QUARTERLY TECHNICAL PROGRESS REPORT 10
JANUARY - MARCH, 1995

**ENGINEERING DEVELOPMENT OF ADVANCED PHYSICAL
FINE COAL CLEANING FOR PREMIUM FUEL APPLICATIONS**

Prepared for
U. S. Department of Energy
Pittsburgh Energy Technology Center
Pittsburgh, Pennsylvania 15236

By
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DOE Contract No. DE-AC22-92PC92208
Amax R&D Project No. 91455

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April 27, 1995 We have no objection from a patent
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TABLE OF CONTENTS

Section	Page
ABSTRACT.....	1
EXECUTIVE SUMMARY	2
INTRODUCTION AND BACKGROUND	12
SPECIFIC OBJECTIVES OF THE PROJECT	12
APPROACH	13
Phase I.....	13
Phases II and III.....	14
Phase IV	14
ACCOMPLISHMENTS DURING QUARTER.....	19
TASK 3 DEVELOPMENT OF NEAR-TERM APPLICATIONS.....	19
Subtask 3.2 Engineering Development	19
Subtask 3.3 Dewatering Studies.....	20
TASK 4 ENGINEERING DEVELOPMENT OF ADVANCED FROTH FLOTATION.....	20
Subtask 4.2 Process Optimization Research.....	21
Subtask 4.3 Advanced Flotation - CWF Formulation Studies	21
Subtask 4.4 Bench-Scale Testing and Process Scale-up	22
Combustion Test Work - Combustion Engineering	22
Combustion Test Work - The Pennsylvania State University.....	23
Toxic Trace Elements.....	24
TASK 5 DETAILED DESIGN OF PDU AND ADVANCED FLOTATION MODULE.....	24
Detailed Design Package	24
Equipment Drawings.....	25
Fine Grinding Mill	25
Water and Reagent Usage Estimates	26
TASK 6 ENGINEERING DEVELOPMENT OF SELECTIVE AGGLOMERATION.....	26
Subtask 6.3 Process Optimization Research.....	26
Subtask 6.4 CWF Formulation Studies	27
Subtask 6.5 Bench-Scale Testing and Process Scale-up	27
Test Plan	27
Design	27
Construction	29
Agglomeration Unit Testing.....	29

TABLE OF CONTENTS (Cont'd)

Section	Page
TASK 8 PDU AND ADVANCED COLUMN FLOTATION MODULE	35
Subtask 8.2 PDU Construction	35
Solicitation and Award of PDU Construction Subcontract	35
TIC Construction Activities	36
Procurement of PDU Capital Equipment	37
Refurbishing of Existing PDU Equipment	37
Assembly of Spare Parts List	39
Procurement of Electrical Engineering Consultation Services	39
Transformer Installation	40
Procurement of Permits for PDU Construction	40
Process Control Meeting with Bechtel	40
On-Line Ash Analysis of Microcel™ Flotation Column	40
Selection/Procurement of Control and Data Acquisition System	41
Equipment Hold Points / Shop Inspections	41
PLANS FOR NEXT QUARTER	42
REFERENCES	43

LIST OF FIGURES

Figure	Page
Figure 1. Project Management Organization Chart.....	15
Figure 2. Project Schedule	17
Figure 3. Laboratory Microcel™ Flotation of Lady Dunn Slurry	20
Figure 4. Bench-Scale Agglomeration Process Flow Diagram.....	28

List of Tables

Table	Page
Table 1. Outline of Work Breakdown Structure.....	16
Table 2. Test Coals Selected for Project.....	21
Table 3. Washed Coal Samples Sent to Combustion Engineering	22
Table 4. Column Flotation Samples Sent to Combustion Engineering.....	23
Table 5. Quality of Indiana VII Coal Produced for Penn State E&FRC	23
Table 6. Approved Vendor Equipment Drawings	25
Table 7. PDU Reagent Usage and Inventory Estimates.....	26
Table 8. Status of Capital Equipment Procurement	38
Table 9. Existing Equipment Items for Reconditioning.....	39

ABSTRACT

The primary goal of this project is the engineering development of two advanced physical fine coal cleaning processes, column flotation and selective agglomeration, for premium fuel applications. The project scope includes laboratory research and bench-scale testing on six coals to optimize these processes, followed by design, and construction of a 2-t/hr process development unit (PDU). The PDU will then be operated to generate 200 ton lots of each of three project coals, by each process. The project began in October, 1992 and is scheduled for completion by June, 1997.

During Quarter 10 (January - March, 1995), preliminary work continued for the Subtask 3.2 in-plant testing of the Microcel™ flotation column at the Lady Dunn Preparation Plant. Towards this end, laboratory flotation testing and refurbishing of the column have been started. The final version of the Subtask 4.2 Advanced Flotation Process Optimization Research topical report was issued, as was a draft version of the Subtask 4.3 report discussing the formulation of coal-water slurry fuels (CWF) from advanced flotation products.

A number of product samples from Subtask 4.4 testing were sent to both Combustion Engineering and Penn State for combustion testing. The evaluation of toxic trace element analyses of column flotation products also continued. The detailed design of the 2 t/hr PDU was essentially completed with the approval of various process flow, plant layout, electrical, and vendor equipment drawings.

The final version of the Subtask 6.5 - Selective Agglomeration Bench-Scale Design and Test Plan Report was issued during this reporting quarter. Design and construction of this 25 lb/hr selective agglomeration test unit was completed and preliminary testing started. Construction of the 2 t/hr PDU began following the selection of TIC - The Industrial Company as the construction subcontractor.

EXECUTIVE SUMMARY

This project is a major step in the Department of Energy's program to show that ultra-clean coal-water slurry fuel (CWF) can be produced from selected coals and that this premium fuel will be a cost-effective replacement for oil and natural gas now fueling some of the industrial and utility boilers in the United States, as well as for advanced combustors currently under development.

The replacement of oil and gas with CWF can only be realized if retrofit costs are kept to a minimum and retrofit boiler emissions meet national goals for clean air. These concerns establish the specifications for maximum ash and sulfur levels and combustion properties of the CWF.

This multi-year cost-share contract started on October 1, 1992. This report discusses the technical progress made during the 10th quarter of the project from January 1 to March 31, 1995.

SPECIFIC OBJECTIVES OF PROJECT

The project has three major objectives:

- The primary objective is to develop the design base for prototype commercial advanced fine coal cleaning facilities capable of producing ultra-clean coals suitable for conversion to coal-water slurry fuel for premium fuel applications. The fine coal cleaning technologies are advanced column flotation and selective agglomeration.
- A secondary objective is to develop the design base for near-term application of these advanced fine coal cleaning technologies in new or existing coal preparation plants to efficiently process minus 28-mesh coal fines and convert them to marketable products in current market economics.
- A third objective is to determine the removal of toxic trace elements from coal by advance column flotation and selective agglomeration technologies.

APPROACH

The project team consists of Cyprus Amax Minerals Company through its subsidiaries Amax Research & Development Center (Amax R&D) and Cyprus Amax Coal Company (Midwest and Cannelton Divisions), Arcanum Corporation, Bechtel Corporation, Center for Applied Energy Research (CAER) of the University of Kentucky, Center for Coal and Mineral Processing (CCMP) of the Virginia Polytechnic Institute and State University, and The Industrial Company (TIC). Entech Global manages the project for Amax R&D and provides research and development services. Dr. Douglas Keller of Syracuse

University and Dr. John Dooher of Adelphi University are both consultants to the project.

The project effort has been divided into four phases which are further divided into eleven tasks, including coal selection, laboratory and bench-scale process optimization research, and design, construction, and operation of a 2 ton/hr process development unit (PDU). Tonnage quantities of the ultra-clean coals will be produced in the PDU for combustion testing by DOE. Near-term applications of advanced cleaning technologies to existing coal preparation plants is also being studied.

ACCOMPLISHMENTS DURING QUARTER

Activity continued during the January - March 1995 quarter on Phases I and II of the project, Tasks 3 through 8, as described below.

Task 3 Development of Near Term Applications

Based on a 1993 Bechtel engineering analysis evaluating potential applications for column flotation and selective agglomeration, economic projections favored column flotation. A column flotation application at the Lady Dunn Preparation Plant was found to be particularly attractive since the plant was already being considered for a major capacity expansion. Because of the potential advantages of installing column flotation rather than mechanical flotation cells in the expanded fine coal cleaning circuit, Lady Dunn management was pleased to offer their plant as the study site for a near-term application of column flotation. The Microcel™ flotation column was selected for this study and the Center for Coal and Mineral Processing (CCMP) at Virginia Tech was assigned the responsibility for the Subtask 3.2 Engineering Development test work. Subtask 3.3 "Dewatering Studies" has been added to the project. This work will also be performed by CCMP.

Subtask 3.2 Engineering Development

As a result of several meetings, it has been determined that the in-plant testing will be carried out utilizing a 30-inch diameter column. As such, an existing column is being refurbished prior to installation. The column will be shipped to Lady Dunn for installation during April, allowing the in-plant testing to begin in May.

Preliminary laboratory tests, carried out in a 2-inch diameter column using Lady Dunn flotation feed slurry, indicate that a 7 to 8 percent ash clean coal can be produced at about 80 percent combustible material recovery. While additional testing will determine optimum cleaning performance, it has already been determined that a 21-foot column height is sufficient for this application, and that the feed slurry solids concentration is high enough that the column will not be hydraulically overloaded. As such, column capacity will be limited by the clean coal carrying capacity.

Task 4 Engineering Development of Froth Flotation

Task 4 is divided into five subtasks. Subtasks 4.1 Grinding and 4.5 Conceptual Design of the PDU and Advanced Froth Flotation Module have been completed and were reported during previous quarters. There was activity on each of the three remaining subtasks during the tenth quarter of this project.

Subtask 4.2 Process Optimization Research

The Subtask 4.2 Topical Report was issued on March 15, 1995, after review by team members. As described last quarter, the general conclusions were that all five of the bituminous coals responded quite well to column flotation. The residual ash and heating value recovery specifications were met for the Taggart, Sunnyside, and Elkhorn No. 3 coals, but the specifications may need to be relaxed for the Indiana VII and Winifrede coals because of the fine grinding needed in order to liberate the ash minerals in these two coals. It was recommended that both the Ken-Flote™ and the Microcel™ columns be examined during the Subtask 4.4 bench-scale testing.

Subtask 4.3 CWF Formulation Studies

The topical report covering Subtask 4.3 slurry formulation testing was completed during this reporting quarter. A DRAFT version of this report was issued to DOE and other project partners for review on March 3, 1995. This report was also sent to the newest project team member, Dr. John Dooher of Adelphi University. Dr. Dooher has been retained as a consultant for the Subtask 6.4 test work, Selective Agglomeration CWF Formulation. In this capacity, he is to provide comments on the Subtask 4.3 report.

