QUARTERLY TECHNICAL PROGRESS REPORT NO. 23

For

ENGINEERING DEVELOPMENT OF ADVANCED PHYSICAL FINE COAL CLEANING TECHNOLOGIES – FROTH FLOTATION

Prepared for
U.S. DEPARTMENT OF ENERGY
PITTSBURGH ENERGY TECHNOLOGY CENTER
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ICF KAISER ENGINEERS

With

Ohio Coal Development Office

Babcock & Wilcox

Consolidation Coal Company

Center for Research on Sulfur in Coal

EIMCO Process Equipment Company

Illinois State Geologic Survey

Kentucky Energy Cabinet Laboratory

Virginia Polytechnic Institute & State University

DISCLAIMER

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QUARTERLY TECHNICAL PROGRESS REPORT NO. 23

FOR PERIOD

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1.0 INTRODUCTION

A study conducted by Pittsburgh Energy Technology Center of sulfur emissions from about 1,300 United States coal-fired utility boilers indicated that half of the emissions were the result of burning coals having greater than 1.2 pounds of SO_2 per million BTU. This was mainly attributed to the high pyritic sulfur content of the boiler fuel. A significant reduction in SO_2 emissions could be accomplished by removing the pyrite from the coals by advanced physical fine coal cleaning.

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

1.1 Scope of this Document

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

This document a quarterly report prepared in accordance with the project reporting requirements covering the period from October 1, 1993 to December 31, 1993. This report provides a summary of the technical work undertaken during this period, highlighting the major results. A brief description of the work done prior to this quarter is provided in this report under the task headings.

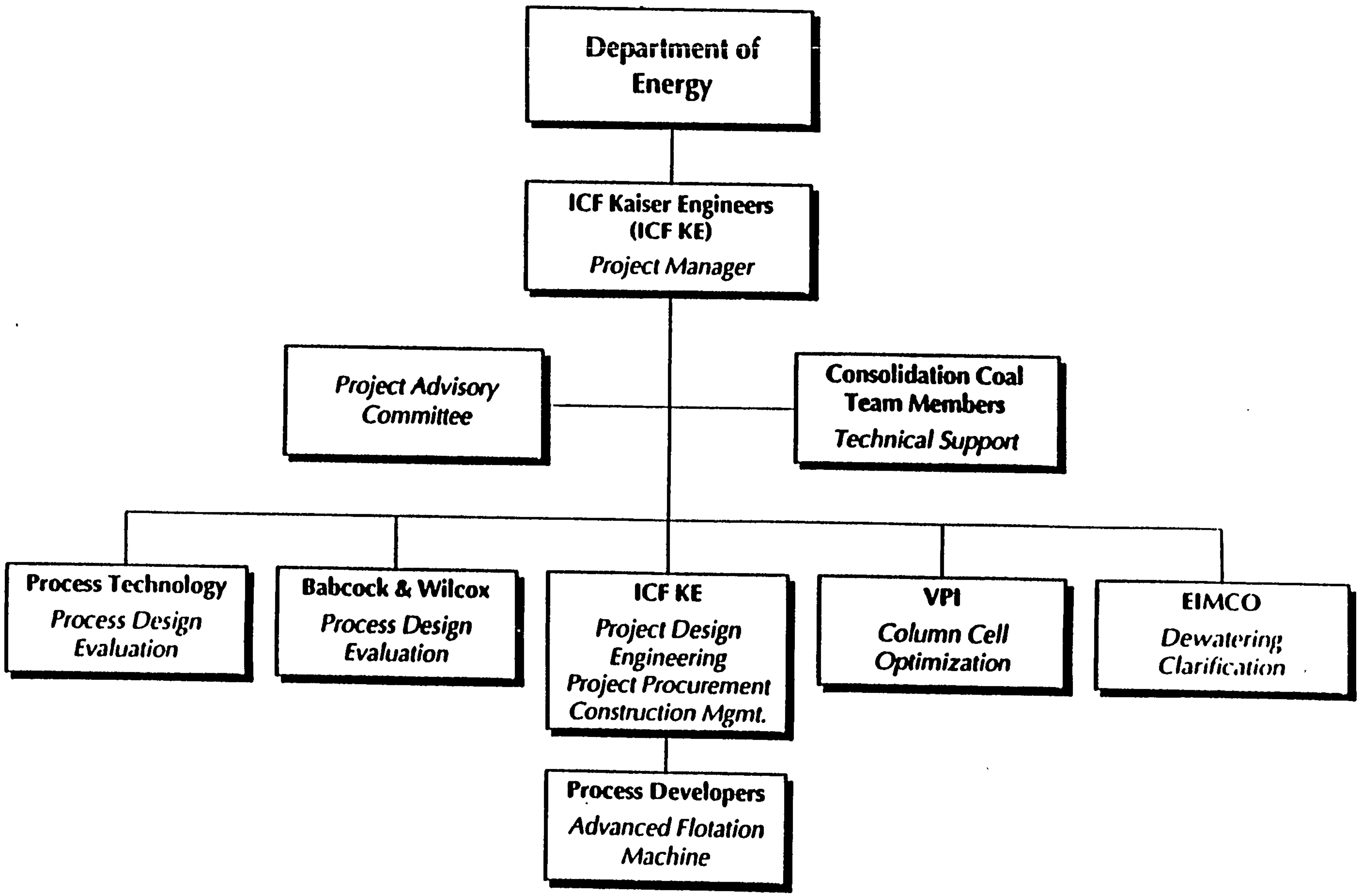
1.2 Overall Project Scope

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

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

Figure 1-1

Project Organization Chart



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

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

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

1.3 Work Executed at Different Locations

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

Table 1.1
Task and the Responsible Team Member

Task 1	Project Planning	ICF KE
Task 2	Preliminary Conceptual Design	ICF KE, B&W, EIMCO, TSG, TAC
Task 3	Determination of Critical Areas	ICF KE, B&W, EIMCO, TSG, TAC
Task 4	Test Plan Formulation	ICF KE, B&W, EIMCO, TSG
Task 5	Bench Scale Testing	ICF KE, B&W, EIMCO, PTI, TSG, TAC
Task 6	Component Development	VPI, TSG
Task 7	Analysis of Test Results	ICF KE, B&W, EIMCO, VPI, TSG
Task 8	Revised Conceptual Design	ICF KE
Task 9	POC Module Design	ICF KE, B&W, EIMCO, TSG, TAC
Task 10	POC Procurement and Fabrication	ICF KE
Task 11	POC Installation and Startup	ICF KE, B&W, EIMCO, TSG
Task 12	POC Test Plan Formulation	ICF KE, B&W, EIMCO, TSG, TAC
Task 13	POC Testing and Operation	ICF KE, B&W, EIMCO, TSG
Task 14	Analysis of POC Test Results	ICF KE, B&W, EIMCO, TSG
Task 15	Final Conceptual Design	ICF KE, B&W, EIMCO, TSG
Task 16	POC Module Removal	ICF KE

2.0 TASK 2 PRELIMINARY CONCEPTUAL DESIGN

2.1 Overview and Scope

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

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

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

2.2 Review of Work Completed This Quarter

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

3.0 TASK 3 CRITICAL AREA DETERMINATION

3.1 Overview and Scope

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

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

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

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

3.2 Review of Work Completed This Quarter

The final report of this task has been submitted to DOE. No additional work was planned nor completed during this quarter.

4.0 TASK 4 TEST PLAN FORMULATION

4.1 Overview and Scope

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

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

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

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

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

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

The detailed, quantified tests addressed obtaining data necessary for solving problems uncovered in the deficiency review. Each identified deficiency had a plan developed to address the reason for the testing, the means for the test matrix to obtain results and the expected results. Each test plan established procedures, adhering as much as possible, to known and industry-acceptable procedures for sampling and data collection. Raw data collection would be reduced to minimize expenses and to better be able to compare results and obtain meaningful information, especially scale-up factors.

The Development Test Plan for both parts one and two contained schedules, manpower requirements, and resources necessary to obtain information to define a commercially available system.

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

4.2 Review of Work Completed This Quarter

The Task 4 Report was submitted to DOE as a final report. No additional work was planned nor completed during this quarter.

5.0 TASK 5 BENCH-SCALE PROCESS TESTING

5.1 Overview and Scope

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

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

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

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

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

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

5.2 Review of Work Completed This Quarter

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

6.0 COMPONENT AND UNIT OPERATIONS DEVELOPMENT

6.1 Overview and Scope

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

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

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

6.2 Review of Work Completed this Quarter

This task has been completed and the results of this task are reported in the Task 7 Report. No additional work was planned or completed during this quarter.

7.0 EVALUATION OF BENCH-SCALE AND COMPONENT TEST RESULTS

7.1 Overview and Scope

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

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

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

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

7.2 Review of Work Completed this Quarter

This task has been completed and the Task 7 Report submitted to DOE in its final version. No additional work was planned or completed during this quarter.

8.0 REVISED CONCEPTUAL DESIGN OF SEMI-WORKS PLANT

8.1 Overview and Scope

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

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

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

8.2 Review of Work Completed this Quarter

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

9.0 POC MODULE DESIGN

9.1 Overview and Scope

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

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

9.2 Review of Work Completed this Quarter

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

10.0 POC MODULE FABRICATION

10.1 Overview and Scope

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

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

10.2 Review of Work Completed this Quarter

This task has been completed. No additional work was planned or completed during this quarter.

11.0 POC INSTALLATION AND START-UP

11.1 Overview and Scope

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

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

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

11.2 Review of Work Completed this Quarter

All construction has been completed. No additional work was planned or completed during this quarter.

12.0 POC TEST PLAN FORMULATION

12.1 Overview and Scope

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

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

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

12.2 Review of Work Completed this Quarter

No additional work was planned or completed during this quarter.

