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PHASE I: THE PIPELINE GAS DEMONSTRATION PLANT

Annual Technical Progress Report
for the Period
1 July 1978 - 30 June 1979

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Prepared for the
United States Department of Energy
Division of Fossil Fuel Processing
under Contract EF-77-C-01-2542

TABLE OF CONTENTS

ABSTRACT

Contract No. EF-77-C-01-2542 between Conoco Inc. and the U.S. Department of Energy requires Conoco Inc. to design, construct, and operate a demonstration plant for the manufacture of high-Btu gas from bituminous coal. The project is currently in the design phase.

The main accomplishments during the past year were:

a. The preliminary design and economic evaluation of a commercial plant based on the process to be demonstrated was completed and fully reported;

b. The design of the Demonstration Plant was restarted in March 1979 following a DOE stipulated delay of 14 months;

c. The site data - topographic maps and soil analysis - for the proposed Demonstration Plant site in Noble County, Ohio, were obtained and reported;

d. A majority of the environmental data required for EPA permits and preparation of the Environmental Impact Statement has been obtained;

e. The technical support work required for the design of the Demonstration Plant was completed and reported.

f. The requisite process trade-off studies for selecting the process units to be included in the Demonstration Plant were completed and reported.

1.0 INTRODUCTION

Conoco Inc., formerly Continental Oil Company, and the United States Department of Energy executed Contract No. EF-77-C-01-2542 on May 27, 1977. This contract requires Conoco Inc., as Contractor, to analyze, design, construct, test, evaluate, and operate a demonstration plant capable of converting high-sulfur bituminous caking coal into a pipeline quality gas.

The contract specifies that the work shall proceed in three phases:

Phase I - Development and Engineering
Phase II - Demonstration Plant Construction
Phase III - Demonstration Plant Operation

The contractual-stated cost of Phase I is $25.15 million. The estimated budgetary costs for Phases II and III in 1975 dollars are $170 and $176 million, respectively. More accurate cost estimates for these two phases will be established during Phase I.

Phase I costs are financed entirely by the United States Government. Phase II and III costs will be shared equally by the United States Government and private industry. Work on Contract No. EF-77-C-01-2542 started on July 1, 1977.

Six major subcontractors have been assigned various work activities under the contract:

a. Foster Wheeler Energy Corporation
   Livingston, New Jersey

b. Lurgi Kohle und Mineraloeltechnik, GmbH
   Frankfurt (Main), Federal Republic of Germany

c. British Gas Corporation
   London, United Kingdom

d. Ackenheil & Associates Geo Systems, Inc.
   Pittsburgh, Pennsylvania

e. Energy Impact Associates
   Pittsburgh, Pennsylvania

f. USS Engineers and Consultants, Inc.
   Pittsburgh, Pennsylvania

Phase I work activities are divided into the following 12 tasks:

I - Design and Evaluation of Commercial Plant

II - Demonstration Plant Process Design

III - Site Evaluation and Selection

IV - Demonstration Plant Environmental Analysis

V - Materials and Licenses

VI - Demonstration Plant Engineering & Design

VII - Construction Planning

VIII- Economic Reassessment

IX - Technical Support

X - Long-Lead Time Items

XI - Project Management

XII - Process Trade-off Studies

The process selected by Conoco Inc. for demonstrating that acceptable pipeline quality gas can be manufactured from bituminous coals utilizes the following technologies:

British Gas/Lurgi Fixed-bed Slagging Gasification
Rectisol Process (for H_2S removal)
Conventional CO Shift Process
Hot Potassium-Carbonate Process (for CO_2 removal)
Fixed-bed, Gas Recycle Methanation Process
Conventional TEG Gas Drying Process
Phenolsolvan Process (for recovery of phenols)
Stretford Process (for recovery of sulfur)
Phosam W Process (for recovery of ammonia)

An alternative design in which a combination shift/methanation process replaces the separate shift and methanation processes will be evaluated as part of the Task II effort. Either a combined process or separate processes will be selected for the Task VI design effort based on this evaluation.

The Contractor estimates Phase I will be completed on June 30, 1981.

All the Task I work requirements have been completed and reported. The Task I reports are cited on page 5 of this report. All the scheduled Task XII work requirements have been completed and reported. These Task XII reports are cited on page 152 of this report. The Contractor has recommended that the remaining Task XII requirements be deleted from the contract because the remaining work is no longer germane. All the Task IX work requirements specified in the contractual Statement of Work have been completed and reported.

Technical progress by tasks for the period July 1, 1978 - June 30, 1979, is reported in the succeeding sections of this document. Previous technical progress reports are identified below:

Report No.	Reporting Period
FE-2542-1	July 1 - September 30, 1977
FE-2542-2	October 1 - December 31, 1977
FE-2542-6	January 1 - March 31, 1978
FE-2542-12	July 1, 1977 - June 30, 1978
FE-2542-14	July 1 - September 30, 1978
FE-2542-15	October 1 - December 31, 1978
FE-2542-18	January 1 - March 31, 1979

Copies of these reports are available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia, 22161.

2.0 TASK I - DESIGN AND EVALUATION OF COMMERCIAL PLANT

The purpose of Task I is to prepare a preliminary design for a commercial scale plant based upon the process proposed for demonstration. The Commercial Plant design consisted of a process design, project engineering design, plot plans, estimates of capital and operating costs, and an economic analysis. The scope of the Demonstration Plant will be based in part upon the design of the Commercial Plant.

Task I was started in July 1977 and was completed in July 1978. The results were reported to DOE in four volumes, as follows:

Design and Evaluation of Commercial Plant

FE-2542-10 Vol. 1
Executive Summary

FE-2542-10 Vol. 2
Process and Project Engineering Design

FE-2542-10 Vol. 3
Economic Analysis and Technical Assessment

FE-2542-10 Vol. 4
Environmental Assessment and Site Requirements

These reports are available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia, 22161. No further work is planned for Task I.

The Commercial Plant was designed to manufacture 241.7 million standard cubic feet per stream day of pipeline gas from 16,879 tons per day of Illinois No. 6 coal.

An additional 4,488 tons of coal are consumed for on-site steam/power generation. The by-products consist of naphtha, tar oil, crude phenols, anhydrous ammonia, and sulfur. Coal fines, smaller than ¼ inch in size, are produced for sale.

The cost of producing pipeline gas was determined under the methods for private financing and for utility financing. The bases for both methods are summarized below:

1. Plant operation continues for 20 years.
2. Four years are required for construction.
3. First quarter 1978 dollars are used (inflation is not considered).

4. Sixteen year sum-of-digits depreciation is used for DCF method.
5. Illinois No. 6 coal used as feed.
6. For the DCF method, time zero occurs at the commencement of construction.

Two base cases were prepared for the private financing method; the cases differing in income tax rate and DCF rate of return. For each case, a sensitivity analysis was done showing the variation in gas price with coal costs, DCF rates of return, operating costs, and capital investment.

The public utility financing method was applied to only a single base case. A sensitivity analysis was also included in the public utility economic assessment.

The product gas cost, under the above guidelines, was calculated to be as follows:

Case	$/million Btu
Private Financing	
12% DCF, 48% income tax	6.605
9% DCF, 0% income tax	4.851
Utility Financing	
First year cost	6.378
Twenty year average cost	5.140

Following the issuance of the four-volume Task I report, Conoco Inc. evaluated other technical alternatives which might be employed to reduce the cost of gas. The original base case was developed under a conservative risk/benefit philosophy using many processes already proven in coal gas applications. A number of alternative processes exist which could improve the project economics with a moderate increase in the technical risk. These alternatives are discussed below.

Alternative I - Improved Power Cycle

The base case Commercial Plant design is self-sufficient in steam and power, utilizing a 1500 psig industrial-type boiler. A potential improvement in fuel usage is possible by using a high pressure utility-type power generation system; typically producing steam at 2600 psig and 1000°F with one reheat cycle at 1500 psig and 920°F.

The utility boiler permits using electric motors in place of the smaller, relatively inefficient turbine drives, and this in turn requires a larger, more efficient turbogenerator system. In essence, the many smaller turbine drives are replaced by a larger, more efficient turbogenerator providing a net improvement in plant efficiency.

Alternative II - Elimination of Zero Discharge Requirement

The base case Commercial Plant was designed for zero discharge of aqueous pollutants in accordance with the national goal of achieving zero discharge by 1985. This requirement increases both capital and operating cost of the plant. The zero discharge constraint also increases the overall risk factor by increasing the complexity of the plant equipment. Furthermore, the disposal of the solid residue may pose yet another problem.

Alternative II proposes eliminating the evaporation stage of the waste water system and discharging a treated waste water stream.

Alternative III - Combined Shift/Methanation

The base case Commercial Plant uses a conventional gas processing system, downstream of the gasifiers. The downstream processing sequence is shift conversion, gas cooling, gas purification, methanation, gas drying, and gas compression.

The conventional gas processing system incurs certain disadvantages when processing gas from the British Gas/Lurgi slagging gasifier. The slagging gasifier produces a gas containing a high concentration of carbon monoxide and a relatively low moisture content. Consequently, the shift conversion unit requires the addition of a large amount of steam. Steam reacts with carbon monoxide to produce hydrogen and carbon dioxide. A large excess of steam forces this reaction to proceed to the extent that the ratio of hydrogen to carbon monoxide is suitable for producing methane. The excess steam leaves the shift converter unreacted and must be removed by condensation in the gas cooling train. This increases the amount of gas liquor which must be treated in downstream units.

A modified processing sequence in which gas purification precedes the shift conversion step offers numerous potential economic advantages. The substitution of a combined shift/methanation process for separate shift and methanation processes offers additional economic advantages.

These two revisions in the base case Commercial Plant were evaluated as Alternative III. The raw gas from the gasifier is cooled and fed to the gas purification unit. The cooled gas contains only the carbon dioxide produced in the gasifier, and since the carbon dioxide content of the gas is relatively low, the gas purification unit is greatly simplified. The absence of steam from an up-stream shift conversion step reduces the amount of oily condensate present in the system and reduces the size of the units processing this condensate. Specifically, the gas liquor separation, phenol extraction, ammonia recovery, and waste water treatment units are smaller.

A further effect of the combined shift/methanation process is to reduce the steam and power requirements.

Alternative IV - Sulfuric Acid By-Product

The base case Commercial Plant was designed to produce sulfur using the Claus process. If the Claus process is replaced with a sulfuric acid plant, the 820 long tons per day of sulfur by-product is replaced by 2,800 short tons per day of sulfuric acid. Assuming the sulfuric acid is worth $56.00 per short ton and the sulfur is valued at $40.00 per long ton, the cost of pipeline gas production is reduced by $0.49 per million Btu. The risk in manufacturing sulfuric acid as a by-product depends upon the availability of a market. Sulfur would be a more readily saleable product.

While Alternatives I, II and III could produce an improvement in the plant thermal efficiency by seven percent, it should be recognized that there is little room for improvement in gas cost through this mechanism of fuel efficiency. If all of the boiler fuel could be "saved" (zero boiler fuel consumption), the gas cost would be reduced by only $0.36 per million Btu compared to a total cost of $6.60 per million Btu (private financing).

If all of the alternatives mentioned above were implemented under private financing, the potential savings in capital expenditure would be over $250 million and an associated reduction in the cost of gas would be $1.70 per million Btu. Under utility financing, the capital savings would be over $250 million and the associated reduction in the cost of gas would be $1.40 per million Btu. The alternatives and their effects on gas price are summarized in the following table:

	Dollars Per Million Btu	
	Private Financing	Utility Financing (20-yr average price)
I. Improved Power Cycle	0.057	0.057
II. Eliminate Zero Discharge Requirement	0.162	0.133
III. Combined Shift/ Methanation	0.998	0.710
IV. Sulfuric Acid By-product	0.487	0.530
Total	1.704	1.430
Cost of Gas, utilizing all improvements	4.901	3.710

3.0 TASK II - DEMONSTRATION PLANT PROCESS DESIGN

The main purpose of Task II is to prepare the process design for the Demonstration Plant. Other objectives of the task are to obtain a preliminary capital investment estimate and an economic evaluation in order to compare the Commercial and Demonstration Plants.

Design of the Demonstration Plant was initially started in July 1977, but all Task II work was temporarily stopped in January 1978 at the request of DOE. At that time about 25 percent of the Task II effort had been completed.

Work on Task II was restarted in March 1979. During the 14-month period of inactivity on this task, several improvements in the Demonstration Plant were conceived. These improvements will reduce Phase II and III costs, provide a better operating process, and reduce the cost of the SNG product for a conceptualized commercial plant. Many of the improvements are a result of the Task I design effort.

The improvements include a reduction in the capacity (size of the Demonstration Plant), rearrangement of the downstream gas processing sequence, and design and evaluation of a combined shift/methanation process.

It was proposed originally to construct a Demonstration Plant with three 10-foot British Gas/Lurgi slagging gasifiers. This plant would produce about 50 million standard cubic feet per day of pipeline quality gas. The Contractor now intends to include only one gasifier, plus one spare, in the Demonstration Plant. This will reduce its output to about 19 million standard cubic feet per day. The smaller sized plant will adequately demonstrate the process without adversely affecting scale-up, and the investment cost will be about 50 percent of the larger Demonstration Plant. Feedstock costs for the Phase III program will be reduced by about two-thirds.

The downstream gas processing will be modified to provide for removal of the hydrogen sulfide in the crude syntheses gas prior to the CO shift conversion step. A carbon dioxide removal unit will be added between the shift and methanation steps. This reordering of downstream gas processing will decrease the plant investment cost and will eliminate some potential operating problems with shift conversion and acid gas removal. The new processing sequence will reduce the quantity of gas liquor so that the phenol and ammonia recovery units will be smaller.

A simple Rectisol unit will be used to remove the hydrogen sulfide, and a hot potassium carbonate process will be selected for carbon dioxide removal. The simple Rectisol will be much easier to operate and can better handle fluctuating crude synthesis gas compositions than the more complex two-stream Rectisol that was originally selected. The shift conversion unit will receive a clean feed gas so that potential carbonization problems that could occur with a dirty feed, as originally proposed, will be eliminated. Work began in April to select a hot potassium carbonate system. Proposals have been received from licensors and are being evaluated.

The new processing sequence will permit a concurrent Task II design of a combination shift/methanation process at little added cost. Preliminary economic studies have indicated that such a combination process will significantly reduce the cost of the product gas. By designing both separate and combination shift/methanation processes concurrently, it will be possible to evaluate in detail the relative advantages and disadvantages of the two processing sequences. Only one sequence will be selected for the Task VI design effort.

Lurgi began its design work in March 1979, and the design effort has remained on schedule since then.

3.1 Sub-Task II-A: Basis of Design

Conoco Inc. is responsible for establishing the basis of design for the Demonstration Plant and for coordinating the design work by the various engineering subcontractors. It is expected that some aspects of the basis of design will have to be modified as the design work proceeds. A summary of the basis of design follows:

General Plant Description

The Demonstration Plant will be a grass-roots plant to be built in Noble County, Ohio, and will include all process systems, utility and environmental support facilities, tankage, and buildings with the exception of electric power generating facilities. The complex will be designed to process 942 tons per day of moisture and ash-free (MAF) coal in the gasifiers.

The Demonstration Plant will be self-sufficient with respect to the general plant facilities required to operate and maintain the complex. These will include offices, shops, warehouses, control rooms, sewers, fire protection, first-aid facilities, roads, fences, security buildings, and facilities at entry points.

The overall process consists of several interconnected process units, supporting facilities, and general plant facilities. These are listed below with their corresponding area designations:

Plant Area Designation	Plant Facility
100	Feedstock Preparation
200	Air Separation
300	Gasification
400	Rectisol
500	Shift Conversion
600	CO_2 Removal
700	Methanation
800	Compression and Drying
900	Sulfur Recovery
1000	Slag Handling
1100	Gas Liquor Separation
1200	Phenol Extraction
1300	Ammonia Recovery
2000	Water Treating and Steam Plant
2400	Cooling Water
2500	Plant and Instrument Air
2700	Waste Water Treatment
3000	Flare
3200	Miscellaneous Offsites and Tank Farm
4000	Electrical and Communications
4100	Buildings

Figure 3-1 is a block flow diagram of the Demonstration Plant.

General Process Description

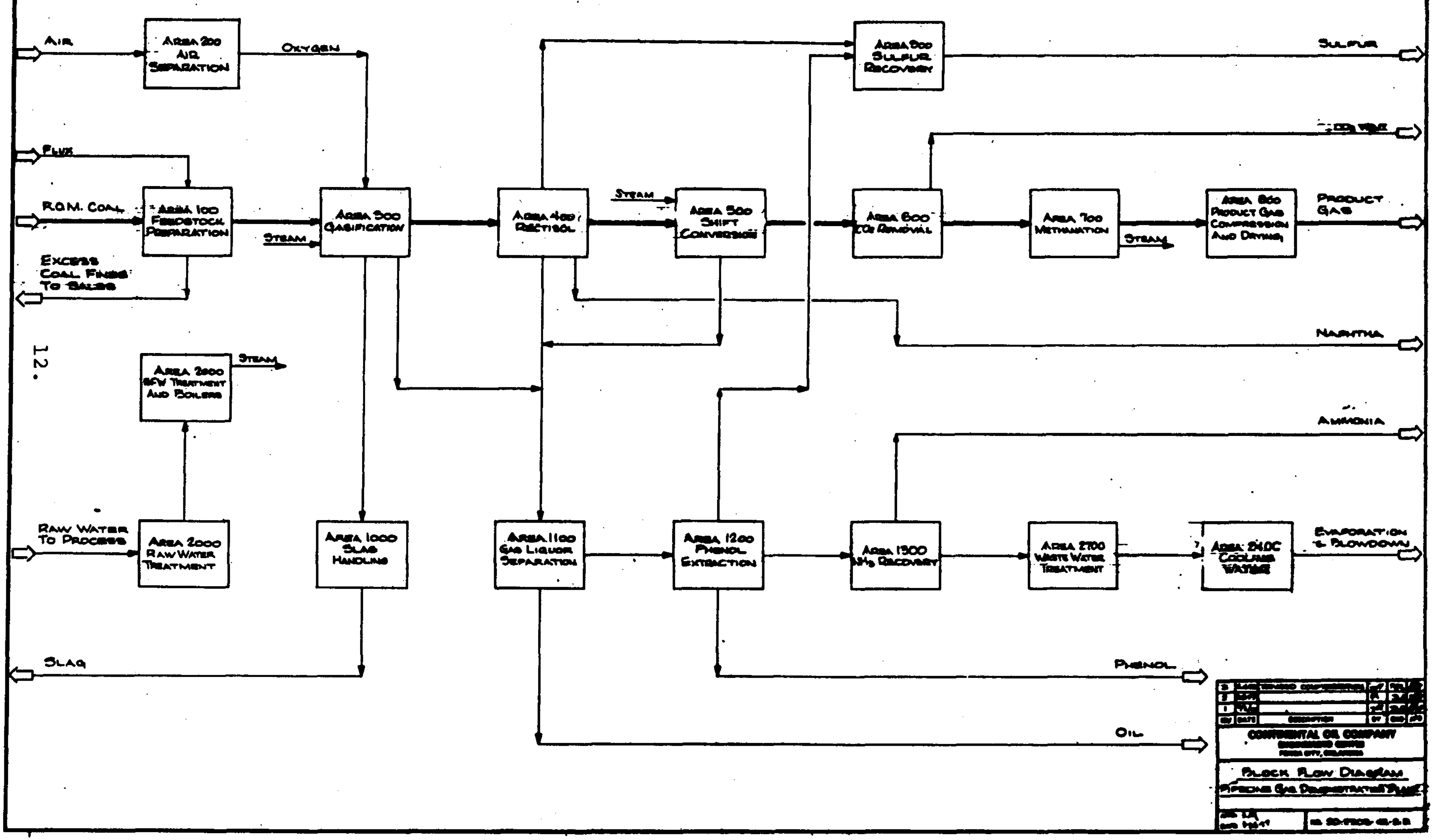
Run-of-the-mine, high sulfur (minimum 2.5 percent sulfur on a MAF basis) coal is crushed, washed, and screened to provide ¼-inch x 2-inch sized coal to be fed to a high pressure, fixed-bed, countercurrent, oxygen-blown slagging gasifier identified as the British Gas/Lurgi slagging gasifier. Here the coal is gasified with steam and oxygen introduced into the bottom of the gasifier through tuyeres. Molton slag falls through a tap hole into a water quench vessel. It immediately solidifies and is removed by means of conveyor system. Crude synthesis gas leaves the top of the gasifier and enters a scrubber. The scrubber cools the gas and removes aqueous gas liquor which consists of the condensibles, primarily water mixed with tars, oils, dust, phenols, and ammonia.

The gas is cooled further to remove additional condensible liquids and to recover waste heat. The cooled gas is treated in a Rectisol acid gas absorption unit, which uses cold methanol as the absorbent.

The purified gas from the Rectisol unit is processed through a CO shift conversion unit to increase the hydrogen-to-carbon monoxide ratio prior to methanation. The shift conversion reaction is:

$$CO + H_2O \rightleftharpoons CO_2 + H_2$$

Figure 3-1


AIR
AREA 200 AIR SEPARATION
OXYGEN
FLUX
R.O.M. COAL
AREA 100 FEEDSTOCK PREPARATION
EXCESS COAL FINES TO SALES
STEAM
AREA 300 GASIFICATION
AREA 400 RECTISOL
STEAM
AREA 500 SHIFT CONVERSION
AREA 900 SULFUR RECOVERY
SULFUR
AREA 600 CO_2 REMOVAL
AREA 700 METHANATION
STEAM
AREA 800 PRODUCT GAS COMPRESSION AND DRYING
PRODUCT GAS
NAPHTHA
AREA 2800 BFW TREATMENT AND BOILERS
STEAM
AMMONIA
RAW WATER TO PROCESS
AREA 2000 RAW WATER TREATMENT
AREA 1000 SLAG HANDLING
AREA 1100 GAS LIQUOR SEPARATION
AREA 1200 PHENOL EXTRACTION
AREA 1300 NH_3 RECOVERY
AREA 2700 WASTE WATER TREATMENT
AREA 2400 COOLING WATER
EVAPORATION & BLOWDOWN
SLAG
PHENOL
OIL
CONTINENTAL OIL COMPANY
BLOCK FLOW DIAGRAM

The shifted gas is then processed through a CO_2 removal unit where the majority of the CO_2 is removed by contact with a circulating hot potassium carbonate stream.

The purified gas from the CO_2 removal unit is fed to a catalytic fixed-bed adiabatic methanation unit which primarily converts carbon monoxide into methane following the reaction:

$$CO + 3H_2 \quad CH_4 + H_2O \text{ exothermic}$$

Product gas from methanation, after compression, is further processed through a conventional tri-ethylene glycol (TEG) unit to reduce the moisture to meet pipeline gas moisture specifications.

The dried gas leaving the TEG drying unit is introduced into a natural gas pipeline system.

By-product processing units are provided for gas liquor separation, phenol recovery, ammonia recovery, and sulfur recovery. All of these units are based on commercially-proven processes or concepts.

Off-site units to be installed include a raw water treating system, cooling water system, waste water treatment, slag disposal, by-product storage, and miscellaneous facilities, i.e., incineration, flares, plant air, product loading, and buildings. The Demonstration Plant will have a startup boiler which will produce supplemental steam during normal operation. Any excess steam in the plant will be used to generate electric power. The remainder of the plant power requirements will be supplied by purchased electric power.

Coal Feedstock Analysis

The plant will demonstrate its capabilities to produce a pipeline quality gas, primarily on locally-mined Ohio No. 9 coal. Other coals will be selected to be run in the future.

The process units downstream will be sized on the requirements for processing the Ohio No. 9 coal only. The feed rate for other coals will be adjusted, if required, to fit the downstream process units.

Proximate Analysis (As Received Basis)	Wt %
Moisture	2.5
Ash	22.5
Volatile Matter	35.0
Fixed Carbon	40.0

Elemental Analysis (Moisture and Ash Free)	Wt %
Carbon	78.00
Hydrogen	5.65
Nitrogen	1.25
Sulfur	6.30
Oxygen	8.75
Chlorine	0.05

Heating Value (Moisture and Ash Free Basis)	14,560 Btu/Lb

Ash Fusion Properties (Reducing Conditions)	^{o}F
Softening Point	2,100
Melting Point	2,200
Flow Point	2,450

The above analysis is for an unwashed coal. The ash content may vary between 14.0 and 35.0 percent. The sulfur content may vary between 3.5 and 6.3 percent. Both washed and unwashed coals will be evaluated on the Demonstration Plant.

Calculation Basis

In order to maintain consistency in calculations, the following factors shall be used in all calculations for the plant design.

Standard conditions for gas volume calculations shall be 14.696 psia and 60^{o}F. For consistency, one pound mole of gas shall be equal to 379.5 standard cubic feet.

The following atomic weights will be used:

Carbon	12.011
Hydrogen	1.008
Oxygen	16.000
Nitrogen	14.007
Sulfur	32.064
Chlorine	35.453

The following gross heating values and molecular weights shall be used for the indicated components. Molecular weights were calculated from the above atomic weights. Gross heating values are at standard conditions and have been obtained from the NGPA publication 2172-72 and the NGPSA Engineering Data Book.

Component	Gross Heating Value Btu/SCF	Molecular Weight
Hydrogen	325.02	2.016
Carbon Monoxide	321.37	28.011
Carbon Dioxide	0.00	44.011
Nitrogen	0.00	28.014
Oxygen	0.00	32.000
Hydrogen Chloride	0.00	36.461
Hydrogen Sulfide	637.00	34.080
Carbonyl Sulfide	620.50	60.075
Carbonyl Disulfide	1,202.90	76.139
Methane	1,009.70	16.043
Ethane	1,768.80	30.070
Ethylene	1,599.70	28.054
Propane	2,517.50	44.097
Propylene	3,333.70	42.081
Butane (as n-Butane)	3,262.10	58.124
Butene (as 1-Butene)	3,080.70	56.108
Ammonia	434.00	17.031
Hydrogen Cyanide	756.3	27.026

The plant will be designed for an operating on-stream factor of 330 days a year.

Product Gas

The product gas from the Demonstration Plant will consist primarily of methane. It must meet the following specifications:

Gross Heating Value, Btu/SCF	955 Min.
Water Content, pounds/million SCF	7 Max.
CO Content, volume percent	0.1 Max.
Sulfur Content, grains/100 SCF	1 Max.
H_2S Content, grains/100 SCF	0.25 Max.
Battery Limits	
Pressure, psig	750 Min.
Temperature, °F	110 Max.

Raw Water Analysis

The source of raw water is Senecaville Reservoir which is located about eight miles north of the proposed Demonstration Plant site. Properties of the water for design purposes are given below:

	Average	Maximum	Minimum
Totals Solids, mg/l	228.0	271.0	186.0
Suspended Solids,mg/l	12.0	3,075.0	5.0
pH	7.7	8.4	6.5
Turbidity,JTU	16.0	60.0	1.0
Conductivity, micromhos/cm	385.0	580.0	325.0
Total Alkalinity, mg/l of $CaCO_3$	111.0	138.0	95.0
Total Hardness, mg/l of $CaCo_3$	175.0	216.0	154.0
Total Calcium, mg/l as Ca	39.0	55.0	24.0
Total Magnesium, mg/l as Mg	14.0	15.0	12.0
Total Sodium, mg/l as Na	7.0	7.9	6.5
Total Potassium, mg/l as K	2.1	2.4	1.8
Total Iron, µg/l as Fe	851.0	3,075.0	138.0
Dissolved Iron, µg/l as Fe	275.0	75.0	100.0
Ammonia, mg/l as N	0.23	1.0	0.05
Kjeldahl Nitrogen, mg/l as N	0.78	1.6	0.2
Nitrates and Nitrites, mg/l as N	0.18	0.4	0.1
Total Phosphorus, µg/l as P	96.0	310.0	10.0
Ortho Phosphorus, µg/l as P	61.0	125.0	10.0
Chloride, mg/l as Cl	3.9	5.4	3.1
Sulfate, mg/l as SO_4	56.0	68.0	40.0
Silica, mg/l as SiO_2	3.4	5.3	1.6

Miscellaneous Design Considerations

Ambient conditions for plant design are shown below:

Summer Maximum Temperatures

	1%	2 1/2%	5%
Dry Bulb, °F	91	89	86
Wet Bulb, °F	77	76	75

Winter Minimum Temperatures

	Min.	99%	97 1/2%
°F	-6	0	4

Local Barometric Pressure

The local barometric pressure may be assumed to be 14.21 psia at an elevation of 1,000 feet above sea level.

The cooling water system shall be designed to supply 85°F cooling water at an ambient dry bulb of 86°F and an ambient wet bulb of 75°F (5 percent conditions). Maximum allowable temperature rise of the cooling water through exchangers shall be 30°F. Exchangers shall be designed for a maximum pressure drop of 10 psig from the 60 psig minimum header pressure.

Air coolers shall be designed for an inlet air temperature of 92°F.

Design conditions for air blowers and air compressors shall be 100 percent relative humidity and 92°F dry bulb temperature.