Subtask 4.4 Bench-Scale Testing and Process Scale-up

Subtask 4.4 efforts this quarter were directed toward preliminary combustion testing of the three PDU test coals and toxic trace element analyses of advanced flotation products.

Combustion Test Work - Combustion Engineering - Ten coal samples were sent to Combustion Engineering of Windsor, Connecticut, for combustion test work. These samples represent the five bituminous coals being evaluated under this Premium Fuels Project. A washed coal sample along with a sample cleaned by advanced column flotation was furnished for each of the five coals.

Combustion Test Work - The Pennsylvania State University - Indiana VII coal was procured and cleaned in the 12-inch Microcel™ column for combustion testing at Pennsylvania State University's Energy and Fuels Research Center. A total of fifteen drums of clean coal filter cake was shipped to Penn State for completion of this work.

Toxic Trace Elements - The reduction in toxic trace element concentration accomplished during column flotation will be determined for each of the five bituminous coals. Trace element analyses will be performed for each coal on products from tests where good flotation performance was accomplished.

Head samples of raw and washed test coals were analyzed for the eleven toxic trace elements during 1993, the results of which were reported in the 4th Quarterly Report. These results indicated that the analytical procedures utilized were not sensitive enough to quantify the amounts of certain trace elements in the coals. For this reason, five samples from Subtask 4.4 testing were submitted to two independent laboratories to determine if one laboratory could offer improved sensitivity over the other.

The two laboratories used different methods for decomposing the coal samples and analyzing the solutions. For the most part, the first laboratory decomposed the samples by a variation of ASTM ashing methods and analyzed the solutions by atomic absorption spectroscopy. In contrast, the second laboratory utilized perchloric acid decomposition and inductively coupled plasma spectroscopy for solution analyses. Since a comparison of results indicated that the second laboratory did offer lower detection limits for certain elements (antimony, beryllium, cobalt and lead), this laboratory's analyses will be used to determine reductions in toxic trace element concentrations by column flotation.

Task 5 Detailed Design of PDU and Advanced Flotation Module

Detailed Design Package

The DRAFT Detailed Design Package was submitted to DOE on March 23, 1995. The document prepared by Bechtel contains process flow diagrams (PFDs), piping and instrument diagrams (PIDs), plant layout, and electrical drawings for the selective grinding, column flotation, and product dewatering areas of the PDU. These drawings were approved by Entech Global, issued for construction, and incorporated into the contract bid package which was sent to prospective construction subcontractors.

Equipment Drawings

During this reporting quarter, equipment drawings were received from a number of vendors and approved by both Bechtel and Entech Global engineers. While the bulk of these drawings represented various process sumps and tanks, drawings for the following additional equipment were also approved:

- Bin activator
- Screw conveyor
- Fine grinding mill

- Fine sizing screens
- Microcel™ flotation column
- Tailings thickener

Fine Grinding Mill

During the month of January, sound level testing was performed on a Netzsch LME-500 mill (identical to the unit which will be installed in the PDU). It was found that the dBA readings directly at the rear of the machine exceed the 85 dBA maximum requirement stated in the Request for Quotation. As such, Netzsch will install a sound insulation panel at the rear of the machine.

Because previous testing has shown that elemental metal concentrations in coal slurries may increase when ground with steel media, an evaluation is being conducted to determine the effects of media type on metal contamination. Two media types, steel and glass, are being evaluated. Samples of washed coal will be ground for selected time periods with each media. If this testing indicates that the metal concentration of the ground slurry is lower when using glass than steel, the glass shot may be utilized in the PDU's fine grinding mill. This testing commenced during this reporting quarter and is expected to be concluded during the upcoming quarter.

Water and Reagent Usage Estimates

A measurement was made of the make-up water available to the PDU. The proposed 2-inch make-up water line located near the existing electrical junction box was tapped and a flow determination made. Overall, approximately 67 gpm is available at a static pressure of 70 psi. This should be adequate for the PDU operation.

An estimate of anticipated PDU reagent usage rates was carried out. The reagents, their expected usage rates, and the maximum anticipated inventory were estimated to determine any environmental implication for the site. None was predicted.

Task 6 Engineering Development of Selective Agglomeration

Task 6 is divided into six subtasks. Subtasks 6.1 Agglomerating Agent Selection, 6.2 Grinding Studies, and 6.6 Conceptual Design of the Selective Agglomeration PDU Module have been completed and were reported during previous quarters. There was activity on each of the three remaining subtasks during the tenth quarter with work focusing on Subtask 6.3 Laboratory-scale Process Optimization Studies and the Subtask 6.5 Agglomeration Bench-scale Unit.

Subtask 6.3 Process Optimization Research

Work began on the Subtask 6.3 topical report during this reporting quarter. This report will summarize all testing carried out as part of this subtask and a draft will be issued during the next reporting quarter. This report will include the results of test work comparing pentane and heptane as well as low-oil comparison studies. Also included in this report will be the effects of pH adjustment and activators on the agglomeration of the subbituminous Dietz coal and the Indiana VII coal. Finally, the results of continuous testing in the 50 gram/minute unitized agglomeration reactor for each of the six coals, and the results of two-stage agglomeration for two of the coals will also be reported.

Subtask 6.4 CWF Formulation Studies

The final version of the Subtask 6.4 Test Plan was issued to DOE and other project partners during the previous reporting quarter. Discussions were held with Joel Morrison of Penn State concerning similar slurry formulation work being carried out there. Dr. John Dooher of Adelphi University was retained as a consultant for the Subtask 6.4 test work. In this capacity he has reviewed the Subtask 4.3 topical report and provided us with some general recommendations for the Subtask 6.4 test work. His expertise will be especially useful in evaluating our slurry feed coal's volumetric packing capabilities. In addition, he will provide guidance on rheological testing, data analysis, and atomization criteria development.

Subtask 6.5 Bench-Scale Testing and Process Scale-up

Comments were received concerning the Subtask 6.5 Preliminary Design and Test Plan draft report issued during the last reporting quarter. These comments were incorporated and the final test plan issued to DOE and other project partners on January 31, 1995. This document discusses the selective agglomeration process in general along with the design of the continuous bench scale unit. In addition, it presents the test plan to be utilized during Subtask 6.5 testing.

Design and construction of the 25-lb/hr selective agglomeration bench-scale unit was completed during this reporting quarter. Utilizing the Taggart coal (62 mesh tosize grind) as feed, a variety of conditions were tested to evaluate the operability of both the agglomeration and steam stripping sections of the test unit. Based on this testing, the following comments, observations, and conclusions have been made concerning the various unit operations.

Feed System - The agglomeration circuit coal feed system was found to operate well with no plugging problems experienced to date. While the coal feed was found to remain relatively constant over time, a variation of approximately 5% was observed from the beginning to the end of several runs.

High Shear - The high-shear reactor was found to achieve inversion over a wide range of feed conditions including coal feed rates of 25, 50, and 75 lb/hr. Generally, it appears that a minimum of approximately 20% heptane (dry-ash-free coal basis) is required to achieve inversion during high-shear for the Taggart coal. More heptane (up to 25%) is needed to achieve growth during low shear.

Low Shear - Due to the failure of the low-shear motor during initial testing, subsequent testing utilized an air-powered motor for low shear. While this motor works well, its speed fluctuates considerably as a function of both the available air pressure and the amount of coal in the low-shear reactor. This varying rpm is believed to attribute to observed inconsistencies in low shear product size and the phenomenon of cyclic discharge from the vessel. Depending on the impeller tip speed, low shear residence time, and heptane concentration utilized, the low shear product varies in size from approximately 0.5 mm to 5 mm.

Vibrating Screen - Vibrating screen recovery of the low-shear product has proven successful with only minimal blinding of the 48-mesh screen deck occurring. It was found that the screen water spray is too strong, degrading the agglomerates and increasing the amount of coal in the tailings. Since it is anticipated that this phenomenon will be reduced as more consistent and stronger agglomerates are generated, the screen has been operated without spray water and provided a product of approximately 1.5% ash. Spray nozzles with a finer (misting) spray will be located for future testing. The screen product moisture content has been found to vary depending on the size of the agglomerates, with the smallest product estimated to contain about 60% coal, 25% water, and 15% heptane. In contrast, the larger agglomerated product (3-5 mm) is estimated to contain 70% coal, 17.5% heptane, and 12.5% water. These estimates will be confirmed with further testing and analysis.

Stripper Circuit Feed - Difficulty encountered in feeding agglomerated product to the steam stripper was resolved when the Moyno pump was replaced with a peristaltic pump. Upon stripper start-up, it was found that the agglomerates were very difficult to mix in the feed drum, with a constant layer of agglomerates remaining floating on the surface. As such, a more powerful mixer with larger impellers has been ordered to improve this mixing.

Steam Stripper - Initial stripper testing utilized a packed bed of 5/8" pall rings approximately 24-inches high. Feed entered the stripper about 2-inches above the top of the pall rings and the slurry level was maintained just below the pall rings (6 inches above the stripper discharge). In this scenario (continuous steam phase), it was found that the incoming agglomerates were held up at the top of the pall rings while their associated water drained to the vessel discharge. As such, the upper portion of the column filled with agglomerates and plugged the feed line. After several attempts, an inconsistent coal discharge was obtained from the vessel. In an effort to improve stripper operability, less pall rings were utilized, the slurry level in the column was raised, and a vent was added to the discharge line to prevent product siphoning. These

changes provided a more consistent discharge from the stripper column, but product surging still occurred.

Future plans for testing of the steam stripper include operating the vessel flooded, i.e., with a slurry level near the feed inlet point. In this scenario, the column would contain a continuous slurry phase with steam bubbling through it. The pall rings (probably a much smaller volume) would then be used to help distribute the flow of steam across the column. This arrangement will allow testing of various slurry residence times in the stripper to help define those conditions necessary to generate an acceptable product. The process of determining heptane content in the stripped product has been initiated through discussions with Huffman laboratories of Golden, CO.

Condenser - Operation of the condenser (which appears to have sufficient capacity) has proceeded smoothly. During typical operations to date, the stripper vapor product averages about 203 °F and the condensate about 50 °F. It has been found that under certain stripper operating conditions, some coal has been carried over into the condenser.

Gravity Separator - Once condensed, the water and heptane mixture enters the center of the gravity separator column. This separator has worked well with the water/heptane interface easily observed. Utilizing a U-tube discharge of the water from the bottom of the separator, steady-state operation has been achieved in which consistent flows of both water from the bottom and heptane from the top occur. Preliminary analysis of this recovered heptane indicates that it is virtually identical in composition to the fresh heptane. Analysis of water samples taken from the separatory column indicate a total volatile organic content of approximately 8 ppm, indicating minimal solubility of the heptane in water at the temperature of these condensed liquids.

Task 8 PDU and Advanced Column Flotation Module

The majority of the work effort for this task was directed to the solicitation and award of the PDU construction subcontract. In addition, work continued on the inspection and evaluation of existing DOE equipment transferred from Wilsonville and slated for use in the PDU.