13.0 POC OPERATION

13.1 Overview and Scope

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

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

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

13.2 Review of Work Completed This Quarter

The recently enacted Clean Air Act Amendments (CAAA) contained provisions that would set standards for the allowable emissions of 190 hazardous air pollutants (HAPS). These 190 air toxics could be associated with any number of source categories that emit pollutants to the environment. Many of these HAPS could possibly be emitted from coal-fired electric generating stations.

Title III, the Hazardous Air Pollutants section of the CAAA, requires the EPA to determine stationary source categories that have the potential to emit any of the 190 HAPS listed in the act. Coal-fired electric utilities are on a draft list of 750 sources that the EPA has already developed. The EPA will designate as major sources those stationary sources that could emit 10 tons per year of any single HAP or 25 tons per year of a combination of HAPS.

Considerable actual HAPS emission data exist for many of the stationary sources that will be targeted as major sources. In these cases, the EPA will be able to use sound scientific data to prepare regulations. However, no such extensive data base exists for coal-fired utility boilers. Many of the literature accounts of toxic emissions from coal combustors consist of calculated values based on test burns under controlled conditions or incomplete material balance studies that related the emissions of trace metals to the inorganic composition of the input coal. Also, there is a high degree of uncertainty concerning much of the data on some of the more volatile components in flue gas. For example, results from a literature survey indicated that wet scrubbers remove anywhere from 20% to 80% of the mercury from utility boiler flue gas.

Efforts are underway to develop a more complete database on potential HAPS emissions from electric utilities. In a limited study, the Electric Power Research Institute (EPRI) has begun to assess the emissions from power plants under the PISCES (Power Plant Integrated Systems: Chemical Emission Studies) program using a consistent and comprehensive analytical protocol that evaluates all input and output streams at the utility.

The CAAA calls for the EPA to conduct a 3-year study of the potential health risks specific to utility sources. The study is to be completed by the end of 1993. At that time, EPA will determine whether the air toxics emissions from electric utilities will need to be regulated.

If regulations are promulgated, coal preparation could play a significant role in controlling air toxics. Physical coal cleaning can effectively reduce the quantity of power plant ash and SO_2 emissions for most coals. New studies have shown that coal cleaning can also decrease the concentration of many trace elements, reducing the possibility of atmospheric release during combustion. Certain trace elements have an affinity for the inorganic component of coal, while others have an affinity for the organic portion. However, organic and inorganic associations of trace elements can vary widely from coal to coal, and can show both extremes in their affinities. Because trace element removal before combustion is a relatively new, and potentially very important application of coal cleaning technology, new coal cleaning methods such as advanced flotation were studied to find the extent of trace element reduction by the process.

To answer the question about the possibility of advanced flotation making an impact on trace element removal, a test program was arranged during the demonstration runs. The test program consisted of collecting representative samples of the streams in the POC shown in Table 13.1.

Table 13.1
Sample Streams in POC

Sample Name	Sampler Number
Plant Feed	701
Plant Clean Coal	727
Refuse Thickener Feed	728
Ball Mill Feed	2733
Ball Mill Discharge	2734
Column Flotation Feed	2735
Column Flotation Concentrate	2736
Column Flotation Tailings	2737
Heavy Media Cyclone Reject	706

The samples were analyzed for trace elements and reported. The results of the analysis are shown in Appendix A. The analysis work was conducted at CONSOL Inc., one of the project's team members.

At CONSOL R&D, the analytical technique that was developed to determine most of the elements is inductively coupled plasma-mass spectroscopy (ICP-MS), as its name implies is the mass spectrometric determination of inorganic ions that are produced by an inductively coupled plasma. The elements are ionized in the plasma and exit as singly-charged positive ions. The ions produced in the plasma pass through an interface region which extracts the ions from the 8000-10000 K plasma at atmospheric pressure and introduces them to a quadruple mass spectrometer at 10^{-5} atm. There, the ions are separated by mass and detected by a channel electron multiplier.

ICP-MS elemental analysis offers a number of advantages over other techniques. It provides rapid, multi-element quantitative analysis. The entire periodic table can be scanned, reproducibly, in a few milliseconds. It has a wide linear range (10^5) eliminating the need for dilutions. It is extremely sensitive with detection limits in the parts per trillion range. Most importantly, it is highly selective since each ion exhibits only one peak.

The coal sample to be analyzed is burned in a muffle furnace under controlled conditions according to ASTM D3683-78. The resulting ash is then subjected to a multi-acid digestion of aqua regina and hydrofloric acid. This solution is taken to dryness, the solids redissolved in nitric acid, and finally introduced into the ICP-MS. Because mercury and selenium are volatilized and lost during the preliminary ashing step, they are analyzed by different techniques. Mercury is analyzed by the double gold amalgam mercury vapor method. A sample of the coal is burned and the mercury collected on a gold wire. This wire is then heated and the mercury collected on a second wire which is in turn heated causing mercury vapor to flow into an atomic absorption unit. A hydropyrolytic method originally developed at CONSOL for fluorine analysis has proven effective for the analysis of selenium. In this case, the sample is burned in the presence of humidified air. The selenium in the sample is released and captured in a weakly basic solution. An aliquot of the condensate is then acidified and analyzed by ICP-MS.

The data generated for the POC was analyzed and the preliminary results for each coal tested are shown on Tables 13.2 for Pittsburgh No. 8, Table 13.3 for Upper Freeport, and Table 13.4 for Illinois No. 6.

A final topical report will be prepared for this subject and will be released during the month of November.

Table 13.2
Pittsburgh No. 8 Trace Element
Overall Plant Rejection

Trace Element	Feed PPM	Cal. Feed PPM	Refuse PPM	Coal PPM	Trace Element Rejection
As	31.20	24.75	20.94	3.81	41.32%
Ba	181.00	164.88	153.27	11.61	45.40%
Be	2.55	2.40	1.76	0.64	35.85%
Cd	0.39	0.46	0.39	0.07	41.22%
Co	11.20	10.59	8.92	1.67	41.15%
Cr	55.00	54.77	46.99	7.78	41.91%
Cu	29.90	30.18	26.40	3.78	42.73%
F	486.00	497.25	457.70	39.55	44.96%
Hg	0.10	0.11	0.07	0.04	30.77%
Li	45.30	44.92	40.77	4.15	44.32%
Mn	149.00	147.72	138.87	8.85	45.91%
Mo	3.37	3.35	2.35	1.00	32.24%
Ni	41.80	30.70	25.27	5.42	40.21%
Pb	19.00	18.86	16.65	2.21	43.12%
Sb	1.87	1.80	1.21	0.58	33.00%
Se	3.09	2.76	1.88	0.88	33.29%
Sn	2.22	6.92	6.44	0.48	45.48%
Th	7.64	7.15	6.29	0.86	42.97%
Tl	1.94	1.58	1.37	0.20	42.50%
U	2.62	2.49	1.99	0.50	39.00%
V	72.90	77.49	65.67	11.82	41.39%
Zn	54.90	49.06	42.46	6.60	42.27%

Table 13.3
Upper Freeport Trace Element
Overall Plant Rejection

Trace Element	Feed PPM	Cal. Feed PPM	Refuse PPM	Coal PPM	Trace Element Rejection
As	14.00	16.52	14.39	2.13	26.70%
Ba	201.00	209.62	162.67	46.95	23.79%
Be	4.31	4.13	1.00	3.13	7.40%
Cd	0.19	0.21	0.17	0.05	23.71%
Co	7.79	8.07	4.64	3.43	17.64%
Cr	28.90	35.19	17.99	17.20	15.67%
Cu	29.00	30.72	18.79	11.93	18.75%
F	123.00	165.45	111.01	54.44	20.56%
Hg	0.43	0.36	0.23	0.12	19.92%
Li	47.50	42.93	24.69	18.24	17.63%
Mn	114.00	166.73	134.13	32.59	24.66%
Mo	3.38	4.25	2.57	1.69	18.50%
Ni	23.90	126.52	15.01	11.51	17.35%
Pb	25.80	28.68	22.11	6.57	23.63%
Sb	1.03	1.14	0.63	0.51	16.90%
Se	3.88	4.03	2.40	1.64	18.21%
Sn	1.39	1.52	0.70	0.82	14.11%
Th	4.57	4.26	2.02	2.24	14.54%
Tl	2.69	3.09	2.58	0.51	25.56%
U	21.80	2.82	1.39	1.43	15.13%
V	43.40	43.68	14.76	28.92	10.36%
Zn	41.80	47.40	36.10	11.30	23.34%

Table 13.4
Illinois No. 6 Trace Element
Overall Plant Rejection

Trace Element	Feed PPM	Cal. Feed PPM	Refuse PPM	Coal PPM	Trace Element Rejection
As	9.57	10.13	8.19	1.93	35.66%
Ba	162.00	161.13	139.99	21.14	38.30%
Be	2.10	2.12	1.28	0.84	26.60
Cd	6.00	2.71	2.57	0.14	41.81%
Co	9.32	8.72	6.71	2.00	33.96%
Cr	92.00	98.63	84.77	13.87	37.88%
Cu	36.10	28.78	23.23	5.55	35.58%
F	585.00	563.43	529.54	33.89	41.43%
Hg	0.17	0.15	0.10	0.05	29.09%
Li	20.10	20.49	16.19	4.30	34.83%
Mn	131.00	130.92	119.23	11.69	40.14%
Mo	26.40	26.49	17.77	8.72	29.56%
Ni	46.80	52.56	42.99	9.56	36.06%
Pb	48.00	44.33	33.09	11.24	32.90%
Sb	1.55	1.63	1.32	0.31	35.77%
Se	9.58	10.79	8.95	1.84	36.56%
Sn	2.89	1.50	1.10	0.40	32.28%
Th	5.19	5.16	3.97	1.20	33.86%
Tl	2.02	2.15	1.75	0.40	35.83%
U	10.60	12.74	7.86	4.88	27.19%
V	104.00	115.55	91.16	24.38	34.78%
Zn	207.00	162.31	149.50	12.81	40.60%

14.0 TASK 14 POC OPERATIONS ANALYSIS

14.1 Overview and Scope

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

14.2 Review of Work Completed This Quarter

As stated above, the Task 14 report will result in a complete analysis of the results from all the test runs on all the coals processed in the POC module. While this data was being compiled, a flowsheet was being developed for Task 15. This quarterly report will highlight the results from the three seams of coal tested in the POC, Pittsburgh No. 8, Upper Freeport, and Illinois No. 6.