Air conditioning shall be designed for an ambient dry bulb temperature of 91°F and an ambient wet bulb temperature of 77°F to provide an inside building design temperature of 75°F maximum. The administration building, the laboratory, the control building, and other offices shall be air-conditioned.

Heat systems shall be designed to provide a minimum inside temperature of 65°F at an outdoor ambient temperature of 0°F.

Plant equipment shall be winterized for freeze protection, based on an outdoor minimum temperature of -10°F.

The plant will be designed such that all waste products, either solid, liquid, or gaseous, are in compliance with all Federal, State, and local environmental standards.

The plant complex will be designed with maximum reliability built into the systems to minimize the possibility of interruptions in the gas supply from the plant. Equipment shall be selected on the basis that the plant is to be operated as a commercial plant with an operating life in excess of 20 years.

Spare equipment will be provided in parallel at critical locations. These areas will be determined as the designs develop and the critical points become better defined.

Apart from the gasifier, all other processes for the plant shall be commercially proven processes or based on proven concepts. The gasifiers will be designed for maximum turnaround ratio, and the downstream equipment sized and specified so that it will operate at 33 1/3 percent of its design capacity.

The minimum design capacity of all pumps shall be 110 percent of the normal operating capacity. Drivers shall have sufficient capacity to cover the performance curve of the pump. Electric drivers will be used where possible to minimize inplant steam generation. Steam drivers will be considered to insure reliability of critical services for safe emergency shutdown and as required by the steam balance. Spare pump requirements will be agreed as the process design develops, but, wherever possible, common spares will be used.

All fractionation equipment shall be designed to operate at not more than 80 percent of flood load at design capacity.

Facilities shall be provided to measure, monitor, and sample coal feed as received from the mine through each of the coal preparation steps. The samples shall be representative of the coal received and fed to the unit over a 24-hour period.

Remote level and temperature readout from storage tanks shall be located in the main control room. Remote readout of the volumes in the coal storage bins shall be located on the main control panel.

Suitable continuous analyzers to monitor and record the following streams shall be installed and will read out in the control room;

a. The gas stream from the shift conversion reaction shall be analyzed for hydrogen, carbon monoxide, carbon dioxide, and nitrogen.

b. Gas leaving the Rectisol unit will be continuously analyzed for hydrogen, methane, carbon monoxide, carbon dioxide, total sulfur, and nitrogen.

c. Analyzers shall be provided to monitor and record the water content, high heating value, specific gravity, and the carbon monoxide, and carbon dioxide content of the pipeline gas product.

d. Analyzers shall be installed additionally, if considered necessary or highly desirable to the process.

A digital system will be installed for data logging purposes. The system should initially be capable of the collection, reduction, and presentation of selected plant operating variables. The system shall be capable of performing selected heat and material balances and shall have some initial control capability. The system should be designed to provide the capability of expanded logging, computation, and control functions as plant operating experience is obtained. Further definition of the system will be developed jointly by Foster Wheeler and the Conoco Inc. project group as the design proceeds.

Instruments shall be miniature and electronic. Control valves shall be operated pneumatically. Instrumentation is to be finalized during preparation and finalization of the piping and instrumentation diagrams.

Bundle diameter of all heat exchanges shall be limited to 42 inches at grade and 36 inches above grade. Bundle weight shall be limited to 24,000 pounds at grade and 16,000 pounds above grade. Exceptions will be reviewed on an individual basis. Construction of all exchangers will be in accordance with the API 650 and TEMA "R" standards.

All air coolers shall have forced draft fans.

The fired heaters shall be equipped with oil burners. Pilot burners shall be provided for each oil burner. Heater stacks shall be self-supporting. A minimum efficiency of 75 percent is required for all heaters in continuous operation.

Paving is required in the process area and shall consist of 4-inch thick concrete. Accessways shall be paved with 6-inch thick concrete.

All oil drains shall be separate from the rainwater sewer system. A separate sanitary sewer system shall be provided.

Rainwater run-off design factors shall be 1.0 for paved areas and 0.5 for unpaved areas.

Process unit control houses shall be of explosion-proof construction. Compressor shelters shall be steel and transite or prefabricated metal. Substations shall be constructed of prefabricated metal and pressurized. The administration building shall be constructed of masonry. All other buildings shall be constructed of prefabricated metal. Air conditioning is required in the control house, administration building, laboratory, fire station, cafeteria, and other offices.

Minimum operating temperature of piping for personnel insulation protection is 150°F.

Wind velocity to be used for structural design shall be 85 mph (100 year re-occurence). The prevailing wind direction is from the west (winter) and west-southwest (summer). Design snow loading shall be 25 pounds per square foot ground load (25 year re-occurence). Structural design shall include earthquake consideration for Seismic Zone 1.

All local, State, and Federal design and building codes will be met, as well as the applicable sections of ASME, ANSI, AICS, API, OSHA, ISA, and NEMA codes.

Safety

The plant will have a safety and health division that will be properly staffed and equipped to provide all safety and health services necessary for a coal gasification plant. All Federal, State, local, and industry safety codes, standards, and regulations shall be strictly followed.

A comprehensive safety and health program will be developed. The program shall establish and conduct employee training, certification of employees, inspection of all equipment and working conditions, procedures for all types of emergencies, and procedures for plant operation and maintenance functions for each hazardous material encountered in the plant.

Safety features to control noise, radiation, toxic or lethal material or vapor exposure, etc., will be incorporated into the plant design to minimize any possible health or safety hazard. Protective devices will be available in all possible hazardous areas consistent with good design practices and established code requirements.

The Demonstration Plant process, per se, does not have any particularly critical safety aspects. It is expected to be as safe as a modern petroleum refinery.

3.2 Sub-Task II-B: Process Engineering Design

Material balances, utility lists, and process flow diagrams for all sections of the Demonstration Plant are to be prepared under this sub-task. The work which has been completed on June 30, 1979, for the various sections is summarized below.

Section 100 - Feedstock Preparation

The concept of this section of the plant is being formulated. It was decided to purchase prepared coal feedstocks so that coal crushing and washing facilities will not be required. Actual design work on Section 100 will start in July 1979.

Section 200 - Air Separation

Foster Wheeler has begun the design of Section 200. The basis for determining the rates is the Lurgi gasifier balance plus a five percent overdesign. The Lurgi balance shows a continuous requirement of 45,395 pounds per hour of 98-volume percent oxygen (44,487 pounds per hour of pure oxygen). After inclusion of a five percent overdesign factor, the design rate of the Air Separation Plant shall be 571 tpd of 98-volume percent oxygen (561 tpd of pure oxygen). The plant shall be designed to supply 510 psig oxygen leaving the oxygen plant battery limits to insure a delivery pressure of 500 psig to the Gasification Section. The oxygen shall be supplied at the compressor discharge temperature. Liquid oxygen storage shall be provided such that the gasifier can be supplied with gaseous oxygen at the design rate for 72 hours with the oxygen plant out of operation. Vapor and liquid nitrogen facilities shall be estimated by Foster Wheeler and confirmed as the design progresses.

No design information has been issued.

Section 300 - Gasification

Process Description

The Process Flow Diagram for Section 300 shows the major flows in this section. Crude gas is produced from sized coal in a British Gas/Lurgi slagging gasifier. There will be one operating gasifier and one spare in the Demonstration Plant. The sized coal and flux from Section 100 enters the top of the pressurized gasifier via lock hoppers. Steam and oxygen are injected into the bottom of the gasifier and pass upward countercurrently to the descending coal and flux mixture. Devolatilization and gasification of the coal thereby takes place as oxygen reacts to produce carbon monoxide and carbon dioxide, and steam reacts to produce hydrogen and carbon monoxide. Some methane is produced from the devolatilization reactions. Heat is produced in the bottom of the gasifier by combustion of coal char with oxygen. The heat promotes the water-gas reactions and effects the devolatilization and drying of coal in the top part of the gasifier. The crude synthesis gas leaves the top of the gasifier.

The temperature in the bottom of the gasifier is controlled to allow melting of the fluxed coal ash (slag). This liquid slag is tapped from the gasifiers into the quench vessel and is cooled by water. The slag solidifies and fractures upon cooling to form frit. The frit is removed by lock hoppers. The water which leaves with the frit is separated from the frit and recycled to the quench vessel.

The crude synthesis gas leaving the top of the gasifier enters a wash cooler where an aqueous stream removes tar and solids from the gas. The gas then passes through a waste heat exchanger. As much of the heat and condensate are removed from the synthesis gas as possible by first cooling with air then water. Further cooling by refrigeration is accomplished in the Rectisol unit. Gas liquor and tar/oil condensed from the gas are fed to the Gas Liquor Separation Section. Tar from the Gas Liquor Separation Section is recycled to the gasifier.

Material Balance - Section 300

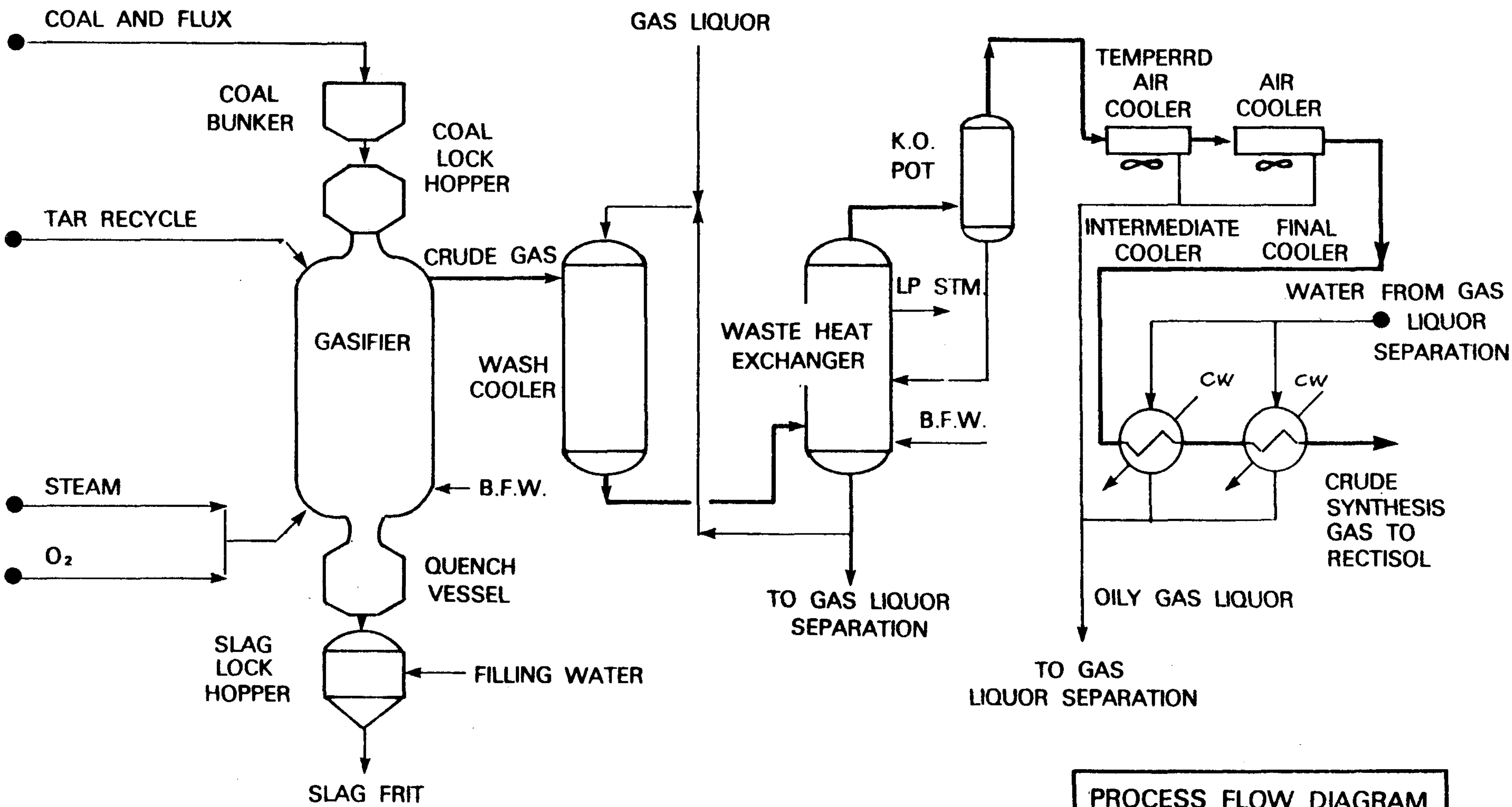
Input	Lb/Hr
Coal	104,720
Steam	32,101
Oxygen	45,395
Fuel Gas	1,868
Tar Recycle	11,275
Flux	10,472
BFW	58,070
Filling Water	38,625
Gas Liquor	96,911
Lock Gas	10,027
Total	409,464

Output	Lb/Hr
Crude Synthesis Gas	147,427
Gas Liquor and Tar	148,443
Slag Frit	53,465
Lock Gas + Vent Gas	8,454
Blowdown	1,592
Water	20,080
Steam	30,003
Total	409,464

Crude Gas Composition	Mol% (Dry)	Lb/Hr
Hydrogen	27.5	3,850
Carbon Monoxide	58.4	113,528
Carbon Dioxide	4.3	13,162
Methane	6.8	7,558
Hydrogen Sulfide	1.9	4,464
Nitrogen	0.6	1,167
Other	0.5	1,647
Subtotal	100.0	145,376
Steam	-	249
Miscellaneous	-	1,802
Total		147,427

Utilities - Section 300

Steam Tracing (298°F, 50 psig)	500 Lb/Hr
Electricity	860 KW
Nitrogen Purge	Intermittent 0-150,000 SCF/Hr
Nitrogen Surge	Intermittent 0-51,000 SCF/Hr
Air (Start-up)	100,000 SCF/Hr
Air (Plant)	Intermittent 0-25,000 SCF/Hr
Air (Instrument)	71,000 SCF/Hr
Fuel Gas (100°F, 500 psig)	2,660 SCF/Hr
BFW	58,070 Lb/Hr
Cooling Water (85°F, 55 psig)	1,094,760 Lb/Hr
Cooling Water Blowdown	5,000 Lb/Hr



PROCESS FLOW DIAGRAM
GASIFICATION
SECTION 300
DEMONSTRATION PLANT

NOTE: This is a simplified schematic and does not necessarily show all equipment and details.

Section 400 - Rectisol

Process Description

The Process Flow Diagram for Section 400 shows the major flows in this section. The unit is a single train which uses cold methanol to absorb acid gases (H_2S, CO_2), naphtha, and other miscellaneous sulfur compounds, including COS, from the cooled synthesis gas. The synthesis gas must have the hydrogen sulfide and other sulfur compounds removed before the gas can be fed to the Methanation Section because the methanation catalyst will be deactivated by any sulfur compounds contained in the gas. The off-gas stream containing mostly hydrogen sulfide and carbon dioxide is sent to a Stretford Unit for sulfur recovery. Naphtha is recovered as a by-product.

The synthesis gas from the Gasification Section is first cooled and chilled in several stages of heat exchange. A small amount of methanol is injected into the gas to prevent freezing. The gas enters the H_2S Absorber where acid gases, water, and naphtha are removed from the gas. The purified synthesis gas stream from the absorber is reheated and sent to the Shift Unit.

The spent methanol used to wash the gas in the absorbers is subjected to multiple stages of clean-up. The methanol, water, and hydrocarbons stream from the H_2S Absorber are fed to the Prewash Flash Regenerator. The overhead gas from the Prewash Flash Regenerator is fed to the Water Wash Column. Naphtha is extracted from the Prewash Flash Regenerator bottoms liquid and sent to storage. The other portion of the bottoms is fed to the Azeotrope Column.

A stream from the H_2S Absorber is also fed to the Flash Regenerator. The overhead vapor from the Flash Generator is compressed and injected into the synthesis gas. The bottom liquid from the Flash Regenerator is sent to the Hot Regenerator.

The overhead vapor from the Hot Regenerator is sent to the Water Wash Column. The bottom liquids from the Hot Regenerator is sent to the H_2S Absorber.

The overhead vapor from the Azeotrope Column is sent to the Water Wash Column. The bottom liquids from the Azeotrope Column are sent to the Methanol-Water Column.

The overhead vapor from the Methanol-Water Column is sent to the Hot Regenerator. The bottom liquid is sent to waste water treatment.

Sodium hydroxide is added to the Methanol-Water Column and make-up methanol is added to the Hot Generator.

Material Balance - Section 400

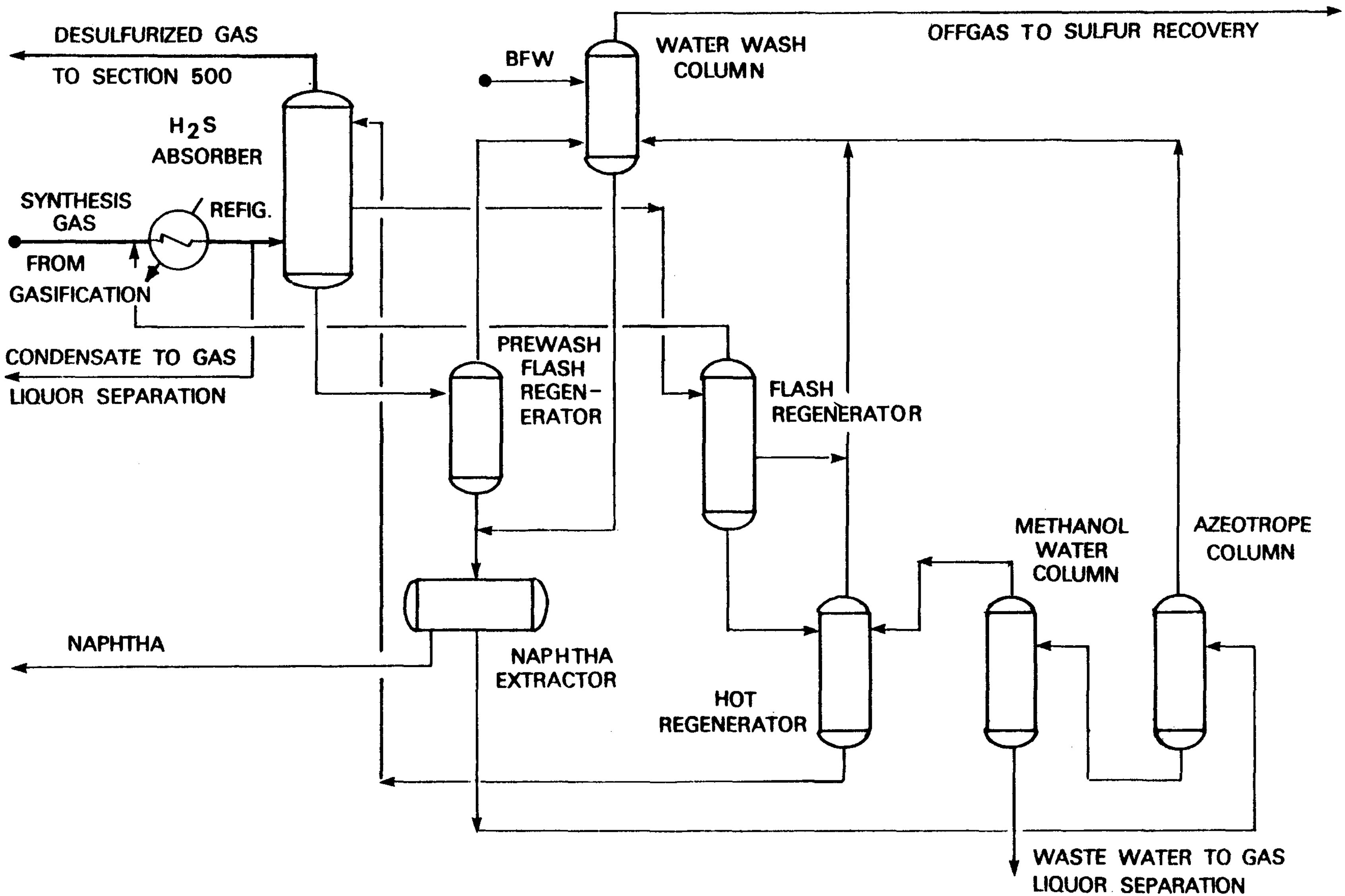
Input	Lb/Hr
Synthesis Gas	147,427
BFW	4,510
Total	151,937

Output	Lb/Hr
Desulfurized Synthesis Gas	133,233
Off Gas	12,193
Waste Water	4,659
Naphtha	1,852
Total	151,937

Purified Synthesis Gas	Mol %	Lb/Hr
Hydrogen	28.8	3,846
Carbon Monoxide	60.9	113,092
Carbon Dioxide	2.4	7,006
Methane	7.0	7,455
Nitrogen	0.6	1,165
Other	0.3	669
Total	100.0	133,233

Utilities - Section 400

Steam (120 psig)	5,820 Lb/Hr
Electricity	310 KW
Steam (55 psig)	10,130 Lb/Hr
Cooling Water (85°F)	8,300 Lb/Hr
BFW (250°F)	4,510 Lb/Hr
Methanol	88 Lb/Hr
NaOH (20 wt.%)	30 Lb/Hr



NOTE: This is a simplified schematic and does not necessarily show all equipment and details.

PROCESS FLOW DIAGRAM
RECTISOL
SECTION 400
DEMONSTRATION PLANT

Section 500 - Shift Conversion

Design of this section has just been started, and no design information has been issued.

Section 600 - CO_2 Removal

Selection of a process licensor for this section is in progress.

Section 700 - Methanation

Design of this section has not been started.

Section 800 - Compression and Drying

Design of this section has not been started.

Section 900 - Sulfur Recovery

Selection of a licensor for the Stretford process is in process.

Section 1000 - Slag Handling

Design of this section has not been started.

Section 1100 - Gas Liquor Separation

Process Description

The Gas Liquor Separation Section's major flows can be followed in the Section 1100 flow diagram. The equipment in this section physically separates dust, oil, and tar from water. The feed streams to this section are the gas liquor streams from the Gasification and Rectisol Sections. Gas liquor is the name given to aqueous and hydrocarbon condensates produced from quenching and cooling the hot gases.

The dusty gas liquor and tar from Gasification is cooled and depressurized in the Dusty Gas Liquor Expansion Vessel. This allows degassing and the gases are sent to the incinerator. The oily gas liquor is cooled and combined with that from the Rectisol Section. The combined stream is fed to the Oily Gas Liquor Expansion Vessel. The gases produced by depressurization in the expansion vessel are also sent to the incinerator.

The liquor from the Dusty Gas Liquor Expansion Vessel goes to the Tar Separator. Dusty tar and clear tar recovered by settling in the separator are piped to the Gasification Section. Oily liquor from the Tar Separator is piped to the Oil Separator.

The liquor from the Oily Gas Liquor Expansion Vessel is settled in the Oil Separator. The tar from the separator is sent to the Tar Slop Pit; the oil to the Oil Tank; and the water to the Final Separator.

The tar which separates in the Final Separator is sent to the Tar Slop Pit; the oil to the Oil Tank; and the water to the Final Gas Liquor Surge Tank. A small portion of this water is used for seals in the Gasification Section. The rest is sent to the Buffer Tank and from there to the Gravel Filter. The major portion of the liquor from the Gravel Filter is sent to phenol extraction. The remainder is sent to the Filter Flushing Tank.

The liquor in the Filter Flushing Tank is used to backwash periodically the Gravel Filter. The backwash liquor is sent to the Mud Liquor Tank. The mud liquor is sent to the Tar Separator.

Drains from all the tanks are sent to the Tar Slop Pit. Materials from the Tar-Oil Slop Pit are sent to the Tar Separator.

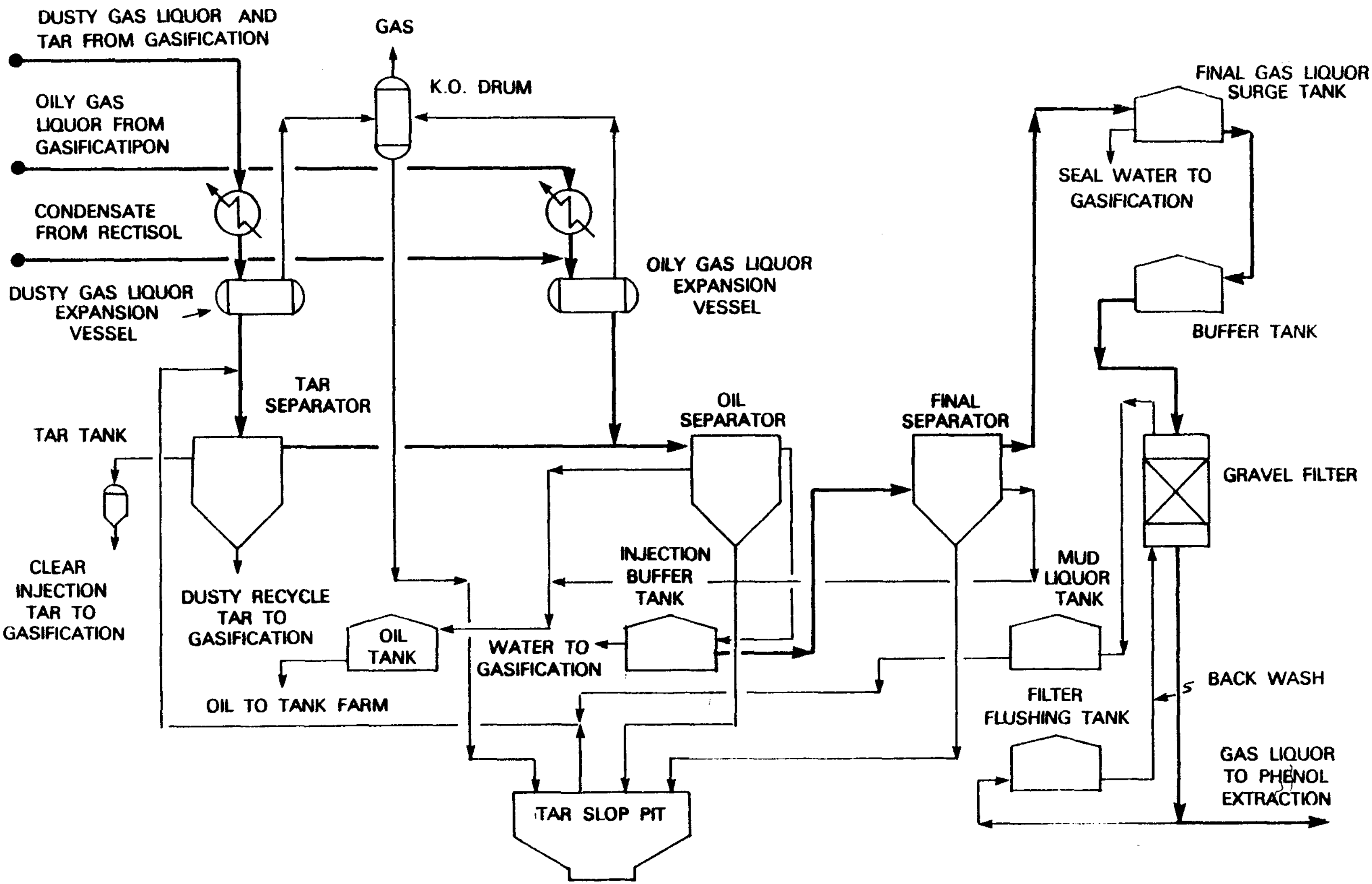
Material Balance - Section 1100

Input	Lb/Hr
Dusty Gas Liquor and Tar from Gasification	60,624
Oily Gas Liquor and Tar from Gasification	87,819
Condensate from Rectisol	4,659
Total	153,102

Output	Lb/Hr
Clear Tar	5,383
Dusty Tar	5,893
Water	96,910
Oil	2,696
Gas Liquor to Phenol Extraction (Section 1200)	41,989
Gas	231
Total	153,102

Utilities - Section 1100

Steam (297°F, 50 psig)	695 Lb/Hr Max.
Cooling Water (85°F, 60 psig)	4,520 Lb/Hr
Electricity	50 KW
Air (Instrument)	Intermittent (0-600) SCF/Hr
Nitrogen (30 psig)	70-2100 Lb/Hr



NOTE: This is a simplified schematic and does not necessarily show all equipment and details.

PROCESS FLOW DIAGRAM
GAS-LIQUOR SEPARATION
SECTION 1100
DEMONSTRATION PLANT

Section 1200 - Phenol Extraction

Design of this section has just been started, and no design information is available.

Sections 1300, 2000, 2400, 2500, 2700, 3000, 3200, 4000, 4100

The design of these sections has not been started.

3.3 Sub-Task II-C: Preliminary Project Engineering Design

The purpose of this sub-task is to develop a preliminary design for comparison with the Commercial Plant. The detailed engineering design will be done under Task VI. Equipment lists will be the major product from this sub-task. No lists have been issued.

3.4 Sub-Task II-D: Preliminary Cost Estimating

Work on this sub-task has not started.

3.5 Sub-Task II-E: Preliminary Economic Evaluation

Work on this sub-task has not started.

3.6 Sub-Task II-F: Process Description and Rationale

Work on this sub-task has not started.

