# U.S. Department of Energy
# National Energy Technology Laboratory

# Early Entrance Co-Production Plant – Decentralized Gasification Cogeneration Transportation Fuels and Steam From Available Feedstocks

DOE Cooperative Agreement DE-FC26-00NT40693

## Quarterly Technical Progress Report
## July to September 2002

WMPI PTY., LLC

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## DISCLAIMER

## ABSTRACT

Waste Processors Management, Inc. (WMPI), along with its subcontractors Texaco Power & Gasification (now ChevronTexaco), SASOL Technology Ltd., and Nexant Inc. entered into a Cooperative Agreement DE-FC26-00NT40693 with the U. S. Department of Energy (DOE), National Energy Technology Laboratory (NETL) to assess the techno-economic viability of building an Early Entrance Co-Production Plant (EECP) in the United States to produce ultra clean Fischer-Tropsch (FT) transportation fuels with either power or steam as the major co-product. The EECP design includes recovery and gasification of low-cost coal waste (culm) from physical coal cleaning operations and will assess blends of the culm with coal or petroleum coke.

The project has three phases. Phase I is the concept definition and engineering feasibility study to identify areas of technical, environmental and financial risk. Phase II is an experimental testing program designed to validate the coal waste mixture gasification performance. Phase III updates the original EECP design based on results from Phase II, to prepare a preliminary engineering design package and financial plan for obtaining private funding to build a 5,000 barrel per day (BPD) coal gasification/liquefaction plant next to an existing co-generation plant in Gilberton, Schuylkill County, Pennsylvania.

The current report covers the period performance from July 1, 2002 through September 30, 2002.

# Table of Contents

**TABLE OF CONTENTS**

# Table of Contents

**List of Figures and Tables**

# Section 1 Introduction and Summary

## 1.1 INTRODUCTION

WMPI, along with its subcontractors Texaco (now ChevronTexaco), Sasol, and Nexant entered into a Cooperative Agreement DE-FC26-00NT40693 with the U. S. Department of Energy (DOE), National Energy Technology Laboratory (NETL), to assess the technical and economic viability of building an Early Entrance Co-Production Plant (EECP) in the U. S. to produce ultra clean Fischer-Tropsch (FT) transportation fuels with either power or steam as the major co-product. The EECP design emphasizes on recovery and gasification of low-cost coal wastes (culm) from coal cleaning operations, and will assess blends of the culm with coal or petroleum coke as feedstocks. The project has three phases.

### 1.1.1 Phase I – Concept Definition and RD&T Planning

Phase I objectives include concept development, technology assessment, conceptual designs and economic evaluations of a Greenfield commercial co-production plant and of a site specific demonstration EECP to be located adjacent to the existing Gilberton Power Station. There are very few expected design differences between the Greenfield commercial co-production plant versus the EECP plant other than:

- The Greenfield commercial plant will be a stand-alone FT/power co-production plant, potentially with larger capacity than the EECP to take full advantage of economies of scale.
- The EECP plant, on the other hand, will be a nominal 5,000 bpd plant, fully integrated into the Gilberton Power Company's Cogeneration Plant's existing infrastructure to reduce cost and minimize project risks. The Gilberton EECP plant will be designed to use eastern Pennsylvania anthracite coal waste and/or a mixture of culm and other fuels as feedstock.

Phase I includes 11 tasks and the following major deliverables.

- A project management plan.
- A process feasibility design package with sufficient details to determine order-of-magnitude cost estimates for preliminary economic and market analyses.
- A preliminary environmental and site analysis.
- A Research, Development and Testing (RD&T) plan for Phase II tasks.
- A preliminary project financing plan.

### 1.1.2 Phase II – R&D and Testing

The Phase II objective is to perform research, development and process performance verification testing of any design deficiencies identified in Phase I. Due to the relative maturity of the two key technologies (Texaco's coal gasification and SASOL's FT) proposed for the EECP designs, Phase II activities will focus on feedstock characterization and gasification process performance testing rather than research and development. Specific Phase II goals include:

- Characterization of anthracite culm and its mixture with other fuels as feedstocks for the Texaco gasifier.
- Gasification performance (pilot plant) testing of design anthracite culm feedstocks at an existing Texaco facility to verify its performance.

### 1.1.3 Phase III – Preliminary Engineering Design

The objective in Phase III is to upgrade the accuracy of the Phase I site-specific Gilberton EECP capital cost from plus or minus 35% to plus or minus 20%. The increased cost estimation accuracy is achieved by updating the Phase I inside battery limits (ISBL) processing plant design packages to incorporate Phase II findings, by refining the outside battery limits (OSBL) utility and offsite support facility design packages to include final and updated ISBL unit demands, by obtaining actual budgetary quotes for all major equipment, and by further engineering to define the actual bulk commodities requirements.

The upgraded Phase III capital cost estimate, together with the updated operating and maintenance cost estimate, are crucial elements to finalize the EECP Project Financing Plan needed to proceed with detailed engineering, procurement and construction of the EECP.

The Phase III goals and deliverables include the development of:

- Preliminary Engineering Design package of the EECP.
- A Project Financing Plan.
- An EECP Test Plan.

The project scope of work consists of sixteen tasks organized into the three phases as shown in Table 1.1. The table also shows the project team members responsible for the leading role for each task. The specific task description details were discussed in the Project Management Plan.