PITTSBURGH NO. 8 TESTING

The Pittsburgh No. 8 coal was obtained from Windsor Coal Company, Brooke County, West Virginia. The mine is an underground mine and is a subsidiary of Ohio Power Company. The Pittsburgh No. 8 coal was donated by Ohio Power Company for the POC operation. This coal is not the same coal as tested in Tasks 5 & 6. There was a logistic problem in obtaining the coal from the Task 5 and 6 supplier and the coal supplier was switched to Windsor Coal Company.

The Pittsburgh No. 8 coal was the primary testing coal in the POC operation. This coal was tested to determine the best cyclone configuration in the heavy-media cyclone, water-only cyclone, the classifying cyclone, the ball mill classifying cyclone, the grinding circuit, and finally a factorial testing program to establish the operating parameters for the advanced column flotation cell.

Unit Operations

Heavy-Media Cyclone

The heavy-media cyclone was the first precleaning unit operation in the circuit. Four (4) tests were conducted on the heavy-media cyclone over a range of specific gravities of media from 1.70 - 1.85. The determining factor was the lowest specific gravity that produced 97% Btu recovery. The results are shown in Tables 14.1 - 14.4. The results show that with 1.75 specific gravity the Btu recovery of 97.8% was obtained. This was the specific gravity used in the remainder of the Pittsburgh No. 8 test program.

Table 14.1

HEAVY MEDIA CYCLONE TEST RESULTS - PITTSBURGH NO. 8
TEST RUN NUMBER: 93030803

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME DISCHARGE	MANUAL	28.40	10201	-
HMC CLEAN COAL	705	11.15	13103	-
HMC REFUSE	706	81.49	1524	-
HMC WT% RECOVERY			75.48	
HMC BTU RECOVERY			96.95	

Table 14.2

HEAVY MEDIA CYCLONE TEST RESULTS - PITTSBURGH NO. 8
TEST RUN NUMBER: 93030804

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME DISCHARGE	MANUAL	28.78	10077	-
HMC CLEAN COAL	705	11.48	13067	-
HMC REFUSE	706	81.80	1538	-
HMC WT% RECOVERY			75.40	
HMC BTU RECOVERY			97.77	

Table 14.3

HEAVY MEDIA CYCLONE TEST RESULTS - PITTSBURGH NO. 8
TEST RUN NUMBER 93030805

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME DISCHARGE	MANUAL	28.30	10225	-
HMC CLEAN COAL	705	11.83	13113	-
HMC REFUSE	706	83.71	1324	-
HMC WT% RECOVERY			77.09	
HMC BTU RECOVERY			98.86	

Table 14.4

HEAVY MEDIA CYCLONE TEST RESULTS - PITTSBURGH NO. 8
TEST RUN NUMBER: 93030806

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME DISCHARGE	MANUAL	28.74	10165	-
HMC CLEAN COAL	705	11.53	13123	-
HMC REFUSE	706	83.36	1436	-
HMC WT% RECOVERY			76.40	
HMC BTU RECOVERY			98.17	

Water-Only Cyclone

The product of the heavy-media cyclone was crushed in a closed circuit to minus-48 mesh and combined with the natural 48 mesh x zero and processed in a water-only cyclone. The water-only cyclone was used to remove high-ash, free-pyrite, and low Btu reject material ahead of conventional flotation. The water-only cyclone has the ability to remove free liberated pyrite that may be collected by flotation. An extensive testing program was implemented in an attempt to maximize Btu recovery and reject free pyrite. The parameters tested for the water-only cyclone involved the different arrangements of vortex diameter/length, apex diameter and feed pressure. The water-only cyclone manufacture was consulted to determine the best arrangement. The test numbers and parameters are shown in Table 14.5.

Table 14.5
Water-Only Cyclone Parameters

Test No.	Vortex Dia, in.	Vortex Length, in	Apex Dia., in.	Pressure, psig
93031002	3.0	7.0	1.0	14.5
93031701	2.5	14.0	1.0	15.0
93031901	3.0	10.5	1.0	14.5
93032201	2.5	14.0	1.0	10.0
93032202	2.5	14.0	1.0	19.5
93032302	3.0	7.0	1.0	30.0
93032501	3.0	7.0	0.625	19.5
93032502	3.0	7.0	.050	19.5
93032601	3.0	7.0	0.625	19.5

A total of nine (9) tests were conducted in an effort to determine the best parameters for the water-only cyclone. The results of these tests are shown in Tables 2.6 - 2.14. The best combination was from test 93031002 that produced a Btu recovery of 98.0%. This arrangement was used in the remainder of the Pittsburgh No. 8 test program.

Conventional Flotation

The heavy-media cyclone and the water-only cyclone were operated at the determined conditions and testing of the conventional flotation began. The Task 5 test work indicated that no grab-and-run product could be obtained for the Pittsburgh No. 8 Coal. This was demonstrated in the first test conducted in the conventional flotation. These results

Table 14.6

WATER ONLY CYCLONE TEST RESULTS - PITTSBURGH NO. 8
TEST RUN NUMBER: 93031002

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME UNDERFLOW	702	20.09	11725	3.06
WOC CLEAN COAL	708	19.99	11574	2.64
WOC REFUSE	717B	33.32	9492	3.18
WOC WT% RECOVERY			99.25	
WOC BTU RECOVERY			97.97	

Table 14.7

WATER ONLY CYCLONE TEST RESULTS - PITTSBURGH NO. 8
TEST RUN NUMBER: 93031701

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME UNDERFLOW	702	20.34	11487	3.14
WOC CLEAN COAL	708	17.60	12159	2.80
WOC REFUSE	717b	35.44	8993	7.04
WOC WT% RECOVERY			84.64	
WOC BTU RECOVERY			89.59	

Table 14.8

WATER ONLY CYCLONE TEST RESULTS - PITTSBURGH NO. 8
TEST RUN NUMBER 93031901

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME UNDERFLOW	702	21.42	11487	2.51
WOC CLEAN COAL	708	21.33	11544	2.94
WOC REFUSE	717b	35.31	9119	6.01
WOC WT% RECOVERY			99.36	
WOC BTU RECOVERY			99.85	

Table 14.9

WATER ONLY CYCLONE TEST RESULTS - PITTSBURGH NO. 8
TEST RUN NUMBER: 93032201

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME UNDERFLOW	702	23.99	10843	2.96
WOC CLEAN COAL	708	19.37	11803	2.48
WOC REFUSE	717B	27.78	10398	4.96
WOC WT% RECOVERY			45.07	
WOC BTU RECOVERY			49.06	

Table 14.10

WATER ONLY CYCLONE TEST RESULTS - PITTSBURGH NO. 8
TEST RUN NUMBER: 93032202

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME UNDERFLOW	702	18.76	11902	3.21
WOC CLEAN COAL	708	19.67	11817	2.56
WOC REFUSE	717B	30.52	9855	5.82
WOC WT% RECOVERY			108.39	
WOC BTU RECOVERY			107.61	

Table 14.11

WATER ONLY CYCLONE TEST RESULTS - PITTSBURGH NO. 8
TEST RUN NUMBER: 93032302

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME UNDERFLOW	702	19.35	11821	3.32
WOC CLEAN COAL	708	17.02	12350	2.67
WOC REFUSE	717B	26.08	8845	7.34
WOC WT% RECOVERY			74.28	
WOC BTU RECOVERY			77.61	

Table 14.12

WATER ONLY CYCLONE TEST RESULTS - PITTSBURGH NO. 8
TEST RUN NUMBER 93032501

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME UNDERFLOW	702	17.46	12056	3.44
WOC CLEAN COAL	708	15.79	12386	2.93
WOC REFUSE	717B	52.14	5923	11.28
WOC WT% RECOVERY			95.41	
WOC BTU RECOVERY			98.02	

Table 14.13

WATER ONLY CYCLONE TEST RESULTS - PITTSBURGH NO. 8
TEST RUN NUMBER: 93032502

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME UNDERFLOW	702	17.09	12088	2.80
WOC CLEAN COAL	708	17.63	11995	2.81
WOC REFUSE	717B	53.31	6016	9.00
WOC WT% RECOVERY			101.51	
WOC BTU RECOVERY			100.73	

Table 14.14

WATER ONLY CYCLONE TEST RESULTS - PITTSBURGH NO. 8
TEST RUN NUMBER: 93032601

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME UNDERFLOW	702	20.34	12487	3.17
WOC CLEAN COAL	708	17.60	12159	3.01
WOC REFUSE	717B	35.44	8993	9.33
WOC WT% RECOVERY			84.64	
WOC BTU RECOVERY			89.59	

are shown in Tables 14.15 and 14.16. Both tests indicate no grab-and-run product was obtained and that the data gathered did not material balance, so it was forced to balance. In any case, an observation of the tailings ash for either side A or side B demonstrates low Btu recovery.

After determining that no grab-and-run product could be obtained, five more tests were conducted to maximize Btu recovery. The results are shown in Tables 14.17 thru 14.21. None of the tests resulted in a product that achieved the goal of 97% Btu recovery. In addition to a low Btu recovery, large amounts of frother had to be employed to produce high recoveries. The large amounts of frother contaminated the recirculating water. The contaminated recirculated water caused operating problems throughout the POC.

Based upon low Btu recovery and the contaminated recirculation water, conventional flotation was eliminated from the POC flowscheme. There are advantages to not incorporating conventional flotation. The capital cost of conventional flotation as well as operating costs can be saved because of the elimination of conventional flotation. In addition, the probability of obtaining 85% Btu recovery in the final product is enhanced.

