 - 121778	
U12	1 - 9	031976 - 080376	
U13	1 - 20	012777 - 122078	
U14	1 - 28	012777 - 112978	
U15	1 - 107	012578 - 112778	
U16	1 - 85	011978 - 121278	
U17	1 - 3699	032075 - 121478	
U18	1 - 5146	053075 - 123178	
U19	1 - 490	112175 - 122778	

APPENDIX F
(continued)

D. Data Cards - cont'd

U20	1 - 844	120975 - 120578
U21	1 - 2496	020376 - 123178
U23	1 - 177	040375 - 123078
U24	1 - 482	010376 - 122878
U25	1 - 544	041277 - 122478
U26	1 - 4	012878 - 020578
U27	1 - 27	012378 - 111278

Data cards related to plant raw material inventory have also been retained for the following time periods:

Daily data cards - 0377 - 1278

Weekly data cards - 042777 - 112478

Several decks of cards are necessary to initialize the computer system. These decks which may be found in the library are:

- PIN - parameter initialization
- RAD - RAD file definition
- OCU - CRT function update
- ANU - analog name update
- SCU - analog scan update
- LGU - log update
- CLU - calculation update
- DNU - digital name update
- DAU - digital alarm scan update
- AZU - analyzer parameter update

APPENDIX F
(continued)

D. Data Cards - cont'd

These decks represent the final condition of the data files used by the computer system. One deck which must be used with the Card Reader Hardware Diagnostic program is also included.

E. Manuals

The following computer system manuals are located in the library:

Modcomp Manuals:

MAX II/III Operating System

MAX II/III Library

System Processors

Modcomp II/III Support Software

MAX II/III Input/Output

MAX II/III Users Guide

Technical manuals - MAX II/III Library

- System Generation

- Central Processing Unit

- Hardware

- Scientific Subroutine Library

Input/Output Diagnostic Manual

Hardware Diagnostics

MAX II/III Linear Programming Package

Hardware Wiring Diagrams - 3 volumes

Technical manuals - 481X Series Communications Channels

- Analog Input Subsystem 1400

APPENDIX F

(continued)

E. Manuals - cont'd

Metromation manuals:

FLIC Specification Manual

FLIC Software Documentation

Volume I

Volume II

Volume III

Peripheral manuals:

Documentation M-200 Card Reader

Wangco Magnetic Tape Transport

Univac Verifying Keypunch

Maintenance Handbook

Servicing Documents

Information and Pricing

1710 Operating Information

Operator's Reference

Diablo Disc Drive

Maintenance Manual - D3140

Maintenance Manual - 81503

Maintenance Manual - Power Supply

Centronics 101 Printer Operator's Manual

Terminet 300 and 1200 Printer Operator's Manual

How to Use the Consul-580 and MRD-380

How to Maintain the Consul-580 and MRD-380

CalComp Pen and Paper User's Guide

Soanivalve Instruction Manual

APPENDIX F
(continued)

E. Manuals - cont'd

User-Written manuals:

Scope Report

Installation and Hardware Manuals

Software and Operating Manual

Computer Operating Instructions

Computer Operating Procedure Manual

APPENDIX G

A PROGRAM TO DISCOVER MATERIALS SUITABLE FOR SERVICE
UNDER HOSTILE CONDITIONS OBTAINING IN EQUIPMENT FOR
THE GASIFICATION OF COAL AND OTHER SOLID FUELS

APPENDIX G

Synthane

First-exposure specimen racks were removed from several test locations in the Synthane plant during the third quarter. These racks were gasifier, off-gas (location 2); gasifier, fluidized bed (location 3); scrubber surge tank, vapor phase (location 4); scrubber surge tank, liquid phase (location 5); decanter, splash zone (location 6); decanter, liquid zone (location 7); and gasifier char cooler (location 8). Operational exposure times for the first exposures were in the range of 590 to 780 hr as reported by pilot plant personnel. Removal of test racks at this time was prompted by a change in process parameters at the plant, but the exposures also represent a reasonable approximation of one operational month (720 hr).

A summary of the operating and standby hours, temperature, and pressure for Synthane test locations is given in Table 2-15. Pilot plant personnel reported that standby conditions are important in determining corrosion rates for locations 4, 5, 6, and 7, but not for locations 2, 3, and 8 based on plant operation. During standby conditions, CO₂ and steam are circulated through the raw gas quench system involving specimens in locations 4, 5, 6, and 7. Standby conditions do not influence corrosion in the gasifier test locations 2, 3, and 8 because of rapid cooling of the gasifier after depressurization.

APPENDIX G

Synthane - cont'd

Results of post-exposure gravimetric and metallographic analysis of corrosion specimens from the Synthane gasifier, off-gas, are contained in Table 2-16. Surface appearance of the corrosion coupons after 781 operating hr is shown in Appendix B1, Fig. B1-11. First exposure in the off-gas resulted in extensive corrosion of 51.9 mils (0.582 in/yr) for 600. All of the remaining twelve alloys, 430, 304, 316, 321, 309, 21-6-9, 22-13-5, 800, 825, RA-333, Alloy X, and 601, had total sound metal loss of 0.4 to 1.7 mils (0.004-0.020 in/yr).

First exposure corrosion data for the gasifier, fluidized bed (location 3), are summarized in Table 2-17. Surface appearance of test specimens is shown in Appendix B1, Fig. B1-12. Alloy selection for the first exposure in this location was the same as in the off-gas location. Extensive corrosion of 600 also occurred in this location; total corrosion was 78.3 mils (0.878 in/yr). Slightly higher corrosion of 316 and 601 was measured, 2.2 mils (0.025 in/yr) and 1.6 mils (0.018 in/yr) total corrosion, respectively, than that in the off-gas location. Thus, the first-exposure results for the Synthane gasifier correlated with those of the HYGAS gasifier fluidized bed (Section 2.3.1.2).

Table 2-15

ENVIRONMENTAL PARAMETERS FOR FIRST EXPOSURE
IN SYNTHANE PILOT PLANT^a

Location	Test Location	Operation Time, hr	Standby Time, hr	Temp., °F		Press., psig
				Range	Avg	
2	Gasifier, off-gas	782	1596	800-1500	1284	600
3	Gasifier, fluidized bed	782	1596	800-1550	1434	600
4	Scrubber Surge Tank, vapor phase	592	1454	350-415	385	600
5	Scrubber Surge Tank, liquid	592	1454	350-415	385	600
6	Decanter, splash zone	592	1454	200-240	220	5
7	Decanter, liquid zone	592	1454	200-240	220	5
8	Gasifier, char cooler	592	1454	600-900	-- ^b	600

^aReported by pilot plant personnel.^bTemperature variation too frequent to obtain meaningful average.

Table 2-16

FIRST-EXPOSURE CORROSION DATA FOR SYNTHANE GASIFIER OFF-GAS
(Location 2)

Alloy Material	Scaling Loss, mils	Rate of Scaling Loss		Diffusion Zone Thickness, mm	Depth of Penetration, mils	Total Sound Metal Loss ^a		Weight Loss	
		in/yr	mm/yr			in/yr	mm/yr	mg/cm ²	mils
304	0.2	0.002	0.06	0	0.8	0.011	0.29	1.5	0.1
309	0.2	0.002	0.06	0	0.6	0.009	0.23	1.6	0.1
800	0.2	0.002	0.06	0	0.5	0.007	0.19	0.9	-
825	0.2	0.002	0.06	0	0.2	0.004	0.11	0.8	-
Alloy X	0.2	0.002	0.06	0	0.3	0.006	0.14	1.4	0.1
RA-333	0.2	0.002	0.06	0	0.6	0.002	0.04	2.2	0.1
316	0.2	0.002	0.06	0	1.5	0.020	0.50	4.5	0.2
321	0.4	0.004	0.10	0	1.3	0.018	0.46	2.9	0.1
21-6-9	0.2	0.002	0.06	0	0.4	0.007	0.17	4.6	0.2
22-13-5	0.2	0.002	0.06	0	0.4	0.007	0.17	3.6	0.2
430	0.2	0.002	0.06	0	0.4	0.006	0.16	7.0	0.3
600	36.8	0.412	10.47	0	15.1	0.582	14.77	304.6	15.0
601	0.5	0.005	0.13	0	0.5	0.011	0.27	1.5	0.1

^aBased on a linear extrapolation of the sound metal loss measured after 781.8 hr under operating conditions.

Temperature range: 800°-1500°F.

Average temperature: 1284°F.

Pressure: 600 psig.

Table 2-17

FIRST-EXPOSURE CORROSION DATA FOR SYNTHANE GASIFIER; FLUIDIZED BED
(Location 3)

Alloy Material	Scaling Loss, mils	Rate of Scaling Loss		Diffusion Zone Thickness, mm	Depth of Penetration, mils	Total Sound Metal Loss ^a		Weight Loss	
		in/yr	mm/yr			in/yr	mm/yr	mg/cm ²	mils
304	0.2	0.002	0.06	0	0.2	0.005	0.13	1.8	0.1
309	0.2	0.002	0.06	0	0.2	0.004	0.11	2.3	0.1
800	0.2	0.002	0.06	0	0.2	0.004	0.11	1.0	-
825	0.2	0.002	0.06	0	0.2	0.004	0.11	1.4	0.1
Alloy X	0.2	0.002	0.06	0	0.3	0.005	0.13	1.2	0.1
RA-333	0.2	0.002	0.06	0	0.2	0.004	0.10	1.9	0.1
316	0.2	0.002	0.06	0	2.0	0.025	0.63	4.1	0.2
321	0.2	0.002	0.06	0	1.3	0.017	0.43	3.1	0.2
21-6-9	0.2	0.002	0.06	0	0.5	0.007	0.19	2.7	0.1
22-13-5	0.2	0.002	0.06	0	0.3	0.006	0.14	2.5	0.1
430	0.2	0.002	0.06	0	0.7	0.010	0.24	5.2	0.3
600	43.9	0.492	12.49	0	34.4	0.878	22.30	674.6	33.2
601	0.2	0.002	0.6	0	1.4	0.018	0.46	1.2	0.1

^aBased on linear extrapolation of the sound metal loss measured after 781.8 hr under operating conditions.

Temperature range: 800°-1550°F.

Average temperature: 1434°F.

Pressure: 600 psig.

APPENDIX G

Synthane - cont'd

Table 28 summarizes corrosion data for the first exposure in the Synthane scrubber surge tank, vapor phase (location 4). Surface appearance of as-exposed coupons is shown in Appendix B1, Fig. B1-13. Alloys exposed in this location included carbon steel, aluminized carbon steel, 410, 430, 304, 316, 800, 600, Monel 400, and titanium. Monel 400 suffered the highest corrosion in this location--85-89 mpy, based on total (operational + standby) exposure and 293-310 mpy based on operational exposure. Comparable maximum corrosion rates determined metallographically for carbon steel were 36-39 mpy (total) and 124-136 mpy (operational). Measureable corrosion, 0.7-6.1 mpy, was also obtained by gravimetric analysis for 600, aluminized carbon steel, 410, and 430. Alloys 304, 316, 800, and titanium did not exhibit significant corrosion. No stress-corrosion cracking was observed in welded 304 and 800 U-bends.

Corrosion rate data for the Synthane scrubber tank, liquid phase (location 5), are summarized in Table 2-19, and surface appearance of first-exposure coupons is shown in Appendix B1, Fig. B1-14. Alloy selection in this location was the same as in location 4. Carbon steel exhibited a higher metallographically determined rate (182-229 mpy) than Monel 400 (120-132 mpy), in the liquid phase. Corrosion rates based on total exposure were 53-66 mpy for carbon steel and 35-38 mpy for Monel 400. Measureable corrosion of 410, 430, and 600 of 1.3-5.5 mpy determined gravimetrically was again obtained. Pitting was measurable on 304, 316, and 800 and one 600 specimen. Again, no stress-corrosion cracking of 304 and 800 welded U-bends was obtained.

APPENDIX G

Synthane - cont'd

Table 2-20 contains first-exposure corrosion data for the first exposure in the decanter splash zone (location 6). Figure B1-14 of Appendix B1 shows the as-exposed surface appearance of the corrosion coupons. Alloys exposed in this location were carbon steel, 410, 430, and 304, with only carbon steel indicating significant general corrosion in 592 hr. Specimens of 410 did have significant pitting. Linearly extrapolated corrosion rate of carbon steel based on metallographically determined maximum corrosion was 112-161 mpy. Based on total exposure time (operational + standby) the corrosion rate was 33-47 mpy. No stress-corrosion cracking was observed on either carbon steel or 304 welded U-bends.

Test exposure data for the Synthane decanter, liquid zone (location 7), is summarized in Table 2-21. Surface appearance of specimens as-exposed are shown in Appendix B1, Fig. B1-15. As in location 6, significant corrosion was measured both gravimetrically and metallographically for carbon steel. Specimens of 410 and 430 exhibited measurable pitting in 592 hr, whereas 304 did not. Corrosion rate of carbon steel determined metallographically was 70-78 mpy based on the 592 hr operational exposure and 20-31 mpy based on the 2046 hr total exposure. No stress-corrosion cracking of welded carbon steel and 304 U-bends was apparent.

Table 2-18

FIRST-EXPOSURE CORROSION DATA FOR SYNTHANE SCRUBBER SURGE TANK,
VAPOR PHASE
(Location 4)

Alloy Material	Gravimetric Analysis		Linearly Extrapolated Corrosion Rate, mils/year		Pit Depth, mils	
	Weight Change, mg	Average Corrosion, mils	Operational ^a	Total ^b	Max	Avg
<u>Flat Specimens</u>						
Carbon steel	-3000.7	3.9	58.2	16.8		
	-2781.9	3.7	54.0	15.6		
Carbon steel	-308.2	0.38	5.6	1.6		
(Al)	-331.1	0.41	6.1	1.8		
410	-214.1	0.28	4.1	1.2	3.2	1.5
	-214.4	0.28	4.1	1.2	6.9	6.1
430	-82.0	0.10	1.5	0.4	3.8	1.4
	-80.0	0.10	1.5	0.4	2.3	0.9
304	-4.2	0.005	-	-	-	-
	-4.1	0.005	-	-	-	-
316	-3.0	0.004	-	-	0.6	-
	-2.9	0.004	-	-	0.7	0.5
800	-4.6	0.005	-	-	1.2	0.4
	-3.8	0.005	-	-	-	-
600	-47.8	0.06	0.9	0.3	4.8	1.3
	-40.2	0.05	0.7	0.2	5.2	1.6
Monel 400	-11665.4	12.8	189.1	54.7	-	-
	-14012.0	15.0	222.6	64.4	-	-
Titanium	-3.5	0.007	-	-	-	-
	-9.2	0.02	-	-	-	-
<u>Metallographic Analysis</u>						
	Thickness Loss, mils	Maximum Corrosion, mils	Metallographic Corrosion Rate, mils/year			
			Operational	Total		
Carbon steel	9.6	8.4	124.3	36.0		
	7.7	9.2	136.1	39.4		
Carbon steel	2.3	4.7	69.5	20.2		
(Al)						
Monel 400	3.2	21.0	310.7	88.9		
	3.2	19.8	293.0	84.8		
<u>Welded U-Bends</u>						
304	No visible cracks					
800	No visible cracks					

^aBased on operational exposure: 592 hr.

