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PHASE I: THE PIPELINE GAS DEMONSTRATION PLANT

Quarterly Technical Progress Report
for the period
1 July 1978 - 30 September 1978

Compiled and Edited by
Glenn A. Sweany

Continental Oil Company
High Ridge Park
Stamford, Connecticut 06' ^4

Prepared for the
United States Department of Energy
Division of Fossil Fuels Processing
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ABSTRACT

Contract No. EF-77-C-01-2542 between Continental Oil Company and the U.S. Department of Energy requires Continental Oil, as Contractor, to design, construct, and operate a Demonstration Plant capable to converting bituminous coal into pipeline quality gas. Work under this contract started on July 1, 1977.

On January 6, 1978, DOE requested that work on Task II be deferred for the present and work on Tasks III, IV, and V be continued at a reduced rate. Work on Task VI was not restarted during the current quarter. Work on the remaining tasks continued as planned.

On July 21, 1978, DOE announced that the Government would conduct a formal, competitive evaluation of Continental Oil Company's project and the Illinois Coal Gasification Group's project. The evaluation process would be completed in October and it is likely that one of the projects would be terminated for the convenience of the Government. All required data, information and position statements from Continental Oil Company were submitted within the required deadlines.

The Design and Evaluation of a Commercial Plant was completed and reported to DOE. Continental Oil Company's Engineering Center has studied and reported four additional technical alternatives to the original design. These alternatives could reduce the cost of gas by $1.40 -$1.70 per million Btu with a moderate increase in the risk of technical failure.

The environmental analysis program was continued at the slowdown rate established in January. The continuous 12-month meteorological and air quality monitoring program was completed. The data has been tabulated in raw form, so it may be retrieved when the project is restarted in November.

The proprietary process license agreements for Phosam W Process and the SCOT process have been submitted to DOE for approval. A secrecy agreement for the Amoco Claus process has been submitted for comments before concluding a license agreement with Foster Wheeler Energy Corporation.

A Network Analysis Report describing the plan and control for the Demonstration Plant design has been issued.

The original Westfield Agreement was terminated on March 31, 1978, and a 2-1/2 month continuation was formulated under the Westfield II Agreement. Four additional runs were completed on the pilot plant slagging gasifier during this time. Both Ohio No. 9 coal and Pittsburgh No. 8 coal were gasified without adding a non-caking component.

Due to the imposed work slowdown, no work was performed on the Demonstration Plant Design (Task II and Task VI) and the site evaluation and selection (Task III). No work was programmed for Task VII, Construction Planning; Task VIII, Economic Reevaluation; and Task X, Long-Lead Time Items.

1.0 INTRODUCTION

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 Continental Oil, as Contractor, to analyze, design, construct, test, evaluate, and operate a Demonstration Plant capable of converting high-sulfur bituminous caking coal to 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. Technical progress has been reported in the periodic reports listed below:

FE-2542-1
Quarterly Technical Progress Report
for the period
1 July 1977 - 30 September 1977

FE-2542-2
Quarterly Technical Progress Report
for the period
1 October 1977 - 31 December 1977

FE-2542-6
Quarterly Technical Progess Report
for the period
1 January 1978 - 31 March 1978

FE-2542-12
Annual Technical Progress Report
for the period
1 July 1977 - 30 June 1978

These reports may be obtained from the U.S. Department of Energy, Technical Information Center, P.O. Box 62, Oak Ridge, Tennessee 37830. The Annual Technical Progress Report covers the work activities for the period 1 April 1978 to 30 June 1978 as well as the work for the previous three quarters. There will be no separate, fourth quarterly report issued for the project.

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

a. Foster Wheeler Energy Corporation
Livingston, New Jersey

Foster Wheeler is the primary architectural and engineering subcontractor.