4.0 TASK III - SITE EVALUATION AND SELECTION

The goals of this task are:

a. To select the location for the Demonstration Plant and to obtain DOE approval of the selected site;

b. To negotiate a purchase option for the approved site;

c. To obtain a soil survey, aerial photographs, and topographic maps for the selected site;

d. To prepare requisite site reports; and

e. To prepare a report summarizing the Contractor's recommendations regarding the design and location of the Demonstration Plant.

4.1 Sub-Task III-A: Site Selection

A site consisting of 1,230 acres has been selected in Noble County, Ohio, by Conoco Inc. It lies immediately south of State Highway 146 and is between Sarahsville and Summerfield, Ohio. The site was selected on the basis of size and terrain, sources of raw materials, product markets, environmental factors, socioeconomic factors, present land use, aesthetics, land and site preparation costs, and availability of transportation.

Conoco Inc. submitted the Site Selection Report, FE/2542-3, to DOE on March 27, 1978.

Conoco Inc. is awaiting DOE approval of the selected site. Upon receipt of DOE approval of the selected site, negotiations with site owners will proceed to establish a purchase price and to obtain a purchase option on the property. The Site Selection Report is available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia, 22161.

4.2 Sub-Task III-B: Site Data

The soil survey and topographic maps of the plant site were completed in March 1979. The Topographic Maps and Aerial Survey Report, FE/2542-16, was submitted to DOE on March 30, 1979. The Foundation Investigation and Soil Analyses Report, FE/2542-19, was submitted to DOE on May 30, 1979.

Topographic Maps

The topographic maps of the plant site were prepared by Eastern Mapping Company of Pittsburgh, Pennsylvania. The topographic map subcontract was executed on November 8, 1978. Work was completed in March 1979.

The maps were prepared from aerial photographs supplied by Consolidation Coal Company. The maps have a horizontal scale of one inch = 100 feet and a contour interval of two feet. All cultural features of the site are shown using symbols defined in the U.S. Geologic Survey Bulletin 788.

Eastern Mapping Company started the project by performing a ground control survey on the site. The ground control survey accurately locates prominent features on the site so that the horizontal and vertical measures on the ground can be correlated with the photographs. The ground control survey was referenced to U.S. Coast and Geodetic Triangulation Stations and Benchmarks.

The topographic maps of the proposed site provide the basis for the plant layout and surface drainage and site grading design. The maps also tie the plant location to national and state plane coordinate systems.

Soil Survey

A reconnaissance soil survey of the proposed plant site was performed by Achenheil & Associates Geo Systems, Inc. of Pittsburgh, Pennsylvania. The Soil Survey subcontract was executed on November 8, 1979, and the final report was issued by Ackenheil to Conoco Inc. on March 8, 1979. The soil survey provides data and recommendations for the design of foundations, roadways, holding ponds, etc. It also provides information on water table stability and soil porosity.

Forty-six standard test borings, totaling approximately 2,500 linear feet, were drilled throughout the plant site in order to provide preliminary data on subsurface conditions and to obtain soil and rock samples for visual observation and laboratory testing. The soil from the test borings was sampled at three-foot intervals using a standard two-inch split spoon sampler. These split spoon samples were used to test the moisture content, grain size, and plasticity of the soil.

Ten relatively undisturbed Shelby Tube samples of cohesive soils were obtained at selected locations for the performance of consolidation, direct shear, unconfined compression, and permeability tests.

The consolidation tests indicate the soils tested have a high compressibility. The soils tested were also found to have low to moderate shear strength. Standard Proctor tests were performed on samples of soil to determine the maximum dry density at the optimum moisture content of the soil. The maximum dry density varied from about 110 to 115 pounds per cubic foot with optimum moisture contents from 10 to 25 percent. The results of the permeability tests indicate very low to practically impermeable soil.

Two water wells were drilled in order to perform pump-out tests to estimate water yields. One well was drilled in the flood plain of Senecaville Reservoir, and one was drilled on the plant site. The possibility of obtaining the plant water supply from a well system was evaluated. After performing the two pump-out tests, it was apparent that insufficient quantities of water are available for plant usage from sub-surface water.

The soils sampled at the test boring locations are residual soils which were formed in place from the weathering and decomposition of bedrock. The soils consist of clay, silt, sand, and rock fragments.

The clays could be used as borrow materials for the core of water retention fills and as liners for holding ponds. The use of the soils for fills to support buildings would probably result in long-term consolidation under foundation loads. Also the soils may not have enough shear strength to support proposed fills with an acceptable safety factor. As a result, fill foundation preparation, such as bedrock keys with drainage provisions, will be required during construction.

The bedrock strata encountered at the test boring locations consist of horizontally-bedded sedimentary compaction and cemented shales, limestones, sandstone, carbonaceous shales, coal, and claystones.

The top of bedrock varies from three feet to 50 feet below the existing ground surface. Generally, if red claystone forms the top of bedrock, the overlying soil zone is thicker.

The sandstone and shales above the Meigs Coal seam (Ohio No. 9) are suitable for foundation support material. If the Meigs Coal seam is removed, the claystones, shales, and limestone below it are also suitable for support of the proposed structures.

The fill materials used in the proposed building areas should be the soils, sandstones, limestones, and shales. Some of the bedrock will break down during excavation and compaction to form a soil-like material. Significant settlements could occur in this type of fill. Therefore, building foundations should bear an undisturbed natural material below such fills.

The clays and claystones should be used to construct the impervious cores for the water retention fills. A fill consisting of clay and claystone compacted to 95 percent modified Proctor density will be relatively impermeable.

The red claystone found on the site should not be used to bear foundations. Red claystone can weather rapidly when exposed to air and moisture. This reduces the shear strength. Low allowable rock pressures can result if red claystone is exposed in cut areas.

Heavily loaded structures, with heavily concentrated loads, should be located in areas where site grading will expose bedrock. This reduces the risk of settlement which could occur if the structures were placed on natural soil or newly placed fill. If a heavily loaded structure must be placed where natural soil or newly placed fill is present, deep foundations bearing in bedrock should be used.

Foundations on the plant site should be provided with adequate drainage. Drain pipes should be placed below the foundation to prevent water infiltration into excavated areas.

The soils and materials on the plant site are suitable for constructing the Demonstration Plant. A large amount of earthwork will be necessary to level a primary process area. Also, caution must be taken in selecting proper fill and borrow materials.

4.3 Sub-Task III-C: Site Master Plan and Associated Studies

The work requirements of this sub-task consist of reporting the information and data developed in Sub-Tasks III-A and III-B and other site information that may be obtained.

The following reports have been submitted to DOE:

a. Real Estate Report FE-2542-4
This report contains the property description, ownership, liens and easements, and arrangements made for entry permits to conduct site investigations on the proposed site.

b. Transportation Report FE-2542-5
This report discusses the availability and adequacy of local transportation systems including air, rail, water, and roads in the site area - Noble County and southeastern Ohio.

c. Water Resources Report FE-2542-9
Alternative sources of water for plant use are identified and arrangements and approvals necessary for the water use are cited. Restraints and impacts are also identified.

d. Site Selection Report FE-2542-3
Several possible plant sites were evaluated for Demonstration Plant use. The site selection criteria plus a comparison of the characteristics of each site are given. The selected plant site and reasons for its selection are presented.

e. Topographic Maps and Aerial Survey Report FE-2542-16
Information from this report is summarized in Section 4.2, above.

f. Foundation Investigation and Soil Analysis Report FE-2542-19
   Information from this report is summarized in Section 4.2, above.

g. Climatological and Meteorological Report FE-2542-17
   This report includes data on rainfall intensity, wind, snow, temperature, and design high low and wet bulb temperatures. This report was submitted to DOE on April 19, 1979. Data from this report are summarized in Section 5.1 of this report (Task IV).

Report No's FE-2542-3, FE-2542-4, FE-2542-5 and FE-2542-9 have been accepted by DOE and are available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia, 22161. Report No's FE-2542-16, FE-2542-17 and FE-2542-19 are expected to be available in the near future.

The remaining reports to be submitted under this sub-task and the scheduled submittal dates are shown below:

Report Title	Scheduled Submittal Date
Local Resources Report	August 10, 1979
Site Master Plan Report	August 31, 1979

Work is proceeding on both reports. Conoco Inc. is preparing the Local Resources Report and Foster Wheeler Energy Corporation is preparing the Site Master Plan.

The Local Resources Report will summarize the extent and availability of local resources in the Noble County area. The report will cover an evaluation of existing roads, waterways, railroads, utilities, fire and police protection, housing, local labor, schools, medical facilities, and local industries and manufacturers.

The Site Master Plan will show the areas to be used during construction such as temporary roads, storage, and other construction operations. Availability of utility services will be determined and interfaces or taps established. Temporary routing for electricity, water, sewage, gas, etc. will be shown on the plan. The location of the Demonstration Plant and waste disposal and retention areas will be delineated.

4.4 Sub-Task III-D: Demonstration Plant Recommendations

The work on the Demonstration Plant Recommendations cannot begin until Tasks I, II, III, and XII have been completed. At this time only Tasks I and XII have been completed.

5.0 TASK IV - DEMONSTRATION PLANT ENVIRONMENTAL ANALYSIS

The purpose of the Task IV environmental analysis is to collect the data and information needed (a) to obtain Ohio and Federal EPA permits to construct and operate the Demonstration Plant, and (b) to prepare an Environmental Impact Statement (EIS).

The environmental analysis is being done by Energy Impact Associates (EIA) under subcontract. The original scope of work for the environmental analysis has been expanded because of new Federal legislation and regulations. The collection of all environmental data is expected to be completed by September 1979, and a draft Environmental Assessment Report (EAR) is scheduled for issuance in October 1979. The final EAR will be issued in January 1980.

The progress of the various environmental field programs is reviewed below. Some of the data and information is preliminary, and revisions will be made before the final EAR is issued.

5.1 Meteorology and Air Quality

The meteorology and air quality program consists of the following:

a. A literature study and summarization of historical climatological information from stations in and near Noble County, Ohio;

b. Continuous sampling of air for H_2S, SO_2 and NO_2 from a sampling tower on the plant site for three weeks during two seasons (late summer and winter) plus bubbler sampling for H_2S, SO_2 and NO_2 and Hi-Vol measurements of total suspended particulates at six-day intervals for a period of one year;

c. Meteorological data consisting of wind speed, wind direction, and ambient temperature from a 30-foot tower on the plant site for a period of one year;

d. Analyses of samples of suspended particulates from the atmosphere for sulfates, nitrates, pertinent metals, benzene soluble organic compounds, and particle size distribution;

e. Continuous sampling of air for ozone and CO for a period of six months from a sampling tower on the plant site; and

f. Atmospheric stability and dew point on an hourly basis for a period of six months.

All of the above items have been completed except for items e. and f. Items e. and f. are in progress and will be completed in August 1979.

The proposed site for the Demonstration Plant is located in Noble County in southeastern Ohio. The climate of the area is classified as continental. Summers are moderately warm; on the average the temperature equals or exceeds 90°F about 21 days a year. Winters are cold; on the average the temperature falls below 32°F about 140 days each year and below 0°F four days each year.

The mesoclimate of the site area can be ascertained from weather data which have been collected from the following near-by stations:

Station	Distance from Plant Site, Miles	Period of Record
Ohio		
Barnesville	15 - NE	1940 - 65
Cadiz	37 - NE	1904 - 65
Caldwell	8 - SW	1936 - 65
Cambridge	18 - NNW	1936 - 65
Columbus*	83 - W	1936 - 76
Marietta	26 - SSW	1948 - 65
McConnelsville	23 - WSW	1894 - 65
Senecaville	7 - NW	1940 - 65
Zanesville	36 - WNW	1946 - 65
West Virginia		
Huntington*	100 - SW	1936 - 76
Parkersburg*	40 - SSW	1936 - 75
Pennsylvania		
Pittsburgh*	85 - NE	1936 - 76

*First order weather stations; all others record temperatures and precipitation only.

Pertinent data from these weather stations are summarized on Tables 5-1 and 5-2.

TABLE 5-1

Summary of Climatological Data for Southeastern Ohio Stations

Parameter	Barnesville	Cadiz	Caldwell	Cambridge	Marietta	McConnelsville	Senecaville	Zanesville
Temperature, °F								
Annual average	49.9	51.4	52.6	52.2	52.9	52.4	51.2	51.1
Maximum monthly average	71.3	73.2	73.3	73.2	73.2	73.6	72.4	72.3
Minimum monthly average	27.8	29.3	30.6	30.7	31.8	31.2	29.2	29.2
Record highest	103.0	106.0	104.0	104.0	102.0	105.0	101.0	102.0
Record lowest	-25.0	-19.0	-20.0	-24.0	-21.0	-29.0	-24.0	-19.0
Precipitation, Inches								
Annual average	40.35	39.66	39.66	38.62	39.74	40.26	38.76	37.62
Record monthly maximum	8.71	9.13	9.96	10.53	120.44	11.11	9.09	9.89
Record 24-hr. maximum	3.04	3.52	3.84	7.18	4.37	4.55	4.95	4.37
Snow Fall, Inches								
Annual average	37.1	39.0	27.1	23.5	23.3	24.9	28.7	23.8
Record monthly maximum	27.0	31.5	24.0	25.7	32.0	32.2	27.0	22.6
Record 24-hr. maximum	14.0	19.7	13.0	16.0	12.0	13.0	12.0	11.7
Mean Number of Days								
Temperature ≥ 90°F	15	16	20	18	10	21	15	14
Temperature ≤ 32°F	141	119	117	121	116	120	130	126
Temperature ≤ 0°F	7	2	2	3	2	3	5	4
Precipitation ≥ .01 in.	121	115	98	121	109	117	121	129
Precipitation ≥ 1.00 in.	8	8	7	7	7	7	7	5

TABLE 5-2
Summary of Climatological Data from First-Order Weather Stations in the Vicinity of the Plant Site

Parameter	Columbus, Ohio	Huntington, W. Va.	Parkersburg, W. Va.	Pittsburgh, Pa.
	Stations			
Temperature, °F				
Annual Average	51.5	55.2	54.6	50.4
Maximum monthly average	73.6	75.3	75.2	71.9
Minimum monthly average	28.4	34.3	32.9	28.1
Record highest	98	100	106	99
Record lowest	-15	-15	-27	-18
Wet Bulb, °F				
Annual average	46.4	50.1	48.3	44.6
Wind				
Annual average speed, mph	8.7	6.3	6.3	9.4
Prevailing direction	SSW	-	-	WSW
Fastest speed, mph	63	47	66	56
Precipitation, Inches				
Annual average	37.01	38.88	38.44	36.23
Record monthly maximum	9.75	8.57	12.05	8.20
Record monthly minimum	0.11	0.01	0.07	0.16
Record 24-hr. maximum	4.81	4.27	4.81	3.56
Snowfall, Inches				
Annual average	22.7	23.2	23.7	45.3
Record monthly maximum	18.4	14.3	34.6	24.6
Record 24-hr. maximum	8.9	8.2	18.3	14.7
Average Station Pressure, MB	987.5	-	-	973.3
Solar Radiation, %	53	-	48	50
Thunderstorms, Ave. Days/Year	42	45	44	36
Heavy Fog, Ave. Days/Year	18	63	12	19

The data collected for suspended particulate matter in the atmosphere for the one year monitoring period are summarized below:

	24-Hour Concentration of Particulates, $\mu g/m^3$			
Season	Range	Arithmatic Mean	Standard Deviation	Geometric Mean
Fall(1977)	28-157	76.2	40.2	67.3
Winter (1978)	43-82	63.8	13.6	62.4
Spring (1978)	30-114	61.7	24.4	57.8
Summer (1978)	48-89	71.4	14.6	69.8

The Federal primary 24-hour standard for particulate matter is 260 micrograms per cubic meter; the secondary 24-hour standard is 150 micrograms per cubic meter.

Pertinent data from the continuous monitoring of sulfur dioxide are given below:

SO_2 Concentration, PPM	Late Summer Period	Winter Period
Maximum Measured		
1-hour period	0.157	0.170
3-hour period	0.086	0.130
24-hour period	0.025	0.060
Second Highest		
1-hour period	0.107	0.140
3-hour period	0.077	0.120
24-hour period	0.020	0.052
Third Highest		
1-hour period	0.100	0.110
3-hour period	0.073	0.107
24-hour period	0.018	0.050

The Federal 3-hour standard for sulfur dioxide is 0.5 ppm; the 24-hour standard is 0.14 ppm.

NO_2 Concentration, PPM		
Maximum Measured		
1-hour period	0.025	0.037
3-hour period	0.016	0.035
24-hour period	0.008	0.022
Second Highest		
1-hour period	0.021	0.033
3-hour period	0.014	0.025
24-hour period	0.007	0.020
Third Highest		
1-hour period	0.015	0.030
3-hour period	0.013	0.020
24-hour period	0.006	0.014

The Federal average annual primary standard for nitrogen dioxide is 0.05 ppm.

A summary of meteorological data taken at the Demonstration Plant site is presented on Tables 5-3 and 5-4. Table 5-3 presents a summary of wind speeds by months, and Table 5-4 presents a summary of wind direction by months during the one year of continuous data collection.

TABLE 5-3

Summary of Wind Speeds at the
Proposed Demonstration Plant Site
In Miles Per Hour

Month	Minimum	Maximum	Mean
October 1977	0	17.0	6.1
November 1977	0.5	21.5	7.3
December 1977	0.5	22.0	8.0
Janaury 1978	0.5	29.0	7.6
February 1978	NA	NA	NA
March 1978	0.2	19.5	6.9
April 1978	1.0	21.0	7.9
May 1978	0.5	14.5	5.3
June 1978	0	14.5	4.8
July 1978	0	13.5	4.0
August 1978	0	13.5	3.9
September 1978	0	11.5	4.1

NA = Not Available

TABLE 5-4

SUMMARY OF WIND DIRECTION AT THE PROPOSED DEMONSTRATION PLANT SITE IN PERCENT OF OCCURANCE

Wind Sector	Oct. 1977	Nov. 1977	Dec. 1977	Jan. 1978	Feb.* 1978	March 1978	April 1978	May 1978	June 1978	July 1978	Aug. 1978	Sept. 1978
N	8.0	0.7	2.5	4.7	-	5.1	5.6	3.6	2.6	4.8	4.0	3.7
NNE	7.6	1.4	0.5	6.1	-	9.9	10.2	7.7	2.1	5.1	11.0	8.1
NE	8.8	3.2	1.3	1.7	-	8.3	9.7	7.8	2.2	5.0	5.0	4.4
ENE	11.4	4.1	4.1	2.5	-	6.1	3.5	2.5	1.8	3.0	2.8	2.6
E	6.6	3.0	3.8	2.3	-	3.1	2.8	2.7	1.0	3.2	2.3	1.1
ESE	2.2	2.9	4.3	3.0	-	2.8	1.8	4.2	1.9	1.7	1.9	1.7
SE	4.2	3.4	9.0	9.8	-	2.9	3.3	11.1	12.2	6.6	5.2	7.8
SSE	3.2	5.4	8.2	6.4	-	3.1	2.4	9.9	12.2	9.4	13.2	11.2
S	9.9	15.1	21.0	9.4	-	7.6	8.6	10.7	25.9	25.5	23.3	18.5
SSW	11.1	11.3	21.7	32.4	-	7.9	10.4	8.6	5.4	12.6	9.4	11.5
SW	7.1	8.6	7.6	4.5	-	9.0	7.5	5.9	2.8	2.4	2.4	4.4
WSW	2.8	15.1	5.9	2.2	-	5.7	4.5	3.0	1.8	1.5	2.6	4.0
W	2.8	6.3	3.3	5.3	-	10.6	10.8	4.9	4.3	3.0	2.8	4.7
WNW	3.2	5.7	1.9	2.8	-	7.1	5.3	4.4	8.8	4.6	1.3	2.4
NW	7.1	9.5	0.9	3.1	-	3.6	7.5	6.0	9.5	8.2	3.2	6.4
NNW	4.0	1.6	1.4	1.2	-	7.1	6.1	7.0	5.4	3.4	9.5	7.4
CALM	0	2.7	2.5	2.5	-	0	0	0	0	0	0	0

*Data for February 1978 are not available

A meeting was held in Chicago, Illinois, on May 1, 1979, among Conoco Inc., Energy Impact Associates, U.S. EPA Region V, and Ohio EPA representatives to discuss the 12-month air quality and meteorology program. The National and Ohio EPA representatives in essence agreed that the planned program would be adequate.

The six-month continuous sampling of air for ozone and CO and atmospheric stability and dew point is in progress and will be completed in August 1979.

5.2 Aquatic Ecology

The aquatic ecology field program consisted of a four-season sampling schedule for physical, chemical, and biological parameters of Senecaville Reservoir, the East Fork of Duck Creek, and the South Fork of Buffalo Creek. Senecaville Reservoir is located five miles north of the plant site and is expected to supply the raw water requirements for the Demonstration Plant. A small tributary of the East Fork of Duck Creek originates on the plant site, and the natural drainage of the site is into Duck Creek. Buffalo creek runs north and west of the plant site and is in another watershed which adjoins the plant site.

Senecaville Reservoir was sampled in two areas, and two sampling stations were selected on each of two creeks. The field surveys include all of the major biological components of an ecosystem. The surveys were made in August and October of 1977 and in April and June of 1978. Phytoplankton (free-floating microscopic animals), periphyton (microscopic plants attached to underwater substrates), benthic macroinvertebrates (bottom-dwelling organisms), macrophytes (larger aquatic plants), ichthyoplankton (fish eggs and larvae), and juvenile and adult fish were sampled from Senecaville Reservoir. Only benthic macroinvertebrates and juvenile and adult fish were sampled from the two creeks. Trap nets, seines, and electroshocking were used to obtain the fish samples.

In situ measurements of water temperature, pH, dissolved oxygen, and specific conductance were made at all water sampling stations during the four field surveys. Water samples were collected for the usual analyses including total suspended solids (TSS), total dissolved solids (TDS), phenols, cyanides, sulfates, ammonia, fecal coliform, biochemical oxygen demand (BOD), iron, manganese, lead, zinc, cadmium, copper, arsenic, and mercury. The reservoir and both streams were sampled in November 1977 and analyzed for the EPA 129 priority pollutants.

The following species of fish were found in Senecaville Reservoir during one or more of the four field surveys:

Scientific Name	Common Name
CATOSTOMIDAE (suckers	
Carpiodes cyprinus	Quillback
Catostomus commersoni	White Sucker
Moxostoma erythrurum	Golden redhorse
CENTRARCHIDAE (sunfish)	
Lepomis cyanellus	Green sunfish
Lepomis gibbosus	Pumpkinseed
Lepomis gulosus	Warmouth
Lepomis humilis	Orangespotted sunfish
Lepomis macrochirus	Bluegill
Lepomis megalotis	Longear sunfish
Micropterus dolomieui	Smallmouth bass
Micropterus salmoides	Largemouth bass
Pomoxis annularis	White crappie
CLUPEIDAE (herring)	
Dorosoma cepedianum	Gizzard shad
CYPRINIDAE (minnows-carp)	
Carassius auratus	Goldfish
Cyprinus carpio	Carp
Ericymba buccata	Silverjaw minnow
Notropis atherinoides	Emerald shiner
Notropis cornutus	Common shiner
Notropis spilopterus	Spotfin shiner
Pimephales notatus	Bluntnose minnow
Semotilus atromaculatus	Creek chub
ICTALURIDAE (freshwater catfish)	
Ictalurus nebulosus	Brown bullhead
Ictalurus melas	black bullhead
Ictalurus punctatus	Channel catfish
Plyodictis olivaris	Flathead catfish
PERCICHTHYIDAE (temperate basses)	
Morone chrysops	White bass
PERCIDAE (perch)	
Perca flavescens	Yellow perch
Percina caproides	Logperch
Stizostedion vitreum vitreum	Walleye
Etheostoma nigrum	Johnny darter

The following species of fish were found in the South Fork of Buffalo Creek and/or the East Fork of Duck Creek during one or more of the field surveys:

Scientific Name	Common Name
CATOSTOMIDAE (suckers)	
Catostomus commersoni	White sucker

Scientific Name	Common Name
Hypentelium nigricans	Northern hog sucker
CENTRARCHIDAE (sunfish)	
Ambloplites rupestris	Rock bass
Lepomis cyanellus	Green sunfish
Lepomis megalotis	Longer sunfish
CYPRINIDAE (minnows-carp)	
Campostoma anamalum	Stoneroller
Ericymba buccata	Silverjaw minnow
Notropis ariommus	Popeye shiner
Notropis cornutus	Common shiner
Notropis stramineus	Sand shiner
Pimephales notatus	Bluntnose minnow
Pimephales promelas	Fathead minnow
Phoxinus erythrogaster	Southern redbelly dace
Semotilus atromaculatus	Creek chub
ICTALURIDAE (freshwater catfish)	
Ictalurus nebulosus	Brown bullhead
PERCIDAE (perch)	
Etheostoma blennioides	Greenside darter
Etheostoma caeruleum	Rainbow darter
Etheostoma flabellare	Fantail darter
Etheostoma nigrum	Johnny darter
Etheostoma squamiceps	Spottail darter
Percina caproides	Logperch

The following ichthyoplankton were collected in Senecaville Reservoir during the June survey:

Common Name/Developmental Stage

CENTRARCHIDAE (sunfishes)
- Sunfish/late-prolarva
- Crappie/late-prolarva
- Crappie/early-postlarva
- Crappie/mid-postlarva

CLUPEIDAE (herring)
- Gizzardshad/mid-prolarva
- Gizzardshad/early-postlarva
- Gizzardshad/mid-postlarva

CYPRINIDAE (minnows)
- Minnow/mid-prolarva
- Minnow/late-prolarva

PERCICTHYIDAE (sea basses)
- White bass/late-prolarva
- White bass/early-postlarva

White bass/mid-postlarva

PERCIDAE (perches)
Yellow perch/mid-postlarva

The benthic macroinvertebrates were collected by Ponar dredge from Senecaville Reservoir. Species identified include:

ANNELIDA
- Oligochaeta (aquatic earthworms, leeches, polychaetes)
  - Naidae
    - Dero dero
    - Nair sp.
  - Tubificidae
    - Aulodrilus limnobius
    - Aulodrilus pigueti
    - Bothrioneurium vejdovskyanum
    - Branchiura sowerbyi
    - Ilyodrilus templetoni
    - Limnodrilus cervix
    - Limnodrilus claparedianus
    - Limnodrilus hoffmeisteri

ARTHROPODA
- Diptera (flies, mosquitos, midges)
  - Ceratopogonidae
    - Bezzia sp.
    - Probezzia sp.
  - Chaoboridae
    - Chaoborus punctipennis
  - Chironomidae
    - Ablabesmyia annulata
    - Chironomus sp.
    - Coeltanypus scapularis
    - Crytochironomus fulvus
    - Harnischia sp.
    - Hydrobaenus sp.
    - Polypedilum sp.
    - Procladius sp.
    - Tanypus stellatus
    - Zenochironomus scopula
- Ephemeroptera (mayflies)
  - Baetidae
    - Baetis sp.
  - Ephemeridae
    - Hexagenia bilineata
    - Hexagenia limbata

BRYOZOA
- Ectoprocta
  - Lophopodiadae
    - Pectinatella (staloblasts)

PLATYHELMINTHES (flatworms)
Turbellaria
Planariidae
Cura sp.

The following phytoplankton were identified in Senecaville Reservoir during one or more of the four seasonal surveys:

Scientific Name

BACILLARIOPHTA (Diatoms)
Achananthes lanceolata
Cyclotella menenghiniana
Cymatopleura solea
Cymbella tumida
Melosira granulata
Navicula confervacea
Navicula radiosa
Nitzschia acicularis
Nitzschia holsatica
Nitzschia linearis
Nitzschia palea
Nitzschia sigmoidea
Stephanodiscus hantzschii
Surirella sp.
Synedra acus
Synedra ulna

CHLOROPHYTA (Green Algae)
Actinastrum hantzchii
Ankistrodesmus convolutus
Ankistrodesmus falcatus
Carteria sp.
Chlamydomonas globosa
Chlorogonium sp.
Chlorophyta g. sp.
Closterium gracile
Coelastrum cambricum
Coelastrum microporum
Crucigenia fenestrata
Crucigenia rectangularis
Crucigenia tetrapedia
Dyctiosphaerium pulchellum
Elakatothrix sp.
Golenkinia sp.
Haematococcus lacustris
Micractinium pusillum
Oocystis solitaria
Oocystis sp.
Pediastrum boryanum
Pediastrum tetras
Scenedesmus acuminatus
Scenedesmus quardricauda
Scenedesmus dimorphus

CHLOROPHYTA (Green Algae) continued

- Schroedria setigera
- Selenastrum westii
- Tetraedron minimum

CYANOPHYTA (Blue-green Algae)

- Anabaena flos-aquae
- Chroococcus sp.
- Coelosphaerium sp.
- Lyngbya sp.
- Merismopedia elegans
- Merismopedia glauca
- Oscillatoria sp.
- Schizothrix calcicola

OTHER

- Ceratium hirundinella
- Chromomanas sp.
- Cryptomonas ovata
- Dynobryon sertularia
- Euglena acus
- Euglena oxyuris
- Euglena viridas
- Euglena tripteris
- Glenodinium quadridens
- Mallomonas sp.
- Ochromonas sp.
- Peridinium sp.
- Phacus pleuronectes
- Phacus pyrum
- Synura uvella
- Trachelomonas hispida

The following zooplankton were found in Senecaville Reservoir during the summer and fall (1977) aquatic ecology field surveys:

Scientific Name

CLADOCERA

- Ceriodaphnia sp.
- Chydorus sphaericus
- Daphnia parvula
- Diaphanosoma leuchtenbergianum

COPEPODA

- Cyclops vernalis
- Cyclops bicuspidatus
- Diaptomus pallidus
- Mesocyclops edax
- Nauplius

ROTIFERA

- Anureopsis fissa
- Asplanchna priodonta

ROTIFERA continued
- *Brachionus angularis*
- *Brachionus caudatus*
- *Brachionus calyciflorus*
- *Brachinous urceolaris*
- *Colotheca* sp.
- *Euchlanis* sp.
- *Filinia longisetta*
- *Gastropis* sp.
- *Hexarthra* sp.
- *Keratella cochlearis*
- *Polyarthra dolichoptra*
- *Polyarthra vulgaris*
- *Polyarthra* sp.
- Rotatoria g. sp.
- *Synchaeta* sp.
- *Trichocerca* sp.