^bBased on total exposure--operational exposure plus standby exposure: 2046 hr.

Temperature range: 350°-414°F.

Average temperature: 385°F.

Pressure: 600 psig.

Table 2-19

FIRST EXPOSURE CORROSION DATA FOR SYNTHANE SCRUBBER SURGE TANK,
LIQUID PHASE

(Location 5)

Alloy Material	Gravimetric Analysis		Linearly Extrapolated Corrosion Rate, mils/year		Pit Depth, mils	
	Weight Change, mg	Average Corrosion, mils	Operational ^a	Total ^b	Max	Avg
<u>Flat Specimens</u>						
Carbon steel	-2857.8	3.74	55.3	16.0		
	-2673.0	3.49	51.6	14.9		
Carbon steel (Al)	-308.0	0.39	5.8	1.7		
	-260.8	0.33	4.9	1.4		
410	-230.4	0.30	4.4	1.3	7.9	2.6
	-277.2	0.37	5.5	1.6	4.7	2.1
430	-157.9	0.19	2.8	0.8	-	-
	-157.2	0.19	2.8	0.8	-	-
304	-5.0	0.006	-	-	-	-
	-5.2	0.006	-	-	1.5	-
316	-7.6	0.01	-	-	1.2	-
	-13.4	0.02	-	-	0.9	-
800	-8.1	0.009	-	-	0.6	-
	-3.2	0.004	-	-	0.2	-
600	-82.9	0.10	1.5	0.4	-	-
	-72.4	0.09	1.3	0.4	7.0	2.4
Monel 400	-3588.5	3.84	56.8	16.4	-	-
	-3196.9	3.45	51.1	14.8	-	-
Titanium	-10.4	0.02	-	-	-	-
	-11.4	0.02	-	-	-	-

Metallographic Analysis

	Thickness Loss, mils	Maximum Corrosion, mils	Metallographic Corrosion Rate, mils/year	
			Operational	Total
Carbon steel	9.0	12.3	182.0	52.7
	9.1	15.5	229.4	66.4
Carbon steel (Al)	2.3	5.4	79.9	23.1
Monel 400	8.0	8.1	119.9	34.7
	8.0	8.9	131.7	38.1

Welded U-Bends

304	No visible cracks
800	No visible cracks

^aBased on operational exposure: 591.8 hr.^bBased on total exposure--operational exposure plus standby exposure: 2046 hr.

Temperature range: 350°-415°F.

Average temperature: 385°F.

Pressure: 600 psig.

Table 2-20

**FIRST-EXPOSURE CORROSION DATA FOR SYNTHANE DECANter, SPLASH ZONE
(Location 6)**

Alloy Material	Gravimetric Analysis		Linearly Extrapolated		Pit Depth,	
	Weight Change, mg	Average Corrosion, mils	Corrosion Rate, mils/year		mils	
			Operational ^a	Total ^b	Max	Avg
<u>Flat Specimens</u>						
Carbon steel	-2219.1	2.7	40.0	11.6	-	-
	-2594.7	3.2	47.4	13.7	-	-
410	-132.8	0.17	2.5	0.7	12.1	5.4
	-35.9	0.05	0.7	0.2	4.9	1.8
430	-6.4	0.01	-	-	-	-
	-10.0	0.01	-	-	-	-
304	-2.7	-	-	-	-	-
	-2.5	-	-	-	-	-
<u>Metallographic Analysis</u>						
	Thickness Loss, mils	Maximum Corrosion, mils	Metallographic Corrosion Rate, mils/year			
			Operational	Total		
Carbon steel	9.2	7.6	112.5	32.5		
	12.5	10.9	161.3	46.7		
<u>Welded U-Bends</u>						
Carbon steel	No visible stress-corrosion cracks					
304	No visible stress-corrosion cracks					

^aBased on operational exposure: 591.8 hr.

^bBased on total exposure--operational exposure plus standby exposure: 2046 hr.

Temperature range: 200°-400°F.

Average temperature: 220°F.

Pressure: <5 psig.

Table 2-21

FIRST-EXPOSURE CORROSION DATA FOR SYNTHANE DECANter, LIQUID ZONE
(Location 7)

Alloy Material	Gravimetric Analysis		Linearly Extrapolated Corrosion Rate, mils/year		Pit Depth, mils	
	Weight Change, mg	Average Corrosion, mils	Operational ^a	Total ^b	Max.	Avg
<u>Flat Specimens</u>						
Carbon steel	-1528.3	1.9	28.1	8.1		
	-1653.0	2.0	29.6	8.6		
410	-43.1	0.06	0.9	0.3	12.8	3.3
	-42.1	0.06	0.9	0.3	9.2	2.3
430	-30.3	0.04	0.6	0.2	4.6	2.5
	-19.7	0.03	0.4	0.1	4.2	2.9
304	-1.6	-	-	-	-	-
	-0.3	-	-	-	-	-
<u>Metallographic Analysis</u>						
	Thickness Loss, mils	Maximum Corrosion, mils	Metallographic Corrosion Rate, mils/year			
			Operational	Total		
Carbon steel	7.5	5.3	78.4	31.3		
	5.8	4.7	69.6	20.1		
<u>Welded U-Bends</u>						
Carbon steel	No visible stress-corrosion cracks					
304	No visible stress-corrosion cracks					

^aBased on operational exposure: 591.8 hr.

^bBased on total exposure--operational exposure plus standby exposure:
2046 hr.

Temperature range: 200°-240°F.

Average temperature: 220°F.

Pressure: <5 psig.

APPENDIX G

Synthane - cont'd

Table 2-22 summarizes first-exposure data in Synthane gasifier, char cooler (location 8). In this location, carbon steel flat corrosion coupons were not included in the first exposure. Metallographically determined corrosion for carbon steel was measured on the unstressed portions of the bend specimens. As in locations 6 and 7, 410 specimens had significant pitting reflected in specimen weight loss. Pitting was also observed on 304 stainless steel specimens exposed in the char cooler. Corrosion rate of carbon steel based on operational exposure was 114-145 mpy and 33-42 mpy based on operational plus standby exposure (2046 hr). Welded U-bends of carbon steel and 304 did not indicate any stress-corrosion cracking.

Comparison of corrosion data obtained to date for the Synthane plant shows high corrosion rates for both Monel 400 and carbon steel in quench system test locations. Corrosion data in the vapor (vapor-liquid) tended to be higher than that of the liquid phase in the same vessels. For example, corrosion rates for carbon steel were higher in the decanter splash zone than in the liquid zone. Similar results were obtained for both carbon steel and Monel 400 in the scrubber surge tank. Reasons for this behavior are not apparent at present. Corrosion data for the subsequent exposures in the Synthane quench system may clarify this initial observation.

Table 2-22

FIRST-EXPOSURE CORROSION DATA FOR SYNTHANE GASIFIER, CHAR COOLER
(Location 8)

Alloy Material	Gravimetric Analysis		Linearly Extrapolated Corrosion Rate, mils/year		Pit Depth, mils	
	Weight Change, mg	Average Corrosion, mils	Operational ^a	Total ^b	Max	Avg
<u>Flat Specimens</u>						
410	-250.3	0.33	4.9	1.4	14.8	8.8
	-104.8	0.14	2.1	0.6	12.0	6.4
304	-5.5	0.01	0.2	-	7.7	3.6
	-14.7	0.02	0.3	0.1	6.6	3.5
<u>Metallographic Analysis</u>						
	Thickness Loss, mils	Maximum Corrosion, mils	Metallographic Corrosion Rate, mils/year			
			Operational	Total		
Carbon steel	12.4	9.8 ^c	145.0	42.0		
	9.7	7.7 ^c	113.9	33.0		
<u>Welded U-Bends</u>						
Carbon steel	No visible stress-corrosion cracks					
304	No visible stress-corrosion cracks					

^aBased on operational exposure: 591.8 hr.

^bBased on total exposure--operational exposure plus standby exposure: 2046 hr.

^cMeasured on carbon steel U-bends.

Temperature range: 600°-900°F.

Pressure: 600 psig.

APPENDIX G

Bi-Gas

No specimen racks completed exposure during 1977.

Battelle

No specimen racks completed exposure during 1977. Approved alloy selections for the first exposure in the combustor (location 4) and gasifier (location 6) are listed in Table 2-23.

Steam-Iron

No specimen racks completed exposure during 1977. Approved alloy selections for the first exposure in the Steam-Iron and producer reactors are given in Table 2-23.

Agglomerating Ash

No specimen racks completed exposure during 1977. Approved alloy selections for the Agglomerating Ash PDU exposure are given in Table 2-23.

Synthane

Refractory specimens for Synthane are of the same configuration as those installed at CONOCO COAL. First-exposure refractory specimens were recovered and returned to IITRI in late September. One gasifier location (location 13) had received refractory specimens as described in Section 2.2.2. Rotating rod abrasion tests have been completed at room temperature on these specimens. Abrasion data will be reported when the 1400°F tests are complete, and density in kerosene can be determined.

APPENDIX G

Synthane - cont'd

In general, the specimens were similar in appearance, and had similar weight changes to the CONOCO COAL gasifier specimens. The Refrax 20 specimen exhibited considerable volume expansion, and was severely fractured as shown in Fig. 2-6. As seen in the photograph, expansion was sufficient to deform the metal rack. This behavior is believed to be due to conversion of the carbide to cristobalite, as discussed for the CONOCO COAL specimen. A comparison of an unexposed SiC sample with the Synthane gasifier exposed sample is shown in Fig. 2-7. Exposure conditions for this location were approximately those given for metals location 3 in Table 2-15.

Deterioration of SiC in gasifier atmospheres has also been reported by Stanczyk at the Bureau of Mines, Tuscaloosa.⁽¹⁾ In these tests, a number of SiC samples were subjected to a $H_2O-CH_4-CO-CO_2-H_2$ environment for 1000 hr at 1800°F. In view of results obtained in the CONOCO COAL and Synthane plants, it would appear that silicon nitride bonded SiC would not be a good candidate for gasifier atmospheres containing water vapor. However, the temperature dependence of the degradation mechanism has not been fully established.

Neg. No. 46984

1/3X

Figure 2-6

Ladder Rack Containing Refractory Specimens Exposed in Synthane Gasifier (Location 13) Showing Expanded Refrax 20 Specimen

Neg. No. 47631

1X

Unexposed

Exposed

Figure 2-7

Appearance of Refrax 20 Specimens Before and After
First Exposure in Synthane Gasifier (location 13)

APPENDIX H

LIST OF ENGINEERING CHANGES

<u>Project No.</u>	<u>Description</u>
1-4	Install ventilation in coal pit
2-4	Install multiple orifice downstream FA-308
3-4	Add additional chemical injection pump
4-4	Insulate condensate header
5-4	Insulate tar tank
6-4	Replace PSV on LPG tanks
7-4	Provide vaporizer for LPG
8-4	Modify electrical equip. at waste disposal
9-4	Provide fire protection LPG tank
10-4	Relocate LPG tank
11-4	Separate DW and PW Systems.
12-4	Install TAH on char cooler at 650°F
13-4	Install TAL on overhead gasifier
14-4	Install LAL on FA-202
15-4	Condensate pot to Deaerator
16-4	Install CO Alarm
17-4	Install Alarm Panel Utility Bldg.
18-4	Heater for BFW to Water Treating
19-4	Helium injection system
20-4	LAH on FA-211
21-4	GA-206 PSV
22-4	Strainer GA-404
23-4	Pond Piping
24-4	Gasifier shut-off XV-256
25-4	TAL 204 Gasifier
26-4	Spray nozzles, Burner BC-101X
27-4	GB-301 Elect. trips & GB-303
28-4	New Instru. Air Reg.
29-4	Desuperheater Gasifier
30-4	Change Valves Willis Choke
31-4	Modify C.W. GB-301 & S
32-4	Argonne Elbow

APPENDIX H

LIST OF ENGINEERING CHANGES (continued)

<u>Project No.</u>	<u>Description</u>
33-4	CO ₂ Purge Meter
34-4	Steam Purge Meter
35-4	Snubbers GB-301 & S
36-4	High level alarm FA-401
37-4	Sequence Control., Emerg. Gen.
38-4	Maintenance & Warehouse Office
39-4	Relocate valves on rotometers
40-4	Cooling Coils Bypass on valves
41-4	PAI Sampler
42-4	Parallel line Willis Choke
43-4	Petrocarb Vent Valves
44-4	Air Compressor Holding Tank
45-4	Relocate Acid Pumps, IWT
46-4	Catwalk T.O.
47-4	Gasifier Instrumentation
48-4	Fuel Oil Pressure Control
49-4	Valves GA-201 and 207
50-4	Package CO ₂ Problems
51-4	GA-302 Revision
52-4	Tapco Valve & Piping
53-4	T.O. Stack gas samples
54-4	Suction Filter GB-303 & S
55-4	Duplicate Controls FB-302/311
56-4	6" Rockwell Valves in Petrocarb
57-4	Alignment Problems - Rupture Discs

APPENDIX H

LIST OF ENGINEERING CHANGES

(continued)