Subtask 8.2 PDU Construction

Solicitation and Award of PDU Construction Subcontract - Request for Quotation (RFQ) packages for the construction of the PDU were issued to several companies and three bid packages were received. After careful review of the quotation packages, Amax R&D awarded the construction subcontract to TIC - The Industrial Company of Steamboat Springs, CO. TIC mobilized onto the PDU site March 27, 1995.

Procurement of Capital Equipment - Entech Global personnel continued the procurement of capital equipment for use in the PDU. During the first quarter of 1995,

RFQ packages for 20 equipment items were issued. Award packages, were also issued for 23 capital equipment items, while 20 equipment items were received during the quarter.

Refurbishing of Existing Equipment - During this quarter, 13 used equipment items were identified as requiring refurbishing and/or reconditioning. Eight units have been inspected and corrective actions identified. The remaining five units will be inspected during the next reporting quarter.

Assembly of Spare Parts List - A spare parts list has been assembled and is currently being evaluated for short listing. Only wear items that are most likely to fail during the first year of operation will be purchased. The short list is expected to be complete during the upcoming quarter when spare parts ordering will also commence.

Procurement of Electrical Engineering Consultation Services - In order to expedite the construction of the PDU, as well as to aid in the procurement of all electrical equipment and control instrumentation, Mr. Robert Reynouard, P.E. has been retained to provide electrical engineering consultation services.

Transformer Installation - Information regarding the proposed installation of a new 1,500 kVA transformer was sent to Public Service Company of Colorado. This information included the proposed location of the unit and a motor list with total expected loads. They are currently reviewing this information.

Procurement of Permits for PDU Construction - Two copies of the civil/structural drawings were delivered to the Jefferson County Planning Department, who reviewed, approved, and forwarded the drawings to the Building Department. After initial review, the Building Department requested that the prints be stamped by a Colorado Professional Engineer. The prints, which are being reviewed by Bechtel's staff engineers, should be stamped during the first week of April.

Process Control Meeting with Bechtel - A meeting between Bechtel and Entech Global engineers was held at Bechtel's San Francisco office to discuss and update the PDU process control scheme. Provisions were made to eliminate remote hand station starting of the PDU equipment and replace with single point start-up via the process controller. In addition, the interlock sequence was finalized.

On-Line Ash Analysis of Microcel™ Flotation Column - In order to control clean coal quality and monitor yield, tests are currently being conducted to evaluate the possibility of using on-line ash probes to determine the ash content of the Microcel™ feed, clean coal, and tailings streams. Nalco Chemical Company of Naperville, Illinois, is currently supplying many coal producers with on-line ash analyzers to monitor and control flotation circuits. Feed, tailings, and clean coal samples for the Sunnyside, Taggart, and Indiana VII coals were collected and shipped to Nalco's Richlands, Virginia, laboratory. Nalco will compare ash probe values with actual laboratory values.

If successful, Nalco has agreed to rent three probes to Amax R&D for use in the PDU's flotation circuit.

Selection and Procurement of Control and Data Acquisition System (CDAS) - After careful evaluation, Honeywell has been selected to supply and deliver a Control and Data Acquisition System for use in the PDU. Honeywell will supply a S9000 controller along with a SCAN3000 computer data acquisition unit. The S9000 controller is object oriented while the SCAN3000 unit utilizes UNIX based windows. Because of the unit's simplicity, Entech Global personnel can perform a considerable amount of the configuring and programming resulting in substantial cost savings.

Equipment Hold Points / Shop inspections - Inspection of the Enviro-Clear Tailings Thickener was conducted on February 14, 1995, at GECO Steel Company, Calgary, Alberta, Canada. Overall, the unit was in very good condition and a release for shipment was granted.

INTRODUCTION AND BACKGROUND

The main purpose of this project is the engineering development of advanced column flotation and selective agglomeration technologies for premium fuel applications. Development of these technologies is an important step in the Department of Energy (DOE) program to show that ultra-clean fuel can be produced from selected United States coals and that this fuel will be a cost-effective replacement for a portion of the oil and natural gas burned by electric utility and industrial boilers in this country, as well as for advanced combustors currently under development. Capturing even a relatively small fraction of the total utility and industrial oil-fired boiler fuel market would have a significant impact on domestic coal production and reduce national dependence on petroleum fuels. Significant potential export markets also exist in Europe and the Pacific Rim for cost-effective premium fuels prepared from ultra-clean coal.

The replacement of oil and natural gas with CWF can only be realized if retrofit costs and boiler derating are kept to a minimum. Also, retrofit boiler emissions must be compatible with national clean air goals. These concerns establish the specifications for the ash and sulfur levels and combustion properties of ultra-clean coal discussed below.

This multi-year cost-shared contract effort began on October 1, 1992, and is scheduled for completion by June 30, 1997. This report discusses the technical progress made during the tenth quarter of the project, January 1 to March 31, 1995. Nine quarterly reports have been issued previously [1-9].

SPECIFIC OBJECTIVES OF THE PROJECT

The three major objectives of this project are discussed below.

The primary objective is to develop the design base for prototype commercial advanced fine coal cleaning facilities capable of producing ultra-clean coals suitable for conversion to stable, highly loaded coal-water slurry fuels. These slurry fuels should contain less than 2 lb ash/MBtu HHV (860 grams ash/gigajoule) but preferably less than 1 lb ash/MBtu HHV (430 grams ash/gigajoule), and less than 0.6 lb sulfur/MBtu HHV (258 grams sulfur/gigajoule). The advanced fine coal cleaning technologies to be employed are advanced column froth flotation and selective agglomeration. Operating conditions during the advanced cleaning processes should recover at least 80 percent of the heating value in run-of-mine source coals at an annualized cost of less than \$2.50/MBtu (\$2.37/gigajoule), including the mine mouth cost of the raw coal.

A secondary objective of the work is to develop a design base for near-term commercial applications of these advanced fine coal cleaning technologies. These applications should be suitable for integration into new or existing coal preparation plants for the purpose of economically and efficiently processing minus 28-mesh coal fines. The

design base will also include the auxiliary systems required to yield a shippable, marketable product such as a dry clean coal product.

A third objective of the work is to determine the distribution of toxic trace elements between clean coal product and refuse during the cleaning of various coals by advanced froth flotation and selective agglomeration technologies. Eleven toxic trace elements have been identified. They are antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, and selenium. The results will show the potential for removing these toxic trace elements from coal by advanced physical cleaning.

APPROACH

A team headed by Amax Research & Development Center (Amax R&D) was formed to accomplish the project objectives. Figure 1 shows the project organization chart. Entech Global, Inc. is managing the project for Amax R&D and also performing laboratory research and bench-scale testing. Entech Global will also be responsible for the operation and evaluation of the 2 t/hr process development unit (PDU). Cyprus Amax Coal Company is providing operating and business perspective, the site for the near-term testing, and some of the coals being used in the program. Bechtel Corporation is providing engineering and design capabilities, and the operating experience it gained while managing similar proof-of-concept projects for DOE. The Center for Applied Energy Research (CAER) at the University of Kentucky and the Center for Coal and Mineral Processing (CCMP) at the Virginia Polytechnic Institute and State University are providing research and operating experience in the column flotation area. Arcanum Corporation is providing similar experience in the selective agglomeration area, while Dr. Douglas Keller of Syracuse University is serving as a consultant in the area of selective agglomeration, and Dr. John Dooher of Adelphi University is serving as a consultant in the area of coal-water slurry formulation. Recently TIC was awarded a subcontract for construction of the PDU and R. Reynourd was retained as a consultant to help with electrical and instrumentation systems.

The overall engineering development effort has been divided into four phases with specific activities as discussed below. As shown in Table 1, Work Breakdown Structure, the four phases of the project have been further divided into tasks and subtasks, with specific objectives which may be inferred from their titles. Subtask 3.3 Dewatering Studies was added during the reporting quarter. Figure 2 shows the revised project schedule.

Phase I

Phase I encompasses preparation of a detailed Project Work Plan, selection and acquisition of the test coals, and laboratory and bench-scale testing. The laboratory and bench-scale work will determine the cleaning potential of the selected coals and

establish design parameters and operating guidelines for a 2 t/hr PDU containing both advanced column flotation and selective agglomeration modules. A conceptual engineering design is being prepared for a fully integrated and instrumented 2 t/hr PDU incorporating the features determined from the laboratory and bench-scale studies. A generic approach is being utilized during laboratory studies to insure that the flotation and agglomeration systems selected for the PDU will meet the project objectives.

Additional activities to be completed during Phase I include:

- Production of ultra-clean coal test lots by bench-scale column flotation and selective agglomeration for end-use testing by the DOE or a designated contractor
- Determination of toxic trace element distribution during production of these test lots
- Evaluation of the properties of slurry fuels prepared from ultra-clean coals
- Evaluation of methods for applying these advanced cleaning technologies to existing coal preparation plants in the near term

Phases II and III

Phases II and III cover the construction and operation of the 2 t/hr PDU. Phase II will investigate advanced column flotation while Phase III will evaluate selective agglomeration. Process performance will be optimized at the PDU-scale, and 200 ton lots of ultra-clean coal will be generated by each process for each of the three test coals. Toxic trace element distributions will also be determined during the production runs. The ultra-clean coals will be delivered to the DOE for end-use testing.

Phase IV

Phase IV activities will include decommissioning of the PDU, restoration of the host site, and preparation of the final project report.