## 1.2 SUMMARY

Main technical activity performed during the current reporting period centers on completing the Greenfield (Texaco gasifier based) EECP design package, capital and operating cost estimates, and preliminary plant emission estimates needed for Phase I Task 7 activity of Preliminary Environmental Assessment.

Table 1-1

Scope of Work Task Summary

| Phase/Task | Description | Task Leaders |
|---|---|---|
| Phase I | **Concept Definition and RD&T Planning** | |
| Task 1 | Project Plan | Nexant |
| Task 2 | Concept Definition, Design Basis & EECP Process Configuration Development | Nexant |
| Task 3 | System Technical Assessment (Trade-off Analysis) | Nexant |
| Task 4 | Feasibility Study Design Package Development | Nexant (w/individual Process Design package from Texaco and Sasol) |
| Task 5 | Market Assessment | Texaco |
| Task 6 | Preliminary Site Analysis | WMPI and Consultants |
| Task 7 | Preliminary Environmental Assessment | WMPI and Consultants |
| Task 8 | Economic Assessment | WMPI and Consultants |
| Task 9 | Research Development and Test Plan | Texaco |
| Task 10 | Preliminary Project Financing Plan | WMPI and Consultants |
| Task 11 | Phase I - Concept Report | Nexant |
| Phase II | **R&D and Testing** | |
| Task 1 | Feedstock Mix Characterization and Gasification Performance Verification | Texaco (w/ support from Nexant and WMPI) |
| Task 2 | Update RD&T Plan | Texaco |
| Phase III | **EECP Engineering Design** | |
| Task 1 | Preliminary Engineering Design Package Development | Nexant – with<br>a) Texaco – Gasification Design Package<br>b) Sasol – FT Design Package<br>c) Nexant – BOP and cost estimate |
| Task 2 | Project Financing Plan | WMPI and Consultants |
| Task 3 | EECP Test Plan | Nexant |

# Section 2 Phase I Task 1 – Project Plan

TASK COMPLETED.

A Project Management Plan was prepared, issued and approved by DOE. A copy was submitted to the AAD Document Control Office of DOE/NETL on May 15, 2001.

This plan provides a road map for the overall project execution delineating the project:

- Objectives.
- Detailed work breakdown structure and obligated deliverables.
- Technical and management approach.
- Control plan – scheduling, budget and reporting.
- Administration details.

# Section 3 Phase I Task 2 – Concept Definition, Design Basis & EECP Process Configuration

TASK COMPLETED.

3.1 EECP concept and process configuration defined, giving full considerations of:

- WMPI's feedstock availability and quality (e.g., ash content, composition and anticipated fusion temperature.)
- Desired mode of operation for Texaco's gasification process in handling the design project feed mix.
- Design consideration of Sasol's Low-Temperature FT (LTFT) process giving the estimated design syngas feed.
- System integration and site-related issues (e.g., syngas clean up, utility availability.)

3.2 Gilberton EECP Design Basis established, and a Basic Engineering Design Data (BEDD) package was developed to guide the overall process design development regarding:

- Plant capacity
- Site data
- Feedstock properties
- Product specifications
- Battery limits and offsite utility specifications

3.3 Project Instruction of Equipment Code of Accounts established.

Details of the above were reported in previous Quarterly Technical Progress reports.

## Section 4 Phase I Task 3 – System Technical Assessment

TASK COMPLETED.

Under this task 1) technical design issues/systems (e.g., ash fusion characteristics of EECP feed mix and its potential effect on gasification performance) identified in Phase 1 Task 2 were assessed in more detail, and 2) preliminary heat, material and utility balance sensitivity analyses were carried out, based on process performance estimates and utility demands from Texaco and Sasol for the gasification and FT synthesis section respectively, to optimize the overall EECP process plant configuration for detailed process design package development of Phase I Task 4 activity.

# Section 5 Phase I Task 4 – Feasibility Design Package Development

Greenfield (Texaco gasifier based) EECP Design Package completed.

Figure 5-1 shows the overall Texaco gasifier based EECP block flow configuration.

Figure 5-1 Overall EECP Process Configuration

Overall ISBL plant consists of two main process sections: Texaco Gasification, and Sasol FT Synthesis and product work up (PWU). It is designed to use anthracite culm of 20% ash as the primary feed. The design has the operation flexibility of feeding in 25% petroleum coke as feed. The plant is supported by nineteen OSBL offsite facilities, descriptions of which were reported in previous quarterly technical reports.

## 5.1 Preliminary EECP Plant Air Emission Estimates

The following preliminary air pollutants emission information for the EECP are based on the Greenfield design material balances of gasifying 100% anthracite culm feed at 600 psig (Texaco Type C Feasibility Study Package), and for synthesizing FT liquid using SASOL iron-based catalyst (SASOL Feasibility Study Package). Total anthracite culm feed is 3534 short tons (dry)/day with a HHV of 11,119 Btu/LB (dry). Total FT liquid produced includes 3732 BPSD of upgraded diesel plus 1281 BPSD of stabilized naphtha. The plant generates approximately 131 MW of electricity, of which 92 MW is consumed internally and 39 MW is available for export. It is assumed that the two CO2-rich streams from the Rectisol unit will be exported to third party for CO2 production or sequestration.