Grinding

The first system tested in the advanced DOE POC was the grinding circuit. The grinding circuit consisted of the mill classifying cyclones in reversed closed circuit with the ball mill. Reversed closed circuit means the incoming feed and the ball-mill product are sized in the mill classifying cyclones ahead of the mill. This permits removal of natural-sized material and ground-sized material before recirculation through the ball mill.

Numerous tests were conducted to establish the correct combination of orifice sizes, pressures, and grinding media to meet the design criteria of 95% passing-200 mesh in the column flotation feed. The results from this test work are shown in Table 14.22, Grinding Circuit Test Results and graphs show Microtrac and screen analysis comparison by test, Figure 14.1, and mean particle size versus ball mill feed rate, Figure 14.2.

Our examination of the data indicated that the ball mill must have the smaller grinding media, and the mill-classifying cyclone must be arranged as shown in test 93041901. A second conclusion is that the feed rate to the column would have to be very low in order to reach the second grinding criteria of 90% passing-325 mesh. In fact, the probability of obtaining this result would be very low. For this reason, and because the testing was behind schedule, the minus-325-mesh test portion was eliminated from the test program.

Table 14.15

CONVENTIONAL FLOTATION TEST RESULTS - PITTSBURGH NO. 8
TEST RUN NUMBER: 93031001 - A BANK

SAMPLER NAME	SAMPLER NUMBER	WT %	ASH %	% SOLIDS BY WT.	BTU
FEED	712A	100.00	16.83	10.99	12267
ROUGHER CONC.	715A	-30.19	11.95	5.90	13027
SCAV. CONC.	713A	96.23	11.35	12.22	13113
TAILINGS	714A	33.96	28.02	2.98	10375
FLOT. WT % RECOVERY			66.04		
FLOT. BTU RECOVERY			70.81		

Table 14.16

CONVENTIONAL FLOTATION TEST RESULTS - PITTSBURGH NO. 8
TEST RUN NUMBER: 93031002 - A BANK

SAMPLER NAME	SAMPLER NUMBER	WT %	ASH %	% SOLIDS BY WT.	BTU
FEED	712A	100.00	14.82	5.11	12625
ROUGHER CONC.	715A	60.17	13.41	4.46	12589
SCAV. CONC.	713A	2.93	10.14	28.42	13359
TAILINGS	714A	36.91	17.49	4.32	12193
FLOT. WT % RECOVERY			63.09		
FLOT. BTU RECOVERY			63.09		

Table 14.15

WATER ONLY CYCLONE TEST RESULTS - PITTSBURGH NO. 8
TEST RUN NUMBER 93031901

SAMPLER NAME	SAMPLER NUMBER	WT %	ASH %	TOTAL SULFUR %	BTU
FEED	712a	100.00	26.89	2.38	10700
ROUGHER CONC.	715A	141.37	25.73	2.39	10756
SCAV. CONC.	713A	-31.21	25.34	2.23	10895
TAILINGS	714A	-10.16	15.51	2.98	12507
FLOT. WT % RECOVERY				110.16	
FLOT. BTU RECOVERY				110.33	

Table 14.16

CONVENTIONAL FLOTATION TEST RESULTS - PITTSBURGH NO. 8
TEST RUN NUMBER: 93031002 - B BANK

SAMPLER NAME	SAMPLER NUMBER	WT %	ASH %	TOTAL SULFUR %	BTU
FEED	712A	100.00	38.76	2.02	8723
ROUGHER CONC.	715A	-4.09	20.07	2.26	11776
SCAV. CONC.	713A	69.27	30.25	2.20	10191
TAILINGS	714A	34.81	53.50	1.69	6321
FLOT. WT. % RECOVERY				65.19	
FLOT. BTU RECOVERY				75.41	

Table 14.17

CONVENTIONAL FLOTATION RESULTS FOR PITTSBURGH NO. 8
TEST RUN NUMBER: 93032201 - BANK A

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
FEED	712A	14.89	12617	2.76
ROUGHER CONC.	715A	11.48	13277	3.03
TAILINGS	714A	19.41	11793	2.59
FLOT. WT% RECOVERY			57.00	
FLOT. BTU RECOVERY			59.98	

BANK B

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
FEED	712a	46.49	7578	1.89
ROUGHER CONC.	715A	26.17	10656	2.02
TAILINGS	714A	52.85	6493	1.38
FLOT. WT % RECOVERY			23.84	
FLOT. BTU RECOVERY			33.52	

Table 14.18

CONVENTIONAL FLOTATION RESULTS FOR PITTSBURGH NO. 8
TEST RUN NUMBER: 93032202 - BANK A

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
FEED	712A	15.33	12495	2.94
ROUGHER CONC.	715A	10.36	13211	2.95
TAILINGS	714A	22.66	11234	2.62
FLOT. WT% RECOVERY			59.59	
FLOT BTU RECOVERY			63.01	

BANK B

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
FEED	712A	41.83	8060	1.84
ROUGHER CONC.	715A	30.15	9742	2.08
WOC REFUSE	714A	53.61	6323	1.65
FLOT. WT% RECOVERY			50.21	
FLOT BTU RECOVERY			60.69	

Table 14.19

CONVENTIONAL FLOTATION RESULTS FOR PITTSBURGH NO. 8
TEST RUN NUMBER: 93032302 - BANK A

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
FEED	712A	12.86	13026	2.87
ROUGHER CONC.	715A	9.67	13439	2.88
TAILINGS	714A	53.23	6452	2.77
FLOT. WT% RECOVERY			92.68	
FLOT. BTU RECOVERY			95.62	

BANK B

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
FEED	712a	31.72	9640	2.18
ROUGHER CONC.	715A	24.16	10630	2.42
TAILINGS	714A	64.98	4418	1.57
FLOT. WT % RECOVERY			81.48	
FLOT. BTU RECOVERY			89.85	

Table 14.20

CONVENTIONAL FLOTATION RESULTS FOR PITTSBURGH NO. 8
TEST RUN NUMBER: 93032501 - BANK A

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
FEED	712A	14.45	12549	3.19
ROUGHER CONC.	715A	10.43	13208	3.18
TAILINGS	714A	70.76	3449	4.05
FLOT. WT% RECOVERY			93.34	
FLOT BTU RECOVERY			98.24	

BANK B

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
FEED	712A	36.33	8914	1.80
ROUGHER CONC.	715A	15.03	12519	2.00
WOC REFUSE	714A	50.39	6804	1.66
FLOT. WT% RECOVERY			39.76	
FLOT BTU RECOVERY			55.84	

Table 14.21

CONVENTIONAL FLOTATION RESULTS FOR PITTSBURGH NO. 8
TEST RUN NUMBER: 93032503 - BANK A

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
FEED	712A	13.89	12549	3.00
ROUGHER CONC.	715A	9.45	13208	2.96
TAILINGS	714A	63.23	3449	4.32
FLOT. WT% RECOVERY			91.74	
FLOT. BTU RECOVERY			96.56	

BANK B

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
FEED	712A	35.87	9304	1.91
ROUGHER CONC.	715A	18.34	11765	1.96
TAILINGS	714A	70.89	3580	1.62
FLOT. WT % RECOVERY			66.64	
FLOT. BTU RECOVERY			84.27	