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

Lurgi is providing the basic engineering design packages for the gasification, shift conversion, gas cooling, acid-gas removal, gas liquor separation, and phenol extraction process units.

c. British Gas Corporation
London, United Kingdom

British Gas is implementing a gasification technical support program at its Westfield Development Centre, Cardenden, Scotland and is designing certain proprietary equipment items for the gasifier.

d. Westinghouse Electric Corporation
Pittsburgh, Pennsylvania

Westinghouse is implementing the environmental analysis required to construct and operate the Demonstration Plant. Westinghouse has subcontracted the environmental work to Energy Impact Associates.

e. Energy Impact Associates
Pittsburgh, Pennsylvania

Energy Impact Associates is performing the environmental analysis work for Westinghouse, and under separate subcontract with Continental Oil Company, they are performing additional environmental work which has been recently required by EPA regulations.

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

At the request of DOE and effective on January 8, 1978, all work on Task II was deferred for an indefinite period. Work on Tasks III, IV, and V was continued, but at a reduced rate. Task VI work assignments which had been previously deferred have not been restarted; nevertheless, a network analysis of Task II and Task VI work activities has been completed under Task VI by authority of a modification to the contract. Work on Tasks I, IX, XI and XII was continued as planned and remained essentially on schedule. Task I and a 2-1/2 month continuation of Task IX were completed during the period 1 July 1978 - 30 September 1978. Work on Tasks VII, VIII and X is not scheduled to commence until a later date in the project.

On July 21, 1978, DOE announced that the Government would conduct a formal, competitive evaluation of the two pipeline gas demonstration projects, namely, Continental Oil Company's project and a project managed by the Illinois Coal Gasification Group (ICGG). Both contractors were informed that the evaluation process would likely result in the termination of one of these projects for the convenience of the Government.

The evaluation of the two projects will consider the contractor's execution of the contract provisions and the perceived feasibility and risks of the technology which is to be demonstrated. The Government also required the contractor to submit position statements regarding the adequacy of the experimental data, the adequacy of the proposed plant site, and the financial support for the project. The Project Management Team was also required to prepare and submit budgets and schedules to complete Phase I, assuming the project was restarted on November 1, 1978.

Continental Oil Company's Project Management Team acquired the necessary information from the participating organizations and prepared the formal response to the DOE's inquiry. All data, information, and position statements were submitted within the established cut-off dates of the evaluation. The DOE decision to proceed, or not to proceed, with this project will be based on the selection from the competitive Evaluation Committee.

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 will consist 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 upon the design of the Commercial Plant.

Task I was started on 1 July 1977 and was completed on August 21, 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 through the U.S. Department of Energy, Technical Information Center, P.O. Box 62, Oak Ridge, Tennessee, 27830.

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. A substantial quantity of coal fines, smaller than 1/4 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, estimated under the above guidelines, was reported 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

The details of the economic analysis are discussed in the Design and Evaluation of Commercial Plant, Volume 3, Economic Analysis and Technical Assessment (FE-2542-10 Vol. 3).

During the reporting period, July 1 through September 30, 1978, Continental Oil Company 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.

Alternate 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.

Alternate II - Elimination of Zero Discharge Requirement

The base 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.

Alternate II proposes eliminating the evaporation stage of the waste water system and discharging a treated water stream which does not down grade the existing environment.

Alternate III - Combined Shift-Methanation

The base Commercial Plant uses a conventional gas processing system, downstream of the gasifiers. The processing units, in order, are shift conversion, gas cooling, gas purification, and finally methanation.

The conventional gas processing system incurs certain disadvantages when processing gas from the BGC/Lurgi slagging gasifier. The slagging gasifier produces a gas containing a high concentration of carbon monoxide and a low moisture content, compared to the Lurgi dry bottom.

In this application, the shift conversion unit requires 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 and increases the amount of liquids which must be treated in downstream units.

The combined shift-methanation process, while unproven commercially, offers numerous advantages. 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, only non-selective acid gas removal is required. Thus, the gas purification unit is greatly simplified, reducing the refrigeration load and eliminating the need for an incinerator to purify the carbon dioxide stream before it is vented.