There are four continuous atmospheric vents for the EECP:

- Combined cycle power plant gas turbine/HRSG flue gas;
- Hydrocracker reactor fired heater flue gas;
- Hydrocracker fractionator fired heater flue gas;
- Sulfur Recovery/Tail Gas Treating Unit thermal oxidizer exhaust.

There are two intermittent but regular vents of displaced vapor from tank truck loading, and from storage tank filling. The estimated daily average tank truck loading and storage tank filling displacement volumes are 20 ACFM each, which is equivalent to the daily average FT diesel and naphtha production rate.

Intermittent emissions from startup and shutdown vents and flares are not included. These intermittent loads and venting durations will vary depending on the final plant startup and shutdown procedures. Also, not included are leaks and tank breathing vents.

Air pollutants include SO2, NOx, CO, VOC, and PM. Following are the preliminary estimated total continuous pollutant emissions for the EECP Greenfield Plant:

| | Lbs/Hr | Tons/Year (1) |
|---|---|---|
| CO | 14.4 | 54 |
| NOx | 18.6 | 70 |
| SOx | 7.8 | 29 |
| VOC | 2.2 | 8 |
| Particulates | 6.2 | 23 |

Notes:

(1) Assumed 7500 operating hours per year (85% onstream factor).

Detailed emission rates for the continuous vents are discussion in the following sections.

## Section 5 Phase I Task 4 – Feasibility Design Package Development

5.1.1 Combined Cycle Power Plant Gas Turbine Flue Gas Air Pollutants Emission

Excess process offgases are burned in a gas turbine (GT) to generate electricity. The GT is equipped with HRSG to recover waste heat from the GT exhaust by preheating boiler feed water and generating high pressure superheated steam. After meeting the overall plant steam demands, excess steam from the HRSG and other process producers are converted to electricity in a condensing steam turbogenerator (STG).

Table 5.1 is a listing of the flows and compositions of the fuel gas to, and the corresponding flue gas from the GT.

Emissions of VOC and PM are calculated based on fuel gas HHV per EPA AP-42 Section 3.1 (Stationary Gas Turbines for Electricity Generations). The fuel gas fired in the GT has a HHV of 841 MMBtu/Hr, and the emissions based on the published EPA emission factors are:

| | | |
|---|---|---|
| VOC | 0.0021 lbs/MMBtu (HHV) | 841 x 0.0021 = 1.8 Lbs/Hr |
| PM | 0.0066 lbs/MMBtu (HHV) | 841 x 0.0066 = 5.6 Lbs/Hr |

Steam injection is included in the GT combustion to control the NOx level in the GT exhaust to 25 ppmV (98,900 MPH at 15% O2). The HRSG is equipped with SCR to further reduce the NOx and the CO emission rates to 2.5 and 3.0 ppmV (at 15% O2) respectively. The estimated NOx and CO emissions from the CC HRSG stack are:

| | | |
|---|---|---|
| CO | 3.0 ppmV @ 15% O2 | 3.0 x 98900 / 1000000 x 28 = 8.3 Lbs/Hr |
| NOx | 2.5 ppmV @ 15% O2 | 2.5 x 98900 / 1000000 x 46 = 11.4 Lbs/Hr |

For SOx emissions, it is assumed that all of the sulfur in the syngas feed to the FT block (which includes both the FT plant and the PSA Hydrogen plant) is included in the FT tailgas. Total syngas feed to the FT block is 21,367 moles/Hr or 195 MMSCFD. With a design sulfur content of 40 ppbV to meet Sasol Iron-based FT process specifications, total sulfur in the syngas feed is 21,367 x 40 / 1,000,000,000 = 0.00085 moles/Hr, and the maximum SOx emission from the GT is 0.00085 x 64 = 0.055 Lbs/Hr as SO2. And maximum H2S content in 70.8 MMSCFD of fuel gas is thus 40 x 195 / 70.8 = 110 ppbV.

Table 5.1
Fuel Gas to and Corresponding Flue Gas from the GT

| Description | GT Fuel Gas | Combustion Air | NOx Steam | GT Flue Gas |
|---|---|---|---|---|
| Type | HP Med Btu Syngas | Ambient Air | ---- ---- | ---- ---- |
| **Heating Values:** | | | | |
| MMBtu/Hr (HHV) | 841 | 10 | 84 | 165 |
| MMBtu/Hr (LHV) | 767 | 0 | 0 | 0 |
| Btu/SCF(LHV) | 261 | 0 | 0 | 0 |
| **Gas Flow Rates & Properties:** | | | | |
| MMSCFD (1) | 70.5 | 458.4 | 40.6 | 546.2 |
| LB/Hr (1) | 167,300 | 1451,900 | 80,390 | 1,699,600 |
| Mole Wt | 21.6 | 28.9 | 18.0 | 28.3 |
| **Gas Composition, Vol%:** | | | | |
| $N_2$ + Ar | 6.8 | 78.3 | ---- | 66.5 |
| $O_2$ | ---- | 20.7 | ---- | 11.3 |
| $CO_2$ | 20.6 | ---- | ---- | 7.5 |
| Water | 0.1 | 1.0 | 100.0 | 14.7 |
| $H_2$ | 38.9 | ---- | ---- | ---- |
| $C_1$'s | 2.5 | ---- | ---- | ---- |
| $C_2$'s | 0.3 | ---- | ---- | ---- |
| $C_3$'s | 0.5 | ---- | ---- | ---- |
| $C_4$'s | 0.3 | ---- | ---- | ---- |
| $C_5$+'s | 0.3 | ---- | ---- | ---- |
| $H_2S$ | 110 ppbV (1) | ---- | ---- | ---- |
| CO | 29.7 | ---- | ---- | 5 ppmV |
| NOx | ---- | ---- | ---- | 4 ppmV |
| SOx | ---- | ---- | ---- | 14 ppbV (1) |
| Hydrocarbons | ---- | ---- | ---- | 1 ppmW |
| Particulates | ---- | ---- | ---- | 3 ppmW |
| **Estimated Pollutant Emission, Lbs/Hr:** | | | | |
| CO | 64,620 | ---- | ---- | 8 (3) |
| NOx | ---- | ---- | ---- | 11 (3) |
| SOx | ---- | ---- | ---- | 0.055 (1) |
| VOC | ---- | ---- | ---- | 1.8 (2) |
| Particulates | ---- | ---- | ---- | 5.6 (2) |