Table 14.22

Mill Circuit Testing Pittsburgh No. 8

Note: Ball mill charge changed to finer media prior to run number – 93041901

TEST NUMBER		93040101	93040102	93040701	93040702	93040801	93040802	93040803	93041201	93041301	93041401	93041402	93041901	93041902	93041903	93042201
MILL SPEED – RPM		27.70	27.70	27.70	27.70	27.70	27.70	27.70	27.70	27.70	27.70	27.70	27.70	27.70	27.70	27.70
MILL FEED – TPH		4.42	2.08	1.25	2.79	3.01	2.76	2.48	9.30	5.84	4.45	2.72	2.61	6.52	1.99	3.80
MILL FEED – % SOLIDS		53.27	53.49	27.62	45.96	49.44	47.48	44.97	18.86	32.24	29.16	47.61	42.43	53.55	37.49	53.76
CYC FEED – TPH		8.35	4.29	2.28	4.74	5.64	4.92	4.23	11.56	8.11	6.47	4.96	5.07	13.46	3.28	7.06
CYC FEED – GPM		250.10	241.12	272.34	275.95	232.84	243.45	239.14	429.64	303.86	342.56	242.45	252.45	282.78	238.35	237.14
CYC FEED – % SOLIDS		12.92	6.99	3.32	6.76	9.47	7.93	6.96	10.48	10.39	7.41	8.03	7.87	18.18	5.42	11.56
NO. OF CYCLONES		2	2	2	2	2	2	2	3	2	3	2	2	2	2	2
VORTEX FINDER – DIA		1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.25	1.25	1.25	1.25	1.25	1.25
APEX – DIA		0.75	0.63	0.75	0.75	0.75	0.75	0.75	1.25	1.00	0.75	0.63	0.63	0.63	0.63	0.63
PRESSURE		27.40	22.20	34.10	34.10	20.00	37.80	15.50	22.20	39.30	31.00	36.00	35.50	35.00	35.00	34.00
COLUMN FEED																
MEAN SIZE – MICRONS		38.22	40.65	36.47	39.26	42.24	41.69	38.25	75.42	41.44	39.01	35.29	65.35	118.53	37.02	43.66
D 95 – MICRONS		126.58	113.83	100.95	109.21	122.12	123.00	109.96	230.53	119.62	115.08	112.60	205.03	285.73	112.54	107.45
MICROTRAC	+200	15.76	16.11	11.41	13.75	16.78	16.16	13.54	37.32	16.08	14.20	13.08	48.02	68.96	11.93	16.66
	200 x 325	15.13	19.99	18.61	19.85	20.47	19.52	18.88	17.64	19.48	18.21	15.81	24.79	18.39	16.33	25.23
	325 x 0	69.11	63.90	69.98	66.40	62.75	64.32	67.58	45.04	64.44	67.59	71.11	27.19	12.65	71.74	58.11
SCREEN ANALYSIS	+200	–	–	8.62	9.19	8.79	10.10	12.90	22.00	11.84	14.11	12.12	6.22	31.79	9.34	14.57
	200 x 325	–	–	17.07	15.72	11.57	14.62	19.86	17.08	17.60	15.84	17.63	19.75	15.60	15.66	18.18
	325 x 0	–	–	74.31	75.09	79.64	75.28	67.24	60.92	70.56	70.05	70.25	74.03	52.61	75.00	67.25
BALL MILL FEED																
MEAN SIZE – MICRONS		174.50	170.55	128.47	144.31	154.57	175.61	163.27	121.12	127.92	102.18	108.33	184.07	243.64	83.45	174.53
D 95 – MICRONS		402.34	387.12	307.09	335.74	342.61	413.16	396.46	278.26	305.21	222.63	228.00	430.83	494.96	181.74	389.61
MICROTRAC	+200	81.75	82.09	68.65	76.28	80.30	82.07	77.86	66.60	69.68	61.95	65.04	84.93	95.32	49.64	84.98
	200 x 325	9.70	10.86	18.68	16.25	12.86	12.22	14.82	18.92	19.21	23.73	23.28	11.67	3.83	27.57	11.01
	325 x 0	8.55	7.05	12.67	7.47	6.84	5.71	7.32	14.48	11.11	14.32	11.68	3.40	0.85	22.79	4.01
SCREEN ANALYSIS	+200	–	–	67.29	69.40	76.05	71.96	70.56	58.17	57.11	58.82	73.85	62.93	84.28	75.55	74.79
	200 x 325	–	–	18.17	16.34	12.19	14.07	14.73	20.07	21.68	21.77	11.99	21.01	5.58	8.11	10.97
	325 x 0	–	–	14.54	14.26	11.76	13.97	14.71	21.76	21.21	19.41	14.16	16.06	10.14	16.34	14.24
BALL MILL DISCHARGE																
MEAN SIZE – MICRONS		94.24	50.46	75.85	78.92	96.65	87.96	80.42	62.61	112.69	79.75	61.20	101.51	116.20	70.76	83.76
D 95 – MICRONS		240.15	156.46	208.72	209.47	237.51	231.13	212.03	207.17	264.12	179.54	163.72	206.49	242.00	163.16	169.42
MICROTRAC	+200	52.40	24.42	40.27	43.28	55.21	47.95	44.44	45.16	63.46	46.93	32.30	64.71	70.11	39.28	52.51
	200 x 325	18.37	17.26	21.10	21.24	18.52	19.69	19.27	23.68	19.72	27.04	22.54	22.29	18.53	28.28	29.26
	325 x 0	29.23	58.32	38.63	35.48	26.27	32.36	36.29	31.16	16.82	26.03	45.16	13.00	11.36	32.44	18.23
SCREEN ANALYSIS	+200	–	–	25.95	30.98	35.95	30.83	27.92	45.09	47.01	32.47	24.61	18.48	44.69	31.22	35.87
	200 x 325	–	–	21.56	22.57	21.68	21.18	21.06	18.44	22.96	28.49	26.46	32.89	14.02	21.16	18.19
	325 x 0	–	–	52.49	46.45	42.37	47.99	51.02	36.47	30.03	39.04	48.93	48.63	41.29	47.62	45.94
REDUCTION RATIO		1.85	3.38	1.69	1.83	1.60	2.00	2.03	1.93	1.14	1.28	1.77	1.81	2.10	1.18	2.08

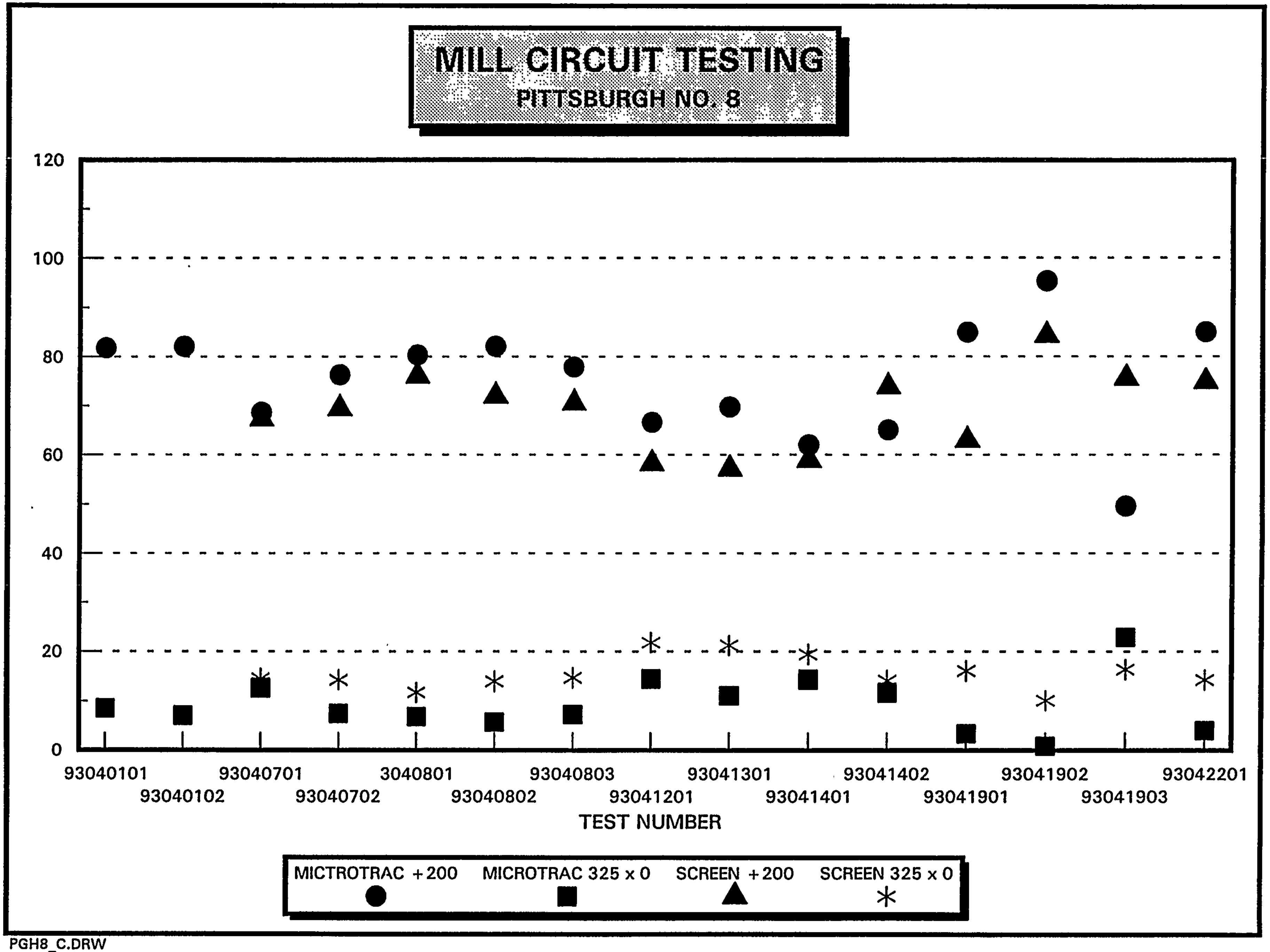


Figure 14.1 Mill Circuit Testing - Microtrac & Screen Analysis Comparison by Test