The absence of steam from an up-stream shift conversion step also 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.

The methanation unit in the combined shift methanation process is designed for excess carbon oxides in the feed. The carbon oxides are removed in a hot potassium carbonate system which is a new unit that must be added to the processing train. The hot potassium carbonate system allows the bulk of the carbon dioxide to be vented without incineration.

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

While Alternatives I, II and III could produce an improvement in the plant thermal efficiency by 7%, 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 $0.36 per million Btu. compared to a total cost of $6.60 per million Btu. (private financing).

Alternate IV - Sulphuric 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. Continental Oil Company believes sulfur would be a more readily marketed product.

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 individual effects on gas price are summarized in the following table:

	Dollars Per Million Btu: Private Financing	Dollars Per Million Btu: 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

No further work is contemplated under Task I.

3.0 TASK II - DEMONSTRATION PLANT PROCESS DESIGN

The main purpose of this task is to prepare the process design for the Demonstration Plant. The design will be in sufficient detail so that it can be evaluated and modified, if necessary, before the detailed engineering design is completed in Task VI. 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.

Work on Task II was started in July, 1977, with the preparation of the Basis of Design by Continental Oil Company. After the Basis of Design was issued on August 25, 1977, Lurgi Kohle und Mineraloeltechnik, GmbH, British Gas Corporation, and Foster Wheeler Energy Corporation started the design work. In January, 1978, further work on Task II was deferred at the request of DOE and no work was performed on this task during the period January 15, 1978 through September 30, 1978.

Preliminary process designs and equipment lists were completed for the following sections before the work stopped.

200	Air Separation
300	Gasification
400	Shift Conversion
500	Gas Cooling
600	Rectisol
700	Methanation
1100	Slag Handling and Disposal
1200	Phenol Extraction

During the period July 1 to September 30, 1978, the Demonstration Plant concept was reevaluated and it was determined that the technology for coal gasification could be adequately demonstrated on a much smaller scale than originally proposed. The original Demonstration Plant Basis of Design specified three slagging gasifiers with one spare feeding 2,430 tons per day of sized coal (MAF). Continental Oil Company has proposed reconfiguring the plant for only one gasifier with one spare. This change effectively reduced the plant capacity to one-third of the original capacity, yet demonstrates a full-scale gasifier reactor.

If DOE accepts Continental Oil Company's proposal for the smaller capacity, then the work completed on Task II to date will be modified. Task II is scheduled to restart on November 1, 1978.

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 photograph, and topographic maps for the selected site;

d. To prepare requisite site reports;

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

At the request of DOE, work on Task III was deferred, effective January 8, 1978. Site related reports which were in progress were completed, reviewed by DOE, and submitted to the U.S. Department of Energy, Technical Information Center, P.O. Box 62, Oak Ridge, Tennessee 37830. The site reports are listed below.

FE-2542-3
Site Selection Report

FE-2542-4
Real Estate Report

FE-2542-5
Transportation Report

FE-2542-9
Water Resources Report

Task III is scheduled to restart on November 1, 1978 with an immediate execution of the soils survey contract.

5.0 TASK IV - DEMONSTRATION PLANT ENVIRONMENTAL ANALYSIS

The purpose of the Task IV environmental analysis is to collect the data and information needed (1) to obtain Ohio and Federal EPA approval to construct and operate the Demonstration Plant and (2) to prepare an Environmental Impact Statement (EIS). Continental Oil will obtain EPA approval and the associated permits. DOE will be responsible for the preparation of the EIS.

Work on Task IV has proceeded largely in accordance with the Statement of Work in Contract EF-77-C-01-2542. The environmental analysis work was originally subcontracted to the Environmental Systems Department of Westinghouse Electric Corporation (WESD) which later separated from Westinghouse to become Energy Impact Associates (EIA).

During the slowdown period of the project, EIA has continued the field monitoring program to acquire environmental data on the proposed site. While this provided the required continuity in data acquisition, no provisions were made to report or interpret the data. Consequently, the data is in a raw form, readily retrievable when the project restarts.