<u>Project No.</u>	<u>Description</u>
1-5	CSO Drain Valve FA-201
2-5	Add PI check and recycle line FA-201
3-5	Benfield Items per RMS 09
4-5	Add diaphragm gauges GA-202 & 212
5-5	Add PSV at FD-201
6-5	Convert HCV to grade PCV at stripper
7-5	Install purge instruments DA-202
8-5	Insulate instruments DA-202, DA-203
9-5	Add vents and drains to pumps
10-5	Put GA-203 & Stretford on emergency power
11-5	Add antifoam tank on system
12-5	Modify drawings showing control LT-1101, FCV-2203
13-5	Put GA-502 on emergency power
14-5	Charge gate to globe FI-1701
15-5	Install PSV GA-505
16-5	Apply epoxy paint to diffusers and piping
17-5	Construct sulfur filter bldg.
18-5	Install check GA-254, PI & suction valve
19-5	Steam trace & insulate FI-2202
20-5	Install PI on EJ-1401
21-5	Install PI on steam to sulfur storage
22-5	Remove trap from condensate sulfur storage
23-5	Install overflow FA-501
24-5	Meloy analyzer package
25-5	Replace piping GA-204
26-5	Relocate sample cooler SC-206
27-5	Jumper 4" 2459 to 3" 2455
28-5	Jumper 3" 2454 to 3" 2455
29-5	Repair EA-205
30-5	Connect return 2456 condensate
31-5	Install CO ₂ Purge Benfield

APPENDIX H

LIST OF ENGINEERING CHANGES

(continued)

<u>Project No.</u>	<u>Description</u>
1-6	Relocate shift vent 10' above platform
2-6	Move spec break CV-214
3-6	Add PSV DC-203
4-6	Insulate line downstream PSV-221
5-6	Purchase Portable pump for Dowtherm
6-6	Install drain GA-214 pump strainer
7-6	Add chemical injection FA-223
8-6	Steam trace BFW to FA-223
9-6	Install vent valve before methanator
10-6	Install double block DC-206
11-6	Move spec break P-2602
12-6	Install trip XCV-220, GB-202 shutdown
13-6	Relocate TG Outlet C.W. line
14-6	Relocate PSV to atmosphere GB-202
15-6	Steam trace line 2610
16-6	Relocate TW-263
17-6	Check design of CD on FA-207 & 212
18-6	Move TAH & TR to DC-206
19-6	Vent packings GB-202 above roof
20-6	Install double block DC-205
21-6	Add plugs to vents and drains
22-6	Install thermal relief EA-209
23-6	Blind High & Low Point EA-209
24-6	Add 3/4" drain FA-206
25-6	Relocate TW-257 to outlet line
26-6	Check design of CD on FA-206
27-6	Install trip XCV-215 on GB-201 shutdown
28-6	Trace line 2559
29-6	Relocate PSV GB-201 to atmosphere or flare
30-6	Relocate packing vent GB-201
31-6	Flange CDs for repair
32-6	Rerange TCV-214
33-6	Install MTI Compressor & Filter

APPENDIX H

LIST OF ENGINEERING CHANGES

(continued)

<u>Project No.</u>	<u>Description</u>
1-7	Add K.O. Pot on fuel gas to boiler
2-7	Enlarge neutralizing pit
3-7	Install double trip on propane LP Boiler
4-7	Install K.O. Pot fuel gas to H.P. Boiler
5-7	Insulate LCV-310 at CT
6-7	Insulate check and block GA-306 A & B
7-7	Walter Kidde System for Gasifier
8-7	Char Flow Measurement
9-7	Inert gas generator
10-7	Platforms dry storage bin
11-7	Grit Blast Bldg.
12-7	ERDA Weather Station
13-7	Fire Protection Modifications
14-7	Convert inline burner to propane
15-7	Waste Treatment modifications
16-7	Fuel oil meters BF-301, 402
17-7	Aeration steam lines RMS-22
18-7	Fixed Ladders
19-7	Passenger Elevator
20-7	MCC-2 Revisions
21-7	Ground Fault 480 Volt TR-2
22-7	Motor ground fault relays MCC-1B

APPENDIX H

LIST OF ENGINEERING CHANGES

(continued)

<u>Project No.</u>	<u>Description</u>
1-8	Provide orifice for purge FA-401
2-8	Relocate TI-200 to process stream
3-8	Relocate TG line 4205 to EA-401 outlet
4-8	Install thermal relief
5-8	XV-411 Fail closed
6-8	Steam trace BFW to H.P. Slurry
7-8	Steam trace and insulate CD-401 vent
8-8	Convert LAH 407 to LALH
9-8	Remove PIC 428 from system
10-8	Add SQ to drain filtrate from FA-404
11-8	Relocate minimum flow GA-401 to FA-404
12-8	Remove LCV 411A from systems
13-8	Add SC to FA-404
14-8	Add LSH & LSL to FA-404
15-8	Modify instrument to conform to logic diagram
16-8	Install trap HCV-410 A & B
17-8	CSO Valves outlet FD-401 A & B
18-8	Change spec on blind FD-401
19-8	Relocate purge XC-407A
20-8	CSO block before XV-417 A & B
21-8	Change PLH to PDSD & PDI
22-8	Fail close XV-401, 404, 406, 431, 409
23-8	Modify XV-400
24-8	Add diaphragm gauges GA-409 & S
25-8	Fail close SV-421, 422, PCV-428
26-8	Install thermal relief EA-402
27-8	Add lowpoint drain EA-402
28-8	Add screw FA-406
29-8	Add position lights on panel
30-8	Add EV-400C and PDY 402B to system

APPENDIX H

LIST OF ENGINEERING CHANGES

(continued)

<u>Project No.</u>	<u>Description</u>
31-8	Change sequence of valves per logic diagram
32-8	Add limit switches (2) XV-417 A & B
33-8	Add bug screens SV valves
34-8	Check that SCV-14 fails open
35-8	Replace Kamyrr and EBV Valves
36-8	Set pins and hangers
37-8	Replace insulation char lock hoppers
38-8	Remove steam line from flange char hoppers
39-8	Char lock hopper instrument sequence

APPENDIX I

SPECIAL ENGINEERING DEPARTMENT REPORTS

1. Synthane Gasifier - Mechanical Report
2. GA-201, 207 & S History
3. Thermal Oxidizer Repair History
4. Historical Summary - Inert Gas System
5. Project 109-7 Concrete Problems Status Report
6. Piping System Analysis (204-4)
7. Project 106-7 Valve Failure Analysis Summary Report

APPENDIX I

I. Synthane Gasifier Mechanical Report

A. Description of Gasifier

The SYNTHANE Gasifier is comprised of two sections totalling approximately 100 feet in height. The upper 70 feet is the gasifier proper and the lower 30 feet is the char cooler section. The gasifier shell is monel clad carbon steel, 5 feet in outside diameter and lined with a six-inch layer of light insulating castable refractory and three inches of dense erosion-resistant castable refractory. An Incoloy 800 shroud further restricts the inside diameter to 37 inches. The char cooler is carbon 1/2 moly steel. The upper 9' (plenum zone) is clad with 316 stainless steel. The bottom 15 feet of the char cooler is reduced to 30 inches outside diameter. The char cooler section is separated from the gasifier by an internal dished head.

The gasifier has the following internals:

- a. A conical distributor containing 160 nozzles, of which 128 are available to distribute a steam and oxygen mixture from the plenum zone to the fluidized bed.
- b. An internal cyclone to separate entrained fines from the overhead gas stream leaving the gasifier.
- c. The cyclone dip leg to convey solids from the cyclone back to the fluidized bed. A trickle valve bolted to the end of the cyclone dip leg provides a seal during start-up.
- d. A deep bed feed pipe to permit injection of coal into the fluidized bed.
- e. A downcomer from the gasifier to the char cooler to convey char and maintain a fluidized bed level in the gasifier. This downcomer is sealed from the plenum zone and thermal expansion is compensated for by an expansion joint.

APPENDIX I

I. Synthane Gasifier Mechanical Report

A. Description of Gasifier - cont'd

- f. A unique slot valve is installed on the end of the char cooler downcomer to control the flow of char from the gasifier to the char cooler.
- g. A char cooling distributor cone, containing 27 special nozzles, to distribute steam and to maintain a fluidized bed in the char cooler, and to cool the char cooler and char to below 800°F.
- h. Numerous pressure taps to measure gasifier pressure and differential pressure across various sections of the gasifier and char cooler, to determine fluidized bed heights and densities.
- i. Multi-element thermocouple bundles to measure various gasifier temperatures.

The gasifier section is externally painted with heat sensitive paint to indicate hot spots caused by internal refractory failure. In addition, it is equipped with a Walter Kidde surface temperature measuring and alarm system. The char cooler section has external cooling coils to protect it from overheating in the event of an excessive dump of hot char and failure of the fluidizing steam to adequately cool the vessel. Skin thermocouples are used to detect overheating. They alarm in the control room. The cooling water flow can be actuated automatically or manually. The cooling coils are covered with external insulation.

APPENDIX I

I. Synthane Gasifier Mechanical Report - cont'd

B. Mechanical Problems and Modifications

There have been numerous changes made to the gasifier since its fabrication. Some of these changes were due to mechanical problems and failures. Others were made as gasifier technology was developed and operating experience revealed the need.

Modifications to the gasifier are summarized below in chronological order.

The gasifier was fabricated by Fritz W. Glitsch, Inc., of Dallas, Texas, in 1972 and 1973. It was shipped to Bruceston in December 1973 and arrived the first week of January 1974.

January 1974 - The gasifier arrived at Bruceston by rail and was offloaded on flatbed trailer trucks for movement to the plant site. While moving through the Bureau of Mines, the upper section of the gasifier fell from the truck onto the roadway and embankment adjacent. Nozzle 11B (coal feed) was bent. The gasifier was erected in the structure and the nozzle straightened out in March, using procedures furnished by the manufacturer (see equipment file on gasifier, DC-202, for details).

APPENDIX I

I. Synthane Gasifier Mechanical Report

B. Mechanical Problems and Modifications - cont'd

- Gasifier internals were installed. Some field changes were required for proper fit and to make the bottom head removable. Installation of the reaction zone baffle was deferred pending process studies. (Subsequent studies indicated no advantage would be obtained and the baffle was never installed. A separate process report was issued on this subject in June 1978.)

June 1975

- The initial pressure check of the gasifier revealed a leak in the internally welded gasket at the main body flange. Repairs took approximately six weeks.

March 1976

- During cold fluidization tests, the internal head between the gasifier and the char cooler was damaged by overpressure and was buckled downward. The expansion joint (Zallea Brothers C-30576-9) was returned to the vendor for repair. The internal head was left in its deformed condition and reinforced with bracing as shown on SKA-7426-752 through 758 and Glitsch Dwg. 38212. The bracing enables the internal head to withstand a differential pressure of 25 psi in either direction. The expansion joint, dip leg and head insulation were reinstalled per the original design. Three rupture disc loops were installed to relieve high differential pressure between gasifier compartments.

APPENDIX I

I. Synthane Gasifier Mechanical Report

B. Mechanical Problems and Modifications - cont'd

- July 1976 - TR-268 was a bundle of 12 Incoloy 800 thermocouples installed to measure the temperature of the distributor cone in the gasifier. These thermocouples failed during the first gasifier run and were replaced with a duplicate set. The second set failed in a similar manner a week or so later. A detailed analysis of the failure was issued in a report by Argonne National Laboratory. These thermocouples were subsequently replaced again at a later date and failed, but experience in the meantime indicated that they were not necessary since the distributor cone temperature never exceeded 700°F. Accordingly, these thermocouples were finally eliminated.
- September 1976 - The upper purge connection in the char cooler dip leg was moved upwards to just under the gasifier internal head to promote increased fluidizing in the dip leg. This was expected to eliminate the plugging encountered in the dip leg. Another purge was also added to the dip leg (BB-12A) that was originally to be used to purge the char cooler overflow nozzles. The purges were subsequently changed as detailed below to support a larger dip leg.

APPENDIX I

I. Synthane Gasifier Mechanical Report

B. Mechanical Problems and Modifications - cont'd

A new thermocouple (TE-269) was added to the reaction zone to determine the temperatures at the shroud support. The thermocouple was inserted into nozzle #16.

Another modification made at this time concerned the addition of a new purge at the top of the cyclone dip leg just below the cyclone. This new purge differed from others in that it went into only one side of the pipe. The new purge was given designation BB-15.

October 1976

- Following Run #1-M, the gasifier was opened for inspection. Inspection revealed that the Incoloy 800 shroud above the cone in the gasifier was warped and that the insulating brick and covering shroud in the plenum zone had sagged approximately three inches and was resting on the internal head. The condition of the internals of the gasifier led to a strong suspicion that bed temperatures were well in excess of 1600°F, the specified operating temperature. Temporary repairs were made immediately and the main shroud was permanently repaired in May 1977. No further repairs were deemed necessary to the shroud in the plenum zone.

APPENDIX I

I. Synthane Gasifier Mechanical Report

B. Mechanical Problems and Modifications - cont'd

- November 1976 - The trickle valve on the bottom of the standpipe between the gasifier and the char cooler was automated. An actuator shaft was extended out through nozzle #66B to a pneumatic control valve operator. This valve was intended to control gasifier bed height automatically by controlling the rate of char withdrawal using a signal from the bed height differential pressure transmitter. Although improved, the behavior of the char withdrawal system was still not satisfactory, and the valve was further modified in July 1977 (see Dwgs. SKS7-4 REL 7 through 13 and SK 7848-BAR-1 through 3).
- December 1976 - An Incoloy 800 screen with 3/4-inch openings was designed, fabricated and installed above the outlet of the gasifier cone prior to Run 1-T. This screen was installed to prevent plugging of the char cooler standpipe by pieces of agglomerated coal or refractory (see Dwgs. SK4392-RS-1 and 2).

APPENDIX I

I. Synthane Gasifier Mechanical Report

B. Mechanical Problems and Modifications - cont'd

January -

February 1977

- A steam eductor was designed and fabricated by Schutte and Koerting Company and was installed in the cyclone dip leg just below the cyclone. This installation was intended to increase the differential pressure between the cyclone and the gasifier fluid bed so that fines removed from the gasifier overhead gas stream could be more easily returned and so that plugging of the cyclone dip leg with entrained tar and fines would be minimized. After one run, the inlet to the eductor was found to be bridged with solids and the throat was restricted. The dip leg from the eductor to the trickle valve was clear. The eductor was subsequently removed and the cyclone dip leg was reinstalled with its original purge piping (see Shutte & Koerting Dwg. 76G-X120J revised to Lummus SK-REL-030677A).
- The gasifier was modified by the installation of piping to provide for the injection of coal feed deep into the fluid bed. This installation was intended to reduce entrainment of fines into the scrubbing system by reducing tar production which was thought to cause plugging of the cyclone dip leg. This installation was based on studies conducted by the Pittsburgh Energy Technology Center (PETC) of the U.S. Department of Energy (DOE).