OTHER
- *Chaoborus* sp.
- Chironomidae sp.
- Ciliata g. sp.
- *Difflugia* sp.
- Protozoa g. sp.

The following zooplankton were identified during the April and June (1978) surveys:

Scientific Name

CLADOCERA
- *Alona* sp.
- *Bosmina longirostris*
- *Ceriodaphnia* sp.
- *Chydorus sphaericus*
- *Daphnia ambigua*
- *Daphnia parvula*
- *Pleuroxus striatus*

COPEPODA
- *Cyclops bicuspidatus*
- *Cyclops vernalis*
- *Diaptomus pallidus*
- *Eucyclops agilis*
- *Mesocyclops edax*
- Nauplius
- *Tropocyclops prasinus*

ROTIFERA
- *Brachionus angularis*
- *Brachionus colyciflorus*
- *Brachionus quadridentatus*
- *Conochilus unicornis*
- *Filinia longiseta*

ROTIFERA continued
- *Gastropus* sp.
- *Keratella cochlearis*
- *Polyarthra dolichoptera*
- *Polyarthra vulgaris*
- *Rotatoria* g. sp.
- *Synchaeta* sp.

OTHER
- *Chaetogaster* sp.
- *Codonella* sp.
- *Difflugia* sp.
- *Nematoda* g. sp.
- *Vorticella* sp.

Moderate (M) and abundant (A) quantities of the following periphyton were found in Senecaville Reservoir:

Scientific Name	August Survey	October Survey	April Survey	June Survey
BACILLARIOPHYTA (Diatoms)				
Achnanthes minutissima	-	M	M	M
Cymbella affinis	M	-	M	A
Cymbella prostrata	-	A	-	M
Cymbella tumida	M	-	-	-
Cymbella tumidula	-	M	-	-
Diatoma vulgare	-	-	-	A
Epithemia sorex	-	M	M	-
Fragilaria leptostauron	-	-	M	-
Fragilaria vaucheriae	M	A	M	M
Gomphonema affine	-	-	-	M
Gomphonema olivaceum	-	-	M	-
Melosira distans	A	A	M	M
Melosira granulata	M	-	-	-
Navicula cryptocephala	M	M	M	-
Navicula minima	-	-	M	M
Navicula salinarium	-	M	M	M
Navicula sinuata	-	-	-	M
Nitzchia acicularis	M	-	M	-
Nitzchia dissipata	-	A	M	A
Nitzchia frustulum	M	-	-	M
Nitzchia palea	M	M	-	-
Nitzchia sinuta	-	M	M	M
Rhoicosphenia curvata	-	M	-	-
Stephanodiscus invisitatus	M	M	-	-
Synedra rumpens	-	M	M	-
CHLOROPHYTA (Green algae)				
Cladophora glomerate	A	A	-	M
Dedogonium sp.	M	-	-	M

Scientific Name	August Survey	October Survey	April Survey	June Survey
CYANOPHYTA (Blue-green algae)				
Calothrix paraetina	-	-	A	M
Oscillatoria sp.	-	-	-	M
Raphidiopsis curvata	M	-	-	-
Schizothrix calcicola	A	M	-	A
OTHER				
Euglena sp.	M	-	-	-

Macrophyte (aquatic vascular plants) growth in Senecaville Reservoir was determined by visual inspection of the 47-mile perimeter of the reservoir. Five species of macrophytes were found:

Scientific Name	Common Name
Nelumbo lutea	American lotus
Nuphar sp.	Spatterdock
Potamogetan sp.	Pondweed
Scirpus sp.	Bulrush
Typha sp.	Cattail

The American lotus was the predominate plant in terms of area covered.

Benthic macroinvertebrates were collected by a Surber square-foot sampler from the South Fork of Buffalo Creek and the East Fork of Duck Creek during each of the seasonal surveys. Species identified in the samples are given below:

ANNELIDA
- Hirundinea (leeches)
  - Glossophoniidae
    - *Batrachobdella pieta*
- Oligochaeta (aquatic worms)
  - Naididae
    - *Nais* sp.
    - *Ophidonais sepentina*
    - *Pristina idrensis*
  - Tubificidae
    - *Aulodrilus pigueti*
    - *Bothrioneurum vejdovskyanum*
    - *Limnodrilus claparedianus*
    - *Limnodrilus hoffmeisteri*
    - *Limnodrilus udekemianus*

ARTHROPODA
- Coleopters (beetles)
  - Elmidae
    - *Stenelmis* sp.
  - Psephenidae
    - *Psephenus* sp.

Crustacea
  Astacidae
    Orconectes sp.
Diptera (flies, mosquitos, midges)
  Ceratopogonidae
    Bezzia sp.
    Palpomyia sp.
  Chaoborinae
    Chaoborus sp.
Chironomidae
    Ablabesmyia annulata
    Brillia sp.
    Chironomus sp.
    Coelotanypus sp.
    Conchapelopia sp.
    Cricotopus sp.
    Cryptochironomus sp.
    Dicrotendipes sp.
    Labrundina sp.
    Larsia sp.
    Microcricotopus sp.
    Microtendipes padellus
    Natarsia sp.
    Orthocladius sp.
    Paracladopelma sp.
    Parametriocnemus sp.
    Phenopsectra sp.
    Polypedilum scalaenum
    Procladius sp.
    Psectocladius sp.
    Rheotanytarsus sp.
    Stempellinella brevis
    Stictochironomus sp.
    Tanytarsus sp.
    Thienemanniella sp.
    Thienemannimyia sp.
  Simuliidae
    Simulium sp.
  Tabanidae
    Crysops sp.
  Tipulidae
    Dicranota sp.
    Eriocera sp.
    Hexatoma sp.
    Tipula sp.
Ephemeroptera (mayflies)
  Baetidae
    Baetis sp.
    Centroptilium sp.
    Heterocleon curiosum
  Caenidae
    Caenis sp.
  Ephemeridae
    Ephemera simulans

Ephemera varia
Hexagenia limbata
Heptigeniidae
Stenonema interpunctatum
Leptophlebiidae
Leptophlebia sp.
Hemiptera (bugs)
Valiidae
Velia sp.
Megaloptera (alderflies, dobson flies, fish flies)
Sialidae
Sialis sp.
Plecoptera (stone flies)
Acroneuridae
Acroneura abnormalis
Nemouridae
Nemoura sp.
Perlodidae
Isogenus sp.
Tricoptera (caddis flies)
Hydropsychidae
Cheumatopsyche sp.
Hydropsyche betteni
Hydroptilidae
Ochrotrichia sp.

MOLLUSCA
Bivalvia
Sphaerium sp.
Gastropoda
Ancylidae
Ferrissia sp.

NEMERTEA (proboscis worms)
Prostoma rubrum

PLATYMELMINTHES (flatworms)
Planariidae
Cura Pormannii

The in situ temperature and dissolved oxygen content at various depths at a point near the dam in Senecaville Reservoir are given in Table 5-5. Conductivity and pH measurements are given in Table 5-6. Similar data for the South Fork of Buffalo Creek and the East Fork of Duck Creek are given in Table 5-7. Sampling station BFC-1 is located on the South Fork of Buffalo Creek below the confluence of Little Buffalo Creek and near the junctions of State Routes 146 and 147. Sampling station BFC-2 is located on the South Fork of Buffalo Creek near the northwest corner of the plant site and about two miles west of Whigville, Ohio. Sampling station DKC-1 is located on the East Fork of Duck Creek about one-half mile below the plant site and just above its confluence with Wolfpen Run. Sampling station DCK-2 is located on the East Fork of Duck Creek near State Route 260 and about three-fourths mile below its confluence with Barnes Run.

TABLE 5-5

In Situ Determinations of Temperature and Dissolved Oxygen in Senecaville Reservoir

Water Depth, Feet	Temperature, °F				Dissolved Oxygen, mg/l			
	Aug. 30, 1977	Oct. 31, 1977	Apr. 5, 1978	June 5, 1978	Aug. 30, 1977	Oct. 31, 1977	Apr. 5, 1978	June 5, 1978
0	78.8	55.8	49.1	71.6	9.0	8.6	11.0	8.2
1	78.8	55.8	48.7	71.6	9.0	8.5	11.1	8.2
2	78.8	55.8	48.2	71.6	9.0	8.5	11.1	8.2
3	78.8	55.6	48.0	71.6	9.0	8.5	11.1	8.2
4	78.4	55.6	47.1	71.6	8.9	8.6	11.0	8.2
5	78.3	55.6	47.1	71.6	8.9	8.5	10.9	8.2
6	78.3	55.6	46.4	71.6	8.3	8.5	10.8	8.2
7	77.0	55.6	46.0	71.6	7.0	8.4	10.8	8.1
8	77.0	55.6	45.7	71.6	5.8	8.4	10.4	8.1
9	76.5	55.6	45.5	71.4	5.0	8.4	10.3	8.1
10	75.2	55.6	45.0	71.1	4.7	8.4	10.2	8.1
12	74.3	55.6	44.6	69.1	2.5	8.4	10.0	7.9
13	74.3	55.6	44.2	66.4	1.4	8.5	10.0	7.1
14	73.9	55.6	43.7	63.9	0.7	8.5	10.0	7.0
15	73.6	55.6	43.7	61.7	0.4	8.5	10.0	6.0
16	73.4	55.6	43.7	60.1	0.3	8.5	10.0	5.2
17	73.4	55.6	43.7	59.5	0.2	8.9	10.0	3.1
18	72.9	55.6	43.7	58.1	0.2	8.8	9.8	1.7
19	72.9	55.6	43.2	57.6	0.2	8.8	9.6	1.4
20	72.5	55.6	43.2	57.4	0.2	8.6	9.4	0.7
21	72.5	-	42.8	57.4	0.2	-	9.4	0.7
22	72.5	-	42.3	57.2	0.2	-	9.4	0.7

TABLE 5-6

In Situ Determinations of Conductivity and pH in Senecaville Reservoir

Water Depth, Feet	Conductivity, micromhos per cm.				pH			
	Aug. 30 1977	Oct. 31, 1977	Apr. 5, 1978	June 5, 1978	Aug. 30, 1977	Oct. 31, 1977	April 5, 1978	June 5, 1978
0	260	350	330	400	8.3	7.6	7.7	8.2
1	260	350	330	400	8.3	7.6	7.7	8.2
2	265	350	330	400	8.3	7.6	7.7	8.2
3	265	350	330	400	8.3	7.6	7.7	8.2
4	265	350	330	400	8.3	7.6	7.7	8.2
5	265	350	330	400	8.2	7.6	7.7	8.2
6	265	355	335	400	8.1	7.6	7.7	8.2
7	270	355	335	400	7.8	7.6	7.7	8.2
8	270	355	340	400	7.7	7.6	7.7	8.2
9	270	355	340	400	7.7	7.6	7.7	8.2
10	270	355	340	400	7.4	7.6	7.6	8.2
11	275	355	340	400	7.4	7.6	7.6	8.2
12	275	355	340	400	7.4	7.7	7.6	8.2
13	280	355	340	410	7.3	7.7	7.6	8.2
14	280	355	340	410	7.2	7.7	7.6	8.2
15	280	355	340	420	7.2	7.7	7.6	8.2
16	285	355	340	420	7.2	7.7	7.6	8.2
17	285	355	340	430	7.2	7.7	7.6	8.2
18	290	355	340	430	7.2	7.7	7.6	8.2
19	290	355	340	440	7.2	7.7	7.6	8.2
20	290	380	340	440	7.2	7.5	7.6	8.2
21	295	-	345	445	7.2	-	7.6	8.2
22	300	-	345	450	7.2	-	7.6	8.2

TABLE 5-7

In Situ Measurements of Properties of Streams near Plant Site

Sampling Station	Aug. 30, 1977	Oct. 31, 1977	Apr. 5 1978	June 5, 1978
Buffalo Creek: BFC-1				
Temperature, °F	78.8	56.7	60.1	70.0
Dissolved Oxygen, mg/l	10.8	14.0	9.6	8.2
Conductivity, umhos/cm	660	550	420	670
pH	7.0	8.2	8.0	8.1
Buffalo Creek: BFC-2				
Temperature, °F	70.5	55.4	58.1	68.9
Dissolved Oxygen, mg/l	8.2	10.8	11.0	9.0
Conductivity, umhos/cm	500	550	300	500
pH	7.6	8.1	8.5	8.1
Duck Creek: DKC-1				
Temperature, °F	72.0	59.0	56.3	74.7
Dissolved Oxygen, mg/l	6.3	10.6	9.4	9.2
Conductivity, umhos/cm	330	465	375	500
pH	7.6	8.2	8.1	8.1
Duck Creek: DKC-2				
Temperature, °F	75.0	51.4	59.2	69.8
Dissolved Oxygen, mg/l	4.4	12.4	9.3	8.2
Conductivity, umhos/cm	410	485	400	550
pH	7.4	8.1	8.2	8.1

The location of the raw water intake from Senecaville Reservoir was selected. An aquatic ecology study of the reservoir area near the intake point was started on April 10, 1979. The purpose of this study is to describe spatial and temporal distribution of fish eggs and larvae. In situ temperatures and dissolved oxygen are being measured concurrently with the aquatic organism sampling. The sampling is being done at 10-day intervals for a five-month period.

5.3 Terrestrial Ecology

The terrestrial ecology field program consisted of a four-season sampling plan to determine the types of vegetation and animal wildlife that inhabit the plant site. The field survey dates and seasons were as follows: fall, October 6-13, 1977; winter, February 14-17, 1978; spring, May 11-16, 1978; and summer, July 24-28, 1978.

Vegetation found on the plant site is typical of the region. Vegetation types identified include black walnut-American sycamore forest, upland hardwood forest (mature and successional), fencerow, and pasture.

Black walnut-American sycamore forest occupies deep alluvial soils in the narrow stream valleys where soil nutrients are plentiful, atmospheric humidity increased, soil moisture abundant and leaf decay rapid as evidenced by relatively thin leaf litter in the summer. The community is all aged, second growth forest, having an open canopy at 59 feet and covering 65 percent of the soil surface.

Mature upland hardwood forest occupies upland narrow-bench and steep slope locations that apparently have not been previously clear-cut by man. However, selected individual trees have been cut. The community is an all-aged forest having a canopy at approximately 82 feet.

Successional upland hardwood forest occupies land that previously had been cleared for agricultural use and has subsequently been allowed to revert back to forestland. This type includes all successional stages from herbaceous former pasture to shrubby to dense, young, forest growth. It is characterized by few tree-sized stems and numerous saplings.

Fencerow includes woody and herbaceous plant growth within a distance of 1.65 feet of a fence. The community ranges in age from herbaceous to mature forest growth as individual land owners allowed.

Pasture occupies upland and lowland gently sloping to moderately steep topography. The lack of a forest cover and the presence of periodic cattle-hoof soil disturbance allows relatively rapid surface runoff, accelerated soil erosion, relatively low atmospheric humidity at the soil surface, and relatively low soil moisture and soil nutrients. Periodic disturbance and close vegetative cropping by cattle allows eight percent of the soil surface to be exposed to erosion and to plant colonization.

The characteristics of these vegetation types are shown in Table 5-8.

Importance values are a measure of the species ranking in the ecological community. Field data collected included the number of individuals per area sampled and the sizes of these individuals. The number of individuals per area was converted to density per hectare. The basal area per species data was converted to basal area per hectare. From these basal area and density data, the relative density and relative basal area were calculated.

TABLE 5-8

Vegetative Community Habitat Characteristics

Characteristic	Black Walnut-Sycamore Forest	Upland Hardwood Forest		Fencerow	Pasture
		Mature	Successional		
Topographic Slope, Percent					
Average	2	33	19	4	14
Range	1-4	9-75	6-35	3-5	0-30
Canopy Height, Feet					
Average	59	82	31	33	0.3
Range	52-62	64-98	2-58	2-75	0-5
Grazing Intensity, Percent of Habitat	50	60	35	75	100
Strata, Percent Cover					
Canopy - Average	65	60	41	58	-
Range	60-70	45-75	0-95	50-65	-
Subcanopy - Average	32	88	11	-	-
Range	0-60	65-100	0-80	-	-
Shrub - Average	13	18	21	30	-
Range	5-25	5-35	5-60	25-35	-
Ground Cover - Average	98	57	84	99	88
Range	95-100	25-70	35-100	98-100	75-100
Litter - Average	67	94	61	60	10
Range	25-95	90-98	15-100	25-95	5-15
Bare Soil - Average	26	4	4	1	8
Range	0-75	0-8	0-15	0-2	0-15

The frequency of occurrence recorded as percentages of plots containing tree and shrub-size individuals of the species considered was also calculated from the data collected. The sum of the relative density, relative basal area, and relative frequency, divided by three is the importance value of a species.

The importance values of forest trees and forest saplings are given in Tables 5-9 and 5-10, respectively. Table 5-11 gives vegetative community density, basal area, and ground cover.

TABLE 5-9

Forest Tree Importance Values*

Species	Black Walnut-Sycamore Forest	Upland Hardwood Forest Mature	Upland Hardwood Forest Successional	Fencerow
Black Walnut	42			
American Sycamore	23			
Black Willow	15			
Eastern Cottonwood	7			
Slippery Elm	8	10		
Boxelder	5			
Red Maple		2	18	
Tulip Poplar		12	39	
American Beech		19		
Sugar Maple		9		
Sourwood		4		
White Ash		6	20	10
Eastern Hophornbeam		4		
Bitternut Hickory		2		13
Shagbark Hickory		10		16
Northern Red Oak		4		7
White Oak		13		16
Black Oak				17
Black Cherry		5	23	7
Apple				7
Tree-of-Heaven				7
TOTALS	100	100	100	100

*Includes all sampled stems at least 16.5 centimeters in stem diameter at 1.4 meters height. See text for explanation of importance values.

TABLE 5-10

Forest Sapling Importance Values*

Species	Black Walnut-Sycamore Forest	Upland Hardwood Forest Mature	Upland Hardwood Forest Successional	Fencerow
Large Trees				
Black Walnut	26			
American Sycamore	18			
Yellow Buckeye	9			
Black Willow	17			
Slippery Elm	9	9		5
Black Cherry	3		7	4
Cottonwood	4			
Black Ash	4			
Black Locust	2			
Sugar Maple		32		
American Beech		10	1	
Sassafras		6	20	16
American Elm		5	2	
Shagbark Hickory		5		4
Northern Red Oak		3		
White Ash		2	15	5
White Oak		2		
Red Maple			28	2
Tulip Poplar			9	
Tree-of-Heaven				21
Sweet Cherry				5
Black Oak				4
Boxelder				2
Small Trees				
Wild Plum	2			13
American Hornbeam		17		
Flowering Dogwood		9	3	6
Hawthorn			12	
Shrubs and Vines				
Grape Vine	4		1	3
Poison Ivy	2			
Spicebush			2	
American Elderberry				3
Multiflora Rose				5
Virginia Creeper				2
TOTALS	100	100	100	100

*Includes all sampled stems between 1.2 and 16.4 centimeters in stem diameter at 1.4 meters height. See text for explanation of importance values.

TABLE 5-11

Vegetative Community Density, Basal Area, and Cover

Characteristics	Black Walnut-Sycamore Forest	Upland Hardwood Forest Mature	Upland Hardwood Forest Successional	Fencerow	Pasture
Tree-Size Class					
Density, stems/hectare	250	265	37.5	162	--
Basal Area, sq. meter/hectare	13.47	26.24	1.95	20.29	--
Sapling-Size Class					
Density, stems/hectare	1,483	1,140	1,958	2,500	--
Basal Area, sq. meter/hectare	14.07	4.25	5.79	5.32	--
Shrub-Size Class					
Density, stems/hectare	1,667	3,720	1,770	10,500	--
Cover, percent	8	35	16	19	--
Ground Cover					
Density, stems/hectare					
Spring	2,417,000	753,200	1,292,700	1,728,000	1,255,000
Summer	672,000	373,600	632,700	676,000	952,000
Fall	366,000	97,600	499,300	1,228,000	888,000
Cover, percent					
Spring	106	45	65	75	77
Summer	178	73	168	232	129
Fall	116	35	95	101	105

The mammals of the plant site are typical of those expected in eastern Ohio. No rare or endangered species were encountered during the field studies condicted in 1977 through 1978. Mammals of the site and surrounding area may be categorized as game mammals, furbearers, and nongame species. The species in each category were given a rating of abundant, common, and uncommon as shown on Table 5-12.

The plant site provides excellent habitat for many birds. The bird species relative abundance, seasonal occurrance, and habitat preference found on the site are shown on Table 5-13.

There were several raptorial (predatory) birds found on the plant site. The most commonly observed species was the American kestrel. A second small falcon encountered on the site was the Merlin. Other predatory birds encountered on the site include the turkey vulture, red-tailed hawk, broad winged hawk, cooper's hawk, sharp-shinned hawk, and the great horned owl.

Three species of upland game birds were found on the site. The habitat most heavily utilized by these species was mature and successional upland hardwood forest. These upland game birds include the bobwhite, ruffed grouse, and morning dove.

The Demonstration Plant site provides a rich and varied habitat for several herptile species. Small ponds, streams, and dense forests are preferred habitats for these animals. Table 5-14 lists the reptile and amphibian species observed on the site with their habitat and abundance.

The raw water pipeline route has been determined for water from Senecaville Reservoir to the plant site. A terrestrial ecology survey is being performed on the pipeline route. The spring field survey on this route was executed during the weeks of May 18 and 25, 1979.

TABLE 5-12

Mammals Observed on the Proposed Site

Common Name	Season and Relative Abundance			
	Fall	Winter	Spring	Summer
Game Mammals				
Eastern cottontail	A	A	A	A
White-tailed deer	C	C	C	C
Gray squirrel	C	C	C	C
Furbearers				
Opossum	-	C	-	C
Red fox	-	U	-	-
Gray fox	U	U	U	-
Raccoon	C	C	-	C
Nongame Mammals				
Short-tailed shrew	U	-	U	-
Meadow Vole	-	-	C	-
White-footed mouse	-	-	C	-
Woodchuck	-	-	C	C
Eastern chipmunk	C	-	C	C

Legend:

A = Abundant - An abundant mammal is one very likely to be present in large numbers every time a person visits its habitat at the proper season.

C = Common - A common mammal is one likely to be present in moderate numbers nearly every time a person visits its habitat at the proper season.

U = Uncommon - An uncommon mammal is one likely to be present in low numbers occasionally when a person visits its habitat at the proper season.

TABLE 5-13

Bird Species' Relative Abundance, Seasonal Occurrence and Habitat Reference on Proposed Site

Common Name	Habitat Type: Black Walnut Sycamore Forest		Upland Hardwood Forest: Mature		Upland Hardwood Forest: Successional		Upland Hardwood Forest: Pasture	
	Relative Abundance	Season	Relative Abundance	Season	Relative Abundance	Season	Relative Abundance	Season
Green heron	U	Su-R	-	-	-	-	-	-
Turkey vulture	-	-	C	Su-R	C	Su-R	C	Su-R
Sharp-shinned hawk	-	-	-	-	-	-	S	Sp,F-M
Cooper's hawk	-	-	S	Su-R	-	-	-	-
Red-tailed hawk	-	-	C	Su,W-R	C	Su,W-R	C	Su,W-R
Broad-winged hawk	-	-	U	Su-R	U	Su-R	U	Su-R
Merlin	-	-	S	Su-R	-	-	-	-
American kestrel	-	-	C	Su,W-R	C	Su,W-R	C	Su,W-R
Ruffed grouse	-	-	C	Su-R	C	W-R	-	-
Common bobwhite	-	-	-	-	C	Su,W-R	-	-
Killdeer	C	Su-R;Sp,F-M	-	-	-	-	C	Su-R;Sp,F-M
Mourning dove	-	-	-	-	C	Su-R;Sp,F-M	A	Su-R;Sp,F-M
Yellow-billed cuckoo	-	-	-	-	U	Su-R;Sp,F-M	-	-
Great-horned owl	-	-	U	Sp-M	-	-	-	-
Chimney swift	-	-	-	-	C	Su-R	C	Su-R
Belted kingfisher	U	Su-R;Sp,F-M	-	-	-	-	-	-
Common flicker	-	-	-	-	A	Su,W-R	C	Su,W-R
Pileated woodpecker	-	-	U	Su-R;Sp,F-M	U	Su-R	-	-
Red-bellied woodpecker	-	-	C	Su-R;Sp,F-M	C	Su-R	-	-
Yellow-bellied sapsucker	-	-	C	Su-R;Sp, F-M	-	-	-	-
Hairy woodpecker	-	-	U	Su-R;Sp,F-M	-	-	-	-
Downy woodpecker	-	-	C	Su,W-R	A	Su,W-R	-	-
Great-crested flycatcher	-	-	U	Su-R;Sp,F-M	-	-	-	-
Eastern phoebe	-	-	C	Su-R	C	Su-R	-	-

TABLE 5-13 (Continued)

Common Name	Black Walnut Sycamore Forest: Relative Abundance	Black Walnut Sycamore Forest: Season	Upland Hardwood Forest, Mature: Relative Abundance	Upland Hardwood Forest, Mature: Season	Upland Hardwood Forest, Successional: Relative Abundance	Upland Hardwood Forest, Successional: Season	Pasture: Relative Abundance	Pasture: Season
Acadian flycatcher	U	Su-R	-	-	-	-	-	-
Least flycatcher	-	-	C	Su-R	-	-	-	-
Eastern wood pewee	U	F-M	-	-	-	-	-	-
Barn swallow	C	Su-R;Sp,F-M	-	-	-	-	A	Su-R;Sp,F-M
Blue jay	-	-	A	Su-R;Sp,F-M	A	Su-R;Sp,F-M	-	-
American crow	-	-	-	-	C	Su-R	C	Su,W-R
Black-capped chickadee	-	-	A	Su,W-R	C	Su-R	-	-
Tufted titmouse	-	-	C	Su,W-R	C	Su,W-R	-	-
White-breasted nuthatch	-	-	C	Su,W-R	C	Su,W-R	-	-
House wren	-	-	-	-	A	Su-R;Sp,F-M	A	Su-R;Sp,F-M
Carolina wren	A	Su-R,Sp,F-M	A	Su-R,Sp,F-M	A	Su-R;Sp,F-M	-	-
Northern mockingbird	-	-	-	-	U	Su,W-R	-	-
Gray catbird	-	-	-	-	C	Su-R;Sp,F-M	-	-
Brown thrasher	-	-	-	-	C	Su-R;Sp,F-M	-	-
American robin	-	-	-	-	A	Su-R;Sp,F-M	A	Su-R;Sp,F-M
Wood thrush	-	-	C	Su-R;Sp,F-M	-	-	-	-
Hermit thrush	-	-	C	Su-R	-	-	-	-
Eastern bluebird	-	-	-	-	VU	Sp,F-M	-	-
Blue-gray gnatcatcher	-	-	A	Su-R;Sp,F-M	-	-	-	-
European starling	-	-	-	-	A	Su-R;Sp,F-M	A	Su-R;Sp,F-M
White-eyed vireo	U	Su-R	-	-	A	Su-R;Sp,F-M	-	-
Red-eyed vireo	-	-	A	Su-R;Sp,F-M	-	-	-	-
Warbling vireo	-	-	-	-	U	Sp-M	-	-
Black-and-white warbler	-	-	U	Su-R	C	Su-R	-	-

TABLE 5-13 (Continued)

