QUARTERLY TECHNICAL PROGRESS REPORT NO. 25
FOR PERIOD
OCTOBER 1, 1994 THROUGH DECEMBER 31, 1994

DOE CONTRACT #DE-AC22-88PC88881
ICF KAISER ENGINEERS JOB NO. 88107

"This report was prepared as an account of work performed by ICF Kaiser Engineers under sponsorship of the United States Government. Neither the United States nor the United States Department of Energy, ICF Kaiser Engineers, its subcontractors, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately-owned rights. Reference herein to any specific commercial product, process, or service by trade name, mark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof."
TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Scope of this Document  
1.2 Overall Project Scope  
1.3 Work Executed at Different Locations  

2.0 TASK 2 PRELIMINARY CONCEPTUAL DESIGN

2.1 Overview and Scope  
2.2 Review of Work Completed This Quarter  

3.0 TASK 3 CRITICAL AREA DETERMINATION

3.1 Overview and Scope  
3.2 Review of Work Completed This Quarter  

4.0 TASK 4 TEST PLAN FORMULATION

4.1 Overview and Scope  
4.2 Review of Work Completed This Quarter  

5.0 TASK 5 BENCH-SCALE PROCESS TESTING

5.1 Overview and Scope  
5.2 Review of Work Completed This Quarter  

6.0 COMPONENT AND UNIT OPERATIONS DEVELOPMENT

6.1 Overview and Scope  
6.2 Review of Work Completed this Quarter  

7.0 EVALUATION OF BENCH-SCALE AND COMPONENT TEST RESULTS

7.1 Overview and Scope  
7.2 Work Complete this Quarter  

8.0 REVISED CONCEPTUAL DESIGN OF SEMI-WORKS PLANT

8.1 Overview and Scope  
8.2 Review of Work Completed this Quarter  

9.0 POC MODULE DESIGN

9.1 Overview and Scope  
9.2 Review of Work Completed this Quarter  

10.0 POC MODULE FABRICATION

10.1 Overview and Scope  
10.2 Review of Work Completed this Quarter  

168/DOE/QtlyRep/Oct-Dec.94
DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.
# TABLE OF CONTENTS

(continued)

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.0</td>
<td>POC INSTALLATION AND START-UP</td>
<td>14</td>
</tr>
<tr>
<td>11.1</td>
<td>Overview and Scope</td>
<td>14</td>
</tr>
<tr>
<td>11.2</td>
<td>Review of Work Completed this Quarter</td>
<td>14</td>
</tr>
<tr>
<td>12.0</td>
<td>POC TEST PLAN FORMULATION</td>
<td>15</td>
</tr>
<tr>
<td>12.1</td>
<td>Overview and Scope</td>
<td>15</td>
</tr>
<tr>
<td>12.2</td>
<td>Review of Work Completed this Quarter</td>
<td>15</td>
</tr>
<tr>
<td>13.0</td>
<td>POC OPERATION</td>
<td>16</td>
</tr>
<tr>
<td>13.1</td>
<td>Overview and Scope</td>
<td>16</td>
</tr>
<tr>
<td>13.2</td>
<td>Review of Work Completed this Quarter</td>
<td>16</td>
</tr>
<tr>
<td>14.0</td>
<td>POC OPERATIONS ANALYSIS</td>
<td>17</td>
</tr>
<tr>
<td>14.1</td>
<td>Overview and Scope</td>
<td>17</td>
</tr>
<tr>
<td>14.2</td>
<td>Review of Work Completed this Quarter</td>
<td>17</td>
</tr>
<tr>
<td>15.0</td>
<td>FINAL SEMI-WORKS CONCEPTUAL DESIGN</td>
<td>22</td>
</tr>
<tr>
<td>15.1</td>
<td>Overview and Scope</td>
<td>22</td>
</tr>
<tr>
<td>15.2</td>
<td>Review of Work Completed This Quarter</td>
<td>22</td>
</tr>
<tr>
<td>16.0</td>
<td>POC MODULE REMOVAL</td>
<td>23</td>
</tr>
<tr>
<td>16.1</td>
<td>Overview and Scope</td>
<td>23</td>
</tr>
<tr>
<td>16.2</td>
<td>Review of Work Complete This Quarter</td>
<td>23</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Project Organization Chart</td>
</tr>
</tbody>
</table>
## LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Task and the Responsible Team Member</td>
</tr>
<tr>
<td>14.1</td>
<td>Pittsburgh No. 8 Performance During Demonstration Run</td>
</tr>
<tr>
<td>14.2</td>
<td>Upper Freeport Performance During Demonstration Run</td>
</tr>
<tr>
<td>14.3</td>
<td>Illinois No. 6 Performance During Demonstration Run</td>
</tr>
</tbody>
</table>
1.0 INTRODUCTION

A study conducted by Pittsburgh Energy Technology Center of sulfur emissions from about 1,300 United States coal-fired utility boilers indicated that half of the emissions were the result of burning coals having greater than 1.2 pounds of SO₂ per million BTU. This was mainly attributed to the high pyritic sulfur content of the boiler fuel. A significant reduction in SO₂ emissions could be accomplished by removing the pyrite from the coals by advanced physical fine coal cleaning.