APPENDIX I

I. Synthane Gasifier Mechanical Report

B. Mechanical Problems and Modifications - cont'd

- April 1977 - Cracks were detected in the cylindrical Incoloy 800 manway shrouds on the seventh and tenth floors. The problem was analyzed by Lummus Technical Center-Mechanical Engineering Department. It was concluded that the only action required was to prevent further propagation. This was accomplished by drilling holes at the end of each existing crack (see memo 7848-WHVS-018-77 dated 5/9/77).
- May 1977 - Gas was found leaking from spare nozzle
July 1977 #50 on May 27. Inspection revealed the presence of cracks in the Incoloy 800 nozzle. Further investigation revealed potential for leaking in all Incoloy 800 nozzles. During June and July, 22 nozzles were removed and replaced with monel overlay on carbon steel. The replacement nozzles were fabricated by Combustion Engineering in Chatanooga, Tennessee. A detailed report was prepared by Lummus on this subject.

APPENDIX I

I. Synthane Gasifier Mechanical Report

B. Mechanical Problems and Modifications - cont'd

June 1977

- The gasifier cyclone was removed for repair of an erosion hole in the body of the cyclone. A new cyclone was fabricated and later installed (see Dwgs. D-7848-02672 and D-7848-02470).

The bottom circle of eight nozzles in the distributor cone were piped up separately with stainless steel tubing to permit injection of steam only. This was intended to improve char withdrawal. The char cooler dip leg between the gasifier and the char cooler was increased in size from 2 inches to 3 inches to improve control of char withdrawal.

July 1977

- The trickle valve on the char cooler standpipe was modified again in an effort to improve char withdrawal. Design of a 3-inch valve was initiated but the valve was never fabricated. This specially designed "slot" valve is shown on Dwgs. SKA-6157-1 through 10.

August 1977

- The 2" gasifier to char cooler standpipe was replaced with a 3" pipe and the new 2" 'slot' valve was installed.

APPENDIX I

I. Synthane Gasifier Mechanical Report

B. Mechanical Problems and Modifications - cont'd

- June 1978 - A secondary steam-oxygen distributor was designed, fabricated and installed to give better distribution of oxygen and improve fluidization in the gasifier. The design was based on tests done in the atmospheric, two-dimensional model at PETC. Subsequently, the nozzles were revised several times to improve the performance of the distributor (see drawings in Project File 164-4).
- August 1978 - During Run 2-DB-0 at the end of August, a large clinker was found in the gasifier. The cyclone trickle valve had broken off at the weld and was lying on the clinker, and the main gasifier shroud had some clinker behind it, near its lower end, and was buckled in that area. The lower section of the dip leg was replaced and a spare trickle valve was installed. For details on this failure, see report

APPENDIX I

II. Status of Open Projects

There were several modifications at various stages of completion at the time of plant deactivation. Following is a status summary of the modifications not completed at that time.

A. New Internal Head and Distributor Cone to Withstand Higher Differential Pressure Between Gasifier and Char Cooler:

A new internal head and cone for 150 psi differential pressure were designed by Lummus Technical Center-Mechanical Engineering Department (LTC-MED) and quotes were received for the modification. The project was cancelled due to excessive cost and unacceptable schedule. A rupture disc arrangement was designed and installed to protect the gasifier. The details of the proposed internal head and cone are covered in the files of Bloomfield Project E-164.

B. New 1/2" Thick Shroud:

A shroud was designed and fabricated to replace the damaged shroud in the reaction zone. The replacement shroud was fabricated in sections out of 1/2" thick Incoloy 800 plate. A special design allows thermal expansion of the cylindrical shroud as it slides up and down the cone.

The details of the shroud arrangement are covered in Project File 172-4. The shroud pieces are stored in the Warehouse.

APPENDIX I

II. Status of Open Projects - cont'd

C. Smaller Diameter Shroud:

This project was undertaken to increase superficial velocity of the fluidized bed in the reaction zone with the available quantity of high pressure steam. A 25" diameter shroud was proposed to replace the existing 37" diameter shroud for the first 6' above the cone. The 25" diameter shroud was designed and fabricated out of 1/4" thick Incoloy 800 plate. The shroud is in 8 sections which are to be assembled inside the gasifier through a manway. The outside of the shroud is to be wrapped with blanket-type soft insulation. The fabricated shroud pieces are stored in the Warehouse. The details of the fabricated shroud and assembly drawings are covered in Project File 184-4. The gasifier internal modifications to suit the 25" diameter shroud (oxygen distributor, thermowells, etc.) were in the conceptual design phase by the Technical Department at the time of plant deactivation.

D. New Thermowell for Gasifier:

This project was undertaken to alleviate the problem of frequent failure of bare sheath thermocouples in the reaction zone.

The proposed design utilized the spare uninstalled thermowell. The pipe was cut in sections and metal discs were set between the sections to have positive contact of the thermocouple at each level for reliable indication of bed temperature. The details of the thermowell are shown in drawings SKB-7849-792 through 798. The partially fabricated thermowell is stored in the Warehouse.

APPENDIX I

II. Status of Open Projects - cont'd

E. 3" Slot Valve for Char Cooler Dip Leg:

A 3" slot valve was designed to replace the existing 2" valve at the end of the 3" diameter dip leg. The proposed slot valve will eliminate the restriction at the end of the dip leg and allow for better control of char flow from gasifier to char cooler.

An arrangement of sash weights located behind the char cooler shroud is proposed to replace the counterweights and linkages to close the flapper. The actuation of the valve will be by the existing pneumatic diaphragm actuator.

The details of the design are contained in Project File 173-4. The fabrication of the valve was deferred until the performance of the existing 2" slot valve could be evaluated.

F. Oxygen Line Behind the Shroud:

This modification would relocate the feedpipe to the secondary steam-oxygen distributor from the reaction zone to the space behind the shroud, thus eliminating potential seeding points for clinker formation in the reaction zone.

The drawings detailing the modifications and bill of material are in Project File 214-4. The materials were not ordered at the time of plant deactivation.

APPENDIX I

II. Status of Open Projects - cont'd

G. Revised Char Withdrawal Arrangement and Cyclone Dip Leg Modifications:

The conceptual design was in progress by the Technical Department at the time of plant deactivation.

H. Gasifier Refractory Repair:

The refractory lining of the gasifier has suffered localized spalling and loss of thickness above the shrouded section. The refractory condition was checked after each run as a part of post run inspection. Repairs were deferred pending a suitable shutdown period since there were no hot spots noticed on the gasifier shell by hot spot temperature checks or by the Walter Kidde temperature monitoring system. The recommended procedure for repair was being prepared by the Lummus Technical Center-Mechanical Engineering Department (LTC-MED) at the time of plant deactivation. Preliminary recommendations were to strip the damaged area to the metal shell and reline with refractory layers of the original specification.

APPENDIX I
Gasifier Drawings

I. Original Design Drawings

A) Lummus

D6656-02222A-5	5'-0"/2'-6" I.D. Vert Gasifier DC-202 Orientations & Assembly
D6656-02222B	
D6656-02222C-6	5'-0"/2'-6" I.D. Vert. Gasifier DC-202 Details, Nozzles in Reaction Zone
D6656-02222D-6	5'-0"/2'-6" Vert. Gasifier DC-202 Lower Reaction Zone Details
D6656-02222E-6	5'-0"/2'-6" I.D. Vert. Gasifier DC-202 Details, Plenum Zone
D6656-02222F	
D6656-02222G-5	5'-0"/2'-6" I.D. Vert. Gasifier DC-202 Lower Char Cooler Details
D6656-02222H-6	5'-0"/2'-6" I.D. Vert. Gasifier DC-202 Internal Insulation Details
D6656-02222I	
D6656-02222J-O	Guides for Trickle Valve & Thermo- well at nozzle 43 - Char Cooler section 5'-0"/2'-6" Vertical Gasifier DC-202
D6656-02222K-O	Supports for internal pipes for nozzles Nos. 7, 22, 29A & B, 36A & C, 41 5'-0"/2'-6" I.D. Vert. Gasifier DC-202

APPENDIX I

Gasifier Drawings

I. Original Design Drawings - cont'd

B) F. W. Glitch & Sons, Inc.

FWG 27275-5V	Sheet 1 of 37, Assembly of a 30" I.D. x 60" I.D. x 95'-0" overall face of gasket to face of flg. vertical gasifier.
FWG 27775-5V	Sheets 2 & 3 of 37, Elevations and Orientation for a 30" I.D. x 60" I.D. x 95'-0" overall face of gask't. to face of flange vertical gasifier.
FWG 27275-5V	Sheets 4 through 37 of 37 - Misc. details for a 30" I.D. x 60" I.D. x 95'-0" over face of gsk't. to face of flg. vertical gasifier.

C) Lenape Forge

C-7236-1	30" Hillside Insert Section
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D) The Ducon Company

K73-021-1	Arrangement of Coal Gasification Cyclone One size 8VMEE 810
K73-021-2	Ducon Trickle Valve Size 3 type CA Model III
K73-021-3	Ducon Trickle Valve Size 2 type CA Model V

E) Zallea Brothers, Inc.

C-30576-9	2" (5") Self Equalizing Double Expansion Joint.
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APPENDIX I
Gasifier Drawings

I. Original Design Drawings - cont'd

F) National Airoil Burner Company

B-7421 Rev. 2 Assembly of type F-53 water sprayer
B-7558 Water sprayer winch mounting details
S-4337 Assembly of type F-53 (Tungsten)
 Water Sprayer Head

G) Thermosensors Company

494-1441-5 (Item) Thermocouple Assembly

H) Harbison-Walker Refractories

M-429-002-L Sheet 1 & 2 of 2 Lining for DC-202
 Gasifier

APPENDIX I
Gasifier Drawings

II. Modification Drawings

A) Lummus

No Number	Detail of Metal Gask't.
SKA-7426-752	Vert. Gasifier DC-202, Head Reinforcement Location
SKA-7426-753	Gasifier - Internal Head Reinforcement DC-202
SKA-7426-754	Details for Gasifier Internal Head Reinforcement DC-202
SKA-7426-755	Details for Gasifier Internal Head Reinforcement DC-202
SKA-7426-756	Details for Gasifier Internal Head Reinforcement DC-202
SKA-7426-757	Vert. Gasifier DC-202, Insul. of Head & Braces
SKA-7426-758	Gasifier Brace Insul. Shield for Internal Head
SKB-7849-792	Thermowell Assembly for DC-202 Nozzle 36F
SKB-7849-793	Thermowell details for DC-202 Nozzle 36F - Section #1
SKB-7849-794	Thermowell details for DC-202 Nozzle 36F - Sections 2 & 3
SKB-7849-795	Thermowell details for DC-202 Nozzle 36F - Section #4
SKB-7849-796	Thermowell details for DC-202 Nozzle 36F - Section #5
SKB-7849-797	Thermowell details for DC-202 Nozzle 36F Pieces 1, 2, 3, 4, & 5
SKB-7849-798	Thermowell details for DC-202 Nozzle 36F Pieces 6, 7, 8, & 9

APPENDIX I
Gasifier Drawings

II. Modification Drawings

A) Lummus - cont'd

SK87-4 REL 7	Modification to Trickle Valve
SK87-4 REL 9	Trickle Valve Actuator Assemble
SK87-4 REL 10	Actuator Rod Details
SK87-4 REL 11	Linkage Assembly to Trickle Valve
SK87-4 REL 12	Trickle Valve Hinge Detail
SK87-4 REL 13	Actuator Rod Guide Pipe Assembly & Details
SK-7848-BAR-1	Adapter Flange Sht. 1 of 2
SK-7848-BAR-1	Bolt & Stud Orientations Sht. 2
SK-7848-BAR-2	Gland Details
SK-7848-BAR-3	Gland Assembly
SK-4392-RJ-1	Installation of Strainer Cone in Gasifier Distribution Cone
SK-4392-RJ-2	Layout of Cone Strainer of Distributor Cone
SK-REL-030677A	Eductor for Cyclone Dip Leg
SK-128-4-REL 1	Deep Bed Coal Injection Arrangement
SK-128-4-REL 2	Deep Bed Coal Injection Nozzle Pipe Arrangement
SK-128-4-REL 3	Deep Bed Coal Injection Nozzle Pipe
SK-128-4-REL 4	Deep Bed Coal Injection Closure Flange Details
SK-128-4-REL 5	Deep Bed Coal Injection Pipe Support & Guide
SK-128-4-REL 6	Deep Bed Coal Injection - Pipe Guides

APPENDIX I
Gasifier Drawings

II. Modification Drawings

A) Lummus - cont'd

D7848-02674A	DC-202 Nozzle Mk. 29A B, C
D7848-02674B	DC-202 Nozzle Mk. 28
D7848-02674C	DC-202 Nozzle Mk. 24
D7848-02674D	DC-202 Nozzle Mk. 11A & 11B
D7848-02674E	DC-202 Nozzle Mk. 16
D7848-02674F	DC-202 Nozzle Mk. 12
D7848-02674G	DC-202 Nozzle Mk. 39 & 50
D7848-02674H	DC-202 Nozzle Mk. 22
D7848-02674I	DC-202 Nozzle Mk. 41
D7848-02674J	DC-202 Nozzle Mk. 35A & 35B
D7848-02674K	DC-202 Nozzle Mk. 36A through 36F
D7848-02674L	DC-202 Nozzle Mk. 40 & 9
SKD-7848-760	Nozzle Modification Noz. No. 11A
SKD-7848-761	Nozzle Modification Noz. No. 11B
SKD-7848-762	Nozzle Modification Noz. No. 12
SKD-7848-763	Nozzle Modification Noz. No. 16
SKD-7848-764	Nozzle Modification Noz. No. 22
SKD-7848-765	Nozzle Modification Noz. No. 24
SKD-7848-766	Nozzle Modification Noz. No. 28
SKD-7848-767	Nozzle Modification Noz. No. 29A, B & C
SKD-7848-768	Nozzle Modification Noz. No. 35A
SKD-7848-769	Nozzle Modification Noz. No. 35B

APPENDIX I

Gasifier Drawings

II. Modification Drawings

A) Lummus - cont'd

SKD-7848-770	Nozzle Modification Noz. No. 36A, B, C, & D
SKD-7848-771	Nozzle Modification Noz. No. 36 E, F
SKD-7848-772	Nozzle Modification Noz. No. 39
SKD-7848-773	Nozzle Modification Noz. No. 40
SKD-7848-774	Nozzle Modification Noz. No. 41
SKD-7848-775	Nozzle Modification Noz. No. 50
SKD-7848-776	Nozzle Modification Miscellaneous Details
SKD-7848-777	Typical Nozzle Modification Assembly Sequence
SK100-4 REL 1	Repair of Plenum Zone Insulation
D7848-02672	Fabrication Arrangement for Internal Cyclone
D7848-02470	Modifications to Internal Cyclone
SK-A-6157-1	Slot Valve for Char Cooler
SK-A-6157-2	Char Cooler Slot Valve (Modified Trickle Valve)
SK-A-6157-3	Valve Key
SK-A-6157-4	Valve Flapper
SK-A-6157-5	Flapper Guide & Key Stop
SK-A-6157-6	Valve Key Pivot
SK-A-6157-7	Pin
SK-A-6157-8	Pin
SK-A-6157-9	Pin
SK-A-6157-10	Flapper Hinge Pin Support

APPENDIX I

Gasifier Drawings

II. Modification Drawings - cont'd

B) Glitsch

38212

Miscellaneous Parts for Repair of
Damaged Internal Head - Detail of
Reinforcement Assembly

TO K. V. Chauhan
(OFFICE)DATE February 28, 1979FROM R. F. Scherrer
(OFFICE)

NUMBER _____

SUBJECT GA-201, 207 & S History
(Update of T. F. Munro's report dated May 2, 1978)

Attached is the failure history of the circulating pumps in the Gas Scrubbing System. From initial testing to the present, these pumps have been experiencing problems with the seals, bearings, shafts, and casing wear. The probable major cause of these problems is that the pumps were not designed for the severe service which they were subjected to. Despite this, several improvements have been made which have improved their performance.

