Section 1 Introduction and Summary

1.1 INTRODUCTION

WMPI, along with its subcontractors Texaco, 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

The main technical activities performed during the current reporting period include work in the following tasks.

- Phase I, Task 3 – System Technical Assessment
    - Feedstock Ash Fusion Temperature Evaluation
    - Preliminary EECP Plant Balances

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 a) Texaco – Gasification Design Package b) Sasol – FT Design Package c) Nexant – BOP and cost estimate
Task 2	Project Financing Plan	WMPI and Consultants
Task 3	EECP Test Plan	Nexant

- Phase I, Task 4 – Feasibility Study Design Package Development,
- Phase I, Task 5 – Market Analysis,
- Phase I, Task 6 – Preliminary Site Analysis
    - Assessment of FT Reactor Transport and Installation

Results and accomplishments of each are described in more detail in the following sections.

Section 2 Phase I Task 3 – System Technical Assessment

Under this task, critical design issues identified in Task 2 were assessed in more detail. Preliminary heat, material and utility balances were carried out, based on process performance estimates and utility demands from Texaco and Sasol for the gasification and FT synthesis section respectively, with an objective to establish an integrated process/utility model for future optimization trade-off analysis, and to provide preliminary emission data needed for Phase I Task 7 planning.

2.1 Ash Fusion Temperature Prediction for EECP Coal Feeds

Anthracite culm has high ash contents and the ash (rich in silicon and aluminum oxide) has a high fusion temperature. Both factors, left uncorrected, can have an adverse effect on the performance of Texaco's entrained, downflow slagging, gasifier. Thus the ash fusion temperature (along with its molten viscosity) is a major design parameter, and could strongly influence the EECP's technical and economic viability. Laboratory test data shows that the ash fusion temperature of the anthracite culm feed exceeds Texaco gasifier's normal operating temperature (about 2,500° F for quench mode operation), and addition of a flux material (fluxant) such as limestone will be needed to reduce the ash fusion temperature. Ability to estimate or predict the EECP feed ash fusion temperature and the amount of fluxant required for Texaco gasification operation is of importance.

The work performed in this period examines methods to estimate ash fusion temperatures for several feedstocks. The methodology is intended to facilitate selection of alternate blended feeds, and to provide guidelines for the amounts of flux material needed. The results from a review of empirical equations that correlate ash fusion (fluid) temperatures against ash compositions are reported. Empirical equations were identified as means to screen blends of feedstocks and flux materials for the EECP project.

2.1.1 Summary of Results and Applications

After an evaluation of about 100 samples and their ash composition vs. ash fusion temperature relationship, the Winegartner and Rhodes (WR) correlation is selected for estimating ash fusion temperatures (fluid temperature in a reducing atmosphere) for the EECP design study. It is recommended that 150°F be added to the WR estimated value to allow for uncertainty in the estimate.

Examples are provided below for the application of the WR correlations to predict the ash fusion fluid temperature as a function of limestone addition for the potential EECP feeds. The information may be used as part of the Phase I design, especially with respect to oxygen consumption, and to provide guidelines for limestone addition parameters as part of the Phase II RD&T activities. The examples are for the following feedstocks.

- 100% anthracite culm, ash fusion fluid temperature (AFFT) versus limestone addition.
- Blend of 75% anthracite culm with 25% petroleum coke, ash fusion fluid temperature versus limestone addition.

Figure 2-1 is a graph of the WR predicted ash fluid temperature (AFFT) versus the weight percent of limestone flux added to the 100% anthracite culm (20% by weight ash content). Two actual (WMPI measurements) data points, 100% anthracite culm and 95% anthracite culm with 5% limestone, are also shown. The flat portion of the curves are the minimum ash AFFT, approximately 2290° F with 13 to 26 weight percent limestone added, or the equivalent 1.34 to 0.57 ash-to-limestone weight ratio. Using a maximum 2520 °F gasification temperature and a 150° F uncertainty allowance for correlation inaccuracies, approximately 8% limestone (2.30 ash-to-limestone weight ratio) results in a AFFT of 2370° F.

Figure 2-2 is a similar plot for a 75% anthracite culm and 25% petroleum coke feed. The estimated ash fluid temperatures are graphed versus the weight percent limestone addition. A minimum AFFT is approximately 2290° F with 10 to 20 weight percent limestone added, or an equivalent 1.35 to 0.60 ash-to-limestone weight ratio. For a maximum 2520° F gasification temperature and a 150° F design allowance, approximately 6 percent by weight of limestone (2.35 ash-to-limestone weight ratio) gives an estimated AFFT of 2370° F.