The continuous 12-month meteorological and air quality monitoring program has been completed. The last high-volume particulate sample and 24-hour gas samples for NO_2 were taken on September 17, 1978.

The last SO_2 and H_2S bubbler samples were taken on September 1, 1978. The meteorological field program was terminated September 30, 1978.

The Aquatic Ecology data from the Spring and Summer seasonal surveys are being compiled in a data report for Ohio EPA.

The Water Resources Report, FE-2542-9, has been completed and submitted to the Department of Energy, Technical Information Center. The Water Resources Report was abstracted earlier in the Annual Technical Progress Report (FE-2542-12).

The terrestrial summer field survey was executed during the week of July 24, 1978. The data has been compiled for future analysis.

No work was programmed for socioeconomic studies during the reported period.

At the request of DOE, effective January 8, 1978, work effort on Task IV was reduced for an unspecified period of time. Consequently, no work was accomplished in the following areas:

Geohydrology
Land Use, History
Noise
Alternatives, Environmental Trade-Off Analyses
Environmental Analysis Report Preparation

6.0 TASK V - MATERIALS AND LICENSES

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

a. A contractual agreement for a 24-year supply of Ohio No. 9 coal feed for the Demonstration Plant is to be negotiated and executed during Phase I. A 24-year supply will permit operating the plant as a commercial venture upon completion of Phase III of Contract EF-77-C-01-2542.

b. Contractual agreements to supply electric power and raw water to the Demonstration Plant are to be negotiated and executed. 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 and executed. Plans, and possible executed contracts, 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.

At the request of DOE, effective January 8, 1978, the work effort on Task V was reduced for an unspecified period of time. The reduced effort consists of the following:

a. Complete negotiations with Consolidated Gas Supply Corporation to act as a coal resource consultant who will negotiate the coal supply contract for the Demonstration Plant;

b. Complete the Preliminary Coal Mining Plan and submit it to DOE;

c. Defer the plans for obtaining raw materials until a later data;

d. Defer the plans for disposing of the gas product and by-products until a later date;

e. Finish the negotiations for the following process licenses: USS Phosam W Ammonia Recovery Process, Amoco Claus Sulfur Recovery Process, and the Shell SCOT Process; and

f. Complete the preliminary plan for obtaining licenses and permits for the Demonstration Plant and submit it to DOE.

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

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

Continental Oil Company has proposed to the DOE that Ohio No. 9 coal will be the primary coal and Pittsburgh No. 8 coal will be alternate coal "A." The Pittsburgh No. 8 coal will also be used in Task II, Phase III, for shake-down testing and Plant Start-up, but the 12-month operating period in Task III, Phase III Operation, will feed Ohio No. 9 coal.

A third coal, alternate coal "B," will be selected by DOE in Phase II.

During the reporting period, a subcontract has been written with Consolidated Gas Supply Corporation to negotiate with Consolidation Coal Company for the supply of Ohio No. 9 coal for the project. The Consolidated Gas Supply Corporation contract will be submitted to DOE in October with a request for approval and authorization to proceed on November 1, 1978 when the project is restarted.

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

The preliminary coal mining plan, FE-2542-7, was submitted in draft form to DOE on May 16, 1978. DOE's comments were received and Continental Oil Company responded to the comments. The contents of the report are still under discussion.

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

No additional work was performed on this subtask during the reporting period. This activity will be restarted on November 1, 1978.

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

No additional work was performed on this subtask during the reporting period. This activity will be restarted on November 1, 1978.

6.5 Sub-Task V-E: Proprietary Process Licenses

The following process license agreements are being negotiated for the Demonstration Plant:

1. Phosam W Process License for Ammonia Recovery.
2. Shell Claus Off-Gas Treatment (SCOT) Process License for final sulfur recovery.
3. Amoco Claus Process License for sulfur recovery.

The status of the three licenses are summarized in the following paragraphs.