Revised April 25, 1995

Figure 1. Project Management Organization Chart

Table 1. Outline of Work Breakdown Structure

<u>Phase I. Engineering Analysis and Laboratory and Bench-Scale R&D</u>	
Task 1.	Project Planning
Subtask 1.1.	Project Work Plan
Subtask 1.2.	Project Work Plan Revisions
Task 2.	Coal Selection and Procurement
Subtask 2.1.	Coal Selection
Subtask 2.2.	Coal Procurement, Precleaning and Storage
Task 3.	Development of Near-Term Applications
Subtask 3.1.	Engineering Analyses
Subtask 3.2.	Engineering Development
Subtask 3.3.	Dewatering Studies
Task 4.	Engineering Development of Advanced Froth Flotation for Premium Fuels
Subtask 4.1.	Grinding
Subtask 4.2.	Process Optimization Research
Subtask 4.3.	CWF Formulation Studies
Subtask 4.4.	Bench-Scale Testing and Process Scale-up
Subtask 4.5.	Conceptual Design of the PDU and Advanced Froth Flotation Module
Task 5.	Detailed Engineering Design of the PDU and Advanced Flotation Module
Task 6.	Selective Agglomeration Laboratory Research and Engineering Development for Premium Fuels
Subtask 6.1.	Agglomeration Agent Selection
Subtask 6.2.	Grinding
Subtask 6.3.	Process Optimization Research
Subtask 6.4.	CWF Formulation Studies
Subtask 6.5.	Bench-Scale Testing and Process Scale-up
Subtask 6.6.	Conceptual Design of the Selective Agglomeration Module
Task 7.	Detailed Engineering Design of the Selective Agglomeration Module
<u>Phase II. PDU and Advanced Column Flotation Module Testing and Evaluation</u>	
Task 8.	PDU and Advanced Column Froth Flotation Module
Subtask 8.1.	Coal Selection and Procurement
Subtask 8.2.	Construction
Subtask 8.3.	PDU and Advanced Coal Cleaning Module Shakedown and Test Plan
Subtask 8.4.	PDU Operation and Clean Coal Production
Subtask 8.5.	Froth Flotation Topical Report
<u>Phase III. Selective Agglomeration Module Testing and Evaluation</u>	
Task 9.	Selective Agglomeration Module
Subtask 9.1.	Construction
Subtask 9.2.	Selective Agglomeration Module Shakedown and Test Plan
Subtask 9.3.	Selective Agglomeration Module Operation and Clean Coal Production
Subtask 9.4.	Selective Agglomeration Topical Report
<u>Phase IV. PDU Final Disposition</u>	
Task 10.	Disposition of the PDU
Task 11.	Project Final Report

Revised April 25, 1995

Revised April 25, 1995

Figure 2. Project Schedule

Subtask	1995												1996												1997					
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
	28	29	30	31	32	33	34	35	36	37	38	36	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
1.1 Project Work Plan																														
1.2 Project Work Plan Revisions																														
2.1 Coal Selection																														
2.2 Procurement and Storage																														
3.1 NTA Engineering Analyses																														
3.2 NTA Engineering Development																														
3.3 Dewatering Studies																														
4.1 Grinding																														
4.2 Process Optimization Research																														
4.3 CWF Formulation Studies																														
4.4 AF Bench Testing, Scale-up																														
4.5 AF Conceptual Design PDU																														
5.0 Detailed Design PDU, AF Module																														
6.1 Agglomeration Agent Selection																														
6.2 Grinding																														
6.3 Process Optimization Research																														
6.4 CWF Formulation Studies																														
6.5 Sel. Aggl. Bench Testing, Scale-up																														
6.6 Concpt. Design Sel. Aggl. Module																														
7.0 Detailed Design Sel. Aggl. Module																														
8.1 Coal Procurement																														
8.2 PDU Construction																														
8.3 Shakedown, Test Plan																														
8.4 Operation and Production																														
8.5 AF Topical Report																														
9.1 Construction SA Module																														
9.2 Shakedown, Test Plan																														
9.3 Operation and Production																														
9.4 Sel. Agglomeration Topical Report																														
10.0 PDU Decommissioning																														
11.0 Project Final Report																														

Revised April, 25 1995

Figure 2. Project Schedule (Cont'd)

ACCOMPLISHMENTS DURING QUARTER

Work was carried out on Tasks 3, 4, 5, 6, and 8 during the Tenth Quarter (January 1 to March 31, 1995) reporting period. Good progress was made on these tasks as discussed below.

TASK 3 DEVELOPMENT OF NEAR-TERM APPLICATIONS

During 1993 Bechtel performed an engineering analysis evaluating potential applications for column flotation and selective agglomeration at three coal preparation plants operated by what is now Cyprus Amax Coal Company (10). Economic projections favored column flotation over selective agglomeration, and an application at the Lady Dunn Preparation Plant was found to be particularly attractive since the plant was being considered for a major capacity expansion. Because of the potential advantages of installing column flotation rather than mechanical flotation cells in the expanded fine coal cleaning circuit, Lady Dunn management was pleased to offer their plant as the study site for a near-term application of column flotation. The Microcel™ flotation column was selected for this study and the Center for Coal and Mineral Processing (CCMP) at Virginia Tech was assigned the responsibility for the Subtask 3.2 Engineering Development test work. During this reporting quarter, a new subtask 3.3 "Dewatering Studies" was added to the project. This work will also be performed by CCMP.

Subtask 3.2 Engineering Development

Several meetings were held at the Lady Dunn plant during this reporting quarter. It has been determined that the in-plant testing will be carried out utilizing a 30-inch diameter Microcel™ column. A location within the plant for the column was also selected and the area is being cleared for installation of an existing Microcel™ column test unit. This column is being refurbished with a side entry feed pipe, a new water distribution ring, and new bubble generator line valving. Instrumentation for this test unit is also being assembled and calibrated. The column will be shipped to Lady Dunn for installation during April, allowing the in-plant testing to begin in May.

Laboratory testing was carried out using flotation feed slurry collected from the Lady Dunn Plant. The initial tests were completed in a 2-inch diameter column and indicated that clean coal with a 7 to 8 percent ash content can be produced from the 37 percent ash Stockton seam slurry feed. As shown in Figure 3, this product was achieved at approximately 80 percent recovery of combustible material. Additional laboratory testing is planned to determine the optimum cleaning performance achievable with this feedstock. It has been determined, though, that a 21-foot column height is sufficient for this application and that the solids concentration in the feed slurry (6.5 percent) is high

enough that the column will not be hydraulically overloaded. As such, column capacity will be limited by the clean coal carrying capacity.

Figure 3. Laboratory Microcel™ Flotation of Lady Dunn Slurry

Subtask 3.3 Dewatering Studies

This new subtask was added during the reporting quarter. The work to be performed by Virginia Tech will aim at developing a hydrophobic dewatering process for the clean coal fines. Three coals will be tested including the product from near-term testing at the Lady Dunn plant (Subtask 3.2). A Test Plan is under preparation.

TASK 4 ENGINEERING DEVELOPMENT OF ADVANCED FROTH FLOTATION

As described in the Subtask 2.1 report, Coal Selection Plan and Recommendations [11] and in previous quarterly reports [3,4], six coals were identified as good candidate feedstocks for conversion into premium fuel and were selected for testing during Task 4. The six coals selected are described in Table 2.

The test coals were all washed bituminous coals except for the Dietz coal which was a subbituminous coal that had only been crushed before marketing. Washing plant

heating value recoveries were in the 89 to 94 percent range for the five bituminous coals. Thus, near 90 percent heating value recoveries are necessary during the advanced flotation step to meet the project goal of recovering 80 percent of the heating value from the raw coals.

Table 2. Test Coals Selected for Project

<u>Coal</u>	<u>Mine</u>	<u>State</u>	<u>HGI</u>	<u>Ash, %</u>	<u>Sulfur, %</u>
Taggart	Wentz	VA	52	2.07	0.62
Indiana VII	Minnehaha	IN	55	9.25	0.49
Sunnyside	Sunnyside	UT	54	5.11	0.63
Winifrede	Sandlick	WV	47	8.42	0.94
Elkhorn No. 3	Chapperal	KY	46	6.04	0.86
Dietz	Spring Creek	MT	41	4.98	0.33

Task 4 activity during this reporting quarter included work in three areas, Subtask 4.2 Process Optimization Research, Subtask 4.3 Coal Water Fuel (CWF) Preparation, and Subtask 4.4 Bench-scale Testing and Process Scale-up. Results are discussed below.

Subtask 4.2 Process Optimization Research

The Subtask 4.2 Topical Report [12] was issued on March 16, 1995, after review by team members. As described last quarter, the general conclusions were that all five of the bituminous coals responded quite well to column flotation. The residual ash and heating value recovery specifications were met for the Taggart, Sunnyside and Elkhorn No. 3 coals, but the specifications may need to be relaxed for the Indiana VII and Winifrede coals because of the fine grinding needed in order to liberate the ash minerals in these two coals. It was recommended that both the Ken-Flote™ and the Microcel™ columns be examined during the Subtask 4.4 bench-scale testing.

Subtask 4.3 Advanced Flotation - CWF Formulation Studies

A draft version of the Subtask 4.3 topical report [13] was completed and issued to DOE and other project partners on March 3, 1995 for review and comments. This report was also issued to Joel Morrison of Penn State and Dr. John Dooher of Adelphi University. A brief summary of results from the Subtask 4.3 test work was presented at a project review meeting held at Amax R&D on March 10, 1995.

The findings of this report indicate that four of the six project coals could be formulated into coal-water slurries with coal loadings varying from approximately 47% to 70%. The coarsest coal (Taggart) was loaded to the highest levels (68-70%) and the finest coal (Indiana VII) to the lowest levels (47-53%). Viscosities of these formulated slurries varied from several hundred to several thousand centipoise at 100 Sec⁻¹ depending on the coal type, loading level, and whether or not a stabilizer was used. It was generally

generally found that slurry stabilities were poor unless a stabilizer was used, which invariably increased slurry viscosities dramatically. While a number of different approaches were evaluated in formulating these slurries, it was determined that the production of a bimodal coal particle size distribution (PSD) resulted in the best slurry properties. It was found that in order to generate the appropriate PSD, selective regrinding of a fine coal fraction was necessary for coarse coals like the Taggart. In contrast, for an already finely ground coal like the Indiana VII, it was necessary to generate a coarse coal fraction, prior to fine grinding, to achieve the appropriate bimodal PSD.

Subtask 4.4 Bench-Scale Testing and Process Scale-up

Subtask 4.4 efforts this quarter were directed toward preliminary combustion testing of the three PDU test coals, and advanced flotation product toxic trace element analyses.

Combustion Test Work - Combustion Engineering

Ten coal samples were sent to the attention of Dr. Oscar Chow at Combustion Engineering, Windsor, Connecticut, for combustion test work. These samples represent the five bituminous coals being evaluated under the Premium Fuels Project. A washed coal sample (approximately 35 pounds) along with a sample cleaned by advanced column flotation (5 pounds) was furnished for each of the five coals. An overview of each sample's general quality characteristics is shown in Tables 3 and 4 for the washed and advanced flotation products respectively.

It should be noted that for the data presented in Tables 3 and 4, all HHV values were calculated from the following established equations for each coal:

- Elkhorn No. 3: $HHV = 14,935.5 - (163.72 \cdot \text{Ash})$
- Indiana VII: $HHV = 14,534.0 - (158.16 \cdot \text{Ash})$
- Sunnyside: $HHV = 14,882.7 - (165.47 \cdot \text{Ash})$
- Taggart: $HHV = 15,478.2 - (172.03 \cdot \text{Ash})$
- Winifrede: $HHV = 15,013.5 - (165.00 \cdot \text{Ash})$

Table 3. Washed Coal Samples Sent to Combustion Engineering

	<u>Elkhorn No. 3</u>	<u>Indiana VII</u>	<u>Sunnyside</u>	<u>Taggart</u>	<u>Winifrede</u>
Topsize	1/2 inch	1/2 inch	1/2 inch	1/2 inch	1/2 inch
Moisture, %	2.46	16.53	2.38	1.08	2.36
Ash, % (db)	6.09	9.86	5.43	2.08	8.59
HHV (dry Btu)*	13,939	12,975	13,984	15,120	13,596
lb Ash/MBtu	4.37	7.60	3.88	1.38	6.32

* Based on established Ash - BTU relationship

Table 4. Column Flotation Samples Sent to Combustion Engineering

Column	Elkhorn No. 3 Ken-Flote™	Indiana VII Ken-Flote™	Sunnyside Microcel™	Taggart Ken-Flote™	Winifrede Ken-Flote™
Topsizes	62 mesh	325 mesh	100 mesh	62 mesh	D80=11µm
MMD (µm)	36.60	11.40	40.60	60.10	8.28
Ash, % (dry)	2.02	2.72	3.00	1.44	6.80
HHV (dry Btu)*	14,605	14,104	14,386	15,230	13,892
lb Ash/MBtu	1.38	1.93	2.09	0.95	4.90

* Based on established Ash - BTU relationship

Combustion Test Work - The Pennsylvania State University

Indiana VII coal was procured and cleaned in the 12-inch Microcel™ column for combustion testing at Pennsylvania State University's Energy and Fuels Research Center (E&FRC). The clean coal was produced in 12 hour shifts on January 24th, 25th, 26th, and 30th.