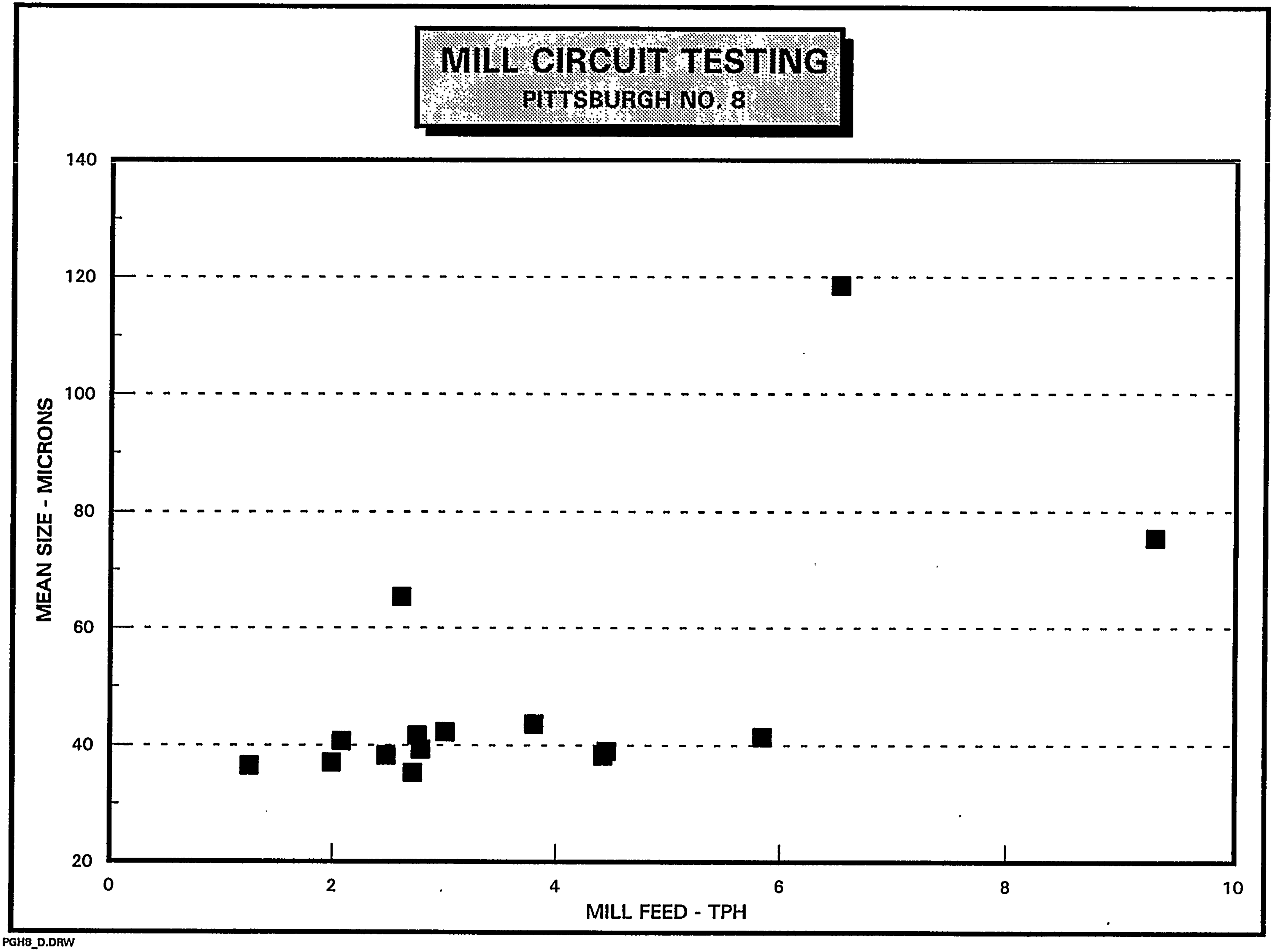


Figure 14.2 Mill Circuit Testing Micron Particle Size vs. Mill Feed Rate

Steady-State Condition Testing

The testing program set up for the POC was a very aggressive approach. The project required conducting a test procedure, collecting the samples and immediately transferring the samples to a commercial coal testing laboratory for overnight analysis. At the beginning of the program a number of analysis errors showed up in the reported values. The team stopped the program to examine what was required to improve results and still maintain the overnight analytical results.

The team working with the commercial laboratory arrived at several conclusions. The first was that the sample size was too large. The second was that the drum liners, which were plastic bags, were not strong enough to resist rough handling. The last conclusion was that the commercial laboratory must improve the sample preparation QA/QC program.

The above conclusions were recognized and remedied. The sample size was reduced especially for all of the slurry samples. The size or quantity of material was reduced but the minimum of eleven (11) cuts during any one test was never compromised, thus insuring that a proper representative sample was collected. The problem of the plastic liners was eliminated by purchasing 20 gallon polyethylene barrels that required no liner. Finally, the laboratory reviewed the sample preparation procedure and improved its quality control.

In order to determine if the changes made any difference, a test was conducted and three sub-samples of six (6) samples were collected and delivered to three (3) laboratories for comparison of results. These results are shown on Table 14.23. The following Table 14.24 indicates the reproducability of results submitted by different laboratories, different equipment, operators, date of test and different portions of the same pulp.

Comparison of Laboratory Results Between Standard, AEP, and Consol
Test Run Number 93032302

#	Sample	Sample Wt.			Average	Standard		Consol		AEP	
		Standard	Consol	AEP	of all labs	Abs. Diff.	Rel. Diff. (%)	Abs. Diff.	Rel. Diff. (%)	Abs. Diff.	Rel. Diff. (%)
702	Deslime Screen Underflow	146.3	148.5	152.9	149.2	−2.97	−1.99	−0.72	−0.48	3.68	2.47
708	Hydrocyclone Overflow	197.0	196.0	196.4	196.5	0.53	0.27	−0.47	−0.24	−0.07	−0.03
712B	Rougher (B) Flotation Feed	103.5	101.5	102.7	102.6	0.93	0.91	−1.07	−1.04	0.13	0.13
713B	Scavenger (B) Flotation Conc.	80.5	83.5	82.4	82.1	−1.63	−1.99	1.37	1.66	0.27	0.32
714B	Scavenger (B) Flotation Tails	89.3	85.0	86.2	86.8	2.43	2.80	−1.82	−2.09	−0.62	−0.71
717B	Hydrocyclone Underflow	8.0	8.0	7.7	7.9	0.10	1.27	0.10	1.27	−0.20	−2.53

#	Sample	% Solids			Average	Standard		Consol		AEP	
		Standard	Consol	AEP	of all labs	Abs. Diff.	Rel. Diff. (%)	Abs. Diff.	Rel. Diff. (%)	Abs. Diff.	Rel. Diff. (%)
702	Deslime Screen Underflow	5.60	5.60	5.01	5.40	0.20	3.64	0.20	3.64	−0.39	−7.28
708	Hydrocyclone Overflow	4.65	4.20	4.03	4.29	0.36	8.31	−0.09	−2.17	−0.26	−6.13
712B	Rougher (B) Flotation Feed	1.02	1.20	1.16	1.13	−0.11	−9.47	0.07	6.51	0.03	2.96
713B	Scavenger (B) Flotation Conc.	3.38	4.50	4.39	4.09	−0.71	−17.36	0.41	10.02	0.30	7.33
714B	Scavenger (B) Flotation Tails	0.33	0.30	0.24	0.29	0.04	13.79	0.01	3.45	−0.05	−17.24
717B	Hydrocyclone Underflow	35.27	34.80	36.55	35.54	−0.27	−0.76	−0.74	−2.08	1.01	2.84

#	Sample	% Ash			Average	Standard		Consol		AEP	
		Standard	Consol	AEP	of all labs	Abs. Diff.	Rel. Diff. (%)	Abs. Diff.	Rel. Diff. (%)	Abs. Diff.	Rel. Diff. (%)
702	Deslime Screen Underflow	19.35	20.49	19.42	19.75	−0.40	−2.04	0.74	3.73	−0.33	−1.69
708	Hydrocyclone Overflow	17.02	17.87	17.56	17.48	−0.46	−2.65	0.39	2.21	0.08	0.44
712B	Rougher (B) Flotation Feed	31.72	34.30	33.74	33.25	−1.53	−4.61	1.05	3.15	0.49	1.46
713B	Scavenger (B) Flotation Conc.	24.16	25.73	26.14	25.34	−1.18	−4.67	0.39	1.53	0.80	3.14
714B	Scavenger (B) Flotation Tails	64.98	68.69	68.17	67.28	−2.30	−3.42	1.41	2.10	0.89	1.32
717B	Hydrocyclone Underflow	36.08	38.31	37.21	37.20	−1.12	−3.01	1.11	2.98	0.01	0.03

#	Sample	% Sulfur			Average	Standard		Consol		AEP	
		Standard	Consol	AEP	of all labs	Abs. Diff.	Rel. Diff. (%)	Abs. Diff.	Rel. Diff. (%)	Abs. Diff.	Rel. Diff. (%)
702	Deslime Screen Underflow	3.32	3.03	2.98	3.11	0.21	6.75	−0.08	−2.57	−0.13	−4.18
708	Hydrocyclone Overflow	2.67	2.49	2.59	2.58	0.09	3.35	−0.09	−3.61	0.01	0.26
712B	Rougher (B) Flotation Feed	2.18	1.84	1.95	1.99	0.19	9.55	−0.15	−7.54	−0.04	−2.01
713B	Scavenger (B) Flotation Conc.	2.42	1.94	2.10	2.15	0.27	12.38	−0.21	−9.91	−0.05	−2.48
714B	Scavenger (B) Flotation Tails	1.57	1.37	1.45	1.46	0.11	7.29	−0.09	−6.38	−0.01	−0.91
717B	Hydrocyclone Underflow	7.34	7.27	7.03	7.21	0.13	1.76	0.06	0.79	−0.18	−2.54

#	Sample	BTU/Lb.			Average	Standard		Consol		AEP	
		Standard	Consol	AEP	of all labs	Abs. Diff.	Rel. Diff. (%)	Abs. Diff.	Rel. Diff. (%)	Abs. Diff.	Rel. Diff. (%)
702	Deslime Screen Underflow	11,821	11,627	11,778	11,742	79	0.67	−115	−0.98	36	0.31
708	Hydrocyclone Overflow	12,350	12,101	12,084	12,178	172	1.41	−77	−0.64	−94	−0.77
712B	Rougher (B) Flotation Feed	9,640	9,468	9,492	9,533	107	1.12	−65	−0.69	−41	−0.43
713B	Scavenger (B) Flotation Conc.	10,630	10,797	10,812	10,746	−116	−1.08	51	0.47	66	0.61
714B	Scavenger (B) Flotation Tails	4,418	3,938	4,086	4,147	271	6.53	−209	−5.05	−61	−1.48
717B	Hydrocyclone Underflow	8,845	8,512	8,837	8,731	114	1.30	−219	−2.51	106	1.21

NOTE: Absolute Difference = Lab − Average

Relative Difference (%) = (Lab − Average) / Average * 100

Table 14.24
ASTM Reproducability Chart

Analysis	Reproducability
ASH %	
No Carbonates Present	0.3%
Carbonates Present	0.5%
Coals __ more than 22% Ash Containing Carbonatew & Pyrite	1.0%
SULFUR %	
Less 2% Sulfur	0.10%
Greater 2% Sulfur	0.20%
BTU	± 100 Btu

The following Table 14.25 indicates a comparison between the three laboratories: Standard/Consol, Consol/AEP and Standard/AEP. The first figure indicates the absolute difference and the second symbol plus (+) compares with ASTM reproducability and minus (-) does not compare with ASTM reproducability criteria.