INTRODUCTION

From startup of the Gas Scrubbing System to the present, there have been continuing problems with the seals, shafts, bearings, and casings in the GA-201, 207 & S, circulating pumps. The following information covering the various approaches to these problems, was obtained from an extensive review of available records.

SEALS

Initially, there were severe problems with char entering the Borg-Warner Model U1500 mechanical seals and causing seal failure in less than one (1) hour. This was due to reduced seal flush; however, increasing the flush to the 3 gpm recommended by the manufacturer overtaxed the Thermal Oxidizer. It was, therefore, necessary to modify the system to maintain low flush water flow. To accomplish this the throat bushing clearance was reduced from 0.024 to 0.004 inches allowing the flush rate to be reduced to 3/4 - 1 gpm. This improved service considerably; however, during operation the clearance increased allowing coal to enter the seal. To alleviate this problem, a teflon lip seal was installed with satisfactory results. During the same period of time, a Chem-Pro Model 605 H-DL double bellows seal was installed in GA-207. This seal operated successfully during a series of pretreater runs; however, during a pump inspection in October of 1977, the "O" ring was damaged causing seal leakage. There was never a failure of the Chem-Pro seal caused by service conditions. Spare parts were ordered (with long delivery time) and during the interim the mechanical seal/teflon lip seal was reinstalled. During Gasifier Run 2-DB-G in April of 1978, this combination experienced an extremely severe service test with the Scrubber System overloaded with char. Upon shutdown inspection, no damage was found in the seal area and has since provided continuing satisfactory service.

SHAFTS

In May of 1977, we experienced a shaft failure on GA-207. The capscrew holding the impeller to the shaft failed resulting into imbalance of the rotating assembly. The capscrew failure was caused by improper heat treatment. The shaft failed because of fatigue due to the imbalance. The fatigue crack had started at the keyway of the shaft because of stress concentration due to small fillet radius of curvature in the keyway. See Argonne National Laboratory Report "Analysis of Pump Shaft (GA-207) Failures from the Synthane Pilot Plant", dated April 1978, for details of the failure analysis.

The shaft was replaced 3 times with successive shaft failures. In December 1977 experienced a broken shaft on GA-207S with inspection indicating a bent shaft prior to failure. Stress evaluation indicated that the GA-201, 207 & S shafts were undersized for the service because of high solid loading; therefore, they have been replaced with 1" diameter shafts. Following this diameter increase, there have been no shaft failures; however, during inspection following Gasifier Run 2-DB-G in April of 1978, found evidence of corrosion to the shaft and threads which would have led to failure. To correct this corrosion problem, 316 SS shafts with 304 SS nuts were installed with no further problems.

BEARINGS

All pumps in the scrubber circulating system have experienced failures of both the thrust and radial bearings. In March of 1977, the high stress at the pump flanges was reduced by the addition of pipe supports; however, the bearing failures continued. Upon inspection, determined that the thrust bearing is a medium 300 series and the radial bearing a light 200 series type. With the increased char loading, these bearings should be stepped up to the next heavier duty series; however, this is not possible with the present pump design (Memo 7849-TFM-004-78). In response to possible vibration problems, a balancing unit was designed and fabricated. Prior to Gasifier Run 2-DB-G in March/April of 1978 the 201 and 207 & S shafts were shop balanced and field checked to be well within vibrational limits -- less than 1 mil. During Gasifier Run 2-DB-G no bearing problems were experienced.

PUMP CASE CORROSION/EROSION

We have experienced continuing problems since startup with corrosion/erosion of the 11-13% chrome steel casings. Two factors are involved in this damage:

1. The higher than design concentrations of char in the system 20-30% rather than trace
2. The continued low pH of the system

Steps have been made to rectify both of these problems with only partial success. pH control was being approached through caustic injection into the Scrubber system. Originally, the injection was directly into FA-215 Scrubber Surge Tank; however, the pH continued to vary considerably, evidently due to poor mixing. In April 1978, the caustic injection point was changed to the pump suction lines resulting in considerable improvement of pH control.

In addition, a program was initiated to determine what case material would withstand the corrosive/erosive conditions present. A brief summary follows:

1. In March of 1977, following several case replacements due to corrosion/erosion, a 3/16" 316 stainless steel liner was installed in GA-207 & S. This liner was not successful and failed after approximately 50 hours of service.
2. The next procedure, in June of 1977, was to weld a "butter-pass" of Coordinated Industries No. 101 rod into the case and weld an overlay of Coordinated Industries No. 204 rod, Rockwell C60. This procedure was rejected due to cracking of the hard surface which propagated into the soft metal and was felt might move into the parent metal.
3. The third procedure, in June of 1977, was to use only one (1) type of weld rod that resulted in a medium surface hardness of Rockwell C-34 to 40. Coordinated Industries Rod No. 101, the same as used for the "butter-pass" in the above procedure was

chosen. This rod gives a deposited material of 88.0% nickel. This method was used with satisfactory results during the separate Pretreater tests; however, during Gasifier run 2-DB-G this coating experienced severe damage in GA-201 following approximately 400 hours of circulation.

4. A fourth procedure, similar to the third, was done by Westinghouse Electric Corporation, Industry Services Division. GA-207 was welded with a martensitic chrome steel with a hardness of Rockwell C-52 to 56. This was installed in May of 1977 and remained in service for one gasifier run (1-DB-0) and two Pretreater runs (2-DB-A, 2-DB-B) until November of 1977 when it was removed due to erosion along the outer edge of the case. This was repaired with 101 rod and put back into service. In April of 1978, following approximately 200 hours of operation, this casing was removed due to excessive damage.
5. A hard surface of Nickel-Chrome-Boron by Machinists, Inc. was installed. This material quickly corroded/eroded and was unsuccessful.
6. The Maintenance Department had also proposed tests using coordinated industries #2005 hard surface, a material specifically developed for high impact corrosive service. However, the material was never tested.

Under severe corrosive/erosive conditions the case material providing the best service had been the coordinated industries #101 rod. It was also found that machining the surface smooth prior to installation also increased the surface life.

In addition to experimenting with different case materials a study was made to check the possibility of reducing pump case erosion by slowing the impeller tip speed, see report by R. F. Scherrer dated May 3, 1978. Pump GA-207 was chosen as the test pump and all modifications recommended in the above report were made, see engineering project file #201-4. Cold tests performed at atmospheric and elevated pressures indicated the pump would work satisfactory. However, the pump performance was drastically reduced when tests were conducted at elevated temperatures. Several unsuccessful attempts were made to operate the pumps at the higher temperatures. System heating was provided through a propane fired inline burner and the writer believes the poor pump performance was caused by carbon dioxide dissolving in the water and later evolving at the low pressure areas at the pump inlet. The carbon dioxide bubbles would displace the water inside the pump body reducing the water flow. The pump was subsequently changed back to its original operating condition and was never tested in a slurry service with the lower impeller tip speed.

Modifications were also made to the scrubber surge tank, FA-215, in an attempt to reduce pump case erosion. They are as follows:

1. All pump suction lines were changed to draw from the west nozzle of FA-215, believed to be the "clean" end.
2. Flocculant was added to the water to promote better solid/liquid separation.
3. Anti-foam was added to the water to prevent foaming.

The pump casing wear rate was only slightly improved after the first two items were tried. However, exceptional improvement was obtained after the addition of anti-foam. It is generally believed that excessive water foaming was occurring either in FA-215 or the pump suction lines. The foam, as it passed through the pumps, would promote erosion and cavitation.

At the time of plant close-out, the pumps, GA201, 207 & S, were providing adequate service. The two major factors contributing to the reduction of case wear were the addition of anti-foam to the water system and the pH control.

TO G. D. Cliff, K. Chauhan, D. Stavsky
(OFFICE)DATE May 3, 1978FROM R. F. Scherrer
(OFFICE)NUMBER 7849-RFS-008-78SUBJECT MODIFICATIONS TO GA-207ABSTRACT

The service life of the Venturi Scrubber Recycle Pump, GA-207, may be extended by modifying the pump to eliminate the internal water recirculation and by reducing the impeller tip speed. The recirculation can be reduced by replacing the existing 11 inch impeller with a 13-1/4 inch impeller, the largest impeller the pump will handle. The tip speed can be reduced by slowing the pump rotation from 3600 RPM to 1800 RPM.¹⁾ The combined effect of these modifications will reduce the impeller tip speed from 170 ft/sec to 104 ft/sec and should result in extended pump service.

BACKGROUND

Due to the erosive and corrosive nature of the Venturi scrubber recycle water, the Venturi Scrubber Pump, GA-207, has historically provided poor service. Experimentation with various casing metals has helped to extend the service life to some degree; however, Maintenance estimates a maximum of only 200 operating hours can be obtained before the pump must be repaired. Efforts to purchase a new pump more suited to the application has also proved futile. Of over ten manufacturers contacted, only Lawrence Pump Company is capable of furnishing a slurry pump for this application and they require a minimum of one year for delivery.

- 1) A 20 H.P. motor would normally be sufficient to drive the pump at these conditions. However, due to the reduced efficiency caused by erosion, Mr. Frank Jackman of Byron Jackson Company suggests installing at least a 30 H.P. motor.

SYSTEM MODIFICATIONS

As an alternative to replacing the pump, attempts are being made to modify the system. The pump service life can be extended if the erosive and corrosive service conditions can be improved and the pump modified to reduce internal wear. Studies attempting to remove the char particles before they reach the pump and to increase the water pH are not yet complete; however, the pump operation has been investigated and information received from Byron Jackson indicate the pump can be successfully modified.

The wear rate in slurry pumps has been studied and found to be proportional²⁾ to the (particle velocity)^m, therefore the pump erosion can be reduced by slowing the impeller tip speed.

The Venturi Scrubber Pump if modified as suggested above will not operate at the design conditions of 230 GPM @ 460 ft. total dynamic head (ΔP); therefore, the flow requirements of the Venturi Scrubber Recycle System must be reduced. According to Dick Stavsky the system will operate satisfactorily at a flow rate of 150 GPM and has, in the past, operated with a flow of only 125 GPM. By performing pressure drop calculations with the reduced flow requirements, the system curve shown in Fig. 1 will be obtained. ³⁾ Information for the pump curve was obtained from Byron Jackson representative Frank Jackman and is based on replacing the present 11 inch impeller with a 13-1/4 inch impeller and reducing the rotation from 3600 RPM to 1800 RPM. By eliminating flow control valve FCV-206 and allowing the system to self-stabilize, the final operating point as shown will be reached.

- 2) The exponent "m" will vary between 2.2 and 3 depending on the parameters of the pump and system. (Materials of construction, particle size, particle shape, particle hardness, particle concentration, and angle of impact).
Reference: Pump Handbook McGraw-Hill, 1976.

- 3) The pressure drop through the flow control valve FCV-206 has not been included in the calculation.

FIG. I

The general feeling among pump manufacturers, according to Joel R. Horton,⁴⁾ is that the impeller tip speed must be reduced to about 100 ft/sec to notice any significant pump wear improvement in slurry applications. The modifications as stated above will result in reducing the impeller tip speed of GA-207 from 170 ft/sec to 104 ft/sec.

It must be noted that the information received from J.R. Horton and obtained in the Pump Handbook deal with erosion applications only and do not include the effects of corrosion.

- 4). Mr. Joel R. Horton of Union Carbide Corporation is presently researching equipment availability and reliability for DOE in relationship to the Coal Gasification Process. He has had extensive contacts with all the major pump manufacturers.

CONSEQUENCES OF MODIFICATIONS

With the incorporation of the changes mentioned above the overall pumping flexibility associated with the scrubber surge tank, FA-215, will be reduced. The present system, see FIG. 2, has three pumps piped in parallel servicing two systems. GA-207 and GA-201 supply water to the Venturi scrubber and the raw gas scrubber respectively and GA-207S is used as a spare for both systems. All three pumps are identical and it is possible under emergency conditions to supply water to both systems with only one pump. This situation has been experienced in the past when two pumps have failed at the same time. When GA-207 is operating at the reduced performance level, due to modifications, it will lose the capability of supplying both systems. For normal operation it will be imperative that either GA-207S or GA-201, along with GA-207, be operational at all times. In the event both GA-201 and GA-207S fail during the same run, the gas cooling and cleaning effects of the raw gas scrubber will be lost and hot (450° F) dirty gas will be sent to the shift converter (DC-208). Since the vessels downstream of the scrubber surge tank have high temperature ratings (540° F for DA-201 and 875° F for DC-208) no system overheating problem will be experienced. However, the particulate carry over into the shift converter may create problems.