A total of 15 drums of clean filter cake was shipped to the attention of Mr. Joel Morrison at Penn State's E&FRC. The first eight drums were shipped January 28, 1995 while the remaining seven drums were shipped January 31, 1995. The coal quality characteristics of each shipped drum is shown in Table 5.

Table 5. Quality of Indiana VII Coal Produced for Penn State E&FRC

Drum #	Weight, lb (ar)	Moisture, %	Weight, lb (db)	Ash, % (db)	Sulfur, % (db)	HHV, Btu/lb (db)	Ash, lb/MBtu	Sulfur, lb/MBtu
1	320.0	48.50	164.81	2.85	0.58	14,225	2.00	0.41
2	330.0	50.38	163.74	2.86	0.58	14,153	2.02	0.41
3	310.0	48.41	159.94	2.82	0.60	14,160	1.99	0.42
4	284.0	46.59	151.68	2.89	0.59	14,189	2.04	0.42
5	312.5	45.07	171.66	2.91	0.64	14,107	2.06	0.45
6	351.0	48.83	179.60	2.88	0.62	14,157	2.03	0.44
7	318.5	43.98	178.41	2.86	0.62	14,117	2.03	0.44
8	290.5	44.07	162.47	2.96	0.64	14,125	2.10	0.45
9	301.5	46.40	161.60	2.91	0.62	14,139	2.06	0.44
10	331.0	48.95	168.96	2.91	0.61	14,137	2.06	0.43
11	306.0	43.46	173.01	2.92	0.59	14,090	2.07	0.42
12	290.5	45.38	158.66	2.76	0.60	14,166	1.95	0.42
13	316.5	46.81	168.34	2.76	0.60	14,253	1.94	0.42
14	299.5	46.52	160.18	2.58	0.59	14,164	1.82	0.42
15	211.0	43.71	118.78	2.73	0.60	14,125	1.93	0.42
Total	4,572.5	46.60	2,441.82	2.84	0.61	14,154	2.01	0.43

Toxic Trace Elements

The reduction in toxic trace element concentration accomplished during column flotation will be determined for each of the five bituminous coals. Trace element analyses will be performed for each coal on products from tests where good flotation performance was accomplished.

Head samples of raw and washed test coals were analyzed for the eleven toxic trace elements during 1993, the results of which were reported in the 4th Quarterly Report [4]. These results indicated that the analytical procedures utilized were not sensitive enough to quantify the amounts of certain trace elements in the coals. For this reason, five samples from Subtask 4.4 testing were submitted to two independent laboratories to determine if one laboratory could offer improved sensitivity over the other.

The two laboratories used different methods for decomposing the coal samples and analyzing the solutions. For the most part, the first laboratory (Standard Laboratories of Evansville) decomposed the samples by a variation of ASTM ashing methods and analyzed the solutions by atomic absorption spectroscopy. In contrast, the second laboratory (Huffman Laboratory of Golden) utilized perchloric acid decomposition and inductively coupled plasma spectroscopy for solution analyses. Since a comparison of results indicated that the second laboratory did offer lower detection limits for certain elements (antimony, beryllium, cobalt and lead), this laboratory's analyses will be used to determine reductions in toxic trace element concentrations by column flotation.

TASK 5 DETAILED DESIGN OF PDU AND ADVANCED FLOTATION MODULE

Detailed Design Package

The Detailed Engineering Design Package was submitted to DOE in draft form on March 23, 1995. It consists of two volumes:

- Volume 1. Drawings and Specifications
- Volume 2. Material Requisitions

After incorporating any comments received from DOE, the document will be finalized and submitted to DOE in May 1995.

Bechtel issued process flow diagrams (PFDs), piping and instrument diagrams (PIDs), plant layout drawings, and electrical drawings for the following three areas of the PDU:

- Plant 100 - Selective Grinding
- Plant 200 - Column Flotation
- Plant 400 - Product Dewatering

to determine the effects of media type on metal contamination. Samples of washed coal will be ground for selected time periods in both steel and glass media. If testing results indicate that the metal concentration of the product slurry is lower when using glass media than when using steel media, the glass shot may be chosen for use in the PDU's fine grinding mill. Testing of the steel shot commenced March 31, 1995, and is anticipated to conclude during the upcoming quarter.

Water and Reagent Usage Estimates

At the suggestion of Bechtel, a measurement was made of the make-up water available to the PDU. The proposed 2-inch make-up water line located near the existing electrical junction box was tapped and a measurement made. Overall, approximately 67 gpm is available at a static pressure of 70 psi. This should be adequate for the PDU operation.

An estimate of the PDU reagent usage was carried out and submitted to Bob Rowe of AR Technologies for review. AR Technologies is responsible for the environmental compliance and reporting for the Amax R&D Center site. The reagents, their expected usage rates and anticipated maximum inventory are shown in Table 7.

Table 7. PDU Reagent Usage and Inventory Estimates

Coal:	<u>Indiana VII</u>		<u>Taggart</u>		<u>Sunnyside</u>		<u>Max Inventory</u>	
<u>Reagent</u>	<u>gal/mo</u>	<u>lb/mo</u>	<u>gal/mo</u>	<u>lb/mo</u>	<u>gal/mo</u>	<u>lb/mo</u>	<u>gal/mo</u>	<u>lb/mo</u>
Nalco 9818	9.4	84	3.1	28	3.1	28	110	990
Nalco 8853	9.4	83	6.2	55	6.2	55	110	973
#2 Fuel Oil	1,680	2,100	168	210	77	97	3,360	4,200
MIBC	880	1,100	336	420	225	281	1,761	2,200
Boiler Anti-scale	0.3	3	0.3	3	0.3	3	55	459
Heptane	0	0	0	0	0	0	1,500	8,762

TASK 6 ENGINEERING DEVELOPMENT OF SELECTIVE AGGLOMERATION

Task 6 activity during this reporting quarter focused on the Subtask 6.3 Laboratory-scale Process Optimization Research, the Subtask 6.4 CWF Formulation Studies, and the Subtask 6.5 Bench-scale Testing and Process Scale-up.

Subtask 6.3 Process Optimization Research

Work began on the Subtask 6.3 topical report during this reporting quarter. This report will summarize all testing carried out as part of this subtask and a draft will be issued during the next reporting quarter. This report will include the results of test work comparing pentane and heptane as well as low-oil comparison studies. Also included in this report will be the effects of pH adjustment and activators on the agglomeration of

The drawings were approved by Entech Global, Inc. and issued for construction. All drawings were incorporated into the contract bid package which was sent to prospective construction subcontractors.

Equipment Drawings

During this quarter, equipment drawings were received from several vendors and approved by both Bechtel and Entech Global. engineers. The vendors and their respective equipment units are shown in Table 6.

Table 6. Approved Vendor Equipment Drawings

<u>Equipment No.</u>	<u>Vendor</u>	<u>Description</u>
100-D-03	Metalcraft, Inc.	Primary Ball Mill Sump
100-D-04	Metalcraft, Inc.	Secondary Ball Mill Sump
100-D-06	Metalcraft, Inc.	Ground Product Sump
100-D-07	Metalcraft, Inc.	Fine Grinding Mill Sump
100-T-05	Kinergy, Inc.	Bin Activator
100-T-06	Rocky Mountain Conveyor	Screw Conveyor
100-Y-03	Netzsch, Inc.	Fine Grinding Mill
100-Y-04	Sizetec, Inc.	Fine Sizing Screens
200-D-01	Brewer Steel	Microcel Feed Sump
200-D-02	Brewer Steel	Final Tailings Sump
200-Y-02	Control International, Inc.	Microcel Column
300-D-01	Metalcraft, Inc.	Slurry Storage Tank
300-D-02	Metalcraft, Inc.	Slurry Storage Tank
400-D-01	Enviro-Clear, Inc.	Tailings Thickener
400-D-02	Metalcraft, Inc.	Clarified Water Sump
400-D-04	Brewer Steel	Tails Filter Press Sump

Fine Grinding Mill

During January, sound level testing was performed on a Netzsch LME-500 mill (identical to the unit which will be installed in the PDU). It was found that the dBA readings directly at the rear of the machine exceed the 85 dBA maximum requirement stated in the Request for Quotation (RFQ). Netzsch said that they could install a sound insulation panel at the rear of the machine if Amax so desired. After discussions between Bechtel and Entech Global, it was decided that this was the best course of action and a letter was issued to Netzsch instructing them to install a sound insulation panel.

Because previous testing has shown that elemental metal concentrations in coal slurries may increase when ground with steel media, an evaluation is being conducted

the subbituminous Dietz coal and the Indiana VII coal. Finally, the results of continuous testing in the 50 gram/minute unitized agglomeration reactor for each of the six test coals, and the results of two-stage agglomeration for two of the coals will be reported.

Subtask 6.4 CWF Formulation Studies

The final version of the Subtask 6.4 Test Plan [14] was issued to DOE and other project partners during the previous reporting quarter. Discussions were held with Joel Morrison of Penn State concerning similar slurry formulation work being carried out there. Dr. John Dooher of Adelphi University was retained as a consultant for the Subtask 6.4 test work. In this capacity he has reviewed the Subtask 4.3 topical report and provided us with some general recommendations for the Subtask 6.4 test work. His expertise will be especially useful in evaluating our slurry feed coal's volumetric packing capabilities. In addition, he will provide guidance on rheological testing, data analysis, and atomization criteria development.

Subtask 6.5 Bench-Scale Testing and Process Scale-up

Test Plan

The final version of the Subtask 6.5 Unit Design and Test Plan Report was issued to DOE and other project partners on January 31, 1995 [15]. This document discusses the selective agglomeration process in general along with the design of the continuous bench scale unit. In addition, it presents the test plan to be utilized during Subtask 6.5 testing.

Design

An overview of the selective agglomeration bench-scale unit design and test plan was presented at a project review meeting held in Golden on March 10, 1995. The design of the 25 lb/hr selective agglomeration bench-scale unit was completed during this reporting quarter. Salient features are shown in the block flow diagram, Figure 4.