An engineering development project was prepared to build upon the basic research effort conducted under a solicitation for research into Fine Coal Surface Control. The engineering development project is intended to use general plant design knowledge and conceptualize a plant to utilize advanced froth flotation technology to process coal and produce a product having maximum practical pyritic sulfur reduction consistent with maximum practical BTU recovery.

1.1 Scope of this Document

The Department of Energy (DOE) awarded a contract entitled "Engineering Development of Advanced Physical Fine Coal Cleaning Technology - Froth Flotation", to ICF Kaiser Engineers with the following team members, Ohio Coal Development Office, Babcock and Wilcox, Consolidation Coal Company, Eimco Process Equipment Company, Illinois State Geological Survey, Virginia Polytechnic Institute and State University, Process Technology, Inc. The organizational chart for this project is presented in Figure 1.1.

This document a quarterly report prepared in accordance with the project reporting requirements covering the period from October 1, 1994 to December 31, 1994. This report provides a summary of the technical work undertaken during this period, highlighting the major results. A brief description of the work done prior to this quarter is provided in this report under the task headings.

1.2 Overall Project Scope

The overall project scope of the engineering development project is to conceptually develop a commercial flowsheet to maximize pyritic sulfur reduction at practical energy recovery values. This is being accomplished by utilizing the basic research data on the surface properties of coal, mineral matter and pyrite obtained from the Coal Surface Control for Advanced Fine Coal Flotation Project, to develop this conceptual flowsheet. The conceptual flowsheet must be examined to identify critical areas that need additional design data. This data will then be developed using batch and semi-continuous bench scale testing. In addition to actual bench scale testing, other unit operations from other industries processing fine material will be reviewed for potential application and incorporated into the design if appropriate.

The conceptual flowsheet will be revised based on the results of the bench scale testing and areas will be identified that need further larger scale design data verification, to prove out the design. The
Figure 1-1

Project Organization Chart

Department of Energy

ICF Kaiser Engineers (ICF KE)
Project Manager

Project Advisory Committee

Consolidation Coal Team Members
Technical Support

Process Technology
Process Design Evaluation

Babcock & Wilcox
Process Design Evaluation

ICF KE
Project Design Engineering
Project Procurement
Construction Mgmt.

VPI
Column Cell Optimization

EIMCO
Dewatering Clarification

Process Developers
Advanced Flotation Machine
proof-of-concept will be accomplished by designing, constructing, operating and testing a 2-3 ton per hour proof-of-concept plant. This plant will be designed for continuous operation and will include two consecutive 5 days, 24 hour per day runs on each of the three test coals to demonstrate process performance on a commercial basis.

The data from the basic research on coal surfaces, bench scale testing and proof-of-concept scale testing will be utilized to design a final conceptual flowsheet.

The economics of the flowsheet will be determined to enable industry to assess the feasibility of incorporating the advanced fine coal cleaning technology into the production of clean coal for generating electricity. This concept should provide an ability to reduce sulfur oxide emissions more economically than FGD systems when compared on a dollar per ton of sulfur removed basis.

1.3 Work Executed at Different Locations

The project team consists of research and engineering groups at ICF Kaiser Engineers, Babcock and Wilcox, Consolidation Coal Company, Eimco Process Equipment Company, Illinois State Geological Survey, Virginia Polytechnic Institute and State University, Process Technology, Inc. and Michigan Technological University Institute of Materials Processing with ICF Kaiser Engineers as the prime contractor with DOE. The work being conducted by different organizations is based upon their area of expertise and this has been incorporated into the project Work Plan. The work undertaken by the different organizations is identified in Table 1.1. This report is prepared in an integrated manner combining work done by each organization by task. This is considered to be a more effective way of presenting the technical data developed by each organization.

<table>
<thead>
<tr>
<th>Task Number</th>
<th>Task Description</th>
<th>Responsible Team Member</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Project Planning</td>
<td>ICF KE</td>
</tr>
<tr>
<td>2</td>
<td>Preliminary Conceptual Design</td>
<td>ICF KE, B&amp;W, EIMCO, TSG, TAC</td>
</tr>
<tr>
<td>3</td>
<td>Determination of Critical Areas</td>
<td>ICF KE, B&amp;W, EIMCO, TSG, TAC</td>
</tr>
<tr>
<td>4</td>
<td>Test Plan Formulation</td>
<td>ICF KE, B&amp;W, EIMCO, TSG</td>
</tr>
<tr>
<td>5</td>
<td>Bench Scale Testing</td>
<td>ICF KE, B&amp;W, EIMCO, PTI, TSG, TAC</td>
</tr>
<tr>
<td>6</td>
<td>Component Development</td>
<td>VPI, TSG</td>
</tr>
<tr>
<td>7</td>
<td>Analysis of Test Results</td>
<td>ICF KE, B&amp;W, EIMCO, VPI, TSG</td>
</tr>
<tr>
<td>8</td>
<td>Revised Conceptual Design</td>
<td>ICF KE</td>
</tr>
<tr>
<td>9</td>
<td>POC Module Design</td>
<td>ICF KE, B&amp;W, EIMCO, TSG, TAC</td>
</tr>
<tr>
<td>10</td>
<td>POC Procurement and Fabrication</td>
<td>ICF KE</td>
</tr>
<tr>
<td>11</td>
<td>POC Installation and Startup</td>
<td>ICF KE, B&amp;W, EIMCO, TSG</td>
</tr>
<tr>
<td>12</td>
<td>POC Test Plan Formulation</td>
<td>ICF KE, B&amp;W, EIMCO, TSG, TAC</td>
</tr>
<tr>
<td>13</td>
<td>POC Testing and Operation</td>
<td>ICF KE, B&amp;W, EIMCO, TSG</td>
</tr>
<tr>
<td>14</td>
<td>Analysis of POC Test Results</td>
<td>ICF KE, B&amp;W, EIMCO, TSG</td>
</tr>
<tr>
<td>15</td>
<td>Final Conceptual Design</td>
<td>ICF KE, B&amp;W, EIMCO, TSG</td>
</tr>
<tr>
<td>16</td>
<td>POC Module Removal</td>
<td>ICF KE</td>
</tr>
</tbody>
</table>
2.0 TASK 2 PRELIMINARY CONCEPTUAL DESIGN