Phosam W License Agreement - Continental Oil Company has submitted the Phosam W License Agreement to DOE for approval of form and content. Continental Oil has also requested that the agreement should be prepared for execution on November, 1, 1978.

Shell Claus Off-Gas Treatment Process License - Continental Oil Company has also submitted the SCOT Process License to DOE for approval of form and content and has requested authority to execute the agreement on November 1, 1978.

Amoco Claus Process License - Continental Oil Company may obtain a license for the Amoco Claus process through Foster Wheeler Energy Corp., but the secrecy agreement which Continental Oil Company would sign under this arrangement would exclude DOE and its representatives from access to the technology. This would be unacceptable to DOE, so Continental Oil Company is negotiating a new secrecy agreement with Standard Oil (Indiana), which would permit DOE to have a limited access to the data. The new secrecy agreement was submitted to DOE for comments.

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

The Plan for Obtaining Permits and Licenses for the Demonstration Plant was submitted to DOE and comments have been received from DOE. Further work in this subtask was deferred for the reporting period.

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 work was undertaken during the period September 1977 to May 1978.

The Contract EF-77-C-01-2542 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.

The Network Analysis Report describes the methodology which Continental Oil Company's Project Management Team will use for planning, scheduling, and control of the work activities of Task II and Task VI, Phase I. The report also contains extensive plots from the TMAPS Network System for both tasks, showing such information as:

1. Critical Path
2. Schedule (time related events)
3. Activity breakdown by contractor
4. Free-float time in events not on the critical path
5. Sequential relationship of events
6. Key milestones

The network analysis is a schedule control device, and it does not provide for allocation of resources, or a resource leveling function. It is the responsibility of the various subcontractors to allocate their cost and manpower within the limitation of budget to meet the schedule. All affected organizations, Foster Wheeler Energy Corporation, Continental Oil Company and Lurgi Kohle und Mineraloeltechnik, GmbH, provided input to build the network.

The Network Analysis Report is based upon the Demonstration Plant design which is currently specified in the contract. If DOE accepts Continental Oil Company's proposal to build a smaller capacity plant, the network analysis will be revised. It is expected that the revisions will be minor.

The network analysis indicates Task II and Task VI will begin on November 1, 1978, and without schedule slippage, Task II will be finished by October 31, 1979, and Task VI will be finished by September 30, 1980.

8.0 TASK VII - CONSTRUCTION PLANNING

Plans and Management Procedures for constructing the Demonstration Plant will be prepared under Task VII. Work on this task 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 definitive 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. Work on this task in scheduled to commence in FY-1980.

10.0 TASK IX - TECHNICAL SUPPORT

The purpose of Task IX is to provide technical support for designing the Demonstration Plant.

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

The work under Sub-Task IX-A was performed under two subcontracts with British Gas Corporation at its Westfield Development Centre, Cardenden, Scotland. 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 4-1/2 months to the program, beginning on April 1, 1978, and expiring on August 15, 1978. The second subcontract was known as the Westfield II Agreement.

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

The results from the Westfield II Agreement are summarized in the following sections and will become part of the Final Report on Task IX, which will be issued on October 31, 1978. (FE-2542-13).

Westfield II, Run A

TSP Run A followed the successful run on Pittsburgh No. 8 coal layered (1:1) with blast furnace metallurgical coke. The main objective of the run 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 9C 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 20:06 P.M. 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 alternate 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 provide a direct comparison with the post-Run 9C bed, the gasifier was shut down in controlled fashion at 01:50 A.M. 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 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 2015-1915	Coal May 31-Jun 1 2015-0110
Moisture	1.14	0.98	1.37	2.3	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	87.6	88.5	87.9	70.9	62.8	67.0
Hydrogen	0.7	1.1	1.0	5.0	4.1	4.7
Nitrogen	1.0	1.0	1.0	0.8	0.8	0.7
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	10.3	10.4	11.22	19.67	17.03
Water	1.14	0.98	1.37	2.3	2.45	1.93
Swelling Index	-	-	-	4.5	5.0	4.5
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	1.0	0.5	2.0	1.0
under 1/8"	4.0	4.0	2.0	2.0	3.0	5.0
Coke Bulk Density, Lbs/CF	35	34	34	34	35	35
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 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	69