Common Name	Habitat Type: Black Walnut Sycamore Forest – Relative Abundance	Black Walnut Sycamore Forest – Season	Upland Hardwood Forest: Mature – Relative Abundance	Mature – Season	Successional – Relative Abundance	Successional – Season	Pasture – Relative Abundance	Pasture – Season
Golden-winged warbler	-	-	U	Sp-M	-	-	-	-
Blue-winged warbler	-	-	U	Sp-M	-	-	-	-
Tennessee warbler	-	-	C	Su-R	C	Su-R	-	-
Yellow warbler	-	-	-	-	C	Su-R	-	-
Yellow-rumped warbler	A	Su-R;Sp,F-M	C	Su-R;Sp,F-M	A	Su-R;Sp,F-M	-	-
Black-throated green warbler	-	-	U	Su-R	-	-	-	-
Blackburnian warbler	-	-	U	Sp-M	-	-	-	-
Black-throated blue warbler	-	-	U	Sp-M	-	-	-	-
Chestnut-sided warbler	-	-	-	-	U	Su-R	-	-
Prairie warbler	-	-	-	-	U	Sp-M	-	-
Kentucky warbler	-	-	C	Sp-M	C	Sp-M	-	-
Common yellowthroat	C	Su-R	-	-	-	-	-	-
Yellow-breasted chat	C	Sp,F-M	-	-	C	Su-R	-	-
Hooded warbler	-	-	U	Sp-M	-	-	-	-
Canada warbler	-	-	U	Sp-M	-	-	-	-
American redstart	-	-	C	Sp-M	-	-	-	-
House sparrow	-	-	-	-	-	-	A	Su,W-R
Eastern meadowlark	-	-	-	-	-	-	A	Su-R;Sp,F-M
Red-winged blackbird	A	Su-R	-	-	-	-	A	Su-R;Sp,F-M
Northern oriole	-	-	-	-	C	Su-R	-	-
Common grackle	-	-	-	-	-	-	A	Su-R;Sp,F-M
Brown-headed cowbird	-	-	-	-	-	-	A	Su-R
Scarlet tanager	-	-	C	Su-R	A	Su-R	-	-
Northern cardinal	-	-	A	Su-R	A	Su,W-R	-	-

TABLE 5-13 (Continued)

Common Name	Habitat Type: Black Walnut Sycamore Forest		Upland Hardwood Forest: Mature		Upland Hardwood Forest: Successional		Upland Hardwood Forest: Pasture	
	Relative Abundance	Season	Relative Abundance	Season	Relative Abundance	Season	Relative Abundance	Season
Rose-breasted grosbeak	-	-	A	Su-R	C	Su-R	-	-
Indigo bunting	-	-	-	-	A	Su-R	A	Su-R
American goldfinch	-	-	-	-	A	Su-R;Sp,F-M	C	Su,W-R
Rufous-sided towhee	-	-	A	Su-R;Sp,F-M	A	Su-R;Sp,F-M	-	-
Vesper sparrow	-	-	-	-	C	Sp-M	C	Su-R;Sp,F-M
Northern junco	-	-	C	W-R;Sp,F-M	-	-	-	-
American tree sparrow	-	-	-	-	U	W-R	-	-
Chipping sparrow	-	-	-	-	C	Su-R	C	Sp-M
Field sparrow	-	-	-	-	C	Su-R;Sp,F-M	A	Su-R
White-throated sparrow	-	-	U	Su,W-R	-	-	-	-
Fox sparrow	-	-	-	-	U	Sp-M	-	-
Song sparrow	A	Su,W-R	-	-	A	Su,W-R	A	Su,W-R

Legend:

A = Abundant - An abundant bird is one very likely to be seen in large numbers every time a person visits its habitat at the proper season.
C = Common - A common bird is one which may be seen most of the time or in smaller numbers under the same circumstances.
U = Uncommon - An uncommon bird is one which may be seen quite regularly in small numbers in the appropriate environment and season.
VU = Very uncommon - A very uncommon bird occupies only a small percentage of its preferred habitat or occupies a very specific limited habitat. It is usually found only by an experienced observer.
S = Special species - A special species bird indicates that it has some degree of rarity or is listed as rare by the State of Ohio or the Federal Government Fish and Wildlife Service.
Sp = Spring
Su = Summer
F = Fall
W = Winter
R = Resident
M = Migrant

TABLE 5-14

Reptile and Amphibian Species Observed on the Proposed Site Area and Surrounding Environrons

Common Name	Scientific Name	Habitat	Relative Abundance	Time of Year Observed			
				Spring	Summer	Fall	Winter
Red-backed salamander	Plethodon cinereus cinereus	L	C	X	X		
Slimy salamander	Plethodon glutinosus glutinosus	L	C	X	X		
Ravine salamander	Plethodon richmondi	W	U	X			
Northern dusky salamander	Desmognathus fucus fucus	W	C	X			
Green frog	Rana clamitans melanota	W	C		X		
Bull frog	Rana catesbeiana	W	C		X		
Spring peeper	Rana pipiens	W	A	X			
Leopard frog	Hyla crucifer	W	U		X		
American toad	Bufo americanus americanus	W	A	X	X		
Eastern garter snake	Thamnophis sirtalis sirtalis	L	U			X	
Eastern box turtle	Terrapene carolina carolina	L	U	X	X	X	

Legend:

A = Abundant - An abundant herptile is one very likely to be seen or heard in large numbers during a given time of the year.

C = Common - A common herptile is one which may be seen or heard at a given time of the year but in lesser numbers

U = Uncommon - An uncommon herptile is one which may be seen or heard regularly but in small numbers.

L = Upland

W = Pond and stream

5.4 Geohydrology

The original scope of work relative to geohydrology was based on the premise that data from the literature supplemented by data from the Task III soil survey would be sufficient to define the geohydrological facets of the environmental analysis. This information, however, has been found to be insufficient; so additional geohydrological data are being gathered.

Seven wells were drilled on the plant site during the week of June 4, 1979. These wells were drilled to the aquifers (80-140 feet deep), and pump tests will be performed on the wells. The flow regimes of the aquifers will be determined and soil analysis will be made. The wells are located on site areas that will be used for solid waste disposal from the plant. This effort is to ascertain the impacts of solid wastes on the site environment.

Leaching tests on various solid wastes are being undertaken. The major solid waste from the Demonstration Plant will be the slag from the gasifiers. Data to date indicate that the slag is essentially impervious to leaching.

5.5 Noise Survey

A daytime noise survey was conducted on and near the plant site in Noble County, Ohio, on November 9, 1978. Twenty noise measuring stations were established. The plant site is located in a rural area; so the noise level is usually quite low. Most noises originate from automobile traffic and aircrafts. The average noise level at the 20 stations was 34 decibles.

5.6 Socioeconomic Study

A socioeconomic survey of Noble, Washington, and Guernsey Counties of Ohio has been completed.

The purpose of performing a socioeconomic impact analysis is twofold. First, it is to assist Conoco Inc. in complying with the Environmental Impact Statement requirements of the National Environmental Policy Act. Second, it is to provide local residents and officials with reasonable estimates of the socioeconomic benefits and costs associated with the Demonstration Plant. To fulfill these two purposes, four tasks were accomplished:

1. Describe the baseline socioeconomic conditions in the study area;
2. Identify key project characteristics;
3. Assess the socioeconomic effects of project construction; and
4. Assess the socioeconomic effects of project operation.

Baseline Socioeconomic Conditions

A three-county study area was established for the socioeconomic impact analysis. This study area included Noble, Guernsey, and Washington Counties. These counties were chosen primarily on the likelihood that they will realize a significant portion of the Demonstration Plant impact and/or benefits.

The study area contains no urban centers with populations greater than 25,000. The area is predominately rural in character. The three-county area has a population of approximately 111,000 and is projected to reach 116,000 by 1980.

In comparison with statewide Ohio data, the study area is higher in median age, comparable in male/female percentages, and lower in percentage of non-whites.

In 1970, approximately 30 percent of all workers in Noble and Washington Counties commuted to work outside their county of residence. In Guernsey County only 19 percent commuted, while the average for Ohio was 22 percent.

Historically, the economic base of the study area has been in primary industries, especially agriculture, mining, and forestry. Over the period of 1940-1970 the economic base has changed. There has been a significant decrease in primary industries and increases in manufacturing, services, and wholesale and retail sectors.

The major employment centers of the three-county study area include the towns of Caldwell, Cambridge, and Marietta. These towns contain a variety of manufacturing firms, service establishments, and retail businesses.

During the period from 1970 to 1978 the labor force of the area grew from 39,600 to 45,400. Unemployment varied considerably during this period. The 1978 unemployment rates were as follows: Noble County, 6.8 percent; Guernsey County, 6.5 percent; and Washington County, 4.9 percent. The statewide unemployment at the same time was 4.9 percent.

Medical facilities within the study area are adequate for most general medical treatment. General hospitals are located in Cambridge and Marietta with a total of 520 beds. Occupancy rates at these facilities range from 70-78 percent. The majority of doctors and dentists in the area are located in the county seat of each county: Caldwell, Cambridge, and Marietta.

Fire protection in the large towns of the study area is adequate. However, rural fire protection is relatively a high risk because of the absence of water lines and the large distance to local fire departments.

Most water service in the study area is provided by water wells. Public water service is currently available to only about 42 percent of the population of Noble County, 63 percent of the population of Guernsey County, and 20 percent of the population of Washington County. These public water systems have safe yield capacity in excess of peak demand levels. Sewage systems are found only in Marietta, Cambridge, Byesville, and Caldwell. All of these systems are capable of accommodating additional connections.

Total housing stock numbers 4,100 units in Noble County, 14,500 units in Guernsey County, and 19,200 units in Washington County. Of the 37,800 units in the study area, nearly 2,100 are vacant. Single-family conventional homes have been losing their predominance in the study area since 1970. A disproportionately high percentage of new units since 1970 were multi-family homes and mobile homes. Zoning ordinances or other regulations controlling land use and housing development are for the most part not operative in the study area.

There are five school districts throughout the three-county area. A total of 12,700 students were enrolled in these districts during 1978. The five districts contain a total of 35 schools with a capacity of nearly 15,300 students. The study area also contains two vocational schools - one each in Marietta and Byesville, a technical college in Marietta, and a four-year liberal arts college in Marietta.

Excellent access to and from the study area is afforded by the interstate highway network. Interstate 77 crosses all three counties in a north-south direction. Interstate 70 crosses Guernsey County in a east-west direction, intersecting I-77 at Cambridge. Both highways link the study area to a number of urban markets.

Key Project Characteristics

There are several key project characteristics that must be identified to serve as a basis for the socioeconomic impact analysis. The Demonstration Plant will be constructed over a 2.5 year period beginning in January 1982 and ending in June 1984. Manpower requirements for construction will peak at approximately 365 workers in 1983. In addition, field staffs for Conoco Inc. and the subcontractors will involve approximately 95 non-manual workers.

The Demonstration Plant construction will require a number of materials and services from within a 50-mile radius of the site. These include concrete, lumber, welding supplies, rental equipment, fuels and lubricants, sand, and gravel. These materials are found in abundance in the urban areas of Marietta, Cambridge, and Caldwell.

The Demonstration Plant will be operated over a 3.5 year period. During this period, the plant will employ a total of 359 workers. Included in the total are 93 administrative and technical support personnel, 45 operation and maintenance personnel, and 221 process operators and maintenance mechanics.

During operation, the primary raw material requirements of the plant will be for coal, limestone, and miscellaneous catalysts and chemicals. The coal requirements will be fulfilled from within a 50-mile radius of the plant site and will support 55 jobs at the coal mine.

Socioeconomic Effects of Construction

There are no severe adverse socioeconomic effects of the Demonstration Plant construction on the surrounding area. There appears to be no problem in obtaining a construction work force. The construction work force may be divided into four types of workers: locals (workers who reside in the study area); commuters (workers who commute to the job site on a daily basis); movers (workers who move into the study area for the duration of their employment with the project); and travelers (workers who live in the study area during the work week and travel home on weekends). The breakdown of construction workers was based on four factors: local labor availability, site accessibility, commuting patterns, and existence of completing projects. Consideration of these factors led to the conclusion that the majority of the work force would be composed of locals and commuters. Locals will account for an estimated 55 percent of the peak work force and commuters will account for 30 percent. Movers will account for 10 percent of the work force and travelers will make up the remaining five percent.

Construction period wages to be paid to manuals and non-manuals are estimated at $23,300,000. Of this figure, $17,200,000 will be paid to study area employees and $6,100,000 to employees residing outside the study area.

Tax benefits during the construction period will be realized by the three counties. Revenues will be returned to the three counties by the state in the form of local government payments ($5,200), income tax rebates ($68,700), and motor vehicle fuel tax rebates ($20,700).

The increases in the study area population attributed to the Demonstration Plant construction is not expected to result in adverse impacts to medical services, fire protection, law enforcement, or sanitary services within the study area. The population increment may actually serve to increase the efficiency of certain services such as medical and utilities.

An estimated 62 school-age children will accompany the peak immigration of construction workers to the study area. There is considerable excess capacity in the school systems and this incremental enrollment may compensate somewhat for recent enrollment declines, thereby increasing the cost effectiveness of the school systems concerned.

It is expected that traffic volumes along the primary access route to the plant will increase by 100 percent. This may result in temporary adverse impacts to residents along the route as well as to other drivers.

Socioeconomic Effects of Operation

The socioeconomic effects of the Demonstration Plant operation are very similar to those during construction. There are no severe adverse effects anticipated during plant operations. The operating force of the Demonstration Plant may be divided into professional/administrative workers and technical/support workers. The professional/administrative personnel will be recruited by Conoco Inc. from across the country and will relocate to the Noble County area. The total number of movers is estimated to be 61 persons. The technical/support group will be recruited from within a 100-mile radius of the plant site. It is estimated that 80 percent of these workers will be locals and 20 percent will be commuters who live outside the study area. No travelers are projected for the operational period.

Wages paid over the operational life of the demonstration phase are estimated at nearly $48,000,000. Of this figure, over $40,000,000 will be paid to employees within the study area and $8,000,000 will be paid to employees who live outside the study area. Total wages for employees at the coal sources are expected to reach nearly $6,000,000.

The operation of the Demonstration Plant will provide a variety of taxes to state and local governments. Property taxes from the facility will result in annual revenues of $1,800,000 between Noble County, Marion Township, and the local school district. Revenues returned to the study area through the local government fund, motor vehicle fuel tax rebates, and state income rebates will amount to an estimated $103,000 annually. Depending upon the level of secondary employment resulting from the Demonstration Plant operation, up to $103,000 in additional sales tax, fuel tax, and income tax rebates could be realized for the study area. Coal severance taxes will result in over $14,000 annually to the state.

During the operational period of the plant, population influx is projected to reach a maximum of 171 persons. This is half as large as during construction. Assuming that the assessment of no significant adverse impacts to public services and facilities during the construction period is accurate under the influx levels projected, it follows that the lower influx estimates made for the operational period will likewise pose no adverse impacts.

The level of worker traffic into and out of the Demonstration Plant in the operational period is expected to diminish somewhat from the level of the construction period. However, delivery of coal and other materials to the site via truck will require a total of 71 round trips per day. For residents along the access route, this could mean being passed by a truck once every three minutes during daylight hours. Means of mitigating these impacts should be developed including road improvements, traffic scheduling, and distribution of trips over more routes.

6.0 TASK V - MATERIALS AND LICENSES

The following assignments are to be undertaken and completed in Task V:

a. Sources of coal feedstock for Phase III of the Demonstration Plant project are to be located, and if required, contractual agreement for the coals are to be completed. Also, a long-term coal supply for a commercial venture on the Demonstration Plant site is to be negotiated.

b. Contractual agreements to supply electrical power and raw water to the Demonstration Plant are to be negotiated. Sources of other raw materials, catalysts, and chemicals are to be identified and plans laid to obtain supplies of them.

c. A contractual agreement to sell the pipeline gas from the Demonstration Plant is to be negotiated. Plans and contracts, if germane, are to be made for the sale and/or disposal of all by-products.

d. The remaining proprietary process licenses required for the Demonstration Plant are to be obtained.

e. All Federal, state, and local licenses and permits required to construct and operate the Demonstration Plant are to be identified and obtained, as required.

On January 8, 1978, DOE requested the work effort on Task V should be reduced for an unspecified period of time. This "slow-down" continued until February 13, 1979, on which date DOE authorized a full restart of Task V activities.

6.1 Sub-Task V-A: Plan for Obtaining Coal

The contract requires Conoco Inc. to select a type and supply of coal which is sufficient as a feed for the Demonstration Plant during the DOE program and for a 20-year period of commercial operation following the DOE program.

Conoco Inc. has negotiated a subcontract with Consolidated Gas Supply Company to negotiate for the long-term supply of Ohio No. 9 coal for the Demonstration Plant. The contract was submitted to DOE on October 13, 1978, for review and consent. In May 1979, DOE requested Conoco Inc. to supply additional information about the subcontract. That information is being prepared.

Initial identification of potential coal suppliers was begun with the restart of this sub-task.

6.2 Sub-Task V-B: Prepare Coal Mining Plan

All work on this sub-task has been completed. A preliminary coal mining plan was issued in April 1978. This plan, FE-2542-7, is available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia, 22161.

6.3 Sub-Task V-C: Plans for Obtaining Water, Power, Catalysts and Chemicals

Present plans call for water to be obtained from the Muskingum Watershed Conservancy District's Senecaville Reservoir and power to be obtained from Ohio Power's 138 KV line which crosses the Demonstration Plant site. Further negotiations for these supplies are planned after the requirements are better defined by Task II design activities. Specific suppliers of catalysts and chemicals will also be sought upon completion of the Task II process design.

6.4 Sub-Task V-D: Plans for Use and Disposition of Products

Work on this sub-task will start upon completion of the Task II process design. The quantity and quality of the products will be known at that time.

6.5 Sub-Task V-E: Proprietary Process Licenses

Conoco Inc. has executed the license agreement with United Engineers and Consultants for the Phosam W process. Work on this ammonia recovery process design will begin when the necessary data are available from the Task II design work.

Work has begun on identifying the licensors for the Stretford and CO_2 removal processes in the Demonstration Plant.

6.6 Sub-Task V-F: Local Permits, Licenses, Codes and Ordinances

All licenses and permits required for the Demonstration Plant are to be identified and obtained under this sub-task. On June 28, 1979, an "Appication for Permit to Install" for the Coal Gasification Demonstration Plant in Noble County, Ohio, was filed with the Ohio Environmental Protection Agency. Information regarding the air discharges was included in the application with data on waste water and solid waste disposal to be submitted later.

The name and quantity of materials that will be used and produced by the Demonstration Plant are shown on the next two pages:

Material Used	Principal Use	Quantity
Methanol	Rectisol	50 lbs/hr
Caustic (50%)	Water Treatment	225 lbs/hr
Triethylene Glycol	Gas Drying	0.08 gal/hr
Isopropyl Ether	Phenol Extraction	1.0 lb/hr
Propylene	Refrigeration	0.08 gal/hr
Fuel Oil	Steam Generation	7,710 lbs/hr
Sulfuric Acid	Water Treatment	80 lbs/hr
Dust Separation Liquid	Coal Handling	0.04 gal/hr
Silica Gel Dessicant	Plant Air	-
Alum (50%)	Raw Water Treatment	10 lbs/hr
Polymer	Raw Water Treatment	1.5 lbs/hr
Lime	Raw Water Treatment	66 lbs/hr
Chlorine	Raw Water Treatment	0.3 lb/hr
Tri-Sodium Phosphate	Raw Water Treatment	1.7 lbs/hr
Morpholine (50%)	Raw Water Treatment	1.5 lbs/hr
Hydrazine (35%)	Raw Water Treatment	0.04 lb/hr
Soda Ash	Raw Water Treatment	228 lbs/hr
Chlorine	Cooling Water	0.6 lb/hr
Dispersant	Cooling Water	3.5 lbs/hr
Chromate Inhibitor	Cooling Water	2.1 lbs/hr
Zinc Inhibitor	Cooling Water	0.6 lb/hr
Phosphoric Acid (54%)	Waste Water Treatment	5.2 lbs/hr
Fixation Chemical	Waste Water Treatment	13.5 lbs/hr
Activited Carbon	Waste Water Treatment	0.8 lb/hr
Coal	Gasification	116,300 lbs/hr
Blast Furnace Slag	Gasification	23,500 lbs/hr
Limestone	Gasification	10,500 lbs/hr
Petroleum Coke	Gasification	20 lbs/hr*
Metallurgical Coke	Gasification	20 lbs/hr*
Shift Catalyst	Shift Conversion	7 lbs/hr
Methanation Catalyst	Methanation	6.5 lbs/hr
Sulfur Catalyst	Sulfur Recovery	0.1 lb/hr
Anthradiquinone Amine	Sulfur Recovery	3.3 lbs/hr
Vanadium	Sulfur Recovery	5.0 lbs/hr
Water	Cooling Water	500,000 lbs/hr
Sodium Carbonate	Sulfur Recovery	191 lbs/hr
Air	Air Separation	355,100 lbs/hr

*For gasifier start-up.

Material Produced	Principal Use	Quantity
Pipeline Gas	Pipeline Gas	30,000 lbs/hr
Naphtha	By-Product	1,800 lbs/hr
Oil	By-Product or Gasifier Feed	2,700 lbs/hr
Phenols	By-Product to Sales	370 lbs/hr
Ammonia (Anhydrous)	By-Product to Sales	710 lbs/hr
Sulfur	By-Product to Sales	4,850 lbs/hr
Coal Fines	By-Product to Sales	11,630 lbs/hr
Slag	To Landfill	47,100 lbs/hr
Nitrogen	By-Product Plant Use & Vent	168,699 lbs/hr
Hot Potassium Carbonate Vent Gas	Vent to Atmosphere	127,945 lbs/hr
Lock Hopper Vent Gas	Vent to Atmosphere	8,128 lbs/hr
Sulfur Plant Incinerator Vent	Vent to Atmosphere	20,019 lbs/hr
Sulfur Plant Oxidizer Vent	Vent to Atmosphere	63,358 lbs/hr
Boiler Vent	Vent to Atmosphere	138,791 lbs/hr(max)
Slag Tap Burner Vent	Vent to Atmosphere	285 lbs/hr
Water Vapor Vent	Vent to Atmosphere	37 lbs/hr
Water	Waste Water Treatment	452,300 lbs/hr

The anticipated air quality and method of disposal for each of the air emissions from the plant are given below.

Exhaust (#1)
Nitrogen Vent from Oxygen Plant

Component	Lbs/hr
O_2	4,000
N_2	163,316
Sub-Total	167,316
H_2O	1,383
Total	168,699
Temperature, ^oF	94
Pressure, psig	0.5

Exhaust (#2)
Boiler Stack Gas

Boiler stack gas is released to the atmosphere through a 150 ft. stack. No special control equipment is required.

	Design Rate	Normal Operating Rate
Steam Rate Lbs/hr 600 psig, 750^oF	110,000	16,000
Firing Rate MMBTU/hr	150	22
Fuel Oil gal/hr	1,070	160
Air Rate MMSCFH	1.737	0.255
NO_x lb/MMBTU	0.25	0.25

FLUE GAS ANALYSIS

Component	Lbs/Hr	Lbs/Hr
CO_2	22,497.4	3,592.1
O_2	5,094.4	747.0
N_2	101,271.0	14,850.0
SO_2	77.1	11.3
NO_x	37.8	5.5
CO	4.0	0.6
Hydrocarbons	3.0	0.4
Sub-Total	128,984.7	19,206.9
H_2O	9,805.2	1,437.8
Particulates	1.5	0.2
Total	138,791.4	20,644.9

Temperature, ^oF	500
Stack height, ft	150
Stack diameter, ft	6
Gas Velocity, ft/sec	30
Gas Volume, ACFM	50,000

Exhaust (#3)
Lock Hopper CO_2 Vent Gas

Lock hopper CO_2 vent material will pass through a filter to remove particulates prior to venting to the atmosphere. The discharge point will be located to protect personnel from the CO_2 released.

Component	Vent Gas Lbs/Hr
CO_2	8,092
CO	5
H_2	2
CH_4	1
Sub-Total	8,100
H_2O	28
Total	8,128
Particulates Lbs/hr	1
Temperature, °F	34
Pressure, psig	10

Exhaust (#4)
Slag Tap Vent Gas

Slag tap vent gas will be released directly to the atmosphere and at a point for personnel protection from CO_2 concentrations.

Component	Lbs/Hr
CO_2	238.0
N_2	0.3
O_2	19.0
Sub-Total	257.3
H_2O	28.0
Total	285.3
Temperature, °F	250
Pressure, psig	5

Exhaust(#5)

Sulfur Plant Oxidizer Vent Gas

Sulfur plant oxidizer vent gas will be released directly to the atmosphere from the top of the vessel.

Component	Lbs/Hr
N_2	48,688
O_2	12,380
H_2	2,290
NH_3	0.01
HCN	0.01
H_2S	0.01
Total	63,358.03
Temperature, ^oF	100
Pressure, psia	14.21

Exhaust(#6)

Sulfur Plant Incinerator Stack Gas

Sulfur plant incinerator stack gas will be released through a 150-ft. stack to the atmosphere.

Component	Lbs/Hr
CO_2	9,391
H_2O	1,794
N_2	8,579
SO_2	18
O_2	237
Total	20,019
Stack Diameter, ft.	2.61
Temperature, ^oF	800
Pressure, psig	0.5
Gas Velocity, ft/sec.	30
Gas Volume, ACFM*	9,279

*ACFM = Actual cubic feet per minute

Exhaust(#7)
Hot Potassium Carbonate Process Vent

Hot potassium carbonate process vent gas will be vented to the atmosphere through a 150-ft. stack.

Component	Lbs/Hr
CO_2	116,430
CO	71
H_2	25
CH_4	19
Sub-Total	116,545
H_2O	11,400
Total	127,945
Stack Diameter, ft.	4.1
Temperature, °F	150
Pressure, psig	0.5
Gas Velocity, ft/sec.	30
Gas Volume, ACFM*	23,603

*ACFM = Actual cubic feet per minute

Exhaust(#8)
Compression and Drying Vent

Compression and drying vent gases will vent directly to the atmosphere.

Component	Lbs/Hr
H_2O	137
Triethylene Glycol (TEG)	0.3
Temperature, °F	220
Pressure, psig	0

Fugitive Hydrocarbon Emissions

The total fugitive hydrocarbon emissions from valves, flanges, pumps, compressors and relief valves is given below:

Hydrocarbons 47 tons/yr.

Fugitive Particulate Emissions

The fugitive particulate emissions from coal storage and coal handling is given below:

Particulates 36 tons/yr.

Total Hydrocarbon Emissions

Fugitive hydrocarbons, tons/yr.	47
Hydrocarbons from boiler stack, tons/yr	2
Total Hydrocarbon Emissions, tons/yr.	49

Total Particulate Emissions

Fugitive hydrocarbons, tons/yr.	36
Particulates from boiler stack, tons/yr.	1
Particulates from lock hopper vent gas	1
Total Particulates, tons/yr.	38

In order to show the Demonstration Plant's proposed source compliance with laws, rules and regulations of the Ohio EPA and U.S. EPA, the following analysis by Energy Impact Associates had these key points:

a. Emissions of hydrocarbons and particulate matter are less than 50 ton/year after controls. Thus, the plant will not be a major source of these pollutants. Therefore, no air quality analysis is required and the plant can be permitted by the Ohio EPA without the imposition of the requirements applicable to major new sources locating in non-attainment areas.

b. Air quality modeling for the other pollutants (SO_2, CO and NO_2) indicates that the impact of the plant will be quite small and that the present attainment status of the area for these pollutants will not be threatened. Neither will the Class II PSD increment for SO_2 be threatened.

The plant storage tanks will be: pressure vessels with only an emergency pressure relief vent; or cone roof tanks, nitrogen blanketed and provided with a vapor venting control system.

The following storage tanks were identified in the application:

Fuel Oil Storage (2) - 180,000 gal.
Naphtha Storage (2) - 50,000 gal.
Phenol Storage (2) - 10,000 gal.
Ammonia Storage (2) - 31,000 gal.
Sulfur Storage - 150,000 gal.
Sulfur Skim Tank - NK
Gas Liquor Separator Oil (2) - 61,000 gal.
Slop Oil Storage - 31,500 gal.
Injection Gas-Liquor Buffer - NK
Tar-Oil Tanks - NK
Tar Tank - NK

Tar-Oil Slop Tanks - NK
Final Gas-Liquor Surge Tank - NK
LOX - NK
Liquid Nitrogen - NK
Methanol - 8,000 gal.
Caustic - 3,100 gal.
Propylene (2) - 10,000 gal.
Isopropyl Ether - 4,000 gal.
Organic Waste - 3,000 gal.
Gas Liquor Buffer Tank - NK
Stretford Surge - NK
Raw Water - NK
Filtered Water - NK
Condensate - NK
Demineralized Water - NK
Potassium Carbonate Solution - NK
Phosam W Solution - NK
Sluice Water Surge - NK
Slag Dewatering Bin - NK
Slag Sump - NK
Mud Liquor - NK
Filter Flushing - NK
Neutralization - NK

NK = capacity has not been determined to date.

7.0 TASK VI - DEMONSTRATION PLANT ENGINEERING AND DESIGN

The purpose of Task VI is to complete the engineering and design of the Demonstration Plant. Final project engineering including mechanical design of equipment, equipment specifications, instrument specifications, electrical one-line drawings, building plans and specifications, site preparation and specifications, final plot plans, line lists and inquiry bid packages will be completed in this task. As stipulated by DOE, no Task VI design work was undertaken during the period September 1977 through February 1979.