Notes:

(1) Assume all sulfur in the syngas feed to the FT Block is left in the GT fuel gas.
(2) Based on EPA AP-42 emission factors for uncontrolled natural gas fired GT.
(3) Based on GE's estimate of 3 ppmV for CO and 2.5 ppmV for NOx after SCR.

5.1.2 Hydrocracker Reactor Fired Heater Flue Gas Air Pollutants Emission

FT Hydrocracker reactor feed is preheated in a fired heater before enters the reactor. FT plant low-pressure (LP) offgases mixed with the PSA Hydrogen plant purge gas are burned as fuel in the HC reactor fired heater.

Table 5.2 is a listing of the flows and compositions of the fuel gas to, and the corresponding flue gas from the Hydrocracker (HC) reactor (Rx) fired heater.

Emissions of NOx, CO, VOC and PM are calculated based on fuel gas HHV per EPA AP-42 Section 1.4 (Natural gas fired heater less than 100 MMBtu/Hr). The emission rates will be calculated assuming uncontrolled natural gas fired heaters. The fuel gas fired in the HC Rx heater has a HHV of 20.7 MMBtu/Hr. Emissions based on the published EPA emission factors are:

| | | |
|---|---|---|
| CO | 0.0824 lbs/MMBtu (HHV) | 20.7 x 0.0824 = 1.7 Lbs/Hr |
| NOx | 0.098 lbs/MMBtu (HHV) | 20.7 x 0.098 = 2.0 Lbs/Hr |
| VOC | 0.0054 lbs/MMBtu (HHV) | 20.7 x 0.0054 = 0.11 Lbs/Hr |
| PM | 0.0075 lbs/MMBtu (HHV) | 20.7 x 0.0075 = 0.16 Lbs/Hr |

For SOx emissions, it is assumed that all of the sulfur in the Di-Methyl Di-Sulfide (DMDS) injection for sulfiding the HC catalysts will end up in the LP fuel gas. Maximum DMDS injection rate is estimated to be 1.0 liters/hr, which is 2.35 lbs/hr or 0.025 MPH. Total LP fuel gas burned is 2.88 MMSCFD, or 316 MPH. The maximum H2S content in the LP fuel gas is thus 2 x 0.025 / 316 x 1000000 = 158 ppmV.

Maximum SOx emission from burning LP fuel gas is thus 2 x 0.025 x 64 = 3.2 lbs/Hr as SO2. This rate is conservative since there are potential sulfur losses due to solubility in the liquids and irreversible reactions with the FT catalysts. Since 34.4% of the total LP fuel gas is burned in the HC Rx fired heater, SOx emission from the HC Rx fired heater is 3.2 x 0.344 = 1.1 lbs/Hr.

Table 5.2
Fuel Gas to and Corresponding Flue Gas from the HC Reactor Fired Heater

| Description | HC Rx Fired Htr Fuel Gas | Combustion Air | HC Rx Fired Htr Flue Gas |
|---|---|---|---|
| Type | LPMed Btu Syngas | Ambient Air | ---- ---- |
| Heating Values: | | | |
| MMBtu/Hr (HHV) | 20.7 | 0.10 | 1.6 |
| MMBtu/Hr (LHV) | 19.2 | 0 | 0 |
| Btu(LHV)/SCF | 467 | 0 | 0 |
| Gas Flow Rates & Properties: | | | |
| MMSCFD | 0.99 | 4.74 | 5.41 |
| LB/Hr | 2,300 | 15,000 | 17,300 |
| Mole Wt | 21.2 | 28.9 | 29.1 |
| Gas Composition, Vol%: | | | |
| $N_2$ + Ar | 3.1 | 78.3 | 68.9 |
| $O_2$ | ---- | 20.7 | 2.0 |
| $CO_2$ | 5.3 | ---- | 14.5 |
| Water | 0.6 | 1.0 | 14.6 |
| $H_2$ | 38.0 | ---- | ---- |
| $C_1$'s | 0.1 | ---- | ---- |
| $C_2$'s | 0.2 | ---- | ---- |
| $C_3$'s | 2.3 | ---- | ---- |
| $C_4$'s | 3.8 | ---- | ---- |
| $C_5$+'s | 1.2 | ---- | ---- |
| $H_2S$ | 158 ppmV (1) | ---- | ---- |
| CO | 45.4 | ---- | 102 ppmV |
| NOx | ---- | ---- | 73 ppmV |
| SOx | ---- | ---- | 29 ppmV (1) |
| Hydrocarbons | ---- | ---- | 6 ppmW |
| Particulates | ---- | ---- | 9 ppmW |
| Estimated Pollutant Emission, Lbs/Hr: | | | |
| CO | 1380 | ---- | 1.7 (2) |
| NOx | ---- | ---- | 2.0 (2) |
| SOx | ---- | ---- | 1.1 (1) |
| VOC | ---- | ---- | 0.11 (2) |
| Particulates | ---- | ---- | 0.16 (2) |

Notes:
(1) Assume all sulfur in the DMDS injection for HC catalyst sulfiding is left in the LP fuel gas.
(2) Based on EPA AP-42 emission factors for uncontrolled natural gas fired process furnaces.