Steam Stripper - The design of the steam stripper calls for the use of a 4-inch diameter column approximately 52 inches tall. Recovered agglomerates will enter the stripper approximately 14 inches from the top of the column. The top 5 inches of the stripper will be occupied by 3 overlapping baffles, set at an angle of 5° from horizontal, to prevent the entrainment of solids in the vapor stream (heptane and steam) exiting the top of the vessel. Approximately 28 inches below the feed entry point, a 1/4-inch screen will support the column packing (5/8-inch stainless steel pall rings), whose height will vary from several inches to the maximum of 28 inches. Steam will enter the

Figure 4. Bench-Scale Agglomeration Process Flow Diagram

column (perpendicular, or tangentially) two inches below the 1/4-inch screen. Four inches below this steam entry point the column begins to taper to a one-inch discharge at the bottom of the vessel. A slurry level will be maintained in the column through the use of a U-tube discharge piping arrangement. In addition to these features, fittings will be provided to install a number of thermocouples and pressure gauges on the vessel.

When the column is operated with a continuous steam phase (slurry level below the steam entry point), the height of the pall-ring packing will determine the coal residence time in the column. In contrast, when the column is operated with a continuous slurry phase (or flooded), the maintained slurry level will determine the coal residence time in the vessel. In the column flooding scenario, a yet to be determined level of pall-ring packing will be used to help distribute the incoming steam.

Data Acquisition System - During this reporting quarter, work was essentially completed on the development of an on-line data acquisition system for the selective agglomeration test unit. This system will allow real time data acquisition during operation of the unit, and also provide a data log into which any manually obtained operating conditions can be entered.

Construction

Construction of the 25-lb/hr bench-scale selective agglomeration unit was essentially completed during this quarter with the completion of the vibrating screen, steam stripper, condenser, and gravity separator. A replacement motor was also ordered, received, and installed for the low-shear unit operation. With this new motor, the desired low-shear impeller tip speeds were achieved.

In addition, a number of fittings, hoses, and other miscellaneous parts were obtained and installed. Also, several required utility connections were completed including piping of process water and plant air, along with additional electrical connections.

Agglomeration Unit Testing

During the first test of the agglomeration side of the test unit, the heptane was overdosed due to problems with the heptane flowmeter. As a result the low-shear vessel plugged, damaging one of the low-shear impellers, the mixing shaft seal, and the low-shear motor and/or frequency controller. It was found that moving the heptane flowmeter to the suction side of the heptane pump resulted in accurate and consistent heptane flow readings.

Further testing of the agglomeration circuit was carried out using an air-powered motor for the low-shear vessel. While this motor seemed to work well, its speed fluctuated considerably as a function of both the available air pressure (cycling between 45 and 95 psi) and the amount of coal in the low-shear reactor. It is thought that this low-shear rpm fluctuation may cause inconsistencies in the low-shear operation, particularly

agglomerate growth and discharge from the vessel. As such additional testing of the agglomeration side of the unit was limited to generating product agglomerates for feed to the steam stripper.

The steam flowmeter was received and installed during this reporting period. While the flowmeter was incorrectly calibrated prior to shipping, it has been found to provide consistent readings, which are used to calculate actual steam flows. A new vane for the flowmeter, which will provide accurate steam flow readings is to be shipped to us for installation.

Utilizing the Taggart coal (62-mesh tosize grind) as feed, a variety of operating conditions were tested to evaluate the operability of both the agglomeration and steam stripping sections of the test unit. Based on this testing, the following comments, observations, and conclusions have been made concerning the various unit operations of the 25 lb/hr test unit.

Feed System - The coal feed system to the agglomeration circuit appears to be operating well with no plugging problems experienced to date. It was found however, that during several test runs, the feed flowrate (grams per minute) varied approximately 5% from the beginning to the end of the run. If this proves to be a consistent phenomenon, modifications will be made since this changing feed rate affects the heptane/coal ratio.

High Shear - The high-shear reactor was found to work well over a wide range of feed conditions achieving inversion at coal feed rates of 25, 50, and 75 lb/hr using an 18 m/s impeller tip speed. Generally, it appears that a minimum of approximately 20% heptane (dry-ash-free coal basis) is required to achieve inversion during high-shear for this Taggart coal feed. More heptane (up to 25%), however, is needed to achieve growth in the low-shear vessel.

While no serious high shear plugging problems have occurred to date, it was found that at times the high-shear vessel baffles seem to fill with coal and then clean itself out. This observation is based on a noticeable drop in high-shear power draw for short periods of time. This phenomenon is not a concern since inversion is still continually achieved.

While the power draw of the high-shear reactor is approaching the available limit, no problems were observed. It should be noted however, that as we begin to test other high-shear impellers and coals this may become a concern, which will be handled by reducing the impeller tip speed (as long as inversion is still achieved).

Low Shear - As described above, the DC motor drive of the low-shear vessel failed during initial start-up and has been temporarily replaced with an air-powered mixer. This air mixer has been found to provide inconsistent impeller speeds. This fluctuating operating rpm is believed to attribute to inconsistencies observed in the low-shear

discharge, in particular to the broad size range of agglomerates produced from low shear.

Another factor contributing to this phenomenon is the apparent cyclic build-up and discharge of solids from the low-shear vessel. While this observation has not been completely confirmed, it appears that during periods of lower impeller speeds less solids are discharged from the vessel. Then, as the air pressure increases, increasing the impeller speed, these retained solids are discharged. As a result, the residence time in the low-shear vessel varies, attributing to the lack of a monosize product. It should also be noted that there may be some inherent problem associated with the low-shear discharge configuration which increases the chances of the observed cyclic buildup and discharge of solids in the vessel. However, until this unit operation is operated with a consistent impeller tip speed, no changes in the discharge configuration will be made.

Depending on the impeller tip speed, residence time, and heptane concentration utilized, the low shear product varies in size from approximately 0.5 mm to 5 mm. It has been found that the agglomerate size can be controlled to some extent by the heptane concentration used, with higher dosages resulting in larger agglomerates. No other clear trends have been confirmed for this unit operation to date.

Vibrating Screen - Operation of the vibrating screen for recovery of the low-shear product seems to be working well. Only minimal blinding of the 48-mesh screen deck has been observed to date, with more blinding occurring as the heptane concentration is increased. The screen is being operated at an angle of approximately 38° and provides good agglomerate flow across the screen deck. It should be noted however that until a consistent low-shear product is generated, a thorough evaluation of the screen's operability cannot be made.

It has been found that the use of spray water on the screen results in more coal reporting to the screen tailings. It seems that the spray pattern generated by the nozzles is too strong, resulting in increased agglomerate degradation. This problem may be reduced however as a more consistent and stronger low-shear product is produced. When the screen was operated without the spray water, it provided a product of approximately 1.5% ash. Spray nozzles with a finer (misting) spray will be obtained for future testing.

The screen product varies in moisture content depending on the size of the agglomerates. The smallest product is estimated to contain about 60% coal 25% water, and 15% heptane. In contrast, the larger agglomerated product (3-5 mm) is estimated to contain 70% coal, 17.5% heptane, and 12.5% water. These estimates will be confirmed with further testing.

Stripper Circuit Feed - Much difficulty was encountered in attempting to feed the agglomerated product to the steam stripper. The Moyno pump purchased for this task proved to be incapable of pumping the agglomerates. It was found that due to the

tendency of the agglomerates to float, they continually plugged the pump suction line, the pump itself, and to a lesser degree the pump outlet discharge line. One additional reason for these plugging problems was the relatively large sizes of the pump suction and discharge lines, 1" and 3/4" respectively. Given these diameters, the flow velocities were too low to provide continuous flow, i.e., the flow could not overcome the tendency of the agglomerates to float and plug the line. It was also noted that even at the highest flow rates tested, plugging still occurred within the pump itself, particularly at its inlet.

To rectify this plugging problem the Moyno pump was replaced with a peristaltic pump utilizing a 3/8" diameter hose. This pump proved to provide feed to the steam stripper without any serious plugging problems (due to its smaller line size and higher flow velocities). It was found that when utilizing this peristaltic pump, flows as low as approximately 0.8 liters per minute could be fed to the stripper.

In order to allow testing of the stripper circuit independently of the agglomeration circuit, the system utilizes a 55 gallon drum to collect the vibrating screen product. Once collected, the material in this drum is diluted, mixed, and pumped to the stripper. During early testing, it was found that the agglomerates were very difficult to mix in the drum, with a constant layer of agglomerates remaining floating on the top surface of the drum. In an effort to improve the mixing in the drum, three 6-inch impellers were used with the mixer instead of the original two 4-inch impeller configuration. Two of these 6" impellers were of the cutting/dispersing type to help prevent additional agglomerate growth in the drum (an anticipated concern which has proven unfounded to date). The third impeller was a six-bladed 45° pitch axial flow impeller. It was found that these different impellers, while improving the mixing, still did not provide the vigorous agitation desired. This was due primarily to the lower mixing rpm attained with the additional impellers. As such, a more powerful mixer (4 hp rather than 1.5) was ordered. It is anticipated that this larger mixer, fitted with a number of mixing impellers (6- and 8-inch) will provide the desired mixing to insure consistent feed to the stripper during extended testing.

Another problem encountered when feeding the steam stripper with this arrangement is a phenomenon in which as the pumping rate increases, so does the solids concentration of the material being pumped. No explanation for this phenomenon has been found except that it is related to the relatively poor mixing in the drum. If this phenomenon still occurs with improved mixing, it will require close monitoring of both the stripper feed rate and its solids concentration.

One additional problem resolved during this reporting period was the tendency of the stripper feed line to plug as it discharged into the stripper. The original design utilized a 90° right angle in the feed pipe to provide a downward discharge in the stripper. This arrangement was found to plug, and was therefore replaced with a straight pipe discharge at the approximate center of the stripper column.

Steam Stripper - Once the feed problems were resolved to the point where agglomerates could be pumped to the stripper, preliminary steam stripping testing to remove heptane from the agglomerated product began. Stripper testing carried out during this reporting period emphasized determining the operability of the steam stripper.

Initial testing utilized a packed bed of 5/8" pall rings of approximately 24-inches high. Stripper feed entered the vessel 2-inches above the top of the pall rings and the slurry level in the stripper was maintained just below the pall rings, i.e., about 6-inches above the stripper discharge, or approximately level with the steam inlet. In this scenario, the stripper operated with a continuous steam phase through which the agglomerates flowed down. It was found that with this arrangement, the incoming agglomerates were held up at the top of the pall rings while their associated water drained immediately to the vessel discharge. As such, the upper portion of the column would fill with agglomerates tending to plug the feed line. After several attempts, an inconsistent, often surging coal discharge was observed from the vessel. While this product slurry did not have a heptane odor, it did have a thin oily skim layer on top of it.