Figure 2-1
100 % Anthracite Culm
Ash Fusion Fluid Temperature Versus Limestone Addition

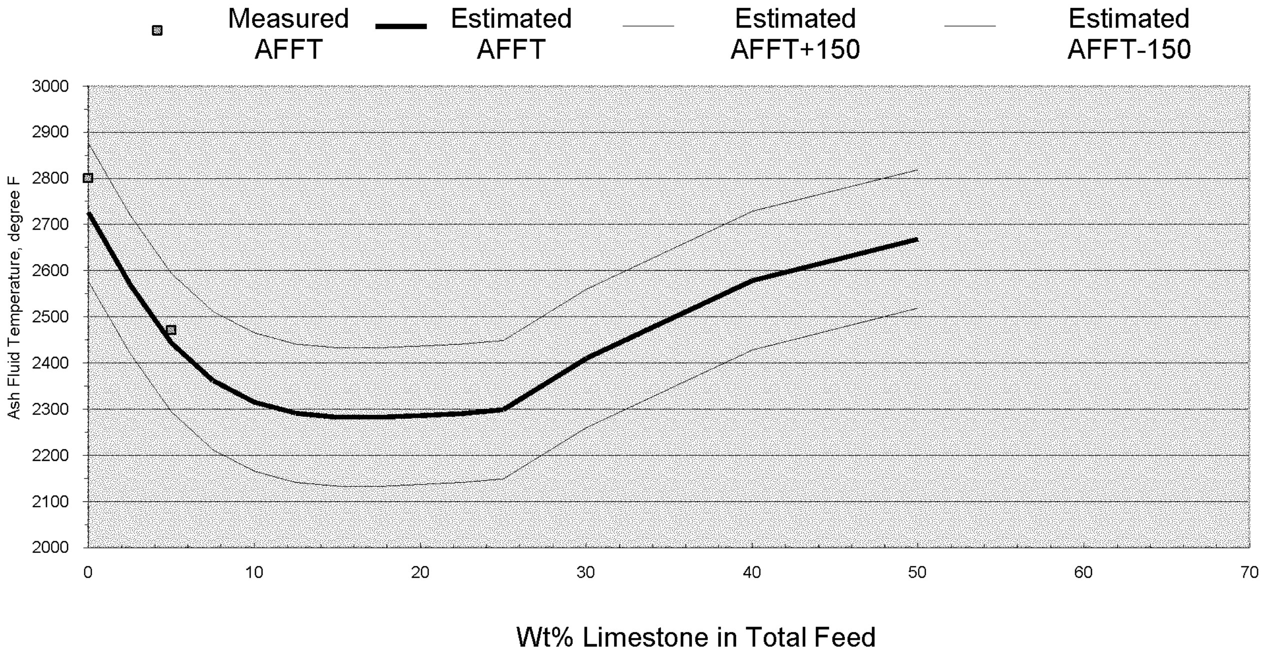
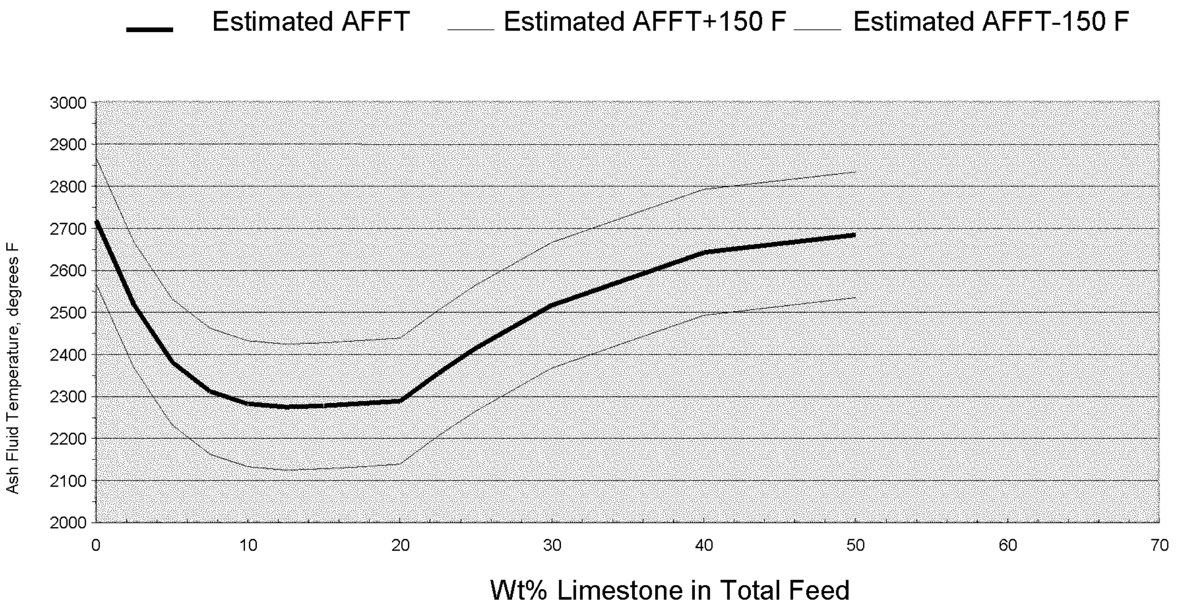
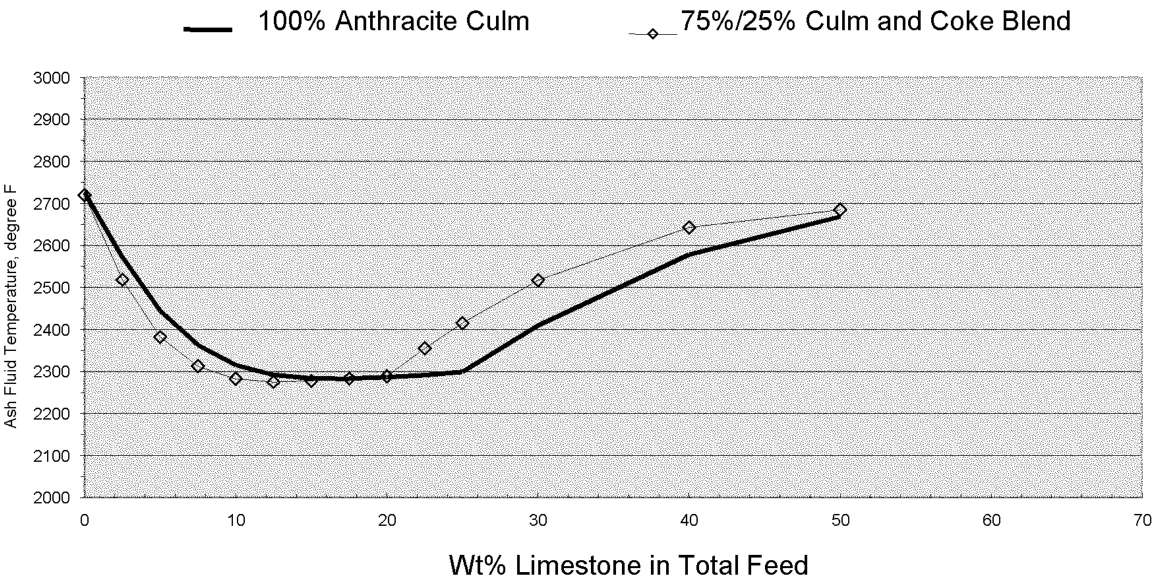