Table 14.25
Inventory Comparison

Analysis	Sampler	STD/CON	CON/AEP	STD/AEP
ASH %	702	-1.14/(-)	1.07(-)	-0.07/(+)
	708	-0.85/(+)	0.31/(+)	-0.54/(+)
	712B	-2.58/(-)	0.57(+)	-2.02/(-)
	713B	-1.57/(-)	-0.41/(+)	-1.98/(-)
	714B	-3.71/(-)	0.52/(+)	-3.19/(-)
	717B	-2.23/(-)	1.10/(-)	-1.13/(-)
SULFUR%	702	0.29/(-)	0.05/(+)	0.34/(-)
	708	0.18/(+)	-0.01/(+)	0.08/(+)
	712B	0.34/(-)	-0.11/(+)	0.23/(-)
	713B	0.48/(-)	-0.16/(+)	0.32/(-)
	714B	0.20/(+)	-0.08/(+)	0.15/(+)
	717B	0.07/(+)	0.24/(-)	0.31/(-)
BTU	702	194/(-)	-151/(-)	43/(+)
	708	249/(-)	17/(+)	266/(-)
	712B	172/(-)	24/(+)	148/(-)
	713B	-167/(-)	15/(+)	-182/(-)
	714B	480/(-)	-148/(-)	332/(-)
	717B	333/(-)	-325/(-)	8/(+)

The above comparisons indicate that Standard did not compare favorably with CONSOL or AEP. There is a good comparison between CONSOL and AEP. This data resulted in a trip to Standard Laboratory in South Charleston, WV to review their QA/QC program. This resulted in a change to their internal QA/QC program. The change required providing higher ash blanks, higher sulfur blanks, and higher pyrite sulfur blanks for repeatability testing. These unknown blanks were incorporated into the samples run for the test program. A check on repeatability later in the program showed good repeatability results.

The quality of the results from the commercial laboratory improved as a result of the lab comparison test and the improvement of the lab QA/QC program. The variation of the feed, the manner of sampling and collection, as well as laboratory procedures all contribute to the possibility of higher than normal reproducability values. In addition, the large number of samples and the rapid turnaround of results could also contribute to the problems. Even though no additional inter-laboratory tests were conducted, the analytical results greatly improved as evidenced by considerably fewer reruns of analyses being reported. All in all, the laboratory results were quite accurate for the purpose of the test program.

In addition to a problem of laboratory results, a question was raised concerning the possibility of the POC not operating at steady-state when the samples were collected for a given test. In order to answer this question of steady-state operation, a testing program was developed to determine if indeed steady-state was occurring.

Test work was conducted to attempt to determine the steady-state time elapsed for given unit operations in the OCTAD precleaning circuit and the POC circuit. The test program was begun, and the plant operated for four (4) continuous hours. Each hour of operation was documented as one sampled test result. The unit operations were analyzed to attempt to determine the performance of each unit operation. The test numbers were designated 701, 702, 703, and 704.

The first two (2) unit operations are the heavy-media cyclone and the water-only cyclone. The performance of these unit operations was determined by probable error plots. With this as a basis, detailed washability of the clean coal and refuse of both unit operations were conducted for test 701 and test 704. An ash balance was used to determine recovery.

The probable error curves shown on Figures 14.3 and 14.4, as well as Table 14.26 indicates the results. If the performance had not reached steady state, then there should be a change in the performance between the first and last test. As can be seen, no change took place. The conclusion can be drawn that the performance of both the heavy-media cyclone and the water-only cyclone did not change with time.

Table 14.26

Performance Comparison of Heavy-Media Cyclone and Water-Only Cyclone

	Heavy-Media Cyclone				Water-Only Cyclone			
Test Number	d50	Ep	Near Gravity	Org. Eff %	d50	Ep	Near Gravity	Org. Eff %
93070701	1.883	.0305	2.76	99.8	1.73	.31	6.81	91.39
93070704	1.877	.0435	4.55	99.6	1.73	.23	4.41	95.02

The next unit operation was the mill-classifying cyclone. Again, the performance of the classifying cyclone was determined by the recovery curve. The cyclone overflow and underflow were sampled and analyzed for size by Microtrac. The mass balance is based on sample

Figure 14.3

HM CYCLONE PERFORMANCE

Pittsburgh Seam Coal

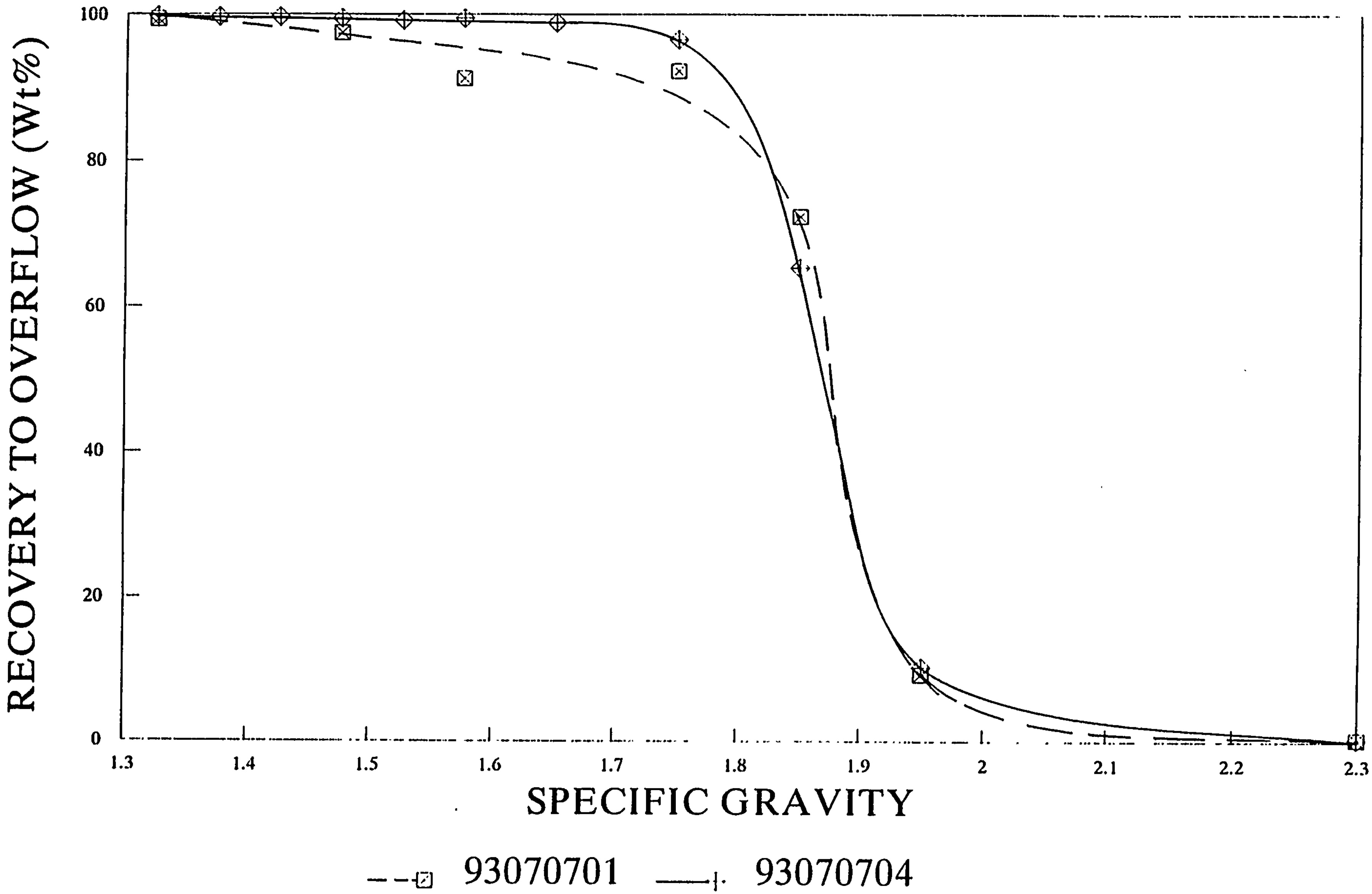
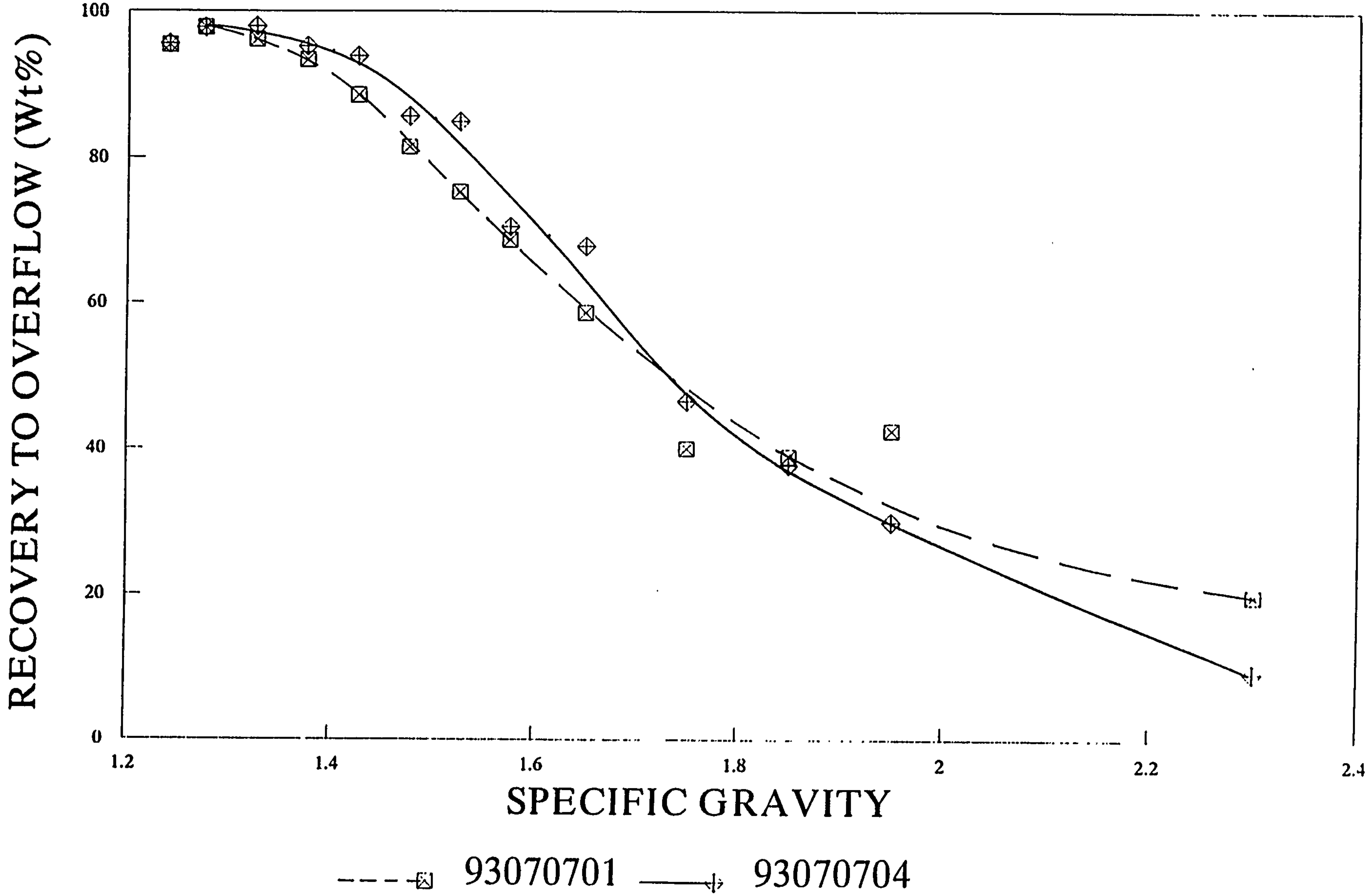