In March 1979, work was restarted on Task VI. Lurgi in co-operation with British Gas Corporation have begun design of the proprietary elements of the gasifier unit. Design work is proceeding on the following items -- gasifier vessel, coal bunker, coal lock feeding chute, coal lock hopper, scraper, wash cooler, mixing pipe, spool piece, slag quench vessel and slag lock hopper. Design work has also begun by Lurgi on the Tar Separator vessel in the Gas Liquor Separation unit.

Foster Wheeler's engineering standards are being reviewed by Conoco Inc. and revised as required to form the basis for the Task VI design.

The Contract specifies that a network analysis study shall be prepared under Task XI as a management report, but under contract modification A013, the network analysis was redefined as part of Task VI. The network analysis study was started on May 19, 1978, and the documentation report was submitted to DOE on September 29, 1978.

DOE reviewed the report and met with Conoco Inc. on November 1 to discuss the DOE comments. Subsequently, the Network Analysis Report was approved.

The Network Analysis Report is based upon the Demonstration Plant design which is described in the Contract. Conoco Inc. with assistance from its subcontractors, Foster Wheeler and Lurgi, has revised the Critical Path Method (CPM) elements for a one-third sized Demonstration Plant.

Foster Wheeler has revised its internal project control system to incorporate the network schedule. Resource allocations (i.e., man-hours) were applied to the network activities for Task II and Task VI. Foster Wheeler activities for these tasks are identical in duration and manpower requirements for the full-sized and one-third sized Demonstration Plants.

8.0 Task VII - CONSTRUCTION PLANNING

The following plans and management procedures for constructing the Demonstration Plant are to be prepared under this task:

a. Construction Configuration Management Plan
b. Field Organization and Staffing Plan
c. Construction Safety Procedures
d. Construction Environmental Control Plan
e. Equipment & Material Procurement Plan
f. Master Project Schedule
g. Final Engineering Schedule
h. Procurement Schedule
i. Construction Schedule
j. Construction Reporting Procedures
k. Construction Labor Surveys

Task VII is scheduled to commence in FY-1980.

9.0 TASK VIII - ECONOMIC REASSESSMENT

The completion of Tasks I, II, III, IV, V, and VI will provide more accurate investment and operating costs for the Commercial Plant and the Demonstration Plant. The data from these tasks will be used to reassess the economics of the proposed coal gasification process for both the Commercial and Demonstration Plants. Work on Task VIII is scheduled to commence in FY-1981.

10.0 TASK IX - TECHNICAL SUPPORT

The purpose of Task IX is to provide the requisite technical support for designing the Demonstration Plant. The Contractor is required in Task IX:

a. To identify data gaps, technological problems, high-risk areas, and other short-comings critical to the success of the Demonstration Plant;

b. To propose solutions to the problems, high-risk areas, and short-comings;

c. To prepare plans and to estimate costs for proving the solutions or filling data gaps; and

d. To implement the plans after receiving DOE approval.

10.1 Sub-Task IX-A: Design Data for Demonstration Plant Coals

The only data gap which existed on the date of execution of the Prime Contract was the lack of yields, product compositions and properties, and operating conditions for designing the Demonstration Plant for Ohio No. 9 and Pittsburgh No. 8 coal feedstocks. The design data have been obtained in a technical support program which was carried out by British Gas Corporation on a large British Gas/Lurgi slagging gasifier pilot plant located in Westfield Development Centre, Cardenden, Scotland.

The work under Sub-task IX-A was performed under two subcontracts with British Gas Corporation. The original Westfield Agreement was signed at the time the Prime Contract was executed and expired on March 31, 1978. A second subcontract was negotiated to add 4½ months to the program, beginning on April 1, 1978, and expiring on August 15, 1978. The second subcontract is known as the Westfield II Agreement.

The run data prepared under the original Westfield Agreement were summarized in the previous Annual Technical Progress Report (FE-2542-12).

The results from the Westfield II Agreement are summarized herein.

Westfield II, TSP Run 12

TSP Run 12 followed a successful run on Pittsburgh No. 8 coal layered (1:1) with blast furnace metallurgical coke. The main objective of Run 12 was to compare gasifier performance on Ohio No. 9 coal with that of Pittsburgh No. 8 coal under the same conditions. Gasifier systems were the same as those for TSP Run 11 except that a new hearth had been installed.

Start-up began on petroleum coke on May 29, 1978. After four hours of steady operation on blast furnace coke, fluxed with blast furnace slag, the gasification rates were adjusted to 130,000 SCFH oxygen and 1.25 steam/oxygen ratio. Gasifier pressure was 350 psig. The first lock of Ohio No. 9 coal was charged to the gasifier at 2006 Hr. Alternate locks of Ohio No. 9 coal and metallurgical coke were fed to the gasifier. The transition from coke to layered operation was somewhat unsettled with erratic bed behavior. The gasifier settled to more stable operation within two hours, but cyclic behavior was still evident with respect to offtake temperature, bed DP's, offgas composition, and slag tapping. Cyclic behavior resulted from the alternating feedstocks. Running continued steadily for the next 24 hours with only a minor incident on May 30 when the bottom cone of the coal lock did not seat properly during depressurization.

Early on May 31, there was concern that the cyclic hearth conditions may have created some wear at the hearth bottom. The situation continued to deteriorate and posed the risk of damage to hearth internals. In order to preserve the bed for post-run inspection and to provide a direct comparison with the post-Run 11 bed, the gasifier was shut down in controlled fashion at 0150 Hr. on June 1.

Inspection of the bed following shutdown revealed alternating layers of coke and Ohio No. 9 coal. The Ohio No. 9 coal layer consisted of a caked mass of coal in the center of the bed surrounded by an 18-inch annulus of loose char.

Some damage to the hearth bottom was sustained and several of the tuyeres had worn slightly, but there was still considerable tolerance for further wear. The quench chamber was in good condition with no significant amount of slag fouling.

1. Raw Data

a. Ohio No. 9 Coal and Randolph Coke

Proximate Analysis (Air Dried), Wt. %	Coke May 29-30 2015-1915	Coke May 30-31 2015-1915	Coke May 31-Jun 1 2015-0110	Coal May 29-30 2015-1915	Coal May 30-31 2015-191	Coal May 31-Jun 2015-0110
Moisture	1.14	0.98	1.37	2.30	2.45	1.93
Ash	10.22	10.30	10.40	11.22	19.67	17.03
Volatile Matter	1.44	3.08	2.53	35.26	32.55	35.33
Fixed Carbon	87.20	85.64	85.70	51.22	45.33	45.71
Ultimate Analysis (Air Dried), Wt. %						
Carbon	87.60	88.50	87.90	70.90	62.80	67.00
Hydrogen	0.70	1.10	1.00	5.00	4.10	4.70
Nitrogen	1.00	1.00	1.00	0.80	0.80	0.70
Sulfur	1.19	1.33	1.35	3.73	4.02	4.46
Chlorine	0.09	0.09	0.11	0.19	0.18	0.24
Ash	10.22	10.30	10.40	11.22	19.67	17.03
Water	1.14	0.98	1.37	2.30	2.45	1.93
Swelling Index	-	-	-	4.50	5.00	4.50
Gray King Coke	-	-	-	G3	G3	G3

a. Ohio No. 9 Coal and Randolph Coke (continued)

Size Analysis, Wt. % - Coke	May 29 1330	May 30 0100	May 30 1330	May 31 0130	May 31 1330	June 1 0030
over 1-1/4"	29.5	26.0	27.5	26.0	26.0	32.5
1-1/4"-1"	22.0	26.0	34.0	22.0	21.5	20.5
1"-3/4"	27.5	25.5	25.5	30.0	25.5	25.5
3/4"-1/2"	10.0	8.5	7.0	13.0	15.0	12.5
1/2"-3/8"	3.0	4.0	2.0	5.0	6.0	1.0
3/8"-1/4"	2.5	2.0	1.0	1.5	2.0	2.0
1/4"-1/8"	1.5	4.0	2.0	2.0	3.0	5.0
under 1/8"	4.0	4.0	2.0	2.0	3.0	5.0
Coke Bulk Density, Lbs/CF	35.0	34.0	34.0	34.0	35.0	35.0
Coke Moisture Content, Wt. %	6.0	7.0	6.0	9.0	9.0	9.5
Size Analysis, Wt. % - Coal						
over 1-1/4"		2.0	2.0	2.5	3.0	3.0
1-1/4"-1"		11.0	17.5	14.5	6.0	14.5
1"-3/4"		30.5	42.0	31.0	31.0	31.5
3/4"-1/2"		35.0	21.5	30.5	25.0	25.0
1/2"-3/8"		13.5	9.0	12.5	15.0	10.0
3/8"-1/4"		4.5	3.0	4.0	7.0	8.0
1/4"-1/8"		1.0	1.0	1.0	5.0	3.5
under 1/8"		2.5	4.0	4.0	8.0	4.5
Coal Bulk Density, Lbs/CF		49.0	48.0	49.0	48.5	49.0
Coal Moisture Content, Wt. %		3.0	3.0	3.5	4.0	3.5

a. Ohio No. 9 Coal and Randolph Coke (continued)

Ash Composition

Component, Wt. %	Randolph Coke Overall Run	Ohio No. 9 Coal Overall Run
SiO_2	41.6	43.5
Al_2O_3	19.6	23.8
CaO	3.1	5.6
MgO	1.2	2.1
Fe_2O_3	24.2	15.0
	89.7	90.0
Silica Number	64.0	69.0

b. Flux-Blast Furnace Slag

Date	Time	Bulk Density, Lbs/CF	Moisture, Wt. %
May 29	1330	74.0	1.0
May 30	0100	75.0	0.5
May 30	1330	74.0	1.0
May 31	0130	75.0	1.5
May 31	1330	75.0	3.5
Jun 1	0030	75.0	1.0

Component, Wt. %	Overall Run
SiO_2	34.7
Al_2O_3	12.2
CaO	40.8
MgO	10.6
Fe_2O_3	0.9
	99.2
Sulfide	0.2
Total Sulfur	1.04
Silica Number	40
Loss on Ignition, Wt. %	-0.9*

* + is a gain

c. Slag

Date:	May 29-30	May 30	May 30-31	May 31	May 31-Jun 1
Time:	2015-0815	0900-2100	2115-0815	0815-2115	2115-0115
Component, Wt. %					
SiO_2	39.20	38.70	39.70	39.70	36.20
Al_2O_3	17.20	16.20	17.20	17.00	16.70
CaO	25.70	24.70	25.90	26.10	26.00
MgO	6.70	6.60	6.80	7.20	7.00
Fe_2O_3	8.60	9.20	8.00	7.70	8.70
Carbon	0.90	0.97	1.32	1.11	0.93
	98.30	96.37	98.92	98.81	95.53
Free Iron as Fe	0.60	1.00	0.90	0.60	0.50
FeO	6.90	7.10	6.20	6.10	7.20
Total Iron as Fe	6.00	6.40	5.60	5.40	6.10
Fe^{+2}	5.40	5.50	4.80	4.70	5.60
Fe^{+3}	Nil	Nil	Nil	0.10	Nil
Sulfide	0.83	0.97	0.86	0.83	0.91
Total Sulfur	0.66	1.39	1.09	0.96	1.40
Silica No.	50	50	50	50	48
Loss on Ignition,%*	+1.6	+2.3	+2.3	+1.7	+1.9

d. Oxygen Purity, Vol. %

Date	Time	Oxygen	Nitrogen	Argon
May 29	1010	92.1	4.6	2.3
	1800	95.3	4.4	0.3
May 30	0230	96.2	ND**	ND
	0700	94.0	ND	ND
	2100	96.1	ND	ND
	2400	95.1	4.0	0.9
May 31	0410	95.7	3.7	0.7
	1110	95.6	3.4	1.0
	1915	95.3	3.8	0.9
	2240	96.1	3.5	0.3
June 1	0400	98.4	1.6	Nil
	0540	98.0	2.0	Nil

* + is a gain

** ND = not determined

e. Recycle Tar

Ultimate Analysis (Dry), Wt. %	Dust Free Tar	Tar Solids
Carbon	88.80	77.00
Hydrogen	7.50	1.10
Nitrogen	0.40	0.70
Sulfur	1.19	2.12
Chlorine	0.02	0.04
Ash	Nil	17.41
Water	Nil	0.84
Heating Value, Btu/lb	16,233	11,855

Moisture Content

Date	Time	Wt. %
May 29	2145	4.0
May 30	1830	1.5
	2230	2.5
May 31	1730	1.2
	2215	1.0

Dust Content

Date	Time	Wt. %
May 29	2145	16.0
May 30	2230	12.0
May 31	2215	20.0

f. Crude Synthesis Gas (Main Stream Samples)

Analysis (Dry basis), Vol. %

Date:	May 29					May 30								
Time:	1130	1530	1800	2145	2230	0345	0530	1030	1330	1333	1336	1339	1342	1345
CH_4	0.19	0.60	0.44	2.24	1.50	6.13	6.32	2.33	6.47	4.46	3.48	2.86	2.13	2.38
CO_2	3.15	3.56	3.85	3.84	2.58	3.37	3.82	3.07	3.47	2.49	3.02	2.93	3.67	3.33
C_2H_4	Nil	Nil	Nil	Nil	Nil	0.11	0.14	Nil	Nil	Nil	Nil	Nil	Nil	Nil
C_2H_6	Nil	Nil	Nil	0.15	Nil	0.36	0.35	Nil	0.25	0.14	0.12	0.09	Nil	0.11
H_2S	0.18	0.18	0.22	0.79	0.55	1.09	1.77	0.81	1.01	0.80	0.97	Nil	0.42	0.47
H_2	27.01	27.10	27.03	27.69	27.46	26.48	26.61	28.66	27.32	27.68	28.10	27.68	27.25	26.26
Ar	0.86	0.83	0.82	0.80	0.75	0.78	0.94	0.85	0.70	0.69	0.73	0.74	0.78	0.70
N_2	4.64	4.10	3.89	3.23	3.97	3.49	2.93	4.11	2.45	2.56	2.79	3.94	3.52	4.18
CO	61.84	63.04	61.28	59.79	58.73	57.00	56.39	57.92	56.67	59.84	59.28	60.51	59.39	60.64
	97.87	99.41	97.53	98.53	95.54	98.81	99.27	97.75	98.34	98.66	98.49	98.75	97.16	98.07

f. Crude Synthesis Gas (Main Stream Samples) (continued)

Analysis (Dry basis), Vol. %

Date:	May 30					May 31							June 1
Time:	1348	1351	1354	1357	2240	0135	0330	0630	0930	1320	1930	2230	0030
CH_4	3.25	5.42	5.89	6.54	5.42	5.41	3.09	6.86	5.44	6.29	3.91	4.19	5.01
CO_2	3.16	2.98	2.88	3.19	3.48	3.63	3.58	3.18	3.32	4.09	3.27	2.94	4.35
C_2H_4	Nil	Nil	Nil	Nil	Nil	0.06	Nil	0.07	0.11	0.09	0.09	0.29	0.13
C_2H_6	0.22	0.24	0.24	0.26	0.23	0.31	Nil	0.42	0.45	0.44	Nil	0.06	0.41
H_2S	0.79	0.91	0.55	1.03	0.96	1.07	0.83	0.83	1.23	1.34	1.14	0.83	0.79
H_2	26.69	26.54	26.83	27.11	26.62	27.53	28.68	26.36	25.40	25.78	26.13	27.59	26.83
Ar	0.80	0.81	0.78	0.73	0.67	0.66	0.69	0.61	0.62	0.67	0.83	0.69	0.71
N_2	4.24	3.84	3.61	3.67	2.61	2.16	3.58	3.63	3.46	2.88	3.24	3.37	2.47
CO	59.57	58.66	58.69	57.19	56.96	56.29	55.60	56.77	58.63	57.19	58.95	59.21	57.17
	98.72	99.40	99.47	99.72	96.95	97.12	96.05	98.73	98.66	98.77	97.56	99.17	97.87

f. Crude Synthesis Gas (continued)

Minor Constituents, g/m^3		NH_3	HCN	Naphthalene	Condensate
Date	Time				
May 29-30	2230-1130	0.077	0.022	0.006	4.11
May 30	1045-1430	0.072	0.052	0.041	5.21
May 30-31	2245-0145	0.018	0.004	0.008	4.80
May 31	1100-1345	0.041	0.023	0.003	5.48
May 31-June 1	2230-0130	0.016	0.012	0.018	7.53

Sulfur Content, PPM		COS	CS_2	Thiophenes
Date	Time			
May 29	2315	782	12.4	56.8
May 30	0630	753	8.7	3.0
	1325	847	14.2	4.7
	1336	746	11.1	4.8
	1350	830	10.7	3.8
	1405	836	14.5	5.1
	2355	805	12.6	4.6
May 31	0630	914	9.9	6.6
	1325	842	12.8	7.5
	2240	847	12.1	3.8

g. Flash Gas

Analysis, Vol. %

Date:	May 30	May 30	May 30
Time:	0515	0225	1400
Separator:	Oil	Oil	Tar
CH_4	4.40	6.80	2.90
CO_2	5.29	5.99	13.70
C_2H_4	Nil	Nil	0.14
C_2H_6	0.21	0.22	0.26
H_2S	2.77	3.04	5.30
H_2	25.44	24.79	21.21
O_2	Nil	Nil	2.19
Ar	1.05	1.08	1.0
N_2	4.04	4.09	12.60
CO	54.22	55.85	31.23
	97.42	101.86	90.53

h. Gas Liquor

Oil Water Analysis, mg/l*

Date:	May 31	June 1
Time:	1930	0900
Tar/Oil Content	1,760	1,900
Total Dissolved Solids	3,672	3,400
Total Sulfur	3,542	3,789
Total Ammonia	21,369	21,080
Free Ammonia	20,893	19,975
Fixed Ammonia	476	1,105
Carbonate as CO_2	40,480	42,680
Chloride	1,773	2,128
pH	8.62	8.54
Specific Gravity	1.032	1.03

Tar Water Analysis, mg/l*

Date:	May 31	June 1
Time:	1930	0900
Tar/Oil Content	4,666	3,500
Total Dissolved Solids	9,330	8,168
Total Sulfur	330	467
Total Ammonia	2,244	2,516
Free Ammonia	1,020	714
Fixed Ammonia	1,224	1,802
Carbonate as CO_2	2,836	3,191
pH	8.78	8.76
Specific Gravity	1.002	1.002

Slag Quench Water Analysis, mg/l

Date:	May 30	May 31	June 1
Time:	0445	0230	0115
Total Dissolved Solids	275	260	240
Total Sulfur	43	49	47
Chloride	16	15	14
pH	6.04	5.46	5.42

*Sampled at plant separators.

2. Heat and Material Balance - Layered 1:1 Ohio 9 Coal and Randolph Coke with Blast Furnace Slag Flux

Material Balance, Pounds (Basis: 1,000 pounds dry fuel and flux)

Input	Rate	Carbon	Hydrogen	Nitrogen	Sulfur	Oxygen	Chlorine	Ash	Heat Balance Therms/Hr.
Coal/Flux	1060	602	31	7	25	84	1	310	2276
Steam	314	-	35	-	-	279	-	-	99
Fuel Gas	4	3	1	-	-	-	-	-	22
Recycle Tar	0	-	-	-	-	-	-	-	0
Oxygen/Air	558	-	-	82	-	476	-	-	3
	1936	605	67	89	25	839	1	310	2400
Output									
Heat Loss	-	-	-	-	-	-	-	-	56
Methane	48	36	12	-	-	-	-	-	269
Carbon Monoxide	1171	502	-	-	-	669	-	-	1230
Hydrogen	37	-	37	-	-	-	-	-	545
Carbon Dioxide	100	27	-	-	-	73	-	-	4
Inert Gas	83	-	-	83	-	-	-	-	4
Ethylene	1	1	-	-	-	-	-	-	6
Ethane	5	4	1	-	-	-	-	-	28
Ammonia	1	-	-	1	-	-	-	-	-
Hydrogen Sulfide	13	-	1	-	12	-	-	-	22
Carbonyl Sulfide	3	1	-	-	2	-	-	-	-
Tar	27	24	2	-	1	-	-	-	109
Naphtha	3	3	-	-	-	-	-	-	16
Liquor	147	1	16	-	-	129	1	-	46
Slag	312	3	-	-	-	-	-	309	64
	1951	602	69	84	15	871	1	309	2399
Input-Output Error, %	0.8	-0.5	3.0	-5.6	-40.0	3.8	0	-0.3	0.0

3. Data Used in Balances - Layered 1:1 Coal: Coke

Coal Heating Value, Btu/lb	9,263*

Coal Proximate Analysis	Wt. %*
Moisture	5.65
Ash	29.12
Volatile Matter	16.41
Fixed Carbon	48.82
	100.00

DAF Coal Ultimate Analysis	Wt. %*
Carbon	87.14
Hydrogen	3.56
Nitrogen	1.06
Oxygen	4.46
Sulfur	3.60
Chlorine	0.18
	100.00

Gas Composition	Vol. %
Methane	4.29
Carbon Monoxide	60.48
Hydrogen	26.53
Carbon Dioxide	3.30
Inert Gas	4.31
Ethylene	0.06
Ethane	0.26
Hydrogen Sulfide	0.55
Ammonia	0.14
Carbonyl Sulfide	0.08
	100.00

Crude Gas Offtake Temperature	430°C
Gasifier Pressure	350 psig
Heat Loss from Jacket & Hearth	11.87 therms/hour

*Includes flux

4. <u>Performance Data - Layered 1:1 Coal: Coke</u>

Steam Consumption	3.64 lb/therm gas
Steam Decomposition	85.2%
Oxygen Consumption	65.26 SCF/therm gas 16,279 SCF/ton DAF coal
Crude Gas Production*	249.5 therms/ton DAF coal
Gas Liquor Yield	1.66 lb/therm gas

Thermal Efficiencies, %	Gas Only	Gas, Tar, Oil & Naphtha
Crude Gas / Coal	87.83	92.49
Crude Gas / Coal, Steam & Oxygen	74.70	78.66

*Includes coal lock gas

Westfield II, TSP Run 13

After the reliable operation achieved on layered Pittsburgh No. 8 coal and blast furnace coke, TSP Run 13 was planned to gasify undiluted (100 percent) Pittsburgh No. 8 coal fluxed with blast furnace slag. Gasifier systems were the same as those of TSP Run 12 except that the hearth was relined.

Standard start-up procedures commenced on June 19, 1978, and satisfactory gasification was established on blast furnace metallurgical coke at 350 psig system pressure with rates adjusted to 130,000 SCFH oxygen and 1.30 steam/oxygen ratio. Pittsburgh No. 8 coal was charged to the gasifier at 2020 Hr. Bed conditions were initially unsteady, characterized by erratic bed DP's, offtake temperature, and distributor torque. After this transition period, which lasted about one hour, the gasifier settled down to steady operation.

Gasification continued in reliable fashion for 48 hours. During this time recycle tar feed to the distributor was systematically turned on and off to assess its effect on gasifier performance.

The oxygen feed rate was increased to 135,000 SCFH at 2000 Hr. on June 21. Oxygen feed rate increases continued in stepwise fashion to 170,000 SCFH. Gasification at the higher loadings was slightly less steady than at lower loadings, but satisfactory. At the highest loading, the stirrer/distributor system tripped out briefly after a high torque incident, and the load was reduced as a precautionary measure. Gasification at 160,000 SCFH oxygen continued satisfactorily for a further 12 hours. The gasifier was shut down in controlled fashion at 1135 Hr. on June 23. All objectives of the run had been achieved.

Following the run, the bed was found to contain primarily loose Pittsburgh No. 8 char below the stirrer. A few 6-inch lumps of char/lightly-caked coal were present. The hearth bricks had suffered minor wear, but the slag tap and tuyeres were in good condition. The quench chamber was in good condition with no significant slag fouling.

1. Raw Data

a. Pittsburgh No. 8 Coal

Proximate Analysis (Air Dried), Wt. %	June 19-20 2215-2115	June 20-21 2215-2115	June 21-22 2215-2115
Moisture	2.20	2.07	2.00
Ash	6.80	7.66	7.46
Volatile Matter	37.18	35.20	35.86
Fixed Carbon	53.82	55.15	54.68
Ultimate Analysis (Air Dried), Wt. %			
Carbon	75.0	75.4	74.5
Hydrogen	4.8	5.2	5.3
Nitrogen	1.4	1.5	1.5
Sulfur	1.48	1.39	2.28
Chlorine	0.09	0.08	0.10
Ash	6.8	7.66	7.46
Water	2.2	2.07	2.0
Heating Value, Btu/lb	13,634	13,440	13,533
Swelling Index	7	7	7.5
Gray King Coke	G7	G8	G8

	June 20		June 21		June 22		
Size Analysis, Wt. %	0005	1330	0005	1330	0005	1400	2215
over 1-1/4"	5.0	1.0	3.5	4.0	4.0	6.0	2.0
1-1/4"-1"	7.5	6.5	8.5	10.5	13.5	14.5	4.5
1"-3/4"	20.0	30.0	24.0	24.5	30.0	24.0	15.5
3/4"-1/2"	28.5	34.0	30.0	28.5	28.5	26.0	28.5
1/2"-3/8"	21.5	18.0	18.0	17.5	14.5	16.5	23.5
3/8"-1/4"	9.5	5.0	13.0	9.5	6.5	9.0	14.5
1/4"-1/8"	4.0	2.0	2.0	3.5	2.0	3.0	7.5
under 1/8"	4.0	3.5	1.0	2.0	1.0	1.0	4.0
Bulk Density, Lbs/CF	49.0	47.0	49.0	49.0	50.0	50.0	49.0
Moisture Content, Wt.%	4.0	4.0	3.0	2.0	2.5	3.0	3.0

a. Pittsburgh No. 8 Coal (continued)

Ash Analysis	Wt. %
SiO_2	48.4
Al_2O_3	24.8
CaO	2.2
MgO	1.0
Fe_2O_3	18.6
	95.0
Silica Number	69

b. Flux - Blast Furnace Slag

Flux Analysis, Wt. %	June 19-22 2215-2115
SiO_2	33.4
Al_2O_3	13.4
CaO	36.9
MgO	11.3
Fe_2O_3	0.7
	95.7
Silica Number	41

Date	Time	Moisture Content, Wt. %	Bulk Density, Lbs/CF
June 20	0005	1.0	67
	1330	5.0	71
June 21	0005	3.0	70
	1330	2.5	69
June 22	0005	3.0	70
	1400	4.0	66
	2215	3.0	69

c. Slag

Analysis, Wt. %	June 20-21 0930-0830	June 21-22 0930-0830	June 22-23 0930-0830
SiO_2	40.1	40.7	40.0
Al_2O_3	18.0	18.0	17.8
CaO	26.5	26.2	26.7
MgO	7.8	7.8	7.8
Fe_2O_3	5.7	5.7	5.9
Carbon	0.6	0.5	0.5
	98.7	98.9	98.7
Free Iron as Fe	0.69	0.66	1.00
FeO	3.90	3.99	3.93
Total Iron as Fe	3.99	3.99	4.13
Fe^{+2}	3.03	3.10	3.05
Fe^{+3}	0.27	0.23	0.08
Total Sulfide	0.33	0.26	0.10
Total Sulfur	0.58	0.52	0.55
Silica Number	50	51	50
Loss on Ignition, Wt.%*	+1.4	+1.6	+1.4

d. Oxygen Purity, Vol. %

Date	Time	Oxygen	Argon	Nitrogen
June 19	0805	93.75	2.58	3.67
	1500	92.15	3.00	4.80
June 20	0145	93.20	2.40	4.40
	0630	94.70	1.10	4.20
	1205	94.40	1.10	4.60
	1630	94.70	0.70	4.60
	1910	94.70	0.70	4.60
	2340	94.60	1.10	4.40
June 21	0350	94.60	0.70	4.40
	0730	94.10	0.30	5.60
	0900	94.70	1.30	4.10
	1345	94.10	0.30	5.60
	1720	94.00	0.80	5.20
	2300	95.70	0.30	4.10
June 22	0315	94.60	1.00	4.40
	0720	94.60	1.20	4.20
	1200	92.50	1.70	5.70
	1425	93.30	2.00	4.70
	1855	94.00	0.70	5.30
	2315	94.60	0.60	4.80
	0330	95.10	0.90	3.90
	0850	95.00	0.30	4.80
	1205	98.00	2.00	-

* + is a gain.

e. Recycle Tar

Ultimate Analysis (Dry, Dust Free)	Wt. %
Carbon	86.40
Hydrogen	1.60
Nitrogen	1.10
Sulfur	1.05
Chlorine	0.03
Ash	Nil
Water	Nil

Heating Value, Btu/lb 16,285

Date	Time	Moisture Content, Wt. %	Dust Content, Wt. %
June 19	2345	5.8	20.0
June 20	1745	4.1	16.0
June 21	0003	3.0	16.0
	0930	2.0	14.0
June 22	0230	2.9	15.0
	1000	2.0	22.0
June 23	0330	2.5	20.0

Dust Ultimate Analysis (Air Dried)	Wt. %
Carbon	78.30
Hydrogen	5.30
Nitrogen	1.50
Sulfur	1.32
Chlorine	0.03
Ash	13.47
Water	1.20