### 5.1.3 Hydrocracker Fractionator Fired Heater Flue Gas Air Pollutants Emission

FT Hydrocracker (HC) fractionator feed is heated in a fired heater before being separated into diesel and naphtha products. FT plant low pressure (LP) offgases mixed with PSA Hydrogen plant purge gas are burned as fuel in the HC fractionator fired heater. In addition to burning LP fuel gas, the HC fractionator also serves to incinerate the small alcohol-contaminated overhead vent from the FT produced water stripper.

Table 5.3 is a listing of the flows and compositions of the LP fuel gas to, and the corresponding flue gas from the Hydrocracker (HC) fractionator (Fract) fired heater.

Emissions of NOx, CO, VOC and PM are calculated based fuel gas HHV per EPA AP-42 Section 1.4 (Natural gas fired heater less than 100 MMBtu/Hr). The emission rates will be calculated assuming uncontrolled natural gas fired heaters. The fuel gas fired in the HC Fract heater has a HHV of 39.5+1.29=40.8.0 MMBtu/Hr. Emissions based on the published EPA emission factors are:

| | | |
|---|---|---|
| CO | 0.0824 lbs/MMBtu (HHV) | 40.8 x 0.0824 = 3.4 Lbs/Hr |
| NOx | 0.098 lbs/MMBtu (HHV) | 40.8 x 0.098 = 4.0 Lbs/Hr |
| VOC | 0.0054 lbs/MMBtu (HHV) | 40.8 x 0.0054 = 0.22 Lbs/Hr |
| PM | 0.0075 lbs/MMBtu (HHV) | 40.8 x 0.0075 = 0.31 Lbs/Hr |

As discussed in the previous Hydrocracker reactor fired heater emission, maximum SOx emission from burning LP fuel gas is 3.2 lbs/Hr as SO2. Since 65.6% of the total LP fuel gas is burned in the HC fractionator fired heater, SOx emission from the HC fractionator fired heater is 3.2 x 0.656 = 2.1 lbs/Hr. And the maximum H2S content in the LP fuel gas is 158 ppmV.

Table 5.3
Fuel Gas to and Corresponding Flue Gas from the HC Fractionator Fired Heater

| Description | HC Fract Fired Htr Fuel Gas | FT Prod Water Strip Ovhd Vent | Combustion Air | HC Fract Fired Htr Flue Gas |
|---|---|---|---|---|
| Type | Med Btu Syngas | CO2 Rich Gas | Ambient Air | ---- ---- |
| Heating Values: | | | | |
| MMBtu/Hr (HHV) | 39.5 | 1.29 | 0.20 | 3.2 |
| MMBtu/Hr (LHV) | 36.6 | 1.25 | 0 | 0 |
| Btu(LHV)/SCF | 467 | 166 | 0 | 0 |
| Gas Flow Rates & Properties: | | | | |
| MMSCFD | 1.88 | 0.18 | 9.43 | 10.91 |
| LB/Hr | 4,390 | 780 | 29,880 | 35,040 |
| Mole Wt | 21.2 | 39.1 | 28.9 | 29.3 |
| Gas Composition, Vol%: | | | | |
| $N_2$ + Ar | 3.1 | ---- | 78.3 | 68.1 |
| $O_2$ | ---- | ---- | 20.7 | 2.0 |
| $CO_2$ | 5.3 | 69.9 | ---- | 15.5 |
| Water | 0.6 | 7.0 | 1.0 | 14.4 |
| $H_2$ | 38.0 | ---- | ---- | ---- |
| $C_1$'s | 0.1 | 1.0 | ---- | ---- |
| $C_2$'s | 0.2 | 0.5 | ---- | ---- |
| $C_3$'s | 2.3 | ----- | ---- | ---- |
| $C_4$'s | 3.8 | ----- | ---- | ---- |
| $C_5$+'s | 1.2 | ----- | ---- | ---- |
| $H_2S$ | 158 ppmV (1) | ----- | ----- | ---- |
| CO | 45.4 | 1.5 | ---- | 101 ppmV |
| NOx | ---- | ----- | ---- | 72 ppmV |
| SOx | ---- | ----- | ---- | 27 ppmV (1) |
| Hydrocarbons | ---- | 20.1 | ---- | 6 ppmW |
| Particulates | ---- | ----- | ---- | 9 ppmW |
| Estimated Pollutant Emission, Lbs/Hr: | | | | |
| CO | 2630 | 8.4 | ---- | 3.4 (2) |
| NOx | ---- | ----- | ---- | 4.0 (2) |
| SOx | ---- | ----- | ---- | 2.1 (1) |
| VOC | ---- | ----- | ---- | 0.22 (2) |
| Particulates | ---- | ----- | ---- | 0.31 (2) |

Notes:
(1) Assume all sulfur in the DMDS injection for HC catalyst sulfiding is left in the LP fuel gas.
(2) Based on EPA AP-42 emission factors for uncontrolled natural gas fired process furnaces.