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

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	39.2	38.7	39.7	39.7	36.2
Al_2O_3	17.2	16.2	17.2	17.0	16.7
CaO	25.7	24.7	25.9	26.1	26.0
MgO	6.7	6.6	6.8	7.2	7.0
Fe_2O_3	8.6	9.2	8.0	7.7	8.7
Carbon	0.9	0.97	1.32	1.11	0.93
	98.3	96.37	98.92	98.81	95.53
Free Iron as Fe	0.6	1.0	0.9	0.6	0.5
FeO	6.9	7.1	6.2	6.1	7.2
Total Iron as Fe	6.0	6.4	5.6	5.4	6.1
Fe^{+2}	5.4	5.5	4.8	4.7	5.6
Fe^{+3}	Nil	Nil	Nil	0.1	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.

e. Recycle Tar

Ultimate Analysis (Dry), Wt. %	Dust Free Tar	Tar Solids
Carbon	88.8	77.0
Hydrogen	7.5	1.1
Nitrogen	0.4	0.7
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	Composite	1330	1333	1336	1339	1342	1345
CH_4	0.19	0.60	0.44	2.24	1.50	6.13	6.32	2.33	3.88	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	2.91	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	Nil
C_2H_6	Nil	Nil	Nil	0.15	Nil	0.36	0.35	Nil	0.13	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	0.97	1.01	0.80	0.97	Nil	0.42	0.47
H_2	27.01	27.1	27.03	27.69	27.46	26.48	26.61	28.66	25.70	27.32	27.68	28.10	27.68	27.25	26.26
O_2	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	0.95	Nil	Nil	Nil	Nil	Nil	Nil
Ar	0.86	0.83	0.82	0.80	0.75	0.78	0.94	0.85	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	6.98	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	54.47	56.67	59.84	59.28	60.51	59.39	60.64
	99.87	99.41	97.53	98.53	95.54	98.81	99.27	97.75	96.84	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	Composite	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	4.30	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	3.30	3.27	2.94	4.35
C_2H_4	Nil	Nil	Nil	Nil	Nil	0.06	Nil	0.07	0.11	0.09	0.06	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	0.27	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	0.55	1.14	0.83	0.79
H_2	26.69	26.54	26.83	27.11	26.62	27.53	28.68	26.36	25.4	25.78	26.56	26.13	27.59	26.83
O_2	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Ar	0.80	0.81	0.78	0.73	0.67	0.66	0.69	0.61	0.62	0.67	0.78	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	3.53	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	60.56	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	99.91	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	2230-0130	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	0.061	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	4.4	6.8	2.9
CO_2	5.29	5.99	13.7
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	12.6
CO	54.22	55.85	31.23
	97.42	101.85	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	176	176
Chloride	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)								Heat Balance
Input	Rate	Carbon	Hydrogen	Nitrogen	Sulfur	Oxygen	Chlorine	Ash	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	2403
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	-0.2

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

Coal Heating Value, Btu/lb.	9263*
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. Performance Data - Layered 1:1 Coal: Coke

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
$\frac{\text{Crude Gas}}{\text{Coal}}$	87.83	92.49
$\frac{\text{Crude Gas}}{\text{Coal, Steam \& Oxygen}}$	74.70	78.66

* Includes coal lock gas.

Westfield II, Run B

After the reliable operation achieved on layered Pittsburgh No. 8 coal and blast furnace coke, TSP Run B 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 A 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 20:20 P.M. 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 results of these trials are discussed in the final report.