2.1 Overview and Scope

The previous completion of this task resulted in the preliminary conceptual design of a 20TPH semi-works advanced froth flotation facility. The non-site-specific plant was designed using the best available information and technology to achieve continuous, steady-state process operation with 90% availability. The process plant is a fully instrumented, integrated, stand-alone facility. A greenfield site was assumed for the plant.

Throughout the project, the work was organized along a task/sub-task basis with each sub-task logically assigned to provide necessary information for the next sub-task, ultimately resulting in completion of the conceptual design. For Task 2, the first sub-task determined the design criteria needed to meet or exceed the advanced froth flotation process specifications. At completion, work under this sub-task provided information to design the flowsheet of the process, and provided an energy and material balance of all process streams. A list of all major process equipment was prepared and used as a basis for a factored estimate for the capital, operating and maintenance costs of the semi-works process and plant.

ICF Kaiser Engineers, assisted by the project sub-contractors and Technical Support Group, was responsible for the performance and completion of this task. This conceptual design is the basis for Tasks 3, 4, 5, and 6 and will be revised in Task 8 for use as a basis for the 2-3TPH POC module design in Task 9.

2.2 Review of Work Completed This Quarter

On August 15, 1989, DOE approved Task 1.2 as submitted. With this as a basis, ICF KE and the team members proceeded with the remainder of the project. No additional work was planned nor completed during this quarter.
3.0 TASK 3 CRITICAL AREA DETERMINATION

3.1 Overview and Scope

Work performed during the conceptual design of Task 2 identified areas where uncertainties exist in the design of the unit operations for the advanced froth flotation process. Some of these problem areas could not be solved based on currently available information or technology. The objective of this task was to determine those critical areas where more information would be necessary and outline the work needed to obtain the design information.

A design deficiency list was generated, and the project team determined the parameters needed for final design of the unit operation - either by further engineering analysis or by experimental data obtained from bench-scale tests. Other solids processing industries, such as phosphate and clay beneficiation, were examined to assess the means by which they effectively process ultra fine particles.

Each identified design deficiency was then ranked according to its relative importance to the successful continuous operation of the advanced froth flotation process. Both a technical and economic analyses of the consequences of not being able to gather the required design information for each deficiency was evaluated.

ICF Kaiser Engineers, Consolidation Coal and the other members of the Technical Support Team (B&W, VPI and EIMCO) have contributed to this task. The process deficiencies identified in this task will be addressed in Tasks 4, 5, and 6 through additional engineering computation and analysis and experimental techniques.

3.2 Review of Work Completed This Quarter

The final report of this task has been submitted to DOE. No additional work was planned nor completed during this quarter.
4.0 TASK 4 TEST PLAN FORMULATION

4.1 Overview and Scope

Work completed in this task produced the criteria for additional engineering analysis, computation and detailed experimental bench-scale testing for areas of uncertainty identified in Task 3. The engineering analysis, computation, bench-scale testing and component development was formulated to produce necessary design information to define a commercially operating system.

In order to produce the required information by means of bench-scale testing and component development, a uniform coal sample was procured. After agreement with DOE, a selected sample of coal from those previously listed was secured.

The test plan was developed in two parts. The first part listed procedures for engineering and computational analyses of those deficiencies previously identified that could be solved without bench scale testing. Likewise, the second part prepared procedures for bench-scale testing and component development for those deficiencies previously identified in Task 3.

The first part, engineering analysis and computation, provided for means of employing presently known theory from other industries to address deficiencies. This included examinations of literature and contacting proven experts and operating personnel in fields related to this deficiency. From the information gathered, engineering calculations will be utilized to resolve this type of deficiency.

The second part, bench-scale testing and component development, became necessary when the part one information was unavailable or when the theory had never been commercially applied. Justification for the test work was provided to show that technical data and process needs could only be obtained by test work and that the test work results would produce necessary information to define a commercially operating system.

The test work planned was based upon non-continuous and/or semi-continuous bench-scale units of general laboratory design and would include only those unit operations identified as deficiencies in Task 3.