A second problem will be encountered if GA-207 fails. As mentioned earlier the pressure drop through the control valve, FCV-206, must be eliminated to insure sufficient flow for the Venturi scrubber recycle system. However, if GA-207 fails and GA-207S is activated it will be impossible to control the flow to the Venturi scrubber. As an alternative it is suggested to install a by-pass around FCV-206 instead of removing it. By flowing through the by-pass, when operating with GA-207, the high pressure drop associated with control valves will be eliminated while retaining the control capability for operation with GA-207S.

R. F. Scherrer
Project Engineer

RFS/psm

FIG. 2

TO K. V. Chauhan
(OFFICE)**DATE** February 28, 1979**FROM** R. F. Scherrer
(OFFICE)**NUMBER** _____**SUBJECT** Thermal Oxidizer Repair History
(Update of J. C. Olson's Report)**INTRODUCTION**

The Thermal Oxidizer, BF-402, was purchased to dispose of the waste water, tars, and product gases generated by the Synthane Coal Gasification Process. The oxidizer was first commissioned in March, 1975 and put in actual service February, 1976. Since then there have been two (2) major problems with the Oxidizer operation: 1) The inability to vaporize water at the design rate and 2) numerous failures of the firebox refractory.

ORIGINAL DESIGN

The original firebox lining consisted of 9" of C-E Lite Wate Castable-70 in the floor and 6 1/2" of C-E Super Castable-32 in the furnace walls starting at the base plate at elevation 101'-8" and extending to elevation 108'-0". Directly above the firebox the upper refractory wall was constructed of a hot face layer, 4 1/2" thick, of C-E Warco XX Firebrick with a back layer, 2" thick, of C-E Lite Wate Castable-70. The upper wall was supported by a metal shelf attached to the Oxidizer shell.

According to the Lummus original design specification No. BF-105, the Thermal Oxidizer was to have the capacity to vaporize a maximum of 16,067 pounds of water per hour (32 GPM).

SUMMARY

The following is a comprehensive summary of the problems experienced and the corrective action taken on the Thermal Oxidizer (BF-402). The table is followed by a discussion of our service and operating experience. All pertinent correspondences and related documentation is in the equipment file BF-402.

<u>Date</u>	<u>Problem or Action</u>	<u>Repair Cost</u>	<u>Ref. Documentation</u>
6/76	Minor cracks were observed in the refractory Problems were encountered in vaporizing water at the design rate. Representatives of John Zink Co. inspected the Thermal Oxidizer and recommended the water guns be changed from brass to stainless steel. The water guns were changed as recommended.		
11/76	The Regan tile for the Oil burner was nearly gone and was replaced per the original design. The Thermal Oxidizer was still unable to vaporize water at the design rate. Representatives of John Zink Co. again inspected the unit and discovered the burner was not designed to use fuel oil as a primary fuel. It was recommended to replace the 30MM BTU/hr burner with a 60MM BTU/hr burner.	\$ 496.00	
12/76	The burner assembly was changed per John Zink recommendations.	\$11,150.00	
1/77	The firebox refractory showed signs of extensive wear and was patched with Harbison-Walker Super Plastic.	\$ 1,500.00	
3/77	The refractory across from the burner was badly spalled and in need of repair. Harbison-Walker Super Plastic was used to repair a 180° area starting from the east wall through north to the Manway on the west wall.	\$ 2,006.40	
4/77	Inspection trip by John Zink Co.	\$ 278.98	Inspection report by John Zink Co. dated May 4, 1977.
5/77	Spalling continued throughout the firebox and was spot patched with H & W Super Plastic.	\$ 1,200.00	

<u>Date</u>	<u>Problem or Action</u>	<u>Repair Cost</u>	<u>Ref. Documentation</u>
6/77	Continued refractory degradation resulted in the need for a complete firebox relining. Per John Zink's recommendations the relining was made using C-E Refractories 90-Ram-HS.	\$25,719.65	Inspection report by John Zink Co. dated May 4, 1978.
10/77	The refractory around the manway collapsed and was repaired using C-E Refractories Blu Ram HS.		
3/78	Extensive spalling continued resulting in the shell reaching a temperature of 1100°F. Inspection of the firebox showed one area completely void of refractory. The 6" wall in other areas had been reduced to 1-3 inches. Repairs were made with Charles Taylor Shamrock 888.	\$ 9,320.00	Report from John Zink Co. dated March 3, 1978.
4/78	Minor spalling was observed and patched with H & W Mullite Plastic.	\$ 1,700.00	
4/78	Per John Zink's recommendations C-E Emerald Ram HS was purchased for a future complete relining.	\$11,412.00	
5/78	Tests were made on the Thermal Oxidizer by the Process Dept. to determine optimum operations procedures.		Letter by E.O. Curtiss dated May 31, 1978. (7849-EOC-1194-78)
5/78	Final inspection trip by John Zink Co.	\$ 1,010.01	Inspection report by John Zink Co. dated June 8, 1978.
6/78	The entire firebox was relined using the C-E Emerald Ram HS purchased in April 1978.	\$ 9,760.00	Correspondence from Chip Munro No. 7849-TFM-023-78 dated June 9, 1978.
TOTAL COST		\$76,133.04	
(Original Thermal Oxidizer Cost \$83,000.00)			

PERFORMANCE DISCUSSION

Due to the inability of the Thermal Oxidizer to vaporize water at the design rate, representatives of John Zink Co. visited the site in June, 1976. After inspecting the unit, they reported that the water guns had been severely eroded resulting in poor water distribution. The original Lummus Engineering Specification for the Thermal Oxidizer, BF-105, included no requirement for entrained solids. However, the waste water contained about 20.0 percent by weight of highly abrasive coal and coal char fines. In order to improve the life of the water guns and provide proper water distribution, John Zink Co. recommended replacing the original brass nozzles with stainless steel.

The original water gun nozzles had a total of five holes; three spraying up and two smaller holes spraying down. The bottom holes caused excessive water accumulation on the firebox floor and were subsequently plugged at John Zink's recommendation.

Although the water gun nozzles were replaced in June, 1976, the Thermal Oxidizer was still unable to vaporize water at the design rate. Further investigation in November, 1976 revealed that the Oxidizer was never designed to burn only fuel oil. The fuel oil burner was to be used only as a supplemental heat source with product gas as the primary fuel. Paragraph 2.1.1 of Specification BF-105 reads:

"2.1.1 Thermal Oxidizer (BF-402)

The gaseous and liquid waste will be incinerated in the Thermal Oxidizer. Supporting fuel will be provided by firing synthetic natural gas or raw product gas. Natural gas will be used during start-up and also as a back-up fuel for the synthetic gas system."

As a result of this information and further evaluation by John Zink Co., an oil burner size increase from 30MM BTU/hr to 60MM BTU/hr was recommended. The resulting operation produced excessive amounts of smoke and vibration, and still did not meet specifications.

Two additional trips to the site by John Zink Co. in April and May of 1978 resulted in several major changes being recommended, see attached inspection reports. Tests were also made on the Thermal Oxidizer by the Process Department to determine optimum operating procedures. These tests were conducted under the supervision of E. O. Curtiss and were reported in correspondence No. 7849-EOC-1194-78. Some of the recommendations made by John Zink Co. and E. O. Curtiss were implemented resulting in a better vaporization rate. However, since all of the recommended changes were not implemented, no complete final performance evaluation can be made.

REFRACTORY REPAIR DISCUSSION

Degradation of the refractory in the firebox has been a continuing problem. Between February, 1976 and December, 1976, when the new burner was installed, only minor refractory cracking and spalling was observed. However, one month after installation of the new burner, the refractory rapidly degenerated to a point where a major repair was required. Two additional repairs were made in March and May of 1977. All repairs up to this point were made with Harbison-Walker Super Plastic.

Due to continuing refractory degradation the entire firebox and part of the upper wall, to an elevation of 110'-3", was relined in June, 1977. After analyzing refractory samples from the Thermal Oxidizer, John Zink Co. recommended the relining be made using C-E Refractories Blu-Ram-HS. Their evaluation indicated that no chemical attack had occurred and the refractory failures were due solely to overheating. The relining was actually made with 5 1/2 inches of 90-Ram-HS, a better grade refractory than the recommended Blu-Ram-HS, backed with one inch of fiber blanket.

In October, 1977, the refractory in the manway collapsed and several areas in the firebox were severely spalled. Repairs were made using C-E Refractories Blu-Ram-HS. The decision to use Blu-Ram-HS instead of 90-Ram-HS was based solely on immediate availability. Samples of the spalled refractory were sent to C-E Refractories Laboratory for analysis.

The refractory continued spalling at a rapid rate and in March, 1978 an area of approximately 18 square feet was found to be completely void of refractory resulting in the shell reaching a temperature of 1100°F. Results of the C-E Refractories Laboratory test performed on the samples submitted in October, 1977, indicated the failures resulted primarily from silica and calcia attack. The chemical attack was apparently originating from the coal fines found in the waste water. Note that this analysis is contrary to the findings of John Zink Co. mentioned above.

Based on the findings of the C-E Laboratory tests, John Zink recommended the use of a chrome-alumina base refractory such as C-E Emerald Ram or Taylor Refractories Shamrock 888. Since the Emerald Ram was not readily available, all repairs were made with Shamrock 888 and the Emerald Ram was placed on order for a future relining.

Repairs of minor cracks and spalling using Harbinson-Walker Mullite Plastic was made in April, 1978; and the entire lining was removed in June, 1978. The new lining was installed using the Emerald Ram, purchased earlier, see attached correspondence No. 7849-TFM-023-78.

After installation of the Emerald Ram Plastic Refractory, the Thermal Oxidizer was not operated for a sufficient length of time at full capacity to thoroughly evaluate the success of the chrome-alumina product.

RECOMMENDATIONS

There are several possible methods to solve the two major problems with the Thermal Oxidizer; 1) Sag formation on the refractory walls and 2) Firebox overheating.

1. Firebox Redesign; The firebox should be a larger size commensurate with the required heat release and burner flame pattern. This is not a feasible modification to the existing unit and will require a complete replacement.
2. Burner Redesign; A high intensity burner with a shorter flame pattern should be used to prevent flame impingement on the forebox walls.
3. Multiple Burners; A better heat distribution could be obtained with the use of several burners eliminating localized hot and/or cold spots.
4. Efficient Quench Air Distribution; Revise the quench air distribution system to have more than one discharge port in order to provide an even cooling effect.
5. Efficient Water Spray; It may be advantageous to provide more than one ring of spray nozzles to obtain better water distribution. The water guns should also be redesigned for a shorter multidirectional spray pattern with good atomization. These changes would provide better firebox cooling, complete water vaporization, and prevent water and entrained solids from touching the refractory surface. Note that if steam is to be used as the atomization, agent measures should be taken to insure that the steam will not be superheated.
6. Provide adequate water filtration in the form of inline filters to remove as much of the coal and char fines as possible. This will reduce erosive wear on the water guns and reduce the possibility of coal slagging on the refractory. New, larger capacity filters were installed for this purpose, but were not commissioned to date.
7. Use brick refractories instead of plastics. Bricks will provide greater resistance to chemical attack than plastics due to their lower porosity and higher refractory stability. See the report by G. R. Crossland, dated June 21, 1978.

TO K. V. Chauhan
(OFFICE)DATE February 28, 1979FROM J. C. Olson
(OFFICE)

NUMBER _____

SUBJECT Historical Summary - Inert Gas System

In March, 1975, the inert gas generating system was first put into operation to provide inerting gas for coal handling. Since then, a number of problems have been recognized and changes have been made to correct the problems as they were found. This report summarizes those problems and changes.

Within four to five weeks after the inert gas generators were first put into operation, problems resulting from the poor gas quality were recognized. The problems included corrosion of valves in the compressors, corrosion of the knockout pots on the inert gas generators and corrosion of other piping and vessels. At this time, the Technical Department began an investigation of the problem and potential solutions. It was discovered that the corrosion resulted from sulfur oxides and nitrogen oxides produced during the combustion of #2 fuel oil in the inert gas generators. In the May, 1975 Monthly Report, it was recommended that the generators be converted to burn propane and that a package CO₂ system be used for backup.

The package CO₂ unit was rented from Liquid Carbonics and was put into operation in July, 1975. Study of the modification of the inert gas generators continued and the Technical Department issued a design report in October, 1975. This report recommended use of propane, the addition of catalyst chambers for removal of sulfur compounds in the propane and NO_x from the inert gas, and the addition of a refrigerant dryer with a 45° dew point for installation in the low pressure inert gas line.

After further discussions with Gas Atmospheres, who manufactured the inert gas generators, a preliminary package was approved in October, 1976. Authorization for the construction subcontractor to begin work on the first phases of the project was granted October 11, 1977. The installation, performed partially by the subcontractor and partially by on-site maintenance, was completed and the system was commissioned in early 1978.

In the meantime, in order to provide the additional fuel requirements, a new 30,000 gallon propane facility was installed by Northern Propane Gas Co. This facility also provides fuel for the fired heat-up burner, the thermal oxidizer, and several pilots. It was commissioned in 1977.

Calculations were performed to verify the cost justification of both the LPG plant and the modifications to the inert gas generators. Based on the cost of CO₂ and propane at the time, a pay-out period of 17 months was calculated with an average monthly savings of about \$19,000 thereafter. A further consideration was that CO₂ could not always be obtained in the quantities required. The inert gas system can reduce the CO₂ demand by up to 40,000 SCFH.

During 1978, several piping components control valves and the CO₂ compressor unloader valves failed. The failures were caused by corrosion and erosion attributed to the moisture in the inert gas.

The inert gas is passed through the refrigerant dryer to condense out the moisture by chilling the gas to +40°F. The gas leaving the dryer is saturated at +40°F and near atmospheric pressure. When the saturated gas is compressed more moisture condenses resulting into wet inert gas at high pressure. The moisture dissolves CO₂ to form carbonic acid and NO_x to form nitrous and nitric acids which corrodes carbon steel equipment and piping. Also, the moisture causes piping and valve failures by erosion at points of high velocity.