5.1.4 SRU/TGU Thermal Oxidizer Exhaust Air Pollutants Emission

Tail gas from the SCOT tailgas treating unit, together with couple of low pressure small vents are incinerated with supplemental natural gas in a thermal oxidizer. The total HHV of these streams corresponds to the supplemental natural gas HHV, which is 10 MMBtu/Hr. Exhaust from the thermal oxidizer is estimated based on Texaco's September 2001 Type C Package heat and material balances modified for exporting the recovered CO2 streams from Rectisol.

Table 5.4 is a listing of the estimated flows and compositions of the thermal oxidizer exhaust.

Emissions of NOx, CO, VOC and PM are calculated based on fuel gas HHV per EPA AP-42 Section 1.4 (Natural gas fired heater less than 100 MMBtu/Hr). The emission rates will be calculated assuming uncontrolled natural gas fired heaters. Based on a thermal oxidizer firing of 10 MMBtu(HHV)/Hr, the estimated emissions using published EPA factors are:

| | | | |
|---|---|---|---|
| CO | 0.0824 lbs/MMBtu (HHV) | 10 x 0.0824 = | 0.83 Lbs/Hr |
| NOx | 0.098 lbs/MMBtu (HHV) | 10 x 0.098 = | 0.98 Lbs/Hr |
| VOC | 0.0054 lbs/MMBtu (HHV) | 10 x 0.0054 = | 0.05 Lbs/Hr |
| PM | 0.0075 lbs/MMBtu (HHV) | 10 x 0.0075 = | 0.08 Lbs/Hr |

Total sulfur in the thermal oxidizer exhaust is per Texaco's heat & material balance, and is given as 0.07 moles/Hr of SO2. This roughly represents a 99.8% sulfur recovery in the SRU/TGU plant. Therefore SOx emission from the SRU/TGU tailgas is 0.07 x 64 = 4.5 Lbs/Hr as SO2.

Table 5.4
Estimated Flow and Composition of Thermal Oxidizer Exhaust

| Description | Thermal Oxidizer Exhaust |
|---|---|
| Type | Flue Gas (1) |
| **Heating Values:** | |
| MMBtu/Hr (HHV) | 3.9 |
| MMBtu/Hr (LHV) | 0 |
| Btu(LHV)/SCF | 0 |
| **Gas Flow Rates & Properties:** | |
| MMSCFD | 10.3 |
| LB/Hr | 34,450 |
| Mole Wt | 30.4 |
| **Gas Composition, Vol%:** | |
| $N_2$ + Ar | 54.3 |
| $O_2$ | 2.0 |
| $CO_2$ | 25.5 |
| Water | 18.2 |
| $H_2$ | ---- |
| $C_1$'s | ---- |
| $C_2$'s | ---- |
| $C_3$'s | ---- |
| $C_4$'s | ---- |
| $C_5$+'s | ---- |
| $H_2S$ + COS | ---- |
| CO | 26 ppmV |
| NOx | 19 ppmV |
| SOx | 62 ppmV |
| Hydrocarbons | 1.5 ppmW |
| Particulates | 2.3 ppmW |
| **Estimated Pollutant Emission, Lbs/Hr:** | |
| CO | 0.83 (2) |
| NOx | 0.98 (2) |
| SOx | 4.5 |
| VOC | 0.05 (2) |
| Particulates | 0.08 (2) |

Notes:
(1) Per Texaco September 2001 gasification block H&M balance modified for exporting CO2.
(2) Based on EPA AP-42 emission factors for uncontrolled natural gas fired process furnaces.

5.1.5 Truck Loading Vent Thermal Incinerator Exhaust Pollutants Emission

Displaced vents from truck loading are incinerated with supplemental natural gas in a Vent Thermal Incinerator. The Vent Thermal Incinerator is sized to handle the total design vents from all truck loading stations, which totals 187 ACFM (equivalent to displacing 48,000 BPSD of naphtha plus diesel) with a HHV of 3.76 MMBtu/hr. Since the truck loading only operates part of the time in eight hours each day and for five days each week, the daily average tank truck loading should be equivalent to the daily average FT diesel plus naphtha production rate which is roughly 5013 BPSD.

Supplemental natural gas firing is assumed to be continuous at the design rate of 6.6 MMBtu(HHV)/hr during the loading period, which has a daily average firing of 6.6 x 8 x 5 / 24 /7 = 1.6 MMBtu(HHV)/hr.

Total daily average HHV of the displaced vent gas is estimated to be 3.76 x 5013 / 48000 = 0.4 MMBtu/hr. Total daily average HHV of displaced vapor plus supplemental natural gas is therefore 2.0 MMBtu/Hr.

Table 5.5 is a listing of the estimated average flows and compositions of the truck loading vent thermal incinerator exhaust.