The detailed, quantified tests addressed obtaining data necessary for solving problems uncovered in the deficiency review. Each identified deficiency had a plan developed to address the reason for the testing, the means for the test matrix to obtain results and the expected results. Each test plan established procedures, adhering as much as possible, to known and industry-acceptable procedures for sampling and data collection. Raw data collection would be reduced to minimize expenses and to better be able to compare results and obtain meaningful information, especially scale-up factors.
The Development Test Plan for both parts one and two contained schedules, manpower requirements, and resources necessary to obtain information to define a commercially available system.

The plan for use of the team members was developed to comply with the results of the DOE uniform coal sample procurement and storage procedures. The quantity of coal necessary for each testing program was calculated. A sample of all three of the referenced coals was to be obtained, preferably from the same source as the Surface Control contractor. This coal would be stored and handled as outlined in the coal procurement and storage plan. These procedures, when properly followed, should minimize physical and chemical changes to the raw coal.

4.2 Review of Work Completed This Quarter

The Task 4 Report was submitted to DOE as a final report. No additional work was planned nor completed during this quarter.
5.0 TASK 5 BENCH-SCALE PROCESS TESTING

5.1 Overview and Scope

The overall goal of Task 5, "Bench-Scale Process Testing" is to develop the necessary unit operation design and process performance data required to 1) reduce or eliminate the technical and engineering uncertainties of the preliminary 20TPH advanced location semi-works plant and 2) design, build and operate a 2-3 TPH advanced flotation POC module.

The unit operation performance and process design information required to support development of the advanced flotation process is being examined in a multi-tier program at B&W and Process Technology, Inc. Laboratory scale studies are being conducted in several key process areas - conventional precleaning of the raw coal, microgrinding of the pre-cleaned coal, advanced froth flotation of the fine coal and dewatering of the product streams. The results of these studies are then being used to guide small, semi-continuous and continuous testing of the key unit operations at approximately 100 lb/hr.

The bench-scale and semi-continuous process design evaluation test programs will provide detailed information for developing process material and energy balances. The material balance data will be used to correctly design and size the equipment for the POC module. The energy balance information will allow for estimation the cost effectiveness of the design.

The bench-scale test programs will also identify the optimum conditions for microgrinding the coal for maximum pyritic sulfur rejection in advanced flotation and the most promising advanced flotation technique which will then be integrated into the overall processing scheme. The 100 lb/hr test program will provide verification of the laboratory tests results and demonstration that these results can be scaled-up for application in the 20TPH semi-works plant design.

Both the bench-scale, semi-continuous and continuous process design evaluation tests will serve as critical reviews of the preliminary process flowsheet. Process deficiencies and limitations discovered in these programs will require modification of the original conceptual flowsheet. This information will aid in identifying solutions to the successful implementation of advanced flotation technology.

The bench-scale and process testing consists of eleven major subtasks performed over a period of 12 months.

5.2 Review of Work Completed This Quarter

This task has been completed and the results of this task are reported in the Task 7 report. No additional work was planned nor completed during this quarter.
6.0 COMPONENT AND UNIT OPERATIONS DEVELOPMENT

6.1 Overview and Scope

The Task 6 effort involves three main elements including column cell development, flotation circuit testing and flotation cell modeling. The work outlined is to research column designs and operation parameters in developing an optimized column flotation cell (OCFC) to meet the overall program objectives. The test results obtained through this effort will be evaluated against the results obtained from the round-robin test program in Task 5. Any design parameters or operating conditions that are unique with the round-robin test winner that were not evaluated as part of the optimized column development work will be reviewed and tested so as to incorporate all possible scenarios in presenting DOE with the best available flotation process for use in the 2 to 3 ton per hour POC.

Following development of the OCFC, various flotation circuit configurations will be evaluated determine the "best" circuit design for the 2 to 3 ton per hour POC. Single and multiple stage flotation, grab and run, rougher/scavenger/cleaner, etc., test circuits will be tested as part of this effort. Upon completion of this test work, the "best" possible flotation cell will have been tested in a number of possible flotation circuit designs to possibly provide the "best" flotation approach in meeting the design criteria.

In conjunction with the flotation test effort, model development work will be conducted to provide a tool in evaluating the various flotation circuit configurations and in predicting flotation performance. The model will be useful in selecting operating conditions in the POC and in evaluating the performance of the POC.

6.2 Review of Work Completed this Quarter

This task has been completed and the results of this task are reported in the Task 7 Report. No additional work was planned or completed during this quarter.
7.0 EVALUATION OF BENCH-SCALE AND COMPONENT TEST RESULTS

7.1 Overview and Scope

A bench-scale and component testing report was prepared and submitted to DOE after completing Task 5 and Task 6.

The report included the preparation, presentation and analysis of all the experimental data obtained in the bench-scale and component unit operations, development and testing. A comparison of the results obtained with the expected limitations and deficiencies that occurred from bench-scale testing was compiled.

Following the evaluation of the bench-scale and component testing results, a residual needs analysis was prepared. This was prepared after comparing results learned in Tasks 5 and 6 with the original residual needs analysis.

Finally, a bench-scale testing summary was prepared. It specifically addressed the results of the bench-scale component testing in respect to the information necessary to define a commercially operating system. This included equipment selection, sizing, evaluation and operation to achieve both coal cleaning as well as the cost of system operation.