Engineering work was in progress for installation of a desiccant type dryer to retrace the moisture in the high pressure inert gas down to -40°F dew point. The dryer package was specified and quotes were received at the time of the plant deactivation. (Reference: Lummus Report "Inert Gas Drying System", dated January 1979).

INTER-OFFICE CORRESPONDENCE

TO K. V. Chauhan
(OFFICE)DATE February 28, 1979FROM J. C. Olson
(OFFICE)

NUMBER _____

SUBJECT Project 109-7 Concrete Problems Status Report - Final

In the last year, a number of problems have been found with concrete structures on the Synthane site. Each of these problems has been studied to determine the apparent cause of failure. In most cases, repair procedures were developed and completed.

The following summarizes the concrete problems, failure analysis, and corrective measures:

1. Degradation of the Foundation on the Low Pressure Co₂ Receiver (FB-311)

The foundation was spalled over a major portion of the exposed surface. Tests by West Penn Testing (April 13, 1978) and by Dr. E. M. Krokosky at Carnegie-Mellon University indicate that the concrete strength both above and below grade was below specified minimum strength. This low strength and degradation was apparently due to a lack of air-entrainment and a high water to cement ratio.

The foundation was repaired according to a design and procedure provided by Jack Endler of Lummus, Bloomfield (W.O. #C4204).

2. Spalling of spill collection Pads and Trench in the Benfield Area

Spalling occurred over large sections of the spill collection pads and a fifteen foot section of the trench wall fell apart. Tests by West Penn Testing and Dr. Krokosky indicate the concrete bulk compressive strength was above specification but that lack of air-entrainment and high water to cement ratio were the major causes of failure. No indication of chemical attack was found.

The pads were repaired with a commercial patching compound. The trench was repaired by a method suggested by Maintenance. After all pads were patched, a commercial anti-spalling compound was applied on all outside pads and walkways in the plant.

3. Failure of the Char Pond Stilling Well Wall

On May 28, 1978, the north wall of the char pond stilling well collapsed. In this case, the bulk compressive strength of the concrete was again found to be above specification. However, a lack of air-entrainment and possible high water to cement ratio were reported by Dr. Krokosky. The major causes of failure were apparently:

- a. Improper bending techniques may have been employed for bending the reinforcing rods. A report by Industrial Testing (June 19, 1978) indicates that some rods may have been overheated and that others may have been bent to a smaller radius than the specifications permit.
- b. The stilling well was cantilevered off the char pond. The pond itself was constructed on almost solid rock. The stilling well was supported only by earth. As a result, the stilling well was essentially hanging from the char pond side.
- c. Accumulated water froze in the stilling well during the previous winter. The expansion of freezing water may have caused the first major weakening of the wall.

The purpose of the stilling well was to separate oily waste from the water. This was not achieved since the oil remained in suspension. The stilling well was eliminated after the wall failure. Piping was connected directly from the nozzles in the char pond to the waste water transfer pump.

4. Horizontal and Vertical Cracks in the Char pond

Horizontal cracks appear at the elevations of the original lifts in the char pond wall. Vertical cracks appear at regular intervals around the pond. The cracks have been attributed to drying shrinkage and thermal shrinkage. These cracks were the result of high water to cement ratio and high mix temperature.

It was determined that the extent of cracking was too great to permit effective use of individual sealing techniques. Numerous plastic lining materials were studied but none was found that could stand up to all constituents of the char slurry. The only approach found workable was the installation of a free-standing steel tank inside the char pond. This tank was constructed with a carbon steel bottom and Core Ten sides. Core Ten was used to reduce corrosion on the outside where painting is not practical because of its installation next to the char pond wall.

5. Degradation of Pipe Bridge Piers

Several piers supporting columns in the pipe bridge are severely deteriorated. In some cases they are cracked. In others, only the grout is separated. We have not determined the cause of the cracks but it appears probable that they resulted from water seeping down the anchor bolts. The cracks were caused by either freezing water or rusting steel. The grout loss appears also to be the result of water accumulation between the steel base plates and the grout. Other piers seem badly eroded by the steam trap discharges.

Repair procedures were developed with the Bloomfield Civil Engineering Department. Because of the winter weather, a temporary repair was made by sealing the surface of the piers to stop further spalling.

6. Underground Structure Deterioration

Deterioration of underground concrete was suspected because of existing acid mine streams around the site. A contract was issued to Engineering Mechanics to survey subsurface soil and water conditions and to ascertain their effects on the underground concrete. Only part of the survey was complete at the time of plant deactivation. Several cone samples of soil and water were taken by Engineering Mechanics and the results were reported. The results show no water or soil conditions that may result in structural damage to the underground concrete. A periodic sampling of subsurface water was planned as a part of the contract that was cancelled at the time of plant deactivation.

For more complete details, see the following reports in the Project 109-7 File:

1.	West Penn Testing Labs	4/13/78
2.	E. M. Krokosky, SC.D., P.E.	
3.	7849-JCO-029-78	5/11/78
4.	Industrial Testing Labs	6/19/78
5.	West Penn Testing Labs	6/13/78
6.	7849-E188	6/15/78
7.	E. M. Krokosky, SC.D., P.E.	6/06/78
8.	7849-JCO-033-78	6/29/78
9.	7849-JCO-037-78	7/21/78
10.	Minutes of July 25, 1978 Meeting	
11.	Weekly Status Reports	
12.	West Penn Testing Labs	8/09/78
13.	E. M. Krokosky, SC.D., P.E.	8/28/78
14.	Engineering Mechanics Report on Subsurface Investigation	12/13/78

INTER-OFFICE CORRESPONDENCE

TO G. D. Cliff
(OFFICE)

DATE September 25, 1978

FROM B. N. McSkimming
(OFFICE)

NUMBER 7849-BNM-0022-78

SUBJECT Piping System Analysis (204-4)

Attached is the final report for the Piping System Analysis Project 204-4. Included in this report are the Gas Scrubbing, Char Slurry and CO2 Systems.

B. N. McSkimming
B. N. McSkimming
Project Engineer

BNM/kte

cc: K. V. Chauhan w/attachments
E. V. Ganapathy w/attachments
O. D. Runnels w/attachments

PIPING SYSTEM ANALYSIS

PROBLEM:

The Synthane Plant has experienced a number of pipe line failures due to corrosion and/or erosion during the past two years. These failures are a safety hazard and, in some cases, have terminated gasifier runs.

OBJECTIVE:

Operating and design conditions were analyzed in the Gas Scrubbing and Char Slurry piping systems, to examine pipe line velocities to determine areas of excessive erosion. A means of eliminating water in the CO₂ System was also analyzed.

RECOMMENDATIONS:

(A) Line failures could be prevented in the Gas Scrubbing System by maintaining the pH of FA-215 water between 7.5 and 8.5 with caustic injection and by inacting a surveillance program of radiography and ultrasonic readings primarily at changes in flow direction.

(b) In the Char Slurry System most erosion related failures are caused by turbulence started at the gap between the pipe and the shoulder of socket weld fitting. These can be prevented by replacing all socket weld fittings with butt weld fittings, and by inacting a surveillance program the same as in (A).

(C) Corrosion related failures in the CO₂ System should be prevented by changing the piping material from carbon steel to stainless steel, by replacing an inefficient knock-out drum, FA-302 with a commercial entrainment separator, and by modifying knockout drum, FA-308, to provide better entrainment separation.

STATUS:

(A) In the Gas Scrubbing System, the caustic injection into the scrubbing water circulating loops of pumps GA-201 and GA-207 has been maintaining the pH of scrubbing water between 7.5 and 8.5, thereby eliminating corrosion related failures in the piping. A surveillance program has begun in April 1978 where ultrasonic readings were taken of the piping system around scrubbing water circulating pumps GA-201 and GA-207.

(B) In the Char Slurry System piping at the outlet of FA-401 is being replaced with stainless steel and we are using butt welded fittings.

(C) In the CO₂ System, there has been a piping material change to stainless steel, the steam heater, EA-308, is in use and the modifications to FA-308 have been completed. The knock-out drum FA-302 will be replaced when the entrainment separator is received. Also, a final design is in progress for a Molecular Sieve type gas drying system.

DISCUSSION:

(A) In the Gas Scrubbing System, failures have been caused by both erosion and/or corrosion. Erosion mainly has taken place at a change in flow direction. In each failure, the eroded portion of pipe was replaced with stainless steel. The major cause of pipe line failures have been caused by a combination of erosion and corrosion. Erosion is due to the large amount of fines carried over from the gasifier, and the scrubbing water due to excessive CO_2 in the system, when the gasifier was not in operation. By maintaining the pH between 7.5 and 8.5 of the scrubbing water by caustic injection, the corrosion problems are minimized by anti-foam addition which helps settling of fines and their removal from the system via blowdown.

(B) In the Char Slurry System failures were caused by erosion. Erosion has taken place at the socket weld fittings because turbulence caused by the gap socket weld fitting. Also the erosion of the pipe or fitting takes place at a change in flow direction.

(C) In the CO_2 System failures were caused by corrosion. Corrosion in the form of carbonic acid was attacking the piping. Carbonic acid is formed by CO_2 in the presence of water. By removing entrained water and changing piping materials to stainless steel, the corrosion failures in the system have been stopped.

GAS SCRUBBING, CHAR SLURRY, AND CO₂ SYSTEMS STATUS

LINE NUMBER

DATE OF FAILURE

STATUS

GAS SCRUBBING:

6" P 2309 D2A

AUG. 24, 1978

CARB STL ELBOW REPLACED
WITH 304 SS ELBOW

FA-215 CIRCULATING
SYSTEM

UT READING WERE
TAKEN MARCH 31 THRU
APRIL 1, 1978

CHAR SLURRY:

1" P 2110 E2B

AUG. 2, 1978

REPLACED CARB. MOLY SOCKET
WELD ELBOW WITH CARB. MOLY

1" A-B CHAR TRANSFER LINE (CARB. STL) JUNE 14, 1978

REPLACED SECTION OF LINE
WITH CARB. STL.

1" P 2112 E2B

DEC. 14, 1978

REPLACED CARB. MOLY BEND
WITH A CARB. MOLY BEND

1" P 4201 A3A

SEPT. 29, 1977

REPLACED CARB. STL. SOCKET
WELD ELBOW WITH CARB. STL.

GAS SCRUBBING, CHAR CLURRY, AND CO₂ SYSTEMS STATUS

LINE NUMBER

DATE OF FAILURE

STATUS

CO₂ SYSTEM:

1 1/2" CG 2107 A2A

AUG. 8, 1978

REPLACED CARB. STL. SECTION OF
LINE WITH STAINLESS STL.

3" CG 3107 D2A

JUNE 20, 1978

REPLACED CARB. STL. SECTION OF
LINE WITH 304 STAINLESS STL.

3" CG 3110 D2A

MAY 26, 1978

REPLACED CARB. STL. SECTION OF
LINE WITH STAINLESS STL.

3" CG 3106 D2A

APRIL 10, 1978

REPLACED CARB. STL. SECTION OF
LINE WITH STAINLESS STL.

LINES FROM THE CO₂ COMPRESSORS THRU PCV-345 HAVE BEEN
CHANGED FROM CARB. STL. TO STAINLESS STEEL.

COAL FEED:

2" P2102 EZK

APRIL 21, 1978

INCREASED LINE SIZE FROM
2" TO 4" IN ORDER TO
REDUCE THE VELOCITY.

SYSTEM: CHAR SLURRY (02005A2)
(04005B)

PIPE P.S.
TEMP °F
PIPE P.S.
SOLIDS CONCENT. %

	SPE LINE NO.	SPEC	FROM	TO	LINE FAILURE	PRESS	TEMP	VEL	SOLIDS LOADING	LUBRIC CONC.	REMARKS
1.	2"	P2112	E2B	DC-202	PDCV-204		600	660	5.8	—	1740 ¹⁶ /m w 360 ¹⁶ /m slm
	2"	"	"	PDCV-204	MIXING TEE		600	660	5.8	—	A = 0.0205 ft
	1"	"	"	MIXING TEE	FA-401	✓	1214	600	660	23.7	A = 0.005 ft
2.	1"	P4201	D3A	FA-401	LCV-405A	✓	414	550	180	9.0	~ 20 gpm
	1"	"	"	P4201	LCV-405B	✓	414	550	180	9.0	~ 20 gpm
	1"	"	"	P4201	LCV-405C			550	180	9.0	~ 20 gpm
	1"	"	"		LCV-405D			550	180	9.0	~ 20 gpm
3.	1"	"	"	LCV-405A	FA-403	—	—	—	—	16.1	VALVES MOUNTED ON FH-403
	1"	"	"	LCV-405B	FA-403	—	—	—	—	16.1	
	1"	"	"	LCV-405C	FA-403	—	—	—	—	16.1	
	1"	"	"	LCV-405D	FA-403	—	—	—	—	16.1	
4.	3"	P4202A	A3A	FA-403	GA-4065		0	165	1.94	—	~ 40 gpm
5.	3"	P4202B	"	P4202A	GA-406		0	165	1.94	—	~ 40 gpm
6.	3"	P4203A	"	GA-4065	PA-402X		15	165	1.94	—	~ 40 gpm

VELOCITY CRITERIA - SOL./LIQ = 15 fps

SYSTEM: CHAR SLURRY (04005B)

DATE: 10/2/02
TIME: 10:15
TEST: P4211C
SUCCESSION: 10/2/02
SUCCESSION: 10/2/02

LINE FAILURE

	SHE	LINE NO.	PIPE	FROM	TO	DESIGN PRESS	DESIGN TEMP	OPERATING PRESS	OPERATING TEMP	VEL	SOUNDING	SLURRY CONC.	REMARKS
7.	3"	P4203B	A3A	GA-406	P4214			15	165	1.94	-	14	~ 40 gpm A=0.0
8.	3"	P4204A	A2A	FA-404x	GA-411			22	135	0.87	-	0.2	~ 20 gpm A=0.0
9.	3"	P4204B	A2A	P4204A	GA-401			-10	165	0.87	-	0.2	~ 20 gpm
10.	3"	P4204C	A2A	P4204B	GA-408			-5	150	0.87	-	0.2	~ 20 gpm ↓
11.	3"	P4205	D2A	GA-401	FCV-403			1055	115	0.967	-	0.2	~ 20 gpm A=0.0
	3"	"	"	FCV-403	FA-401			550	115	0.967	-	0.2	~ 20 gpm A=0.0
12.	2"	P4206	D2A	P4205	FA-401			1055	115	2.17	-	0.2	~ 20 gpm (NORMALLY NOT USED) A=0.0
13.	3"	P4207	"	"	"			610	115	0.967	-	0.2	~ 20 gpm A=0.04
14.	3"	P4211	A2A	GA-408S	OR-433			35	150	0.87	-	0.2	~ 20 gpm A=0.05
	3"	"	"	OR-433	EA-402				150	0.87	-	0.2	~ 20 gpm
15.	3"	P4217	A2A	P4211	XV-437			35	150	0.87	-	0.2	~ 20 gpm
	3"	"	"	XV-437	FA-404x			5	150	0.87	-	0.2	~ 20 gpm
16.	3"	P4218	A2A	GA-408	P4211			35	150	0.87	-	0.2	~ 20 gpm ↓
17.	4"	P4216	A2A	PA-402x	P4210			5	135	0.505	-	0.2	20 gpm A=0.088

DC-202 - 600 psig
FA-401 - 550 psig

3.