The oxygen feed rate was increased to 135,000 SCFH at 20:00 P.M. 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 11:35 A.M. 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	47	49	49	50	50	49
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	3.9	3.99	3.93
Total Iron as Fe	3.99	3.99	4.13
Fe^{+2}	3.03	3.1	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
Jun 19	0805	93.75	2.58	3.67
	1500	92.15	3.0	4.8
	1900	93.2	2.4	4.4
Jun 20	0145	95.2	0.2	4.6
	0630	94.7	1.1	4.2
	1205	94.4	1.1	4.6
	1630	94.4	0.6	5.1
	1910	94.7	0.7	4.6
	2340	94.6	1.0	4.4
Jun 21	0350	94.6	0.7	4.4
	0730	94.1	0.3	5.6
	0900	94.7	1.3	4.1
	1345	94.1	0.3	5.6
	1720	94.0	0.8	5.2
	2300	95.7	0.3	4.1

* + is a gain.

d. Oxygen Purity (continued)

Date	Time	Oxygen	Argon	Nitrogen
June 22	0315	94.6	1.0	4.4
	0720	94.6	1.2	4.2
	1200	92.5	1.7	5.7
	1425	93.3	2.0	4.7
	1855	94.0	0.7	5.3
	2315	94.6	0.6	4.8
	0330	95.1	0.9	3.9
	0850	95.0	0.3	4.8
	1205	98.0	2.0	-

e. Recycle Tar

Ultimate Analysis (Dry, Dust Free)	Wt. %
Carbon	86.4
Hydrogen	1.6
Nitrogen	1.1
Sulfur	1.05
Chlorine	0.03
Ash	Nil
Water	Nil

Heating Value, Btu/lb. 16,285

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

Dust Ultimate Analysis (Air Dried)	Wt. %
Carbon	78.3
Hydrogen	5.3
Nitrogen	1.5
Sulfur	1.32
Chlorine	0.03
Ash	13.47
Water	1.2

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	6.8	6.57	7.4	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	0.9	0.9	1.18	0.83
N_2	3.03	4.12	3.48	3.39	2.7	3.43	3.70	3.49	3.0	2.56	4.25	3.18
CO	47.76	59.29	61.87	52.92	53.74	54.13	53.33	52.4	54.5	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	98.86	97.45

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

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	3.2	3.51	3.47	4.23	4.16
C_2H_4	0.19	0.27	0.20	0.2	0.29	0.14	0.16	0.1	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	0.6	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	4.0	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	97.85	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	Cond.
June 20	0145-0445	0.06	0.0169	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	0.0118	0.0005	0.031	8.76
June 21-22	2300-0230	0.0176	0.0187	0.0255	7.26
June 22	1325-1530	0.029	0.005	0.036	6.5
June 23	0130-0415	0.032	0.078	0.0156	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

	Tar Separator		Oil Separator
Analysis, Vol. %	Gas Phase	Combined	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	1.6	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	2.9
Gaseous NH_3	1.4 (0.002 vol. %)

h. Condensible 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

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

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

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

Material Balance, Pounds (Basis: 1,000 pounds dry Coal & 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

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

3.0 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.

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
$\frac{\text{Crude Gas}}{\text{Coal}}$	83.31	94.04
$\frac{\text{Crude Gas}}{\text{Coal, Steam \& Oxygen}}$	72.90	82.29

* Includes coal lock gas.

Westfield II, Run B2

TSP Run B2 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 gasification 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 22:52 P.M.

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, clay-like 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 03:30 A.M. on June 28, but flow restrictions from the bunker reappeared after four hours of satisfactory gasification. A further 7-hour period of Frances coal gasification was required before Ohio No. 9 coal feed could be resumed at 15:22 P.M.

At 17:10 P.M., 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 run was terminated with a controlled shutdown at 16:32 P.M. 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	4.5	4.5
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	21.0
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

c. Slag

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	-
Naphthalene	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	4840
Total Dissolved Solids	5553	10395
Total Sulfur	3351	656
Total Ammonia	42160	3587
Free Ammonia	38148	1411
Fixed Ammonia	4012	2176
Carbonate as CO_2	63800	2200
Chloride	1773	2837
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 & 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.	9139*
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, Run C

TSP Run C 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 9C and B, 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 C 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 09:52 A.M. 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 20:07 P.M. on August 12. The amount of recycle tar feed was systematically varied. The trials showed that the sensitivity to tar feed observed during TSP Run B had been effectively eliminated.