7.2 Review of Work Completed this Quarter

This task has been completed and the Task 7 Report submitted to DOE in its final version. No additional work was planned or completed during this quarter.
8.0 REVISED CONCEPTUAL DESIGN OF SEMI-WORKS PLANT

8.1 Overview and Scope

Following DOE authorization to proceed with this task, the preliminary conceptual design of a 20TPH semi-works plant (Task 2) was redesigned from all information available at this point in the project. This update of the conceptual design incorporated information derived about fine grinding, advanced froth flotation, and dewatering in Tasks 5 and 6. The summary report produced in Task 7 describing bench-scale test results and component development was used as a basis.

This task complied with all of the design requirements discussed in Task 2. The process flowsheet was updated with complete energy and material balances for all process flowstreams. The equipment list was updated and supplied the base for a recalculation of the factored estimate of the capital, operating and maintenance costs. In addition, differences between the designs in Task 8 and Task 2 were highlighted and their effects on process and plant design credibility, efficiency, maintenance, operation, complexity, control, performance, and economics were discussed.

ICF Kaiser Engineers, with assistance from its sub-contractors and the Technical Support Group, were responsible for the completion of this task. This design will serve as a basis for the POC design in Task 9 and the final semi-works design in Task 15.

8.2 Review of Work Completed this Quarter

This task has been completed and a final report submitted to DOE. No additional work was planned or completed during this quarter.
9.0 POC MODULE DESIGN

9.1 Overview and Scope

In order to develop additional confidence in the conceptual design of the advanced froth flotation circuit, a 2-3 TPH Proof-of-Concept (POC) facility was necessary. During operation of this facility, the ICF KE team will demonstrate the ability of the conceptual flowsheets to meet the program goals of maximum pyritic sulfur reduction coupled with maximum energy recovery on three DOE specified coals. The POC circuit was designed to be integrated into the Ohio Coal Development’s facility near Beverly, Ohio.

OCDO’s facility will provide the precleaning unit operations and ICF KE will add the advanced froth flotation circuitry. The work in this task will include the POC conceptual design, flowsheet development, equipment list, fabrication and construction drawings, procurement specifications and bid packages and a facilities estimate at the completion of design. After DOE approval, the design was finalized for the next task.

9.2 Review of Work Completed this Quarter

This task has been completed and the Task 9 report submitted to DOE. No additional work was planned or completed during this quarter.
10.0 POC MODULE FABRICATION

10.1 Overview and Scope

The overall objective of this task is to obtain the equipment, materials and shop labor to fabricate and assemble each of the individual modules which constitute the POC Module. The ICF KE procurement team will solicit bids, place orders, and expedite all vendors, materialmen and fabricators. Procurement will utilize the drawings and specifications produced in Task 1.9 as the basis for these activities. At the completion of the assembly procedure, a ICF KE representative will inspect and perform a functional check of each module before it leaves the shop.

Several sub-tasks have been identified for their importance in the successful completion of this task. Work will include placing purchase orders, procurement of the equipment and materials, fabrication of the modules, functionally checking the modules, shipping the modules to the jobsite and preparing the installation and maintenance manuals.

10.2 Review of Work Completed this Quarter

This task has been completed. No additional work was planned or completed during this quarter.
11.0 POC INSTALLATION AND START-UP

11.1 Overview and Scope

This task covers the functions necessary to install and successfully start-up the POC module at the jobsite. The installation was carried out by an installation subcontractor with construction management provided by ICF KE. The start-up was supervised by ICF KE and conducted using process engineers from the entire team and craft labor supplied by the installation subcontractor.

This task includes several major subtasks which was carried out to assure a successful, on-schedule installation and start-up. ICF KE will conduct work on installation and interconnection of the modules, preparation of start-up plans and procedures, the start-up functions and the finalization of the operations manual.

DOE's TPO was kept informed of construction progress and has access to the site for inspection of the work. ICF KE's construction manager was assigned prior to the start of construction activities and maintained the job progress through on-site assessment of the work and was using the construction schedule produced in Task 9 for control.

11.2 Review of Work Completed this Quarter

All construction has been completed. No additional work was planned or completed during this quarter.
12.0  POC TEST PLAN FORMULATION

12.1  Overview and Scope

The project team will coordinate its expertise and develop a testing plan that will provide performance data, quality data, scale-up data and operating data. The plan was submitted to DOE for approval after completion of Tasks 9 and 10.

This plan, after approval/revisions, will become the final test plan. The test plan will include long term testing, steady-state operation and effects of recycle operation. The testing program will demonstrate 90% onstream capability, evaluate process control instrumentation, develop information for scale-up, demonstrate compliance with regulatory requirements, evaluate materials of construction, and determine process economics. Ancillary information such as quality of waste stream materials was gathered.

The finalized plan will include a budget and schedule to complete all required tests and to produce batches of material for testing of beneficiated coal.

12.2  Review of Work Completed this Quarter

This Task has been completed. No additional work was planned or completed during this quarter.
13.0 POC OPERATION

13.1 Overview and Scope

This task is the actual demonstration of the advanced froth flotation technology. All previous work has led to this task. ICF KE technicians and process engineers from the team will operate the plant over a 10 month period to demonstrate the capability of the technology to remove 85% of the pyritic sulfur from three different test coals while covering at least 85% of the as-mined coal's energy content.