Figure 2-2
Blend of 75% Anthracite Culm plus 25% Petroleum Coke
Ash Fusion Fluid Temperature Versus Limestone Addition



It is noted that the anthracite culm and coke blend has a lower total ash content (15% by weight) than the 100% anthracite culm (20% by weight), and thus less limestone addition is anticipated for the blend. However, the ash to limestone weight percent ratio for the coal feed blend should be about the same for any given blend's AFFT. In Figures 2-1 and 2-2, the relative weight ratio of feed ash-to-limestone addition is about the same for the two different feeds at a given AFFT. Figure 2-3 superimposes the WR AFFT estimated ash fluid temperature versus limestone addition for 100% anthracite culm and for anthracite culm and petroleum coke blend. The offset lines reflect the feed ash content difference.

Figure 2-3
Comparison of 100% Anthracite Culm and Blend of Culm with Petroleum Coke
Ash Fusion Fluid Temperature versus Limestone Addition



2.1.2 Methodology Review and Ash Fusion Temperature Correlations

Ash fusion temperatures give an indication of the softening and melting behavior of fuel ash. Fusion temperatures at one time were quite subjectively measured, but this has been addressed by the development of automated techniques for performing the measurements. Fusion temperatures are valuable guides to the high-temperature behavior of the fuel's inorganic material. Fusion temperatures typically are measured at four defined points under both reducing and oxidizing conditions. These points are defined as follows.

- Initial deformation temperature (IT): This is the temperature at which the point of sample cone begins to round.
- Softening temperature (ST), sometimes called the spherical temperature, is defined as the point where the base of the cone is equal to its height.
- Hemispherical temperature (HT): The temperature at which the base of the cone is twice its height.
- Ash fusion fluid temperature (AFFT): The temperature at which the cone has spread to a fused mass no more than 1.6 mm in height.