Emissions of NOx, CO, VOC and PM are calculated based fuel gas HHV per EPA AP-42 Section 1.4 (Natural gas fired heater less than 100 MMBtu/Hr). The emission rates will be calculated assuming uncontrolled natural gas fired heaters. Based on a thermal incinerator firing of 2 MMBtu(HHV)/Hr, the estimated emissions using published EPA factors are:

| | | | |
|---|---|---|---|
| CO | 0.0824 lbs/MMBtu (HHV) | 2 x 0.0824 = | 0.16 Lbs/Hr |
| NOx | 0.098 lbs/MMBtu (HHV) | 2 x 0.098 = | 0.20 Lbs/Hr |
| VOC | 0.0054 lbs/MMBtu (HHV) | 2 x 0.0054 = | 0.01 Lbs/Hr |
| PM | 0.0075 lbs/MMBtu (HHV) | 2 x 0.0075 = | 0.02 Lbs/Hr |

Total sulfur in the truck loading vent thermal incinerator exhaust is equivalent to the total sulfur in the supplemental natural gas which is 10 grains/100 SCF or 160 ppmV as $H_2S$. Total sulfur content of the daily average fired natural gas is roughly 1,600,000 / 1035 /379.5 x 160 /1000000 = 0.0007 moles/hr. Therefore SOx emission from the truck loading vent thermal incinerator exhaust is 0.0007 x 64 = 0.05 Lbs/Hr as $SO_2$.

Table 5.5
Estimated Flow and Composition of Truck Loading Vent Thermal Incinerator Exhaust

| Description | Truck Loading Vent Thermal Incinerator Exhaust |
|---|---|
| Type | Flue Gas |
| **Heating Values:** | |
| MMBtu/Hr (HHV) | 1.0 |
| MMBtu/Hr (LHV) | 0 |
| Btu(LHV)/SCF | 0 |
| **Gas Flow Rates & Properties:** | |
| MMSCFD | 5.5 |
| LB/Hr | 17,100 |
| Mole Wt | 28.5 |
| **Gas Composition, Vol%:** | |
| $N_2$ + Ar | 75.1 |
| $O_2$ | 11.2 |
| $CO_2$ | 4.8 |
| Water | 8.9 |
| $H_2$ | ---- |
| $C_1$'s | ---- |
| $C_2$'s | ---- |
| $C_3$'s | ---- |
| $C_4$'s | ---- |
| $C_5$+'s | ---- |
| $H_2S$ + COS | ---- |
| CO | 10 ppmV |
| NOx | 7 ppmV |
| SOx | 1 ppmV |
| Hydrocarbons | 0.6 ppmW |
| Particulates | 1.2 ppmW |
| **Estimated Pollutant Emission, Lbs/Hr:** | |
| CO | 0.16 (2) |
| NOx | 0.20 (2) |
| SOx | 0.05 (1) |
| VOC | 0.01 (2) |
| Particulates | 0.02 (2) |

Notes:
(1) Estimated sulfur in supplemental natural gas.
(2) Based on EPA AP-42 emission factors for uncontrolled natural gas fired process furnaces.

5.1.6 Storage Tank Filling Displacement Vent Pollutants Emission

Displaced vents from internal floating roof storage tank filling are vented directly to atmosphere. Continuous average tank filling displacement is equal to the daily average FT diesel plus naphtha production rate of 5013 BPSD, or roughly 20 ACFM.

There are negligible emissions for NOx, CO, SOx and PM. The major pollutant is VOC. Based on four 23' diameter x 40' high naphtha storage tanks and four 39' diameter x 40' high diesel storage tanks, the estimated VOC emissions using EPA AP-42 (Internal Floating Roof Tank Emissions Report) method are:

| | | | | |
|---|---|---|---|---|
| Naphtha VOC | 536 lbs/year/tank | 536 x 4 / 7500 = | 0.286 | Lbs/Hr for 4 tanks |
| Diesel VOC | 102 lbs/year/tank | 102 x 4 / 7500 = | 0.054 | Lbs/Hr for 4 tanks |
| | | Total = | 0.34 | Lbs/Hr |

Table 5.6 is a listing of the estimated flows and compositions of the average tank filling displacement vent. Because breathing air vent is not included in Table 5.6 while breathing VOC losses is included, VOC concentration shown should be conservative.

Table 5.6
Estimated Flow and Composition of Average Tank Filling Displacement Vent

| Description | Tank Filling Vent | |
|---|---|---|
| Type | Air | |
| | | |
| **Heating Values:** | | |
| MMBtu/Hr (HHV) | --- | |
| MMBtu/Hr (LHV) | 0 | |
| Btu(LHV)/SCF | 0 | |
| | | |
| **Gas Flow Rates & Properties:** | | |
| MMSCFD | 0.3 | (1) |
| LB/Hr | 100 | |
| Mole Wt | 28.9 | |
| | | |
| **Gas Composition, Vol%:** | | |
| $N_2$ + Ar | 78.3 | |
| $O_2$ | 20.7 | |
| $CO_2$ | ---- | |
| Water | 1.0 | |
| $H_2$ | ---- | |
| $C_1$'s | ---- | |
| $C_2$'s | ---- | |
| $C_3$'s | ---- | |
| $C_4$'s | ---- | |
| $C_5$+'s | ---- | |
| $H_2S$ + COS | ---- | |
| CO | ---- | |
| NOx | ---- | |
| SOx | ---- | |
| Hydrocarbons | 1.5 | ppmw |
| Particulates | ---- | |
| | | |
| **Estimated Pollutant Emission, Lbs/Hr:** | | |
| CO | ---- | |
| NOx | ---- | |
| SOx | ---- | |
| VOC | 0.05 | (2) |
| Particulates | ---- | |

Notes:
(1) Average continuous tank filling displaced volume.
(2) Based on API RP-42 emission factors for internal floating roof storage tanks.