Six major subtasks have been included to better define the overall work scope for this task. The ICF KE team will test the Pittsburgh #8 seam, the Illinois #6 seam and the Upper Freeport seam; the team will operate the circuit in a continuous run; the team will analyze all samples generated in those runs and will develop a plan to store and dispose of the coal and refuse products.

All laboratory data generated will be accessible to all team members and the DOE. The TPO will be notified of all run days in advance for the purpose of planning his trips to the site. Sufficient time will be allowed in the test plan, developed in Task 12, to permit quick analysis of data generated from a completed test before continuing to the next test.

13.2 Review of Work Completed This Quarter

This Task has been completed. No additional work was planned or completed during this quarter.
14.0 TASK 14 POC OPERATIONS ANALYSIS

14.1 Overview and Scope

The completion of this task will result in a complete analysis of the results from all the test runs on all of the coals cleaned in the POC module. The work will include, in an organized and readily accessible manner, all available laboratory data and operating results from the Advanced Flotation technology. The information will be utilized to generate results that will be compared to the batch and semi-continuous results with respect to quality and equipment design parameters. This information will then be used for the Final Conceptual Design of the 20 TPH semi-works facility. The results will be contained in a formal POC Testing Summary Report.

14.2 Review of Work Completed This Quarter

As stated above, the Task 14 report resulted in a complete analysis of the results from all the test runs on all the coals processed in the POC module. This quarterly report will highlight the results from the three seams of coal tested in the POC, Pittsburgh No. 8, Upper Freeport, and Illinois No. 6 during the demonstration operation.

The following paragraphs are the executive summary of the Task 14 Report. For additional details, please refer to the Task 14 Report in its entirety.

The primary objective of the Proof-of-Concept (POC) testing was to demonstrate 85 weight percent Btu recovery with 85 weight percent pyritic sulfur rejection on the Pittsburgh No. 8, Upper Freeport, and Illinois No. 6 coal seams based on the run-of-mine coal quality. Results obtained from the POC operations were used to:

- verify, on a larger and continuous basis, the findings of the bench scale testing;
- resolve any remaining design deficiencies related to the advanced froth flotation process;
- finalize the conceptual design for a 20 TPH Semi-Works plant.

All three coals were tested with minus 200 mesh material as feed to the column flotation cell. Precleaning was conducted on all three coal seams with the heavy-media cyclone and water-only cyclone circuits maximized, if possible, to recover 97 percent (± 1 percent) of their size fraction Btu value.

The POC plant was constructed as an addition to the State of Ohio's John P. Apel Ohio Testing and Development Center (OCTAD) located near McConnelsville, Ohio. A separate bay was added to OCTAD to house additional equipment required for the POC module. Additionally, modifications were made to the OCTAD equipment and process streams to accommodate the POC plant.
The POC flowsheet was configured such that crushed raw coal (1/4" x 0) was pumped to a deslime sieve/screen combination for sizing at 48 mesh. The plus 48 mesh material was mixed with media and pumped to a 15-inch diameter heavy-media cyclone (HMC). After recovering the magnetite, the HMC refuse was dewatered and reported to the refuse conveyor while the HMC clean coal was crushed to 48 mesh by zero in a cagepactor crusher. The cagepactor product combined with the natural 48 mesh by zero raw coal from the deslime screen underflow and reported to two six-inch diameter, water-only cyclones. Water-only cyclone underflow or refuse reported to the refuse thickener while the cyclone's overflow, or product, reported to the classifying cyclones. The classifying cyclone underflows (48 mesh by 200 mesh) reported to a 6-feet diameter ball mill with the ball mill product reporting back to the classifying cyclones. The classifying cyclone overflow consisting of crushed 200 mesh by zero material from the ball mill and precleaned 200 mesh by zero from the water-only cyclones, reported to an advanced column flotation cell. The refuse from the column flotation cell reported to the refuse thickener for thickening, and then was pumped to a refuse impoundment. The clean coal from the column flotation cell was thickened in a clean coal thickener and then reported to a solid bowl centrifuge for final dewatering before exiting the POC plant.

The Pittsburgh No. 8 seam coal was the primary coal used for POC operations. Because of the ambitious test plan established for POC operations, certain tests could only be performed with one coal, and the results of these specific tests were used to guide investigators regarding the other two coals. The Pittsburgh No. 8 seam was used to verify the heavy-media cyclone and water-only cyclones orifice configurations. Additionally, a 16-point, resolution IV fractional factorial experiment was conducted using this seam to determine the best aeration rate, washwater rate, and frother type at which to operate the column flotation cell for all three coals. Results from the factorial experiment indicated that MIBC frother should be used throughout the remainder of POC operations with the column operating at an aeration rate of 140 SCFM and a washwater rate of 100 gallons per minute.

With the frother type, aeration rate and washwater rate determined for the column flotation cell, a Box-Behnken test matrix was conducted to determine gas hold-up rate, collector dosage, and feed rate for each coal. For the Pittsburgh No. 8 seam coal, the results of the Box-Behnken test matrix indicated that a gas hold-up rate of 24 percent, a collector dosage of 1.0 lb/ton, and a column feed rate of 2.0 TPH produced the best operating conditions for the column flotation cell. Specifically, the test data indicated that a clean coal concentrate was obtained at a 75 percent ash rejection, a 35 percent pyritic sulfur rejection, and a 95 percent Btu recovery. Based on the feed to the column, the total plant pyrite rejection was 73.5% with a Btu recovery of 89.5%.