Heating Value, Btu/lb 12,452

f. Crude Synthesis Gas (Main Stream Samples)

Analysis (Dry Basis), Vol. %

Date:	June 19				June 20							
Time:	1200	1415	1900	2240	0030	0445	0640	0900	1310	1634	Composite	2240
CH_4	6.18	1.00	0.89	7.85	6.80	6.57	7.40	7.54	7.04	6.82	6.95	7.72
CO_2	2.19	4.13	3.76	3.11	3.19	3.08	3.50	3.55	3.64	3.71	3.30	3.89
C_2H_4	0.25	Nil	Nil	0.10	0.15	0.19	0.19	0.19	0.33	0.13	0.32	0.20
C_2H_6	0.07	Nil	Nil	0.85	0.47	0.50	0.45	0.46	0.58	0.53	1.09	0.53
H_2S	0.51	0.26	0.28	0.47	0.43	0.53	0.51	0.51	0.53	0.50	0.49	0.51
H_2	33.04	27.16	28.12	27.95	28.76	28.33	28.46	29.54	26.76	29.45	28.38	28.34
Ar	0.65	0.98	0.99	0.71	0.68	0.99	0.93	0.92	0.90	0.90	1.18	0.83
N_2	3.03	4.12	3.48	3.39	2.70	3.43	3.70	3.49	3.00	2.56	4.25	3.18
CO	47.76	59.29	61.87	52.92	53.74	54.13	53.33	52.40	54.50	53.38	53.90	52.25
	93.68	96.94	99.39	97.35	96.92	97.75	98.47	98.60	97.28	97.98	99.86	97.45

f. <u>Crude Synthesis Gas (Main Stream Samples) (continued)</u>

Analysis (Dry Basis), Vol. %

Date:	June 21							June 22				June 23	
Time:	0040	0440	0730	1030	1510	Composite	2140	0030	0540	1435	1900	0430	1730
CH_4	7.27	7.05	7.74	6.74	7.04	6.73	6.46	7.22	6.73	6.75	7.01	8.03	8.27
CO_2	3.52	3.65	3.76	4.32	3.70	3.78	3.32	3.12	3.20	3.51	3.47	4.23	4.16
C_2H_4	0.19	0.27	0.20	0.20	0.29	0.14	0.16	0.10	0.12	0.13	0.17	0.16	0.19
C_2H_6	0.46	0.77	0.47	0.49	1.25	0.46	0.46	0.51	0.54	0.46	0.44	0.49	0.59
H_2S	0.67	0.55	0.59	0.53	0.57	0.53	0.53	0.67	0.60	0.52	0.45	0.59	0.59
H_2	28.88	28.32	28.55	28.82	27.54	28.85	28.19	27.82	28.08	28.05	28.57	28.32	28.28
Ar	0.93	0.84	0.83	0.92	0.88	0.82	1.24	0.81	0.82	0.89	0.79	0.78	0.76
N_2	2.83	3.66	3.68	3.29	2.73	3.77	4.44	3.36	3.02	4.00	2.83	3.66	3.04
CO	53.79	52.47	52.52	52.67	54.48	52.76	52.99	55.81	54.51	54.16	53.39	52.61	52.14
	98.54	97.58	98.34	97.98	98.48	97.84	97.79	99.42	97.62	98.47	97.12	98.87	98.02

f. Crude Synthesis Gas (continued)

Minor Constituents, g/m^3 Date	Time	NH_3	HCN	Naphthalene	Condensate
June 20	0145-0445	0.060	0.017	0.056	7.35
	0950-1315	0.011	ND	0.025	4.27
June 21	0130-0445	0.034	0.019	0.021	8.19
	1130-1445	0.012	0.001	0.031	8.76
June 21-22	2300-0230	0.018	0.019	0.026	7.26
June 22	1325-1530	0.029	0.005	0.036	6.50
June 23	0130-0415	0.032	0.078	0.016	6.41

Sulfur Content, PPM Date	Time	COS	CS_2	Thiophenes
June 20	0030	444	3.2	2.9
	0630	446	4.6	4.5
	1855	420	2.0	2.3
June 21	0645	610	8.2	4.9
	1010	644	5.0	6.4
	1525	581	3.65	3.0
June 22	0230	610	7.0	3.7
	0600	587	6.3	2.5
	1540	558	3.4	4.0
June 23	0345	650	6.4	3.1
	0730	613	5.2	2.4

g. Flash Gas

Analysis, Vol. %	Tar Separator Gas Phase	Tar Separator Combined	Oil Separator Gas Phase
CH_4	7.87	5.98	8.91
CO_2	3.72	5.97	12.76
C_2H_4	0.34	0.26	0.31
C_2H_6	0.62	0.47	1.26
H_2S	1.26	4.39	3.83
NH_3	Trace	21.59	-
H_2	27.29	20.73	22.62
Ar	2.11	1.60	1.46
N_2	0.67	5.14	3.74
CO	44.00	33.51	44.64
	87.88	99.64	99.53

Condensate, g/l	
NH_3	7.70
H_2S	2.40
CO_2	2.90
Gaseous NH_3	1.40 (0.002 vol. %)

h. Condensate Naphtha from Crude Synthesis Gas

Ultimate Analysis	Wt. %
Carbon	90.0
Hydrogen	8.8
Nitrogen	0.3
Sulfur	0.33
Chlorine	0.01
Heating Value, Btu/lb	17,945

i. Gas Liquor Analysis, mg/l

Date:	June 22	June 22
Time:	0600	0600
Separator:	Oil	Tar
Tar/Oil Content	1,200	1,520
Total Dissolved Solids	4,696	8,071
Total Sulfur	5,123	730
Total Ammonia	33,286	3,026
Free Ammonia	32,504	1,190
Fixed Ammonia	782	1,836
Carbonate as CO_2	50,600	2,860
Chloride	2,128	1,418
pH	8.5	8.54
Specific Gravity	1.044	1.002

j. Slag Quench Water Analysis, mg/l

Date:	June 20	June 21	June 22
Time:	1530	1530	1800
Total Dissolved Solids	400	335	340
Total Sulfur	70	67	61
Chloride	10	13	8
pH	7.14	7.04	7.41

2. Heat and Material Balance - Pittsburgh No. 8 Coal & Blast Furnace Slag Flux

Material Balance, Pounds (Basis: 1,000 pounds dry Coal and flux)

Input	Rate	Carbon	Hydrogen	Nitrogen	Sulfur	Oxygen	Chlorine	Ash	Heat Balance Therms/Hr
Coal/Flux	1044	648	46	12	13	110	1	214	2811
Steam	320	-	36	-	-	284	-	-	104
Fuel Gas	4	3	1	-	-	-	-	-	22
Oxygen/Air	544	-	-	89	-	455-	-		3
	1912	651	83	101	13	849	1	214	2940
Output									
Heat Loss	-	-	-	-	-	-	-	-	62
Methane	83	62	21	-	-	-	-	-	484
Carbon Monoxide	1120	480	-	-	-	640	-	-	1220
Hydrogen	42	-	42	-	-	-	-	-	649
Carbon Dioxide	108	30	-	-	-	78	-	-	6
Inert Gas	89	-	-	89	-	-	-	-	5
Ethylene	5	4	1	-	-	-	-		25
Ethane	13	10	3	-	-	-	-	-	68
Ammonia	4	-	1	3	-	-	-	-	1
Hydrogen Sulfide	13	-	1	-	12-	-	-	-	22
Carbonyl Sulfide	1	-	-	-	1	-	-	-	-
Tar	72	62	5	1	1	3	-	-	298
Naphtha	3	3	-	-	-	-	-	-	14
Liquor	129	1	14	-	1	113	-	-	43
Slag	215	1	-	-	-	-	-	214	42
	1897	653	88	93	15	834	0	214	2939
Input-Output Error, %	-0.8	0.3	6.0	-7.9	15.4	-1.8	-100.0	0	-0.03

3. Data Used in Balances - Pittsburgh No. 8 Coal

Coal Heating Value, Btu/lb.	11,285*
Coal Proximate Analysis	Wt. %*
Moisture	4.16
Ash	20.52
Volatile Matter	30.78
Fixed Carbon	44.54
	100.00
DAF Coal Ultimate Analysis	Wt. %
Carbon	82.41
Hydrogen	5.27
Nitrogen	1.54
Oxygen	9.05
Sulfur	1.63
Chlorine	0.10
	100.00
Gas Composition	Vol. %
Methane	7.06
Carbon Monoxide	54.73
Hydrogen	28.82
Carbon Dioxide	3.35
Inert Gas	4.37
Ethylene	0.23
Ethane	0.57
Hydrogen Sulfide	0.50
Ammonia	0.33
Carbonyl Sulfide	0.04
	100.00
Crude Gas Offtake Temperature	507°C
Gasifier Pressure	350 psig
Heat Loss from Jacket & Hearth	11.7 therms/hour
Jacket Steam Production	3000 lb/hour

*Includes flux.

Byproducts

Composition Wt. %	Naphtha	Product Tar	Minor Liquor Components
Carbon	90.00	86.10	22.16
Hydrogen	8.80	7.50	-
Nitrogen	0.30	0.90	-
Sulfur	0.33	1.17	14.90
Chlorine	0.01	0.11	3.85
Oxygen	0.56	4.22	59.09
	100.00	100.00	100.00

Heating Value	Btu/lb
Naphtha	17,945
Product Tar	16,374
Minor Liquor Components	0

4. Performance Data - Pittsburgh No. 8 Coal

Steam Consumption	3.27 lb/therm gas
Steam Decomposition	88.02%
Oxygen Consumption	54.86 SCF/therm gas 13,696 SCF/ton DAF coal
Crude Gas Production*	249.7 therms/ton DAF coal
Gas Liquor Yield	1.26 lb/therm gas

Thermal Efficiencies, %	Gas Only	Gas, Tar, Oil & Naphtha
Crude Gas / Coal	83.31	94.04
Crude Gas / Coal, Steam & Oxygen	72.90	82.29

*Includes coal lock gas.

Westfield II, TSP Run 14

TSP Run 14 was a planned short run designed to gasify undiluted (100 percent) Ohio No. 9 coal fluxed with blast furnace slag. The run called for the use of Frances coal instead of blast furnace metallurgical coke as a start-up and purge feedstock. This change was made in an effort to provide smoother transition to Ohio No. 9 coal.

Standard start-up procedures began on June 27, 1978, and steady gasificaion was quickly established on Frances coal fluxed with blast furnace slag at 350 psig system pressure. After adjusting the rates to 130,000 SCFH oxygen and 1.30 steam/oxygen ratio, Ohio No. 9 coal was charged to the gasifier at 2252 Hr.

The transition from Frances coal to Ohio No. 9 coal was quite smooth. After less than two hours, however, problems developed with the feeding of Ohio No. 9 coal from the overhead bunker into the coal lock. There appeared to be a large amount of wet, claylike material in the coal which caused coal particles to lump together and stick to the walls of the bunker. As a result of the feed flow problems with Ohio No. 9, it was necessary to revert to Frances coal feed to the gasifier.

Ohio No. 9 coal charging recommenced at 0330 Hr. on June 28, but flow restrictions from the bunker reappeared after four hours of satisfactory gasification. A further seven-hour period of Frances coal gasification was required before Ohio No. 9 coal feed could be resumed at 1522 Hr.

At 1710 Hr., the fluxing rate was reduced slightly to conserve blast furnace slag stocks. After three hours, slag tapping deteriorated and tuyeres began to flash and go black. This deterioration was arrested when the flux rate was returned to its former level, and the steam/oxygen ratio was reduced to 1.25.

Gasification continued in satisfactory fashion for the remainder of the run, although tuyeres continued to flash and turn black. Slag tapping was satisfactory during the last 25 hours of continuous running, except for a second period of poor tapping due to under-fluxing. The fun was terminated with a controlled shutdown at 1632 Hr. on June 29.

Post-run inspection revealed a bed of mostly loose char below the stirrer with a few larger lumps of lightly fused char/coal. There was one large lump of caked coal, approximately four feet square, attached to the wall about half-way down the shaft of the gasifier. There was also a region of dust and a pocket of flux just above the tuyere level. Gasifier internals had suffered no damage during the run, and quench chamber fouling was minimal.

1. Raw Data

a. Ohio No. 9 Coal

Proximate Analysis (Air Dried), Wt. %		
Date:	June 28	June 28-29
Time:	0440-0800	1910-1410
Moisture	3.08	4.01
Ash	17.12	21.60
Volatile Matter	35.48	33.55
Fixed Carbon	44.32	40.84
Ultimate Analysis (Air Dried), Wt. %		
Carbon	63.30	59.30
Hydrogen	4.80	4.50
Nitrogen	0.90	0.90
Sulfur	4.29	4.17
Chlorine	0.05	0.04
Ash	17.12	21.60
Water	3.08	4.01
Swelling Index	4.50	4.50
Gray King Coke	G	G

Size Analysis, Wt. %				
Date:	June 28	June 28	June 29	June 29
Time:	0115	1730	0530	1045
over 1-1/4"	3.0	3.0	1.0	-
1-1/4"-1"	4.5	6.5	1.0	2.0
1"-3/4"	21.5	30.5	16.5	21.5
3/4"-1/2"	34.5	31.0	43.5	57.5
1/2"-3/8"	20.0	17.0	22.0	12.5
3/8"-1/4"	7.5	3.5	7.0	3.0
1/4"-1/8"	1.5	2.5	4.0	2.0
under 1/8"	7.5	6.0	5.0	2.0
Bulk Density, Lb/CF	ND	51	50	50
Moisture Content Wt. %	5.0	6.0	5.0	6.5

a. Ohio No. 9 Coal (continued)

Ash Analysis	Wt. %
SiO_2	45.4
Al_2O_3	21.1
CaO	2.2
MgO	1.2
Fe_2O_3	21.3
	91.2

Silica Number 65

b. Flux

Size Analysis, Wt. %		
Date:	June 28	June 29
Time:	1500	1045
over 1/2"	6.0	11.0
1/2"-3/8"	69.0	69.5
3/8"-1/4"	23.0	19.0
1/4"-1/8"	1.5	0.5
under 1/8"	0.5	0.5
Bulk Density, Lb/CF	69.0	70.5
Moisture Content, Wt. %	5.0	3.0

Analysis	Wt. %
SiO_2	33.4
Al_2O_3	13.4
CaO	37.5
MgO	10.6
Fe_2O_3	0.8
	95.7

Silica Number 41

Analysis, Wt. %			
Date:	June 28	June 28	June 29
Time:	0440-0800	1630-1830-	0915-1530
SiO_2	39.9	43.1	43.0
Al_2O_3	17.4	19.0	19.0
CaO	21.5	18.0	20.4
MgO	6.4	5.1	5.6
Fe_2O_3	12.2	12.2	9.7
Carbon	1.0	1.1	0.8
	98.4	98.5	98.5

c. Slag (continued)

Analysis, Wt. %

Date:	June 28	June 28	June 29
Time:	0440-0800	1630-0830	0915-1530
Free Iron as Fe	1.06	0.62	1.08
FeO	9.00	9.04	6.99
Total Iron as Fe	8.53	8.53	6.78
Fe^{+2}	7.00	7.00	5.27
Fe^{+3}	0.47	0.91	0.43
Total Sulfides	0.37	0.65	0.78
Total Sulfur	1.44	1.94	1.23
Silica Number	50	55	55
Loss on Ignition, Wt. %*	+3.0	+2.3	+2.3

d. Oxygen Purity, Vol. %

Date	Time	Oxygen	Argon	Nitrogen
June 27	2245	94.0	1.5	4.5
June 28	1405	95.1	0.6	4.2
	0700	95.1	0.9	4.0
	1120	96.1	0.9	3.0
	1500	96.3	1.2	2.5
	1905	96.2	1.3	2.4
	2230	95.1	1.5	3.4
June 29	0100	96.2	1.1	2.7
	0500	95.7	0.9	3.4
	0655	95.7	1.3	3.0
	1055	95.9	1.4	2.7
	1400	95.9	1.2	2.9

* + is a gain.

e. Crude Synthesis Gas (Main Stream Samples)

Analysis (Dry Basis), Wt. %

Date:	June 27	June 28						June 29				
Time:	2335	0400	0705	1115	1540	1915	2210	0200	0400	0700	1030	1430
CH_4	7.06	7.41	7.11	7.70	6.87	8.72	8.10	6.95	7.13	8.17	6.26	6.19
CO_2	4.05	4.01	4.94	3.34	3.98	4.98	5.17	4.87	5.73	5.07	5.70	6.29
C_2H_4	0.14	0.14	0.14	0.19	0.16	0.14	0.14	0.17	0.13	0.26	0.07	0.21
C_2H_6	0.46	0.49	0.45	0.61	0.50	0.57	0.83	0.54	0.58	0.66	0.36	0.72
H_2S	0.79	0.99	1.28	1.00	0.95	1.48	1.28	1.25	1.21	1.34	1.20	1.40
H_2	28.13	28.00	28.07	28.24	27.90	28.47	27.93	27.93	28.19	27.93	27.59	29.68
Ar	0.74	0.67	0.69	0.66	0.70	0.67	0.70	0.61	0.59	0.73	0.70	0.65
N_2	4.11	3.00	2.77	2.70	2.55	2.88	3.02	2.56	4.56	2.95	3.16	2.27
CO	53.95	53.21	52.45	54.84	56.50	51.88	52.73	54.47	51.59	52.81	51.27	48.92
	99.43	97.92	97.90	99.28	100.11	99.79	99.90	99.35	99.71	99.92	96.31	96.33

e. Crude Synthesis Gas (continued)

Minor Constituents, g/m^3

Date:	June 28	June 28
Time:	0630-0750	1945-2300
NH_3	0.136	0.095
HCN	0.024	-
Naphtalene	0.014	-
Condensate	12.6	6.57

Sulfur Content, PPM

Date:	June 28	June 28	June 29
Time:	0515	1900	0510
COS	1270	1385	1347
CS_2	10.3	10.0	10.7
Thiophenes	5.7	6.5	5.3

f. Gas Liquor from Plant Separators, mg/l

Date:	June 29	June 29
Time:	1500	1500
Separator:	Oil	Tar
Tar/Oil Content	400	4,840
Total Dissolved Solids	5,553	10,395
Total Sulfur	3,351	656
Total Ammonia	42,160	3,587
Free Ammonia	38,148	1,411
Fixed Ammonia	4,012	2,176
Carbonate as CO_2	63,800	2,200
Chloride	1,773	2,837
pH	8.38	8.69
Specific Gravity	1.052	1.002

2. Heat and Material Balance - Ohio No. 9 Coal & Blast Furnace Slag Flux

Material Balance, Pounds (Basis: 1,000 pounds dry coal and flux)

Input	Rate	Carbon	Hydrogen	Nitrogen	Sulfur	Oxygen	Chlorine	Ash	Heat Balance Therms/Hr.
Coal/Flux	1065	535	48	8	38	107	-	329	2731
Steam	262	-	29	-	-	233	-	-	100
Fuel Gas	4	3	1	-	-	-	-	-	23
Oxygen/Air	465	-	-	68	-	397	-	-	3
	1796	538	78	76	38	737	0	329	2857
Output									
Heat Loss	-	-	-	-	-	-	-	-	62
Methane	68	51	17	-	-	-	-	-	461
Carbon Monoxide	907	389	-	-	-	518	-	-	1150
Hydrogen	35	-	35	-	-	-	-	-	626
Carbon Dioxide	146	40	-	-	-	106	-	-	7
Inert Gas	68	-	-	68	-	-	-	-	3
Ethylene	3	3	-	-	-	-	-	-	19
Ethane	6	5	1	-	-	-	-	-	38
Ammonia	3	-	1	2	-	-	-	-	-
Hydrogen Sulfide	24	-	1	-	23	-	-	-	50
Carbonyl Sulfide	5	1	-	-	3	1	-	-	-
Tar	51	43	5	-	1	2-	-		242
Naphtha	9	8	1	-	-	-	-	-	48
Liquor	144	1	16	-	1	126	-	-	54
Slag	332	3	-	-	-	-	-	329	78
	1801	544	77	70	28	753	0	329	2838
Input-Output Error, %	0.3	1.1	-1.3	-7.9	-26.3	2.2	0	0	-0.7

3. Data Used in Balance - Ohio No. 9 Coal

Coal Heating Value, Btu/lb	9,139*

Coal Proximate Analysis	Wt. %*
Moisture	6.05
Ash	30.88
Volatile Matter	28.45
Fixed Carbon	34.62
	100.00

DAF Coal Ultimate Analysis	Wt. %
Carbon	79.71
Hydrogen	6.05
Nitrogen	1.21
Oxygen	7.37
Sulfur	5.61
Chlorine	0.05
	100.00

Gas Composition	Vol. %
Methane	6.888
Carbon Monoxide	52.992
Hydrogen	28.594
Carbon Dioxide	5.434
Inert Gas	3.981
Ethylene	0.184
Ethane	0.328
Hydrogen Sulfide	1.177
Ammonia	0.287
Carbonyl Sulfide	0.135
	100.00

Crude Gas Offtake Temperature	410°C
Gasifier Pressure	350 psig
Heat Loss	11.59 therms/hour
Jacket Steam Production	3000 lb/hour**

* Includes flux.
** Estimated.

Byproducts

Composition Wt. %	Naphtha	Product Tar	Minor Liquor Components
Carbon	89.19	85.20	21.56
Hydrogen	9.24	9.30	-
Nitrogen	0.40	0.40	-
Sulfur	1.16	1.89	14.58
Chlorine	0.01	0.03	6.37
Oxygen	-	3.18	57.49
	100.00	100.00	100.00

Heating Value	Btu/lb.
Naphtha	17,945
Product Tar	16,860
Minor Liquor Components	0

4. Performance Data - Ohio No. 9 Coal

Steam Consumption: 3.32 lb/therm gas

Steam Decomposition: 85.08%

Oxygen Consumption: 59.51 SCF/therm
13,998 SCF/ton DAF coal

Crude Gas Production*: 235.2 therms/ton DAF coal

Gas Liquor Yield: 1.77 lb/therm

Thermal Efficiencies, %	Gas Only	Gas, Tar, Oil & Naphtha
Crude Gas / Coal	85.21	94.84
Crude Gas / Coal, Steam & Oxygen	74.61	83.03

* Includes coal lock gas.

Westfield II TSP Run 15

TSP Run 15 was planned to verify gasifier operation on Pittsburgh No. 8 coal. In addition to the 1-1/4 by 1/4-inch sized coal, which had been gasified during TSP Runs 11 and 13, it was planned to steadily increase the concentration of fines (1/4" x 0 material) in the feedstock to the gasifier. This would establish the tolerance of the gasifier and related equipment to high fines content caking feedstocks. Recycle tar feed trials were also planned during TSP Run 15 to investigate the effect of tar feed to the top of the gasifier with a modified tar feed system. The only other modification to the system prior to the run was a partial relining of the hearth.

After a standard start-up on August 11, 1978, slagging gasification was established on Frances coal fluxed with blast furnace slag at 160,000 SCFH oxygen, 1.35 steam/oxygen ratio, and 350 psig system pressure. Although operation was stable while gasifying Frances coal, the stirrer/distributor tripped as a result of high torque on two occasions. In both cases, the stirrer/distributor was restarted quickly.

The load was reduced to 130,000 SCFH oxygen, and sized (1-1/4" x 1/4") Pittsburgh No. 8 coal was charged to the gasifier at 0956 Hr. The transition to the new feedstock was satisfactory and steady gasification continued for four hours.

Three attempts were made to increase the load to the levels established during TSP Run 13. In each case the stirrer/distributor system tripped at the higher loads as a result of torque overload. After the third incident, the rates were adjusted to 135,000 SCFH oxygen and 1.35 steam/oxygen ratio. Gasification continued steadily under these conditions for 17 hours.

Feed of recycle tar to the top of the distributor was started at 2007 Hr. on August 12. The amount of recycle tar feed was systemically varied. The trials showed that the sensitivity to tar feed observed during TSP Run 13 had been effectively eliminated.

The fines content of the Pittsburgh No. 8 coal feedstock was steadily increased beginning at 1000 Hr. on August 13. The fines content was increased from 6 to 23 percent in stepwise fashion over the next 36 hours. Gasifier operation during this period was stable with bright tuyeres and good slag tapping but was marked by frequent stirrer/distributor trips.

Gasification continued steadily on Pittsburgh No. 8 coal with an average of 23 percent fines during the final 24 hours of operation. This period was marked by only one trip of stirrer/distributor system. The gasifier was shut down in controlled fashion at 2209 Hr. on August 15.

Post-run inspection revealed a bed of predominantly loose Pittsburgh No. 8 char. Some football-size agglomerates of caked coal/char were found at the tuyere level.

The bottom-most rows of hearth bricks showed some wear. The shaft bricks and tuyeres did not wear significantly during the run. The quench chamber and slag tap systems were in good condition.

Summary

Date	Time	Coal Feed	Comment
Aug 11	0321-0956	Frances	Startup
Aug 11	0956-1400	Pgh No. 8^1	130,000 SCFH O_2
Aug 11-12	1400-0830	Pgh No. 8^1	Varying O_2 Rate
Aug 12	0830-2007	Pgh No. 8^1	135,000 SCFH O_2
Aug 12	2007-2040	Pgh No. 8^1	Started Tar Recycle
Aug 12-13	2040-0340	Pgh No. 8^1	135,000 SCFH O_2 Tar Recycle at 50%
Aug 13	0340-0800	Pgh No. 8^1	135,000 SCFH O_2 Tar Recycle at 70%
Aug 13	0800-1000	Pgh No. 8^1	No Tar Recycle
Aug 13	1000-1700	Pgh No. 8^2	135,000 SCFH O_2 No Tar Recycle
Aug 13	1700-2207	Pgh No. 8^2	135,000 SCFH O_2 Tar Recycle at 50%
Aug 13-14	2207-1000	Pgh No. 8^3	135,000 SCFH O_2 Tar Recycle at 50%
Aug 14	1000-1750	Pgh No. 8^4	135,000 SCFH O_2 Tar Recycle at 60%
Aug 14	1750-2152	Pgh No. 8^4	135,000 SCFH O_2 No Tar Recycle
Aug 14-15	2152-2209	Pgh No. 8^5	135,000 SCFH O_2 Tar Recycle at 50%

Notes:
1. Pgh No. 8 contains 6% 1/4" x 0 fines
2. Pgh No. 8 contains 10% 1/4" x 0 fines.
3. Pgh No. 8 contains 13% 1/4" x 0 fines.
4. Pgh No. 8 contains 16% 1/4" x 0 fines.
5. Pgh No. 8 contains 23% 1/4" x 0 fines.

The pertinent data from TSP Run 15 are summarized below.