100% FSC
 100% FSC
 100% FSC
 100% FSC
 100% FSC

LINE FAILURE												SINCE: 12/55 F GAS	
SINCE: 12/55 F GAS												SINCE: 12/55 F GAS	
SINE	LINE NO.	MAT'L	FROM	TO	DATE	TIME	OPERATING	TEMP	VEL	SINCE	LINE NO.	REMARKS	
18.	4"	P4210	A2A	P4216	FA-403		21	135	0.505	-	14	20 gpm	A=0.088 ft
19.	2 1/2"	P4214	A3A	P4203B	PA-402X		15	165	3.07	-	14	40 gpm	A=0.029 ft
20.	2 1/2"	P4213	A3A	P4203B	PA-402SX		15	165	3.07	-	14	40 gpm	A=0.029 ft
21.	4"	P4216	A2A	PA-402X	P4210		21	135	0.505	-	14	20 gpm	A=0.088 ft
22.	1"	P2110	E2B	CHARGE COOLER LETDOWN	✓	11/14/77							
COAL FEEDING													
1.	2"	P2102	E2K	PRETREATER	✓	4/21/78							

536

**LINE
FAILURE GAS SCRUBBING AREA**

SPEC	LINE NO.	MAT'L	FROM	TO	DESIGN		OPERATING				SLURRY CONC.	REMARKS
					INCHES	PSIG	TEMP. °F	VEL. FPS	SOLIDS LOADING LB/LB	WT %		
D2A	4" P2301	4"	GA-207S	EA-218		600	400	6.2	—	10	NORMAL FLOW = 96,000 ¹⁵ /hr Process Water Slurry Conc. Range = 0 % to 40 %	
D2A	4" P2302		EA-218	EE-201		840	320	5.4	—	10	NORMAL FLOW = 96,000 ¹⁵ /hr Process Water Slurry Conc. Range = 0 % to 40 %	
D2A	6" P2304		EE-201	FA-215		600	400	2.9	0.008	—	Gas Flow = 203,000 SCFH MW = 24 Vel. = 11.6 f/s Liquid Flow = 101,100 ¹⁵ /hr Vel. = 2.9 f/s	
D2A	6" P2307		DA-201	FA-215		600	345	3.3	—	10	NORMAL FLOW = 84,200 ¹⁵ /hr Process Water Slurry Conc. Range = 0 % to 20 %	
D2A	6" P2308		FA-215	GA-207S		600	400	2.7	—	10	NORMAL FLOW = 96,000 ¹⁵ /hr Process Water Slurry Conc. Range = 0 % to 40 %	
D2A	6" P2309		P2308	GA-207	✓	840	400	2.7	—	10	NORMAL FLOW = 96,000 ¹⁵ /hr Process Water Slurry Conc. Range = 0 % to 40 %	
D2A	4" P2310		GA-207	P2307		840	400	6.2	—	10	NORMAL FLOW = 96,000 ¹⁵ /hr Process Water Slurry Conc. Range = 0 % to 40 %	
D2A	6" P2312		FA-215	GA-201		600	400	2.8	—	4	NORMAL FLOW = 81,500 ¹⁵ /hr Process Water Slurry Conc. Range = 0 % to 20 %	
D2A	4" P2313		GA-207S	P2314		840	400	5.3	—	10	NORMAL FLOW = 81,500 ¹⁵ /hr Process Water Slurry Conc. Range = 0 % to 40 %	
D2A	4" P2314		P2313	EA-201		840	400	5.3	—	4	NORMAL FLOW = 81,500 ¹⁵ /hr Process Water Slurry Conc. Range = 0 % to 20 %	
D2A	6" P2315		P2312	GA-207S		600	400	2.7	—	4	NORMAL FLOW = 96,000 ¹⁵ /hr Process Water Slurry Conc. Range = 0 % to 20 %	
D2A	4" P2316		EA-218S	P2302		840	320	5.4	—	10	NORMAL FLOW = 96,000 ¹⁵ /hr Process Water Slurry Conc. Range = 0 % to 40 %	
D2A	4" P2317		EA-201 EA-201S	DA-201		840	320	5.3	—	4	NORMAL FLOW = 81,500 ¹⁵ /hr Process Water Slurry Conc. Range = 0 % to 20 %	
D2A	4" P2318		P2313	EA-201S		840	400	5.3	—	10	NORMAL FLOW = 81,500 ¹⁵ /hr Process Water Slurry Conc. Range = 0 % to 40 %	
D2A	1" P2324		FA-215	FA-202		600	400	—	—	Unknown	Maximum Flow Thru Blinddown Valve = 121,600 ¹⁵ /hr Maximum Liquid Vel. = 12.8 f/s	
D2A	1 1/2" P2325		FA-215	EA-213		600	400	3.8	—	6	NORMAL FLOW = 9100 ¹⁵ /hr Waste Water Slurry Conc. Range = 0 % to 30 %	
D2A	1 1/2" P2326		P2325	EA-213S		600	400	3.8	—	6	NORMAL FLOW = 9100 ¹⁵ /hr Waste Water Slurry Conc. Range = 0 % to 30 %	

**LINE
FAILURE GAS SCRUBBING AREA**

SPEC	LINE NO.	MAT'L	FROM	TO	OPERATING						REMARKS	
					PRESS		TEMP		VEL	SLURRY LOADING		SLURRY CONCEN.
					PSIG	°F	°F	°F				
D2A	1 1/2" P2327		EA-213	LCV-201			600	250	3.5	—	6	NORMAL FLOW = 9100 15/hr Waste Water Slurry Conc Range 0% to 30%
D2A	1 1/2" P2328		EA-213S	P2327			600	250	3.5	—	6	NORMAL FLOW = 9100 15/hr Waste Water Slurry Conc Range 0% to 30%
D2A	1" P2329		FA-215	FA-202			600	400	—	—	—	D.I. Skimmer - Normally No Flows
D2A	4" P2334		P2318	P2317			840	320	5.3	—	10	NORMAL FLOW = 81,500 15/hr Process Water Slurry Conc Range = 0% to 40%
D2A	4" P2350		EA-201	P2302			840	320	5.9	—	4	NORMAL FLOW = 96,000 15/hr Process Water Slurry Conc Range = 0% to 20%
D2A	4" P2412		GA-201	P2313			840	400	5.3	—	4	NORMAL FLOW = 81,500 15/hr Process Water Slurry Conc Range = 0% to 25%
D2A	3" P2311		DA-201	P2406			600	345	35	—	—	121,900 SCFH Dry Gas MW = 27.9 Water Vapor = 20 vol %
D2A	3" P2406		P2311	EA-203			600	345	35	—	—	121,900 SCFH Dry Gas MW = 27.9 Water Vapor = 20 vol %
D2A	3" P2408		EA-203	FA-203			600	110	19	—	—	121,900 SCFH Dry Gas MW = 27.9 Liquid Flow = 1230 15/hr
D2A	3" P2409		FA-203	PCV-2205			600	110	18	—	—	121,900 SCFH Dry Gas MW = 27.9
D2A	6"		FA-215	2nd Venturi			600	400	111	0.014	—	121,900 SCFH Dry Gas } MW = 24.0 H ₂ O Vapor = 40 vol %
D2A	6"		2nd Venturi	DA-201			600	350	9 VAPOR	—	0.3	156,300 SCFH Wet Gas MW = 25.7 Liquid Flow = 68,800 15/hr

LINE GAS SCRUBBING AREA

SPEC	LINE NO.	MAT'L	FROM	TO	FAILURE		OPERATING					REMARKS
					PRESS	TEMP	PRESS	TEMP	VEL	300103 READING	SHUTTER EFFECT	
					PSIG	°F	PSIG	°F	FPS	LB/LB	WT %	
A2A	1" P2324		FA-215	FA-202			3	215	75 LIQ.		Unknown	Maximum Blowdown Capacity = 121,500 lb/hr Normal Flow = 20 wgt % Vapor
A2A	2" N02302		FA-215	FA-224			3	220	60 LIQ.		Unknown	Maximum Blowdown Capacity = 374,000 lb/hr Normal Flow = 20 wgt % Vapor
A2A	1 1/2" P2330		LCV-201	FA-202			8	220	3 LIQ. 190 VAP.		6 0-30	NORMAL FLOW = 9100 lb/hr 3 wgt % Vapor MAX FLOW = 21,400 lb/hr 20 wgt % Vapor
A2A	3" P2424		PCV-2205	6" RV3100	*		5	110	300			NORMAL FLOW = 121,900 SCFH DRY GAS MW = 27.9
A2A	6" RV3100		P2424	FLARE NO POT			5	110	110			NORMAL FLOW = 121,900 SCFH DRY GAS MW = 27.9

* PIPING LENGTH 10 FEET VERTICALLY UP

Objective

This project was initiated to investigate the failures of the ball valves in the high pressure coal feed system, coal transport, pretreatment and gasification systems, and char letdown system of the plant. The purpose of the investigation was to determine the nature and frequency of failures and to improve the valve performance by material changes and design modifications.

Background

The ball valves in the high pressure coal feed system are manufactured by EBV division of Gulf and Western Energy Products Group. All the valve bodies are made of carbon steel and the balls are of 440 carbon steel in some cases and are of stainless steel 316 in others. Some of the balls are coated with various materials like ceramic, Stellite No. 6 and tungsten carbide. The service conditions in the coal feed system are: pressures varying from atmospheric to 600 psig and temperatures in the range of 150°F. Some valves are on coal dump lines between the lock hoppers and others are on the vent lines from the lock hoppers carrying CO₂ and coal dust.

The EBV ball valves in the pretreatment and gasification section are with stainless steel type 316 bodies and balls with tungsten carbide coating. These valves are in the coal transport lines operating at 600 psig and at 800°F. The transport gas consists of superheated steam, carbon dioxide and oxygen.

The dry char letdown system consisting of two lock hoppers has ball valves made by EBV on one side and those made by Kamy Corp. on the other side. These valves have stainless steel type 316 bodies and balls. The intended service conditions were pressure variations between 1000 psig and atmospheric and temperatures of 800°F. The valves were on hot char dump lines on either side of the char lock hoppers. The system was not put in service because of valve problems.

Problems

1. Corrosion of carbon steel valve bodies and balls.
2. Plugging of spring cavities with coal fines resulting into binding of balls and breaking of valve stems; or loss of seal resulting into excessive gas leakage.

3. Erosion of the ball facing the solids flow.
4. Chipping of ball coating.
5. Leakage of gas through the bonnet packings.

Failure Analysis

1. Carbon steel bodies of EBV ball valves in the high pressure coal feed system were found corroded before the startup of the plant. Rust scale was found in the spring cavities.

The corrosion of the carbon steel valve body occurred while the valves were idle and the vessels were saturated with moisture.

One of the valve bodies was electroplated with nickel to study its corrosion resistance. No significant corrosion was noticed after the valves were put in service.

2. The ball valves failed frequently because of the ball binding in the seats, and in some cases the valve stem was sheared off while turning the ball.

This was caused by plugging of the spring cavities with coal fines. The coal fines deposited within the spring coils and in the cavity hindering the movement of the springs. When the springs were clogged in expanded position, they put excessive force on the seats and caused the ball to bind between the seats.

The valve stems broke when excessive torque was applied to turn the ball in this condition. Also, the excessive speed of the pneumatic cylinder actuators and the sharp shoulders machined on the stems contributed to the stem failures (Ref. Memo from James F. Fee of G&W, dated November 8, 1976).

Another type of failure was caused when the seat springs were clogged in contracted position and were unable to push the seats against the ball. This condition caused loss of seal and excessive gas leakage across the valve.

A modification of the valve internal was proposed to solve these problems caused by coal fines clogging the springs. The modification consists of installing an internal sleeve with packings to isolate the spring cavity from the solids flow path. See P. D. Nies/W.H. VanSweringen's Memo No. LTBE-166, dated September 19, 1978 for the details of the modification.

Also, purging with inert gas would keep the isolated spring cavity free of coal fines. The inert gas flow has to be controlled because of varying pressure inside the valve body.

These modifications were considered, but not yet implemented at the time of the plant deactivation.

Restrictions were added to the air vent lines from the cylinders actuating the lock hopper vent valves to slow down their speed. No stem failures were reported on these valves since.

3. The area around the ball port facing the solids flow was eroded in the valves in pneumatic transport lines carrying coal. The eroded balls were of 440 carbon steel. The balls were changed to stainless steel type 316 with tungsten carbide coating for better erosion resistance.
4. The ceramic coating on the balls was chipped. Also, the Stellite No. 6 coating suffered erosion failures. The balls with tungsten carbide coating had performed better than ceramic or Stellite No. 6.
5. The bonnets of the valves in superheated steam service leaked at the packings. The packings were replaced with those rated for high temperature.

Recommendations

1. All ball valve bodies in the service containing corrosive chemicals and moisture should be either changed to stainless steel or the internal surface be electroplated with nickel.
2. The spring arrangement should be modified to incorporate internal sleeve with packings and the cavity should be purged with controlled flow of inert gas to keep fines solids out of the spring area. The valve vendors may work with the plant engineering personnel for the modified design.
3. All balls and seats should be changed to stainless steel type 316 with tungsten carbide (85% WC, 15% Co) coating for better erosion resistance.