For both the Upper Freeport and Illinois No. 6 seam coals, the results of the Box-Behnken test matrices indicated that a gas holdup rate of 21 percent, a collector dosage of 1.0 lb/ton, and a column feed rate of 2.0 TPH produced the best operating conditions for the
column flotation cell. For the Upper Freeport seam, the test data indicated that a 50 percent ash rejection, a 38 percent pyritic sulfur rejection, and a 90 percent Btu recovery could be obtained, based on column feed. The Illinois No. 6 seam test data indicated that a 28 to 35 percent pyritic sulfur rejection with a 90 to 95 percent energy recovered could be achieved, based on column feed. The total plant pyrite rejection was 76.2% and 79.3% for Upper Freeport and Illinois No. 6 respectively. The Btu recovery was 87.5% and 85.8% for Upper Freeport and Illinois No. 6 respectively.

After completing the Box-Behnken matrix for each of the three coals, all equipment was configured, and all parameters were set at determined values to conduct the 24-hour demonstration tests. The Pittsburgh No. 8 seam was processed for four days during both the first and second weeks of the demonstration run. Both the Upper Freeport and Illinois No. 6 seams were processed for five days during both the first and second weeks of the demonstration runs. During the 24-hour demonstration runs, a complete set of samples were collected every eight hours for all the pertinent circuits in operation. Tables 14.1, 14.2, and 14.3 present the data for the average of all eight-hour sampling periods for the Pittsburgh No. 8, Upper Freeport, and Illinois No. 6 coal seams.

### Table 14.1
**Pittsburgh No. 8 Performance During Demonstration Run**

<table>
<thead>
<tr>
<th>% Ash</th>
<th>Plant Feed</th>
<th>Plant Clean Coal</th>
<th>Plant Refuse</th>
</tr>
</thead>
<tbody>
<tr>
<td>46.05</td>
<td>7.65</td>
<td>81.77</td>
<td></td>
</tr>
<tr>
<td>2.90</td>
<td>2.50</td>
<td>3.27</td>
<td></td>
</tr>
<tr>
<td>2.04</td>
<td>1.12</td>
<td>2.90</td>
<td></td>
</tr>
<tr>
<td>7,329</td>
<td>13,618</td>
<td>1,479</td>
<td></td>
</tr>
<tr>
<td>100.00</td>
<td>26.50</td>
<td>73.50</td>
<td></td>
</tr>
<tr>
<td>100.00</td>
<td>89.50</td>
<td>10.50</td>
<td></td>
</tr>
</tbody>
</table>

### Table 14.2
**Upper Freeport Performance During Demonstration Run**

<table>
<thead>
<tr>
<th>% Ash</th>
<th>Plant Feed</th>
<th>Plant Clean Coal</th>
<th>Plant Refuse</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.18</td>
<td>10.29</td>
<td>59.63</td>
<td></td>
</tr>
<tr>
<td>4.41</td>
<td>2.30</td>
<td>9.80</td>
<td></td>
</tr>
<tr>
<td>3.20</td>
<td>1.06</td>
<td>8.66</td>
<td></td>
</tr>
<tr>
<td>11,048</td>
<td>13,456</td>
<td>4,902</td>
<td></td>
</tr>
<tr>
<td>100.00</td>
<td>23.80</td>
<td>76.20</td>
<td></td>
</tr>
<tr>
<td>100.00</td>
<td>87.50</td>
<td>12.50</td>
<td></td>
</tr>
</tbody>
</table>
As can be seen from Tables 14.1 - 14.3, all three coals had energy recoveries above the project goal of 85 percent. None of the three coals achieved the project's pyritic sulfur rejection goal of 85 percent. However, all three coals approached this goal with the Pittsburgh No. 8, Upper Freeport and Illinois No. 6 achieving pyritic sulfur rejections of 73.5 percent, 76.2 percent, and 79.3 percent, respectively.

The plant availability was excellent for all three coals during the demonstration runs. The plant availability for the Pittsburgh No. 8 seam coal was 98.0 percent. The Upper Freeport seam coal's availability was 97.4 percent, and the plant availability for the Illinois No. 6 seam coal was 89.9 percent. The overall plant availability for all three seams was 94.9 percent.

The POC also tested the removal of trace elements from the raw coal. Coal cleaning can play a significant role in the control of air toxic emissions for coal-fired electric generating stations. As commercially practiced today, coal cleaning is primarily used to reduce the amount of ash and sulfur dioxide emissions for most coal feed sources. However, another unquantified and unadvertised benefit from coal cleaning is the reduction of trace elements that occurs from removing ash-forming minerals from the coal prior to combustion. In this study, the additive effect of conventional coal cleaning combined with advanced column flotation is evaluated as a control technology for hazardous air pollutant reduction.