1. Raw Data

a. Pittsburgh No. 8 Coal

Proximate Analysis (Air Dried), Wt. %

Date:	Aug 11-12	Aug 12-13	Aug 13	Aug 13-14	Aug 14	Aug 15
Time:	1100-1000	1100-0900	1000-2300	2300-1100	1100-2300	2300-2200
Moisture	1.42	1.37	1.56	1.55	1.09	1.11
Ash	9.26	8.18	8.80	8.35	8.05	7.69
Volatile Matter	36.80	36.96	36.34	35.94	37.24	36.72
Fixed Carbon	52.52	53.49	53.30	54.16	53.62	54.48
Swelling Index	7	7-1/2	7	7-1/2		7-1/2
Gray King Coke	G8	G8	G8	G8	G8	G7

Ultimate Analysis (Air Dried), Wt. %

Date:	Aug 11-12	Aug 12-13	Aug 13-14	Aug 14	Aug 14-15
Time:	1100-1000	1100-2300	2300-1000	1100-2300	2300-2200
Carbon	73.70	74.20	74.30	74.70	75.20
Hydrogen	5.10	5.30	5.10	5.20	5.30
Nitrogen	1.50	1.40	1.40	1.30	1.20
Sulfur	1.78	2.37	1.86	1.77	1.88
Chlorine	0.08	0.10	0.09	0.08	0.08
Ash	8.72	8.80	8.35	8.05	7.69
Water	1.40	1.56	1.55	1.09	1.11

a. Pittsburgh No. 8 Coal (continued)

Size Analysis, Wt. %

Date:	Aug 11	Aug 12	Aug 12	Aug 13	Aug 13
Time:	1300	0100	1030	0430	1130
over 1-1/4"	0.5	2	3	3	1
1-1/4"-1"	3.5	12	11.5	14	3
1"-3/4"	13	31	25.5	28	22
3/4"-1/2"	38	29	29	29.5	23.5
1/2"-3/8"	26	12	18	15	19.5
3/8"-1/4"	12	8	8	7.5	8.5
1/4"-1/8"	3.5	2	2	2	10.5
under 1/8"	3.5	4	3	1	12
Bulk Density, Lb/CF	46	45	46.5	46	49
Moisture, Wt. %	4.0	6.0	4.0	4.5	6.5

Date:	Aug 14	Aug 14	Aug 14	Aug 15	Aug 15
Time:	0100	0300	1330	0300	1300
over 1-1/4"	1	5	9	6	3
1-1/4"-1"	6	9	14	8	6
1"-3/4	19	29.5	35	28	12.5
3/4"-1/2"	24	25.5	16.5	23	19
1/2"-3/8"	20	15	9	12	
3/8"-1/4"	16	8	5.5	9	16.5
1/4"-1/8"	11	4	4	7.5	16
under 1/8"	3	4	7	6.5	11
Bulk Density, Lb/CF	ND	48.5	49	48.5	48
Moisture, Wt. %	4.5	4.5	ND	3.0	ND

a. Pittsburgh No. 8 Coal (continued)

Ash Analysis, Wt. %

Date:	Aug 11-12	Aug 12-13	Aug 13-14	Aug 14	Aug 14-15
Time:	1100-1000	1100-2300	2300-1000	1100-2300	2300-2200
SiO_2	49.97	49.09	49.55	48.32	48.05
Al_2O_3	25.02	24.38	24.67	24.21	24.28
CaO	2.04	3.30	1.58	1.88	2.38
MgO	0.99	1.34	1.16	1.00	0.76
Fe_2O_3	17.39	16.15	17.91	18.03	17.37
	95.41	94.26	94.87	93.44	92.84
Silica No.	75	74	74	74	73

b. Flux - Blast Furnace Slag

Flux Analysis	Wt. %
SiO_2	33.74
Al_2O_3	12.85
CaO	36.90
MgO	10.00
Fe_2O_3	0.78
	94.27

Loss of Ignition, Wt. % -0.60

Silica Number 42

Date	Time	Moisture Content Wt. %	Bulk Density, Lb/CF
Aug 11	1300	4.0	69
Aug 12	1100	2.5	67.5
Aug 13	ND	4.5	69
Aug 14	1130	3.5	69
Aug 15	1400	ND	71

c. Slag

Analysis, Wt. %

Date:	Aug 11-12	Aug 12-13	Aug 13-14	Aug 14	Aug 14-15
Time:	1100-1000	1100-2300	2300-1000	1100-2300	2300-2200
SiO_2	41.40	40.68	41.19	38.86	40.44
Al_2O_3	17.41	17.82	17.66	17.49	17.54
CaO	24.73	26.47	26.93	26.29	26.66
MgO	7.15	7.24	7.29	7.18	7.32
Fe_2O_3	5.34	5.39	5.42	5.36	5.29
Carbon	0.29	0.27	0.25	0.39	0.33
	96.32	97.87	98.74	95.57	97.58
Free Iron As Fe	0.28	0.32	0.30	0.28	0.27
FeO	4.06	3.91	4.36	3.87	4.25
Total Iron as Fe	3.73	3.77	3.79	3.75	3.70
Fe^{+2}	3.15	3.03	3.38	3.00	3.29
Fe^{+3}	0.30	0.42	0.11	0.47	0.14
Sulfide	0.34	0.13	0.16	0.26	0.27
Total Sulfur	0.46	0.45	0.44	0.46	0.45
Loss on Ignition, Wt. %*	+0.81	+0.98	+0.86	+0.70	+0.71
Silica No.	53	52	52	51	51

* + is a gain.

d. Oxygen Purity, Vol. %

Date	Time	Oxygen	Nitrogen	Argon
Aug 11	0430	93.2	4.1	2.7
	1030	93.4	4.2	2.4
	1830	95.3	3.4	1.3
Aug 12	0210	94.5	4.3	1.1
	1100	96.5	2.5	0.1
	1900	96.2	3.1	0.7
	2330	95.5	3.6	0.9
Aug 13	0645	95.6	3.6	0.8
	1500	95.6	4.7	0.7
	2245	95.5	3.9	0.6
Aug 14	0630	95.5	3.9	0.6
	1300	97.5	1.7	0.8
	2305	95.5	3.7	0.8
Aug 15	0640	96.4	2.9	0.6
	1300	96.5	3.0	0.5
	1600	96.5	2.7	0.8

e. Recycle Tar

Tar Dust Ultimate Analysis (Air Dried)	Composite Wt. %
Carbon	78.3
Hydrogen	5.3
Nitrogen	1.5
Sulfur	1.5
Chlorine	0.1
Ash	13.2
Water	1.1
Heating Value, Btu/lb.	12,178

e. Recycle Tar (continued)

Tar Ultimate Analysis
(Dry, Dust Free), Wt. %

Date:	Aug 12-13	Aug 13	Aug 14	Aug 14	Aug 15
Time:	0120-0530	1330-2130	0050-0530	1130-2130	0045-2130
Carbon	85.2	85.9	82.6	86.1	86.1
Hydrogen	7.0	6.8	6.5	6.6	6.8
Nitrogen	1.1	1.1	1.2	1.4	1.1
Sulfur	1.1	1.16	2.42	0.82	0.9
Chlorine	0.05	ND	0.05	ND	0.02
Ash	Nil	Nil	Nil	Nil	Nil
Water	Nil	Nil	Nil	Nil	Nil
Heating Value, Btu/lb.	16,039	16,039	15,988	15,986	16,057

Date	Time	Moisture, Wt. %	Dust, Wt. %
Aug 11	2100	ND	9.0
Aug 12	0120	4.5	5.0
	1730	2.55	33.0
	2240	ND	22.0
Aug 13	0130	2.2	6.2
	1330	ND	7.0
	2130	ND	24.2
Aug 14	0050	6.8	22.0
	0530	ND	18.2
	1530	ND	20.8
Aug 15	0045	3.0	24.0
	0930	ND	13.9
	2130	ND	19.2

f. Crude Synthesis Gas (Main Stream Samples)

Analysis (Dry Basis), Vol. %

Date	Aug 11		Aug 12					Aug 13		
Time	1320	1745	0220	1005	0940-1430	1905	2335	0330	1000	1600
CH_4	7.46	7.35	6.94	7.12	8.04	7.82	7.45	6.18	6.75	6.51
CO_2	4.38	4.06	3.76	3.50	3.71	3.87	4.60	4.10	4.15	3.51
C_2H_4	0.14	0.05	0.12	0.21	0.10	0.10	0.09	0.21	0.09	0.10
C_2H_6	0.54	0.44	0.37	0.61	0.44	0.43	0.46	Nil	0.37	0.44
H_2S	0.39	0.33	0.40	0.77	0.53	0.59	0.65	0.63	0.59	0.60
H_2	27.72	29.04	29.46	29.98	28.78	28.72	29.60	31.12	29.22	29.10
Ar	0.82	0.80	0.66	0.41	0.94	0.67	0.59	0.44	0.65	0.60
N_2	2.88	3.61	3.37	3.47	4.02	3.54	2.78	3.10	3.39	3.25
CO	54.54	53.78	53.27	52.61	53.13	53.43	51.59	50.73	52.73	55.22
	98.87	99.46	98.35	98.68	99.69	99.17	97.81	96.51	97.94	99.33

f. Crude Synthesis Gas (Main Stream Samples) (continued)

Analysis (Dry Basis), Vol. %

Date	Aug 13			Aug 14			Aug 15			
Time	1115-1600	2245	0330	0930	1300	0145-0915	0230	0645	0930	0915-1445
CH_4	7.61	6.91	6.26	7.50	7.70	6.58	7.27	6.33	6.28	7.20
CO_2	4.35	3.97	3.62	3.70	5.02	4.91	5.25	5.32	3.79	3.88
C_2H_4	0.12	0.09	0.12	0.09	0.08	0.16	0.13	0.71	0.12	0.11
C_2H_6	0.49	0.48	0.45	0.53	0.45	0.35	0.41	Nil	0.36	0.46
H_2S	0.61	0.65	0.53	0.57	0.57	0.34	0.71	0.40	0.45	0.38
H_2	28.98	29.08	28.84	29.77	30.28	29.77	31.35	29.26	29.26	27.88
Ar	1.12	0.69	0.67	0.65	0.63	0.80	0.66	0.70	0.53	1.44
N_2	3.98	3.14	3.29	3.34	3.48	3.67	3.55	2.13	2.75	4.41
CO	52.56	52.47	53.89	52.70	50.08	49.92	50.35	53.16	54.09	52.92
	99.82	97.48	97.67	98.85	98.29	96.50	99.68	98.01	97.63	98.68

f. Crude Synthesis Gas (continued)

Minor Constituents, g/m^3

Date	Time	NH_3	HCN	Naph-thalene	Conden-sate
Aug 11	1730-1930	0.118	0.010	0.0247	0.88
Aug 12	0215-0515	0.018	0.004	0.0287	10.64
	1145-1400	ND	0.010	0.0271	15.00
Aug 12-13	2130-0100	0.027	0.020	0.0180	15.28
Aug 13	1140-1500	0.019	0.003	0.0378	4.80
Aug 14	0145-0420	0.006	0.004	0.0340	9.46
	1420-1900	0.014	0.005	0.0334	5.07
Aug 14-15	2310-0225	0.002	0.005	0.0310	8.45
Aug 15	1130-1530	0.012	0.004	0.0260	9.10

Sulfur Content, PPM

Date	Time	COS	CS_2	Thiophenes
Aug 11	1430	401	3.2	Nil
Aug 12	0220	401	4.0	3.3
	1115	371	3.8	2.2
	1420	411	5.6	2.6
Aug 13	0040	473	4.1	4.0
	0630	404	4.6	2.3
	1310	445	4.4	2.8
Aug 14	0115	417	5.3	5.7
	0550	440	6.7	ND
Aug 15	0235	390	6.1	9.1
	0610	400	4.6	8.0
	1400	440	5.6	Nil

g. Condensible Naphtha from Crude Systhesis Gas

Ultimate Analysis	Wt. %
Carbon	90.6
Hydrogen	8.9
Nitrogen	0.1
Sulfur	0.22
Chlorine	0.06
Ash	Nil
Water	Nil

Heating Value, Btu/lb. 18,170

h. Side Stream Samples

Sample:	S/S1	S/S2	S/S3	S/S4	S/S5	S/S6
Date:	Aug 12	Aug 12-13	Aug 13	Aug 14	Aug 14	Aug 15
Time Period:	0940-1430	2130-0330	1115-1600	0145-0915	1315-1810	0915-1445
Gas Volume, SCF	1016.4	973.8	1008.5	1717.9	1243.7	1232.2
Tar/Oil Product/grams	723.0	778.0	622.0	1623.0	981.0	964.0
Dust/grams	18.1	31.7	19.7	27.3	6.7	16.0
Gas Liquor Product, grams	2760.0	2803.0	2985.0	5444.0	3491.0	4967.0

i. Combined Tar and Oil (Side Stream Samples)

Ultimate Analysis, Wt. %	S/S1	S/S2	S/S3	S/S4	S/S5	S/S6
Carbon	88.0	86.7	87.0	87.2	87.1	86.9
Hydrogen	7.2	7.4	7.8	7.4	7.9	7.6
Nitrogen	0.9	1.0	0.9	0.9	1.1	1.5
Sulfur	1.24	0.71	0.92	0.76	1.48	0.86
Chlorine	0.01	0.02	0.02	0.02	0.02	0.04
Ash	Nil	Nil	Nil	Nil	Nil	Nil
Water	Nil	Nil	Nil	Nil	Nil	Nil
Heating Value, Btu/lb.	16,229	16,261	16,257	15,778	16,309	16,125

h. Gas Liquor (Tar/Oil Separator Samples)

Analysis, mg/l	Oil Separator	Tar Separator
Tar/Oil Content	330	600
Total Dissolved Solids	3,352	10,192
Total Sulfur	5,141	664
Total Ammonia	11,611	3,570
Free Ammonia	10,540	2,550
Fixed Ammonia	1,071	1,020
Carbonate as CO_2	10,340	30,880
Chloride	2,970	1,418
Sulfide as S	80	48
Sulfate as SO_4	140	305
pH	9.7	9.03
Specific Gravity	1.01	1.002

i. Slag Quench Water, mg/l

Total Dissolved Solids	168
Total Sulfur	86
Chloride	18
Sulfide as S	Nil
Sulfate as SO_4	68.4
pH	6.79

2. Heat and Material Balance - Pittsburgh No. 8 Coal Screened ($1\frac{1}{4}$" x $\frac{1}{4}$")* & Blast Furnace Slag Flux

Material Balance, Pounds (Basis: 1,000 pounds dry coal and flux)

Input	Rate	Carbon	Hydrogen	Nitrogen	Sulfur	Oxygen	Chlorine	Ash	Heat Balance Therms/Hr.
Coal/Flux	1039	630	48	13	15	105	1	227	2849
Steam	324	-	36	-	-	288	-	-	112
Fuel Gas	4	3	1	-	-	-	-	-	22
Oxygen/Air	525	-	-	72	-	453		-	3
	1892	633	85	85	15	846	1	227	2986
Output									
Heat Loss	-	-	-	-	-	-	-	-	72
Methane	95	71	24	-	-	-	-	-	593
Carbon Monoxide	1101	472	-	-	-	629	-	-	1273
Hydrogen	43	-	43	-	-	-	-	-	696
Carbon Dioxide	121	33	-	-	-	88	-	-	6
Inert Gas	103	-	-	103	-	-	-	-	6
Ethylene	2	2	-	-	-	-	-	-	12
Ethane	10	8	2	-	-	-	-	-	57
Ammonia	4	-	1	3	-	-	-	-	1
Hydrogen Sulfide	14	-	1	-	13	-	-	-	25
Carbonyl Sulfide	2	-	-	-	1	1	-	-	-
Tar	43	38	3	-	1	1	-		189
Naphtha	6	5	1	-	-	-	-	-	27
Liquor	146	1	16	-	1	128	-	-	52
Slag	228	1	-	-	-	-	-	227	44
	1918	631	91	106	16	847	0	227	3053
Input-Output Error, %	1.4	-0.3	7.1	24.7	6.6	0.1	-100.0	0	2.2

*Contains 6 percent fines ($\frac{1}{4}$" x 0)

3. Data Used in Balance - Pittsburgh No. 8 Coal (6% fines)

Coal Heating Value, Btu/lb	10812*

Coal Proximate Analysis	Wt. %*
Moisture	3.77
Ash	21.86
Volatile Matter	30.39
Fixed Carbon	43.98
	100.00

DAF Coal Ultimate Analysis	Wt. %
Carbon	81.50
Hydrogen	5.64
Nitrogen	1.66
Oxygen	9.14
Sulfur	1.97
Chlorine	0.09
	100.00

Gas Composition	Vol. %
Methane	8.039
Carbon Monoxide	53.126
Hydrogen	28.777
Carbon Dioxide	3.710
Inert Gas	4.960
Ethylene	0.100
Ethane	0.440
Hydrogen Sulfide	0.530
Ammonia	0.279
Carbonyl Sulfide	0.039
	100.000

Crude Gas Offtake Temperature	498°C
Gasifier Pressure	350 psig
Heat Loss	13.1 therm/hour

*Includes flux

Byproducts

Composition Wt. %	Naphtha	Product Tar	Minor Liquor Components
Carbon	90.60	88.00	15.71
Hydrogen	8.90	7.20	-
Nitrogen	0.10	0.90	-
Sulfur	0.22	1.25	30.35
Oxygen	0.12	2.64	41.88
Chlorine	0.06	0.01	12.06
	100.00	100.00	100.00

Heating Value	Btu/lb
Naphtha	18,170
Product Tar	16,279
Minor Liquor Components	0

4. Performance Data - Pittsburgh No. 8 Coal (6% fines)

Steam Consumption: 3.27 lb/therm gas

Steam Decomposition: 80.97%

Oxygen Consumption: 53.89 SCF/therm
15,526 SCF/ton DAF coal

Crude Gas Production*: 288 therms/ton DAF coal

Gas Liquor Yield: 1.43 lb/therm

Thermal Efficiencies, %	Gas Only	Gas, Tar, Oil & Naphtha
Crude Gas / Coal	88.47	95.81
Crude Gas / Coal, Steam, & Oxygen	76.96	83.35

*Includes coal lock gas

The complete results of the Westfield technical support programs have been reported in Report No. FE-2542-13 entitled "Technical Support Program Report." This report is available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia, 22161.

A number of effluent and by-product samples were taken during TSP Run 13 of the Westfield II Program and were shipped to the Research Division of Conoco Coal Development Company for additional testing. The materials which were received and tested are listed below:

a. Oil separator water (gas liquor),
b. Tar separator water (gas liquor),
c. Slag quench water,
d. Westfield's raw water supply,
e. Slag frit,
f. Naphtha,
g. Tar oil, and
h. Tar

Pertinent data from the analyses are reported below:

a. Raw and Effluent Waters Properties

Parameter	Westfield Raw Water	Oil Separator Water	Tar Separator Water	Slag Quench Water
pH	7.5	9.1	9.2	6.6
Alkalinity ($CaCO_3$), ppm	25	12,550+	4,279	188
Acidity, ppm	0	0	0	0
Hardness, ($CaCO_3$), ppm	42	10	26	97
Nitrate, ppm	0.5	1,100	1,326	29.9
Sulfate, ppm	15	81	38	52
Chloride, ppm	5	58	78	21
Fluoride, ppm	-	28	100+	10
Ammonia, ppm	0.1	1,400+	1,400+	1,075
COD, ppm	-	1,140	1,220	14
Metals, ppm				
Cadmium	-	0.01	0.01	0.01
Calcium	30	1.9	5.4	27
Copper	0.01	0.02	0.02	0.1
Chromium	-	0.03	0.01	0.03
Iron	0.08	231	149	4.17
Magnesium	12	1.2	3	7.3
Manganese	0.01	0.09	0.1	0.03
Nickel	-	0.3	0.1	0.06
Potassium	0.4	10	26.5	6.3
Silver	-	0.03	0.03	0.03
Sodium	3.7	7.1	25	93
Titanium	-	1,600	870	20
Zinc	0.01	0.01	0.21	6

b. Analyses for Priority Pollutants

PPM	Oil Separator Water	Tar Separator Water
Antimony	0.15	0.23
Arsenic	0.52	1.3
Beryllium	0.007	0.007
Cadmium	0.011	0.011
Chromium	0.018	0.021
Copper	0.27	0.025
Cyanide	17	0.38
Lead	0.036	0.036
Mercury	0.76	0.0002
Nickel	0.18	0.086
Selenium	0.087	2.9
Silver	0.007	0.007
Thallium	0.007	0.007
Zinc	0.15	0.15
Phenols	2000	2400
Fluorene	ND	1.3
Acenaphthene	ND	1.4
Naphthalene	2.0	1.6
Phenanthrene	0.78	1.0
Ethylhehylphthalate	0.014	0.23
Pyrene	0.02	ND
Fluoranthene	0.06	ND
Benzene	92	1.9
Toluene	5.8	1.8
Ethyl Benzene	1.1	ND
1,1,1 Trichloroethane	0.16	2.5
Chloroform	0.70	ND
Bromodichloromethane	0.14	ND
2,4 Dimethylphenol	ND	1.2
Polychlorinated Biphenyls	0.3	0.3
Pesticides	0.75	0.75
Asbestos	ND	ND
All Others	0.01	0.01

ND = Not determined.

c. Naphtha, Tar Oil, and Tar

Property	Naphtha	Tar Oil	Tar
Gravity, °API	33.8	17.2	-14.5
Specific Gravity, 60/60°F	0.8602	0.9516	1.2091
Flash Point (PM), °F	-	80	190
Pour Point, °F	-	-5	+20
Conradson Carbon, Wt. %	-	0.35	32.5
ASTM Distrillation, °F			
IBP	-	174	-
10%	-	279	400
30%	-	345	617
50%	-	385	763
70%	-	413	-
90%	-	466	-
EP	-	522	-
Elemental Analysis, Wt. %			
Carbon	-	87.60	85.30
Hydrogen	-	8.39	6.47
Nitrogen	0.06	0.47	1.02
Sulfur	0.50	0.78	0.76
Oxygen	-	2.76	6.45
Heating Value, Btu/lb.	-	17,800	15,300

d. Naphtha PONA Analysis

	Paraffins	Naphthenes	Aromatics	Olefins
C_5	0.1	-	-	-
C_6	0.6	0.4	67.9	-
C_7	0.8	1.1	13.9	-
C_8	1.5	1.1	5.1	-
C_9	0.8	0.6	1.5	-
C_{10}	0.2	0.2	0.3	-
C_{11}	0.1	0.1	-	-
TOTAL	4.1	3.5	88.7	3.7

NOTE: All sulfur and nitrogen compounds are included in the aromatics.

10.2 Sub-Task IX-B: Identify Critical Problem Areas

The purpose of this sub-task is to identify critical design and engineering problems associated with the Demonstration Plant so that studies to solve them can be initiated.

A number of design problems associated with the gasifier arose in carrying out the Westfield TSP. The identification of these problems led to modifying the internals of the pilot plant gasifier in January-February 1978 and to extending the original technical support program. Subsequent pilot plant results showed that no design problems associated with the gasifier remain.

No other critical design or engineering problems associated with the Demonstration Plant have surfaced to date.

11.0 TASK X - LONG-LEAD TIME ITEMS

The purpose of Task X is to identify long-lead time items, if any, which should be ordered prior to the start of Phase II, Demonstration Plant Construction. If such items surface during Phase I, a procurement schedule and bid packages will be prepared. Procurement will be instigated, as required, with DOE approval.

No long-lead time items have been identified as of June 30, 1979.

12.0 TASK XI - PROJECT MANAGEMENT

The basic administration, management, and control of the project during Phase I falls within this task.

12.1 Contract Deliverable Reports

The following reports have been submitted to DOE during the past 12 months to fulfill the requirements of the contract:

	Report	Date Submitted
a.	Formal Oral Briefings:	
	Oral Briefing No. 12 (minutes)	07/18/78
	Oral Briefing No. 13 (minutes)	08/18/78
	Oral Briefing No. 14 (minutes)	09/25/78
	Oral Briefing No. 15 (minutes)	12/18/78
	Oral Briefing No. 16 (minutes)	02/13/79
	Oral Briefing No. 17 (minutes)	03/13/79
	Oral Briefing No. 18 (minutes)	04/09/79
	Oral Briefing No. 19 (minutes)	06/18/79
b.	Special Informal Oral Presentation	none
c.	Monthly Letter Reports: Integrated Project Management Summary Reports:	
	June 1978	07/17/78
	July 1978	08/11/78
	August 1978	09/15/78
	September 1978	10/11/78
	October 1978	11/17/78
	November 1978	12/18/78
	December 1978	01/12/79
	Janaury 1979	02/19/79
	February 1979	03/19/79
	March 1979	04/09/79
	April 1979	05/14/79
	May 1979	06/19/79
d.	Quarterly Technical Progress Reports:	
	July 1978 - September 1978	10/20/78
	October 1978 - December 1978	01/24/79
	January 1979 - March 1979	04/17/79
e.	Annual Technical Progress Report	08/01/78
f.	Phase I Final Report	none

Report	Date Submitted
g. Special Reports:	
1. Design and Evaluation of Commercial Plant.	
Volume 1 - Executive Summary	06/04/78
Volume 2 - Process and Project Engineering Design	05/31/78
Volume 3 - Economic Analysis and Technical Assessment	07/07/78
Volume 4 - Environmental Assessment and Site Requirements	07/21/78
2. Coal Fines Briquetting Study	08/29/78
3. Network Analysis Report	09/29/78
4. Technical Support Program Report	10/31/78
5. Topographical Maps and Aerial Survey Report	03/30/79
6. Climatological and Meteorological Data Report	04/19/79
7. Basis of Design (Revised)	04/24/79
8. Foundation Investigation and Soil Analysis Report	05/30/79
9. Procurement Policies and Procedures	04/18/79
10. Compliance with General Provision 44. Contractor's Organization (EPR 9-7.5006-6)	01/10/79

Conoco Inc. and DOE agreed to cancel the October and November 1978, and the January and May 1979 Oral Briefings.

The minutes of the Oral Briefings and the Integrated Project Management Summary Report constitute the monthly progress reporting mechanism for the project.

All of the required project management plans described under Sub-task XI-A have been approved by DOE. These include the Project Control Plan, the Project Coordination Plan, the Network Analysis Sytem, and the Configuration and Resource Management Implementation Plan.

12.2 Noble County Public Information Meetings

Conoco Inc. is required by contract to establish a public relations contact point which will permit site area residents to obtain information about the project. Beginning in January

1978, informal monthly meetings were held in Caldwell, Ohio, to provide the Noble County residents with an opportunity to ask questions or to talk about the progress of the project.

The frequency of the Noble County meetings was reduced over the past 12 months because the overall level of effort in the project was reduced by DOE.

One Public Information Meeting was held in Noble County on September 18, 1978. Mr. W. B. Carter, Project Manager, and Mr. G. A. Sweany, Sr. Project Coordinator, met with the local residents at a luncheon meeting in Caldwell, Ohio. Mr. Carter reported on the evaluation of the project and the competing project run by the Illinois Coal Gasification Group (ICGG). Mr. Carter also reported on the results of the testing program in Westfield, Scotland. The intent to locate the plant in Noble County was reaffirmed. The meeting was well received with approximately 50 attendees.

Mr. Sweany again visited Noble County on March 9, 1979, to announce the restart of the design of the Demonstration Plant.

13.0 TASK XII - PROCESS TRADE-OFF STUDIES

The purpose of this task is to segregate the process trade-off studies so that these studies will receive the desired degree of effort. Segregation into a separate task will enhance the cost control and reporting of the process trade-off studies and will better permit a later decision regarding capitalization versus expensing of each trade-off study.

13.1 Sub-Task XII-A: Utilization of Coal Fines

A sized coal feed (approximately 2" x 1/4") is usually required for fixed-bed slagging gasification. Some coal fines (less than 1/4") are produced in preparing the coal feed for gasification. The purpose of this sub-task is to investigate various alternative processes for utilizing the coal fines in a commerical plant. The alternatives will be technically, operationally, and economically evaluated. Alternatives to be evaluated include fines agglomeration to permit feeding the fines into the fixed-bed slagging gasifier, fines injection at the tuyeres of the slagging gasifier, fines gasification by processes which require a coal fines feed, fines combustion for on-site steam-power generation (no. B.L. export of steam or power), and sale of fines on the open market.

In the Westfield Technical Support Program it was shown that a substantial quantity of coal fines could be fed into the slagging gasifier with a caking-type feedstock, such as Pittsburgh No. 8 coal. There was no substantial carry-over of the coal fines into the equipment which is downstream from the gasifier. Therefore, the disposal of coal fines may not be a major problem. This finding will be evaluated in more detail in Phase III (Demonstration Plant Operations) of the project.

Fines Agglomeration

Conoco Inc. prepared and issued the Coal Fines Briquetting Study on August 29, 1978. The report included the process and project engineering design of Section 100C in the commercial plant based upon technology supplied by U.S. Army Development and Readiness Command, Lurgi Kohle und Mineraloeltechnik, GmbH, and Foster Wheeler Energy Corporation.

A commercial gasification plant producing 242 million standard cubic feet per day of pipeline quality gas from Illinois No. 6 coal requires 5.6 million tons per year of sized coal for the gasifiers. Under normal conditions, the mine must supply 7 to 10 million tons per year of run-of-mine (ROM) coal to ensure an adequate supply of sized feed for the gasifiers. The additional coal requirement reflects the 20-45 percent naturally occurring fines in the ROM coal.

If the fines, 1/4" x 0, are agglomerated and fed to the gasifiers, the purchased coal requirement is reduced from 7 to 10 million tons per year down to 5.6 million tons per year.

The economic analysis indicates the effect of adding a briquetting plant would increase the investment cost of the Commercial Plant by $7.5 million. Assuming that the gasification process can produce sufficient pitch to sustain the briquetting plant, the maximum benefit to the cost of gas would be 3-5¢ per million Btu. On the other hand, if it is necessary to purchase additional binding pitch, the briquetting plant could increase the cost of gas by as much as 11-12¢ per million Btu. The results of the study are summarized below:

	Change in Product Gas Cost (cents per million Btu)	
	Private Financing	Utility Financing
Case I - Selling Coal Fines (Base Case)	0	0
Case II - Briquetting Coal Fines (100% coal Derived Pitch)	-2.8	-4.6
Case III - Briquetting Coal Fines (50% Asphalt + 50% Pitch)	+5.1	+3.4
Case IV - Briquetting Coal Fines (100% Asphalt)	+12.5	+11.1

- = reduced cost of gas over Case I
+ = increased cost of gas over Case I

The Coal Fines Briquetting Study has been reported in Report No. FE-2542-13. This report is available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia, 22161.

13.2 Sub-Task XII-B: Process Trade-Off Studies Proposed by Contractor

No trade-off studies were undertaken under this sub-task.

13.3 Sub-Task XII-C: Process Trade-off Studies Proposed by DOE

DOE has suggested the following studies:

a. Alternate Waste Water Treatment (Zero Discharge)

b. Utilization of coal fines to fire Fluid Bed Boilers for producing steam/electricity.

c. Utilization of Medium Btu Gas from the gasifier to generate steam/electricity.

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d. Make or buy decision for oxygen supply

e. Optimize plant drives to assure reliability, capability, and successful long-lead time procurement

f. Waste heat recovery options

g. Utilization of coal slag

The zero discharge waste water treatment suggestion was adopted for inclusion in the Task I Commercial Plant design. Items "d", "e", and "f" will be considered in the engineering and design decisions for both the Commercial and Demonstration Plants. A market for the slag will be sought within the Task V work assignments. It was decided that items "b" and "c" should not be included in the project at this time.