Operations with this arrangement continued in an effort to obtain a steady product discharge. A consistent product stream could not be obtained however due to the siphoning effect of the U-tube discharge arrangement used to maintain a slurry level in the column. Therefore, a vent line was added to the highest point of the discharge line along with a separate hose to provide a level indication in the column. While these changes resolved the siphoning problem (and its associated problem of steam discharge from the column bottom), a steady product flow could still not be obtained. It is believed that this surging discharge was due to the pulsing flow of agglomerates through the pall rings.

This phenomenon was not unexpected since it is assumed that the agglomerates must have the bulk of their heptane removed before they break up into smaller particles which can flow through the pall rings. Therefore as steam condensed, providing the heat necessary to strip the heptane, the condensed water along with additional water entering with new feed helped the agglomerates flow to the column discharge.

In an effort to provide a more consistent product from the stripper, approximately 4- to 6-inches of pall rings were removed from the stripper. This action combined with raising the slurry level in the vessel seemed to provide a more consistent discharge from the stripper column. This effect is attributed to the vessel's ability to handle more solids before plugging, i.e., more volume between the top of the pall rings and the feed inlet, and the larger volume of slurry holdup in the bottom of the column. It should be noted however, that there was still significant surging of product from the column during these operations.

Future plans for testing of the steam stripper include operating the vessel flooded, i.e., with a slurry level near the feed inlet point. In this scenario, the column would contain a continuous slurry phase with steam bubbling through it. The pall rings (probably a

much smaller volume) would then be used to help distribute the flow of steam across the column. This arrangement will allow testing of various slurry residence times in the stripper to help define those conditions necessary to generate an acceptable product.

The process of determining heptane content in the stripped product has been initiated through discussions with Huffman laboratories of Golden, Colorado. The primary concern in making these determinations is the many components (12 various hydrocarbons) that make up the commercial grade heptane being utilized. Initial work by Huffman will attempt to determine those components, which when tracked, provide an accurate representation of all the various components remaining on the coal. This work may also investigate the differences in the properties of fresh and recycled heptane to determine if particular components are deficient in the recycled heptane, i.e., remain with the coal.

Stripper feed heptane concentrations will be determined in-house via distillation of feed samples. Through this procedure, the composition of the entire sample (percent heptane, coal, and water) will be determined. Preliminary testing of this procedure has indicated that a significant portion of the heptane is not recovered by this method. As such, the method is being scrutinized to determine if the procedure is faulty or if this unaccounted heptane is actually retained on the coal. Future evaluation of this procedure will also attempt to take into account the solubility of heptane in water at the operating temperature of this distillation procedure, approximately 201°F (the boiling point of water at this atmospheric pressure).

Condenser - Operation of the condenser, which condenses the evaporated heptane and its associated water vapor has proceeded smoothly. It appears that the condenser has sufficient capacity to achieve the goals easily. During typical operations to date, the stripper vapor product temperature averages about 203°F and the condensate temperature about 50°F. Under some stripper operating conditions, usually just prior to plugging of the column, some coal has been carried over into the condenser. To date this has not caused any problems and it is anticipated that under ideal stripper operating conditions this will not occur.

Gravity Separator - Once condensed, the water and heptane mixture enters the center of the gravity separator column. Operation of this separator has proceeded smoothly with the water/heptane interface easily observed. Utilizing a U-tube discharge of the water from the bottom of the separator, steady-state operation has been achieved in which consistent flows of both water from the bottom and heptane from the top can be observed. Preliminary analysis of this recovered heptane indicates that it is virtually identical in composition to the fresh heptane. Analysis of water samples taken from the separatory column indicate a total organic content of approximately 8 ppm, indicating minimal solubility of the heptane in water at the temperature of these condensed liquids.

TASK 8 PDU AND ADVANCED COLUMN FLOTATION MODULE

The majority of the Task 8 work effort was directed toward the solicitation and award of the PDU construction subcontract. In addition, work continued on the inspection and evaluation of existing DOE equipment transferred from Wilsonville and slated for use in the PDU.

Subtask 8.2 PDU Construction

Request for Quotation (RFQ) packages for the construction of the PDU were issued to several construction companies and three bids were received. After careful review of the quotation packages, Amax R&D, Inc. awarded the construction subcontract to TIC - The Industrial Company of Steamboat Springs, Colorado. TIC mobilized onto the PDU site March 27, 1995 and initiated the layout of all concrete work as well as work related to securing the required building permit(s).

Solicitation and Award of PDU Construction Subcontract

During this reporting quarter, RFQ's were issued for the PDU construction subcontract. Entech Global and Bechtel personnel collaborated to resolve issues regarding work scope and components of the RFQ. Final copies of the RFQ which included project drawings were sent to the following construction companies:

1. Bateman Engineering, Inc. of Denver, Colorado
2. CLI Corporation of Pittsburgh, Pennsylvania
3. Farnham and Pfile Construction, Inc. of Belle Vernon, Pennsylvania
4. Kilborn International, Inc. of Englewood, Colorado
5. Lincoln Contracting Company of Stoystown, Pennsylvania
6. Lyntech, Inc. of Denver, Colorado
7. TIC of Steamboat Springs, Colorado

A site inspection and meeting for interested bidders was held on February 2, 1995. Only two construction companies attended this meeting. Those in attendance were as follows:

• CLI Corporation	Craig Jolley - Manager of Estimating
• TIC - The Industrial Company	Thad Middleton - Project Estimator
• TIC - The Industrial Company	Ralph Eighmy - Estimator
• Bechtel	M.V. Chari
• Bechtel	Surinder Bajwa

- Mahesh Jha**
Gene Shields

A third company, Vector Services, who was selected by CLI as a subcontractor approached Amax and requested that they be allowed to submit a bid independently. Their request was approved and a second site inspection and meeting was held on February 16, 1995. Those in attendance at this meeting were:

- Gerald Lamb - President
Roger Dewey - Vice President
Gus Manwaring - President
Kenneth Stockton - Estimator
Mahesh Jha
Gene Shields

The majority of each meeting was used clarifying questions and issues regarding the RFQ package. Each company submitted a bid estimate for construction of PDU - Phase I, on February 28, 1995.

After careful evaluation, the subcontract for the construction of Phase I of the PDU was awarded to TIC - The Industrial Company, of Steamboat Springs, Colorado. An award meeting was conducted on March 15, 1995. Those in attendance at this meeting were:

- TIC - P. Lauretano, T. Middleton, and S. Jones;
- Entech Global - M. Jha, G. Shields;
- Control Technology - B. Reynouard

During the meeting, Amax R&D and TIC agreed to the following:

- TIC will supply a performance bond
- Painting of process and utility lines will be removed from the work scope and replaced with stenciling
- The purchase of all electrical equipment (excluding conduit, wire, and hangers, etc.) will become the responsibility of Amax R&D Inc. Bob Reynouard will specify the equipment while Amax will purchase the equipment directly.

TIC Construction Activities

TIC - The Industrial Company, has been selected as the construction subcontractor for Phase I of the PDU. The following construction activities were completed by TIC during the month of March, 1995:

- Mobilization was initiated on March 27, 1995
- Saw-cut and removed concrete in PDU Area 100
- Saw-cut and removed part of the concrete in PDU Area 200
- Saw-cut and removed part of the concrete in PDU Area 400
- Off loaded Enviro-Clear thickener

Procurement of PDU Capital Equipment

Entech Global personnel continued the procurement of capital equipment for use in the PDU. During the first quarter of 1995, Request for Quotation (RFQ) packages for 20 equipment items were issued. Award packages, were issued to companies for 23 capital equipment items, while 20 equipment items were received during this reporting quarter. The status of each capital item, along with those items awarded and received during the quarter (hi-lighted in boxes) are listed in Table 8.

The Air Compressor is expected to ship April 21, 1995 while the fine Grinding Mill is expected to be shipped on or about April 28, 1995.

Refurbishing of Existing PDU Equipment

The equipment items listed in Table 9 are currently being inspected and scheduled for reconditioning as discussed below.

- Inspection of the elevating conveyor (100-T-03) revealed that only a belt splice is necessary for PDU operation.
- Inspection of the weigh belt feeder (100-T-04) has shown that a new processor/controller is required for PDU operation. A new processing board was ordered in April.
- Canmac Engineering inspected the filtrate pump (400-G-06) and found that it is in good working order. No refurbishing is necessary.
- Inspection of the existing tailings filter presses revealed that they are in good operating condition. Unfortunately, the overall capacity is marginal at 1,200 lb/hr (db). Because the units must be capable of dewatering almost 1,300 lb/hr, an additional 2 chambers must be added to each unit.
- The inspection report for the Netzsch filter presses was received and reviewed. Netzsch recommends that the two units undergo extensive refurbishing. Due to the nature of the work, all work will be performed after the units are installed in the pilot plant. Calculations also show that the existing units have a combined capacity of approximately 1,860 lb/hr, and the filter volumes must be maximized to 40 ft³ each to increase the total capacity to 2,660 lb/hr.
- Mr. John Smith of SEPCO (WesTech representative) inspected the WesTech drum filter. His report is expected during the first part of April.