# Section 6 Phase I Task 5 – Market Analysis

TASK COMPLETED.

Purvin & Gertz, Inc. completed this task under a subcontract to Texaco. Final report was delivered to WMPI. The report contains sensitivity business information that WMPI would prefer not to report it in writing. Under an agreement, DOE can review the report and its findings with WMPI.

# Section 7 Phase I Task 6 – Preliminary Site Analysis

Under this task, WMPI will assess the site-specific project requirements to include:

- Raw material availability
- Site transportation accessibility
- Supporting utility services
- Land availability and cost
- Construction and skilled labor availability

As part of this Task 6, Nexant, with support from Bechtel personnel, helped with examining alternative modes of transporting large process vessels to the EECP site near the existing Gilberton cogen plant. Results were discussed in the July/September 2001 Quarterly Technical Progress Report. Sasol's slurry phase FT reactor is expected to be over 18 feet in diameter. Its dimensions and weight are important parameters governing how the vessel should be most cost effectively fabricated and transported to site.

A topical report, summarizing all Phase I, Task 6 activities is being drafted.

# Section 8  Project Management

## 8.1 BIWEEKLY PROJECT STATUS REPORT

Informal Biweekly Project Status Reports are transmitted to keep the DOE Project Manager updated of all work in progress.

## 8.2 PROJECT MILESTONE PLAN AND LOG

Project schedule and milestone were revised with concurrence from DOE on August 15, 2002 to re-prioritize the remaining work scope in anticipation of WMPI's submittal of a proposal in response to the DOE Clean Coal Power Initiative solicitation, as a means of advancing the WMPI EECP concept to project EPC (engineering, procuremtn and construction) and demonstration.  Figure 8.1 shows the revised project schedule.

Project Milestone Plan and Milestone Log are submitted on time as prescribed by the contract to keep DOE management informed of work-in-progress and accomplishments against major project milestones planned.

# Section 8 Project Management

Figure 8.1

# Section 9 Experimental

## EXECUTIVE SUMMARY

## 9.1 EXPERIMENTAL

## 9.2 RESULTS AND DISCUSSION

## 9.3 CONCLUSION

## 9.4 REFERENCE

NOT APPLICABLE - The current project is a design feasibility and economics study, leading to detailed engineering, construction and operation of an EECP plant. It's not a typical research and development (R&D) project where a topical report format described in this section applied. There was no experimental work performed. This section is included only to fulfill DOE's prescribed reporting format.

**List of Acronyms and Abbreviations**

| | |
|---|---|
| AGR | Acid Gas Removal |
| API | American Petroleum Institute |
| ASTM | American Standard Testing Methods |
| Bbls, bbls | Barrels |
| BEDD | Basic Engineering Design Data |
| BOC | British Oxygen Company |
| BOD | Biological Oxygen Demand |
| BOP | Balance Of Plant |
| BPD | Barrel Per Day |
| BFW | Boiler Feed Water |
| CFB | Circulating Fluidized Bed |
| COD | Chemical Oxygen Demand |
| CPI | Coalescing Plate Interceptor |
| DAF | Dissolved Air Floatation |
| DCS | Distributed Control System |
| DOE | U.S. Department of Energy |
| EECP | Early Entrance Co-Production Plant |
| ft | Feet |
| FT | Fischer-Tropsch |
| GPM | Gallons per Minute |
| GT | Gas Turbine |
| HC | Hydrocracking |
| HER | Heavy End Recovery |
| HHP | High High Pressure |
| HP | High Pressure, Horse Power |
| HRSG | Heat Recovery Steam Generator |
| I/O | Input/Output |
| IP | Intermediate Pressure |
| ISBL | Inside Battery Limits |
| KV | Kilo Volts |
| Lb/CF | Pounds per Cubic Feet |
| LCN | Logic Control Network |
| LHV | Lower-Heating Value |
| LP | Low Pressure |
| LTFT | Low-Temperature Fischer-Tropsch |
| LTGC | Low-Temperature Gas Cooling |
| MMSCFD | Million Standard Cubic Feet Per Day |
| MW | Mega Watt |
| NETL | National Energy Technology Laboratory |
| OSBL | Outside Battery Limits |
| OSHA | US Occupational Safety and Health Administration |
| PMCC | Pensky-Martens Closed Cup |
| PPM | Parts per Million |
| PSA | Pressure Swing Absorption |

PSIG, psig .................................................... Pounds per Squared Inch, gauge
PWU............................................................ Product Work Up
RD&T .......................................................... Research, Development & Testing
RON ............................................................. Research Octane Number
RVP.............................................................. Reid Vapor Pressure
SCFM........................................................... Standard Cubic Feet per Minute
SCR .............................................................. Selective Catalytic Reduction
SRU.............................................................. Sulfur Recovery Unit
STPD............................................................ Short Tons Per Day
SWS ............................................................. Sour Water Stripper
TGTU........................................................... Tail Gas Treating Unit
UBC ............................................................. Uniform Building Code
WMPI........................................................... Waste Processors Management, Inc.
Wt% ............................................................. Weight Percent