During the 24-hour demonstration runs as part of the proof-of-concept testing of an advanced column flotation technology, samples of the feed, clean coal, and refuse products were taken to quantify the ability of conventional coal cleaning and advanced froth flotation to remove trace elements from three major domestic coal seams: Pittsburgh No. 8, Upper Freeport, and Illinois No. 6. On an individual basis, the rejections of the following trace elements are reported in this study: antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, fluorine, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, thallium, thorium, tin, uranium, vanadium, and zinc. In addition, the reduction of total trace element concentration is reported for each coal source.

### Table 14.3
**Illinois No. 6 Performance During Demonstration Run**

<table>
<thead>
<tr>
<th></th>
<th>Plant Feed</th>
<th>Plant Clean Coal</th>
<th>Plant Refuse</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Ash</td>
<td>34.49</td>
<td>7.20</td>
<td>72.08</td>
</tr>
<tr>
<td>% Total Sulfur</td>
<td>4.27</td>
<td>3.00</td>
<td>6.02</td>
</tr>
<tr>
<td>% Pyritic Sulfur</td>
<td>2.41</td>
<td>0.86</td>
<td>4.55</td>
</tr>
<tr>
<td>Btu Per Pound</td>
<td>9,162</td>
<td>13,574</td>
<td>3,084</td>
</tr>
<tr>
<td>% of Raw Coal's Pyrite</td>
<td>100.00</td>
<td>20.70</td>
<td>79.30</td>
</tr>
<tr>
<td>% of Raw Coal's Energy</td>
<td>100.00</td>
<td>85.80</td>
<td>14.20</td>
</tr>
</tbody>
</table>
For the Pittsburgh No. 8 Seam coal, significant rejections in excess of 60% were observed for all trace elements analyzed. For some trace elements, such as arsenic, barium, cadmium, cobalt, chromium, copper, fluorine, lithium, manganese, nickel, lead, tin, thorium, thallium, uranium, vanadium and zinc, rejections of 80% and above were achieved. Due to the high ash content of the raw coal source, more than half of this rejection was achieved by coarse coal cleaning. After extensive additional grinding, advanced coal cleaning contributed an additional 20% to 30% rejection in most cases. Overall, more than 83% of the total ash was rejected along with nearly 91% of the total trace element weight.

For the Upper Freeport Seam coal, the overall total rejections were not as significant. However, the ash content of the raw coal source in this case was significantly lower than the other two coal sources. As a result, the expectations for overall ash and trace element removal should be lower. In fact, over 61% of the ash was rejected in the POC demonstration runs along with nearly 70% of the total trace element weight. In addition, significant rejections for all trace elements except for beryllium (24%) and vanadium (34%) occurred. More than half of the total rejection for most elements was achieved by advanced coal cleaning. On the other hand, more than half of the total rejection for arsenic, mercury, lead, thallium, and uranium occurred by coarse coal cleaning. Perhaps this indicates a preferential association between certain elements and ash-forming mineral matter.

The results for the Illinois No. 6 Seam coal were similar to the Pittsburgh Seam results. Nearly 80% of the total ash was rejected along with over 88% of the total trace element weight. Significant rejections in excess of 60% were observed for all trace elements analyzed and rejections were above 80% for the following individual trace elements: arsenic, barium, cadmium, chromium, copper, fluorine, manganese, nickel, antimony, selenium, thallium, and zinc. For most elements, coarse coal cleaning contributed a greater proportion of the total rejection than advanced coal cleaning.

For all three coals tested, a general linear relationship between ash rejection and trace element rejection has been shown. This observation is in general agreement with other studies on the subject matter. In addition, the additive effect of conventional coal cleaning combined with advanced froth flotation allowed for high trace element rejections to be achieved by physical coal cleaning processes. The combined ability of these technologies to result in high trace element rejections was enhanced where the amount of ash in the parent coal was high.

For additional information, refer to Topical Report No. 5.
15.0 TASK 15 FINAL SEMI-WORKS CONCEPTUAL DESIGN

15.1 Overview and Scope

At the completion of this task, a conceptual design for a 20 TPH semi-works facility will be available. The design will be based on all knowledge gained previously in Tasks 5, 6, and 13. The work in this task will be primarily concerned with updating the conceptual design that was available in Task 8 with results of the POC scale-up operations from Task 13. Further, the team will project the design to a 200 TPH commercial facility and provide a conceptual estimate of the capital and operating costs for that facility.

The task will include several deliverables - the final report, design drawings for the semi-works plant, a detailed capital cost estimate of the semi-works plant and a preliminary conceptual estimate for the commercial plant.

15.2 Review of Work Completed This Quarter

During this quarter, work began on the Final Report.
16.0 TASK 16 POC MODULE REMOVAL

16.1 Overview and Scope

This task involves removing the POC module from the host facility, restoring the site, and protecting and shipping all Contractor-procured government property to PETC.

In decommissioning the process equipment, strict adherence to removing process reagents and contaminants and to capping and blanking all openings on the POC module and OCDO host facility interfaces. All government property will be protected from environmental damage prior to and during shipment to PETC. All DOE and OCDO host facility property will be restored to its condition prior to the start of Task 11.

16.2 Review of Work Completed This Quarter

The DOE/PETC and OCDO reached a Personal Property Loan Agreement concerning the DOE equipment. This equipment will be used by OCDO in conducting future additional coal preparation research at the test site.

No additional work was planned or completed during this quarter.