The fines content of the Pittsburgh No. 8 coal feedstock was steadily increased beginning at 09:00 A.M. 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 22:08 P.M. 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.

The pertinent data from Run C 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	7
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"-1-1/4"	3.5	12	11.5	14	3
3/4"-1"	13	31	25.5	28	22
1/2"-3/4"	38	29	29	29.5	23.5
3/8"-1/2"	26	12	18	15	19.5
1/4"-3/8"	12	8	8	7.5	8.5
1/8"-1/4"	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"-1-1/4"	6	9	14	8	6
3/4"-1"	19	29.5	35	28	12.5
1/2"-3/4"	24	25.5	16.5	23	19
3/8"-1/2"	20	15	9	12	16
1/4"-3/8"	16	8	5.5	9	16.5
1/8"-1/4"	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	1330	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	4.4	0.1
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.	16,029	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 Synthesis 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	778	622	1623	981	964
Dust, grams	18.1	31.7	19.7	27.3	6.7	16.0
Gas Liquor Product, grams	2760	2803	2985	5444	3491	4967

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	3,342	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	30,800
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

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

2. Heat and Material Balance

No heat and material balances have been reported for TSP Run 15.

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. Recent pilot plant results show 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 September 30, 1978.

12.0 TASK XI - PROJECT MANAGEMENT

The basic administration, management, and control of the project during Phase I falls within this task. Report preparation, a major activity in any development project, is set aside as a separate sub-task to permit Conoco and DOE to identify these costs.

12.1 Contract Deliverable Reports

The following reports have been submitted in the period July 1 to September 30, 1978 to DOE to fulfill the requirements of the contract:

Report	Date Submitted
a. Formal Oral Briefings	
Oral Briefing No. 12 (minutes)	7/18/78
Oral Briefing No. 13 (minutes)	8/18/78
Oral Briefing No. 14 (minutes)	9/25/78
b. Special Informal Oral Presentations	None
c. Monthly Letter Reports	
Integrated Project Management Summary Reports	
June, 1978	7/17/78
July, 1978	8/11/78
August, 1978	9/15/78
d. Quarterly Technical Progress Reports	None
e. Annual Technical Progress Report	8/1/78
f. Phase I Final Report	None
g. Special Reports:	
1. Commercial Plant Design and Evaluation Volume 3 - Economic Assessment and Technical Assessment	7/7/78
Volume 4 - Environmental Assessment and Site Requirements	7/21/78
2. Coal Fines Briquetting Study	8/29/78
3. Network Analysis Report	9/29/78

The formal Oral Briefings and the monthly letter reports constitute the monthly progress reporting mechanism for the project.

On August 7, 1978, DOE approved the Project Control Plan which was submitted in revised form on April 21, 1978.

12.2 Noble County Public Information Meetings

Continental Oil Company 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.

During this quarter, the frequency of the Noble County meetings was reduced 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. 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 Continental Oil Company's 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. Continental Oil Company's intent to locate the plant in Noble County was reaffirmed. The meeting was well received with approximately 50 attendees.

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 required for the fixed-bed slagging gasification process. 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 Commercial 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

Continental Oil Company 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 DARCOM, Lurgi, 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, which may appear to be a substantial savings in the cost of gas.

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 in the following table.

	(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 (FE-2542-11) is being reviewed by the Department of Energy and will be issued through the Technical Information Center at some later date.

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

A trade-off study to evaluate a conceptualized combination shift conversion and methanation process has been proposed to DOE. To date DOE has taken no action on the proposal.

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

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 has been 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.

*U.S. GOVERNMENT PRINTING OFFICE: 1979-640-014/4591. Region 4.