Table 8. Status of Capital Equipment Procurement

Equipment Number	Description	RFQ Date	Deadline	Award Date	Company	Delivered Price	Delivery
100-D-03	Pri. Ball Mill Disch. Sump	1/6/95	1/18/95	2/15/95	Metal-Craft	\$2,835	8 weeks
100-D-04	Sec. Ball Mill Disch. Sump	1/6/95	1/18/95	2/15/95	Metal-Craft	\$3,014	8 weeks
100-D-06	Ground Product Sump	1/6/95	1/18/95	2/15/95	Metal-Craft	\$3,014	8 weeks
100-D-07	Fine Grind Mill Feed Sump	1/6/95	1/18/95	2/15/95	Metal-Craft	\$2,151	8 weeks
100-G-01	Pri. Ball Mill Disch. Pump	10/6/94	10/14/94	11/16/94	Quadna Pump Systems	\$7,660	1/24/95
100-G-02	Sec. Ball Mill Disch. Pump	10/6/94	10/14/94	11/16/94	Quadna Pump Systems	\$12,335	2/7/95
100-G-03	Fine Grind Mill Feed Pump	10/6/94	10/14/94	11/16/94	Quadna Pump Systems	\$10,455	1/24/95
100-G-04	Ground Product Pump	10/6/94	11/16/94	12/19/94	Canmac Engineering	\$3,079	8 weeks
100-T-05	Vibrating Bin Bottom	10/21/94	11/4/94	11/29/94	Kinergy, Inc.	\$7,336	3/16/95
100-T-06	Pri Ball Mill Screw Conv.	10/18/94	10/31/94	12/19/94	Rocky Mountain Conveyor	\$6,324	3/3/95
100-Y-03	Fine Grinding Mill	9/15/94	9/29/94	11/10/94	Netzsch, Inc.	\$292,169	24 weeks
100-Y-04	Vibrating Screens	10/12/94	10/21/94	11/10/94	Sizetec, Inc.	\$43,229	1/23/95
100-Y-05	Ground Product Agitator	11/10/94	11/30/94	2/16/95	D.W. Daigler (Lightning)	\$1,307	3/14/95
100-Y-06	Fine Mill Feed Sump Agit.	11/10/94	11/30/94	2/16/95	D.W. Daigler (Lightning)	\$1,112	3/14/95
100-Y-07	Classifying Cyclones	11/11/94	11/23/94	12/19/94	APCOR (Krebs Cyclones)	\$2,658	3/9/95
200-C-01	Compressed Air Receiver	10/18/94	10/31/94	1/4/95	Colorado Compressor	\$0	8 weeks
200-D-01	Column Feed Sump	1/6/95	1/18/95	2/15/95	Brewer Steel	\$3,153	6 weeks
200-D-02	Final Tailings Sump	1/6/95	1/18/95	2/15/95	Brewer Steel	\$3,405	6 weeks
200-D-03	Frother Drum						
200-D-04	Collector Drum						
200-G-01	Column Feed Pump	11/4/94	11/16/94	12/19/94	Canmac Engineering	\$5,908	8 weeks
200-G-02	Column Recirc Pump	11/29/94	12/9/94	12/19/94	Canmac Engineering	\$7,325	8 weeks
200-G-03	Final Tailings Pump	11/4/94	11/16/94	12/19/94	Canmac Engineering	\$5,908	8 weeks
200-G-04	Frother Feeder						
200-G-05	Collector Feeder						
200-G-06	Floor Sump Pump	11/14/94	11/23/94	12/19/94	Canmac Engineering	\$3,263	3/29/95
200-K-01	Air Compressor	10/18/94	10/31/94	1/4/95	Colorado Compressor	\$16,953	8 weeks
200-Y-02	Microcel Flotation Column	10/21/94	11/4/94	12/1/94	Control International	\$69,400	16 weeks
200-Y-03	In-Line Static Mixer	10/21/94	11/4/94	12/1/94	Control International	N/A	16 weeks
200-Y-04	Column Feed Agitator	11/10/94	11/23/94	2/16/95	D.W. Daigler (Lightning)	\$1,594	3/14/95
300-D-01	Slurry Storage Tank A	1/6/95	1/18/95	2/15/95	Metal-Craft	\$3,836	8 weeks
300-D-01	Slurry Storage Tank B	1/6/95	1/18/95	2/15/95	Metal-Craft	\$3,836	8 weeks
300-Y-01	Ground Product Agitator	2/1/95	2/2/95	2/16/95	D.W. Daigler (Lightning)	\$5,000	3/27/95
300-Y-02	Fine Grinding Mill Agitator	2/1/95	2/2/95	2/16/95	D.W. Daigler (Lightning)	\$5,000	3/27/95
400-D-01	Thickener	10/3/94	11/10/94	11/10/94	Enviro-Clear	\$46,500	14 weeks
400-D-02	Thickener Overflow Sump	1/6/95	1/18/95	2/15/95	Metal-Craft	\$5,691	8 weeks
400-D-04	Tailings Filter Feed Sump	1/6/95	1/18/95	2/15/95	Brewer Steel	\$3,231	6 weeks
400-G-01	Filter Press Charge Pump	10/31/94	11/14/94	12/19/94	Quadna Pump Systems	\$1,209	1/20/95
400-G-02	Filter Press Charge Pump	10/31/94	11/14/94	12/19/94	Quadna Pump Systems	\$1,209	1/20/95
400-G-07	Clarified Water Pump	10/27/94	11/4/94	12/19/94	Canmac Engineering	\$3,835	8 weeks
400-G-11	Floor Sump Pump	10/31/94	11/14/94	12/19/94	Canmac Engineering	\$3,263	8 weeks
400-G-12	Cationic Metering Pump	2/28/95	3/6/95	3/6/95	Nalco Chemical Company	\$1,550	3/16/95
400-G-13A	Anionic Metering Pump	2/28/95	3/6/95	3/6/95	Nalco Chemical Company	\$1,550	3/16/95
400-G-13B	Anionic Metering Pump	2/28/95	3/6/95	3/6/95	Nalco Chemical Company	\$1,550	3/16/95
400-T-03	Clean Coal Conveyor	1/19/95	2/3/95	2/28/95	Rocky Mountain Conveyor	\$18,599	8 weeks
400-T-04	Clean Coal Conveyor	1/19/95	2/3/95	2/28/95	Rocky Mountain Conveyor	\$18,599	8 weeks
400-Y-06	Thickener Mechanism	10/3/94	10/6/94	11/10/94	Enviro-Clear	N/A	3/16/95
400-Y-08	Filter Press Sump Agitator	11/4/94	11/10/94	2/16/95	D.W. Daigler (Lightning)	\$2,034	3/14/95

Table 9. Existing Equipment Items for Reconditioning

<u>Equipment Number</u>	<u>Description</u>	<u>Inspected</u>	<u>Price</u>
100-D-01	Dump Hopper		N/A
100-T-02	Vibrating Feeder		N/A
100-T-03	Elevating Conveyor	YES	\$300
100-T-04	Weight Belt Feeder	YES	\$3,800
100-Y-01	Primary Ball Mill		N/A
100-Y-02	Secondary Ball Mill		N/A
400-G-06	Filtrate Pump	YES	\$0
400-Y-01	Tailings Filter Press - A	YES	\$3,400
400-Y-02	Tailings Filter Press - B	YES	\$3,400
400-Y-04	Clean Coal Filter Press - A	YES	\$16,472
400-Y-05	Clean Coal Filter Press - B	YES	\$16,472
400-Y-09	Clean Coal Drum Filter	YES	N/A
N/A	Samplers		N/A

The stream samplers have been shipped to Harrison Cooper Systems for inspection and rebuild. Inspection of all items is scheduled for completion during the upcoming quarter.

Assembly of Spare Parts List

A spare parts list has been assembled and is currently being evaluated for short listing. Only wear items that are most likely to fail during the first year of operation will be purchased. The short list is expected to be completed during the upcoming quarter. Spare parts ordering will also commence during April, 1995.

Procurement of Electrical Engineering Consultation Services

In order to expedite the construction of the PDU, as well as aid in the procurement of all electrical equipment and control instrumentation, Mr. Robert Reynouard, P.E. of Control Technology, Inc., Lakewood, Colorado, has been retained to provide electrical engineering consultation services. Mr. Reynouard has extensive experience in equipment procurement and control instrumentation. As a result, his services will help ensure timely completion of the project and help reduce capital equipment costs.

Currently, Mr. Reynouard is concentrating his efforts as follows:

- Procurement of 1,500 kVA transformer
- Procurement of motor control center equipment
- Procurement of control instrumentation
- Review and approval of electrical schematics

Transformer Installation

Information regarding the proposed installation of a new 1,500 kVA transformer was sent to Mr. Leonard Ellis of Public Service Company of Colorado on January 26, 1995. This information included the proposed location of the unit and a motor list with total expected loads. Mr. Ellis is currently reviewing this information. Currently, his main concerns include:

- Will the two 115 hp ball mill motors be installed with "soft start" units ?
- Will the Netzsch fine grinding mill be installed with a "soft start" unit ?
- What will be the exact location of the proposed transformer ?

A meeting is scheduled with Mr. Ellis during April to discuss and clarify these concerns.

Procurement of Permits for PDU Construction

Two copies of the civil/structural drawings were delivered to the Jefferson County Planning Department, who reviewed, approved, and forwarded them to the Building Department. After initial review, the Building Department requested that the prints be stamped by a Colorado Professional Engineer. A Bechtel engineer from Bechtel's Denver office visited the PDU site on March 24, 1995. Bechtel's engineers are reviewing the prints and should stamped them during the first week of April. The Building Department said that TIC is allowed to proceed with all work not requiring structural modifications.

Process Control Meeting with Bechtel

A meeting was held at Bechtel's San Francisco office on March 22 with S. Bajwa and M.V. Chari (Bechtel), and G. Shields (Entech) to discuss and update the PDU process control scheme. Overall, the meeting was very successful. Provisions were made to eliminate remote hand station starting of the PDU equipment and replace with a single point start-up scheme via the process controller. In addition, the interlock sequence was finalized.

On-Line Ash Analysis of Microcel™ Flotation Column

In order to control clean coal quality and monitor yield, tests are currently being conducted to evaluate the possibility of using on-line ash probes to determine the ash of the Microcel™ column feed, clean coal, and tailings streams. Nalco Chemical Company of Naperville, Illinois, is currently supplying many coal producers with on-line ash analyzers to monitor and control flotation circuits. Though the probes are currently used for accurately determining tailings ash values, Nalco representatives believe that the probes could also be used to analyze feed and clean coal slurry streams.

As a result, feed, tailings, and clean coal samples for the Sunnyside, Taggart, and Indiana VII coals were collected and shipped to Nalco's Richlands, Virginia, laboratory. Nalco will compare ash probe values with actual laboratory analysis. If successful, Nalco has agreed to rent three probes to Amax for use in the PDU's flotation circuit.

Selection/Procurement of Control and Data Acquisition System

After careful evaluation, Honeywell has been selected to supply a Control and Data Acquisition System for the PDU. Honeywell will supply a S9000 controller along with a SCAN3000 computer data acquisition unit. The S9000 controller is object oriented while the SCAN3000 unit utilizes UNIX based windows. As a result, the simplicity of these two units will allow Entech Global personnel to do a considerable amount of the configuring and programming resulting in substantial cost savings.

Equipment Hold Points / Shop Inspections

An inspection of the Enviro-Clear Tailings Thickener was conducted on February 14, 1995 at GECO Steel Company, Calgary, Alberta, Canada. A double bead weld was found in the radial of the unit's base indicating an unmatched fit. This, however, should not impact the integrity of the unit. The cone, de-aeration tank, and support steel was already painted with primer. The remainder was painted during the week of February 20. Overall, the unit was in very good condition and a release for shipment was granted.

PLANS FOR NEXT QUARTER

Following are the activities anticipated for continued work and/or completion during the April - June, 1995 quarterly reporting period:

- Subtask 3.2 - Near Term Applications testing will begin
- The final version of the Subtask 4.3 topical report will be issued once comments from all project partners are received and incorporated
- The Subtask 6.3 topical report, Process Optimization will be drafted and issued
- Work will begin on Subtask 6.4, Selective Agglomeration - CWF Formulation Studies
- Efforts for the Subtask 6.5 work will focus on completing the Subtask 6.5 test work, and providing Bechtel with necessary engineering design data
- Work will continue on the Task 7 detailed design of the selective agglomeration portion of the 2 t/hr PDU
- Subtask 8.2 efforts will be directed toward the following:
 - Continued construction of PDU and Flotation Module
 - Complete procurement of new capital equipment items
 - Complete procurement of electrical equipment items
 - Initialize Installation of new 1,500 kVA transformer
 - Select media for fine grinding mill

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