Figure 14.4

Water-Only Cyclone Performance

Pittsburgh Seam Coal



sizes, because no feed sample was obtainable. The recovery curves and backup data are shown in the Figure 14.5 and Tables 14.27 and 14.28. Again, there was no apparent change in the performance of the classifying cyclone; therefore, it was operating at steady state.

The next parameter examined was the size analysis of the feed to column. In order to better understand the size analysis, the ball-mill feed and product were also sampled. This information is shown on Table 14.29 entitled "Size Variation With Time." This table clearly indicates that all three of the size analyses were similar during the entire four-hour test program. This again demonstrates steady-state operation.

During tests 701 through 704, ICF KE monitored instruments and then printed out several plots. In particular, the feed rate, mill-cyclone-feed density, and column- feed density were recovered. These plots are shown on Figures 14.6 -14.8. As can be noted, the plant feed appears to be fairly constant, the mill-classifying-feed density appears to increase with increasing time, and lastly, the column-feed density likewise appears to increase with time.

The above data were compared statistically to determine if test 703 was different than test 704. The statistical analysis shown on Table 14.30 indicates that the plant feed rate has values that are of the same set; however, both the mill-classifying feed and column-flotation feed indicate that indeed the tests are different.

Two comments should be made concerning what appears to be a major problem. The first comment is that this variation caused ICF KE to stop and re-evaluate several operating conditions within the circuit. There were two closed-loop circuits, one around the cagepactor and one around the ball mill. The circuits were then investigated. The second comment is extremely important, and that is, even though statistically the data points indicate different tests, all of the values are within the operating ranges of the unit operations. Therefore, even though different, the outcome of the tests were not compromised.

The variation in density led ICF KE to explore the possibility of other changes, perhaps in the quality of the different feed streams to different unit operations. A variation did appear during this investigation. The water-only-cyclone (WOC) overflow quality should be the same quality as the feed to the column flotation cell. Time and again, the quality of the feed to the column was variable in pyritic sulfur and total sulfur when compared to the WOC overflow quality. The comparison between the WOC overflow and the column flotation feed is shown on Table 14.31.

Figure 14.5

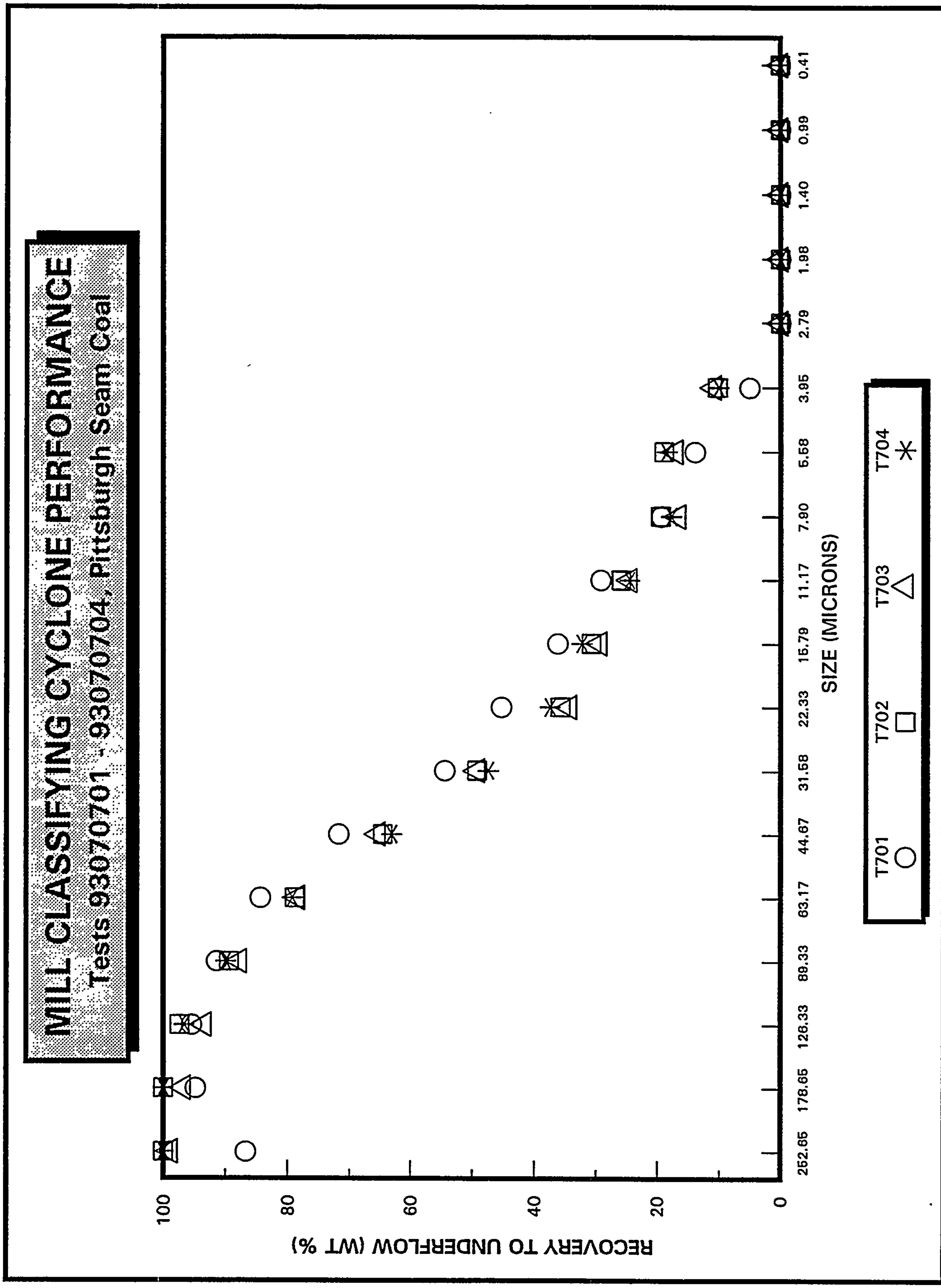

MILL CLASSIFYING CYCLONE PERFORMANCE
Tests 93070701 - 93070704, Pittsburgh Seam Coal
RECOVERY TO UNDERFLOW (WT %)
100
80
60
40
20
0
252.65
178.65
126.33
89.33
63.17
44.67
31.58
22.33
15.79
11.17
7.90
5.58
3.95
2.79
1.98
1.40
0.99
0.41
SIZE (MICRONS)
T701
T702
T703
T704
93701_04

Table 14.27

Mill Classifying Cyclone Performance Results

TEST NO.	93070701	93070701	93070701	93070701	93070702	93070702	93070702	93070702
ORIFICE	O'FLOW	U'FLOW	FEED	PART.	O'FLOW	U'FLOW	FEED	PART.
MEAN SIZE	WT %	WT %	WT %	VALUE	WT %	WT %	WT %	VALUE
252.65	0.13	0.85	0.98	86.73	0.00	0.96	0.96	100.00
178.65	0.28	5.11	5.39	94.81	0.00	4.27	4.27	100.00
126.33	0.52	10.92	11.44	95.45	0.23	8.42	8.65	97.34
89.33	1.47	15.61	17.08	91.39	1.46	12.27	13.73	89.37
63.17	2.81	15.13	17.94	84.34	3.37	12.52	15.89	78.79
44.67	3.93	9.94	13.87	71.67	5.06	9.18	14.24	64.47
31.58	4.28	5.10	9.38	54.37	5.22	5.05	10.27	49.17
22.33	3.37	2.79	6.16	45.29	4.83	2.68	7.51	35.69
15.79	3.55	2.01	5.56	36.15	4.70	2.08	6.78	30.68
11.17	2.84	1.17	4.01	29.18	3.82	1.33	5.15	25.83
7.90	2.05	0.49	2.54	19.29	2.83	0.68	3.51	19.37
5.58	1.80	0.29	2.09	13.88	2.54	0.59	3.13	18.85
3.95	1.32	0.07	1.39	5.04	1.93	0.22	2.15	10.23
2.79	0.88	0.00	0.88	0.00	1.36	0.00	1.36	0.00
1.98	0.67	0.00	0.67	0.00	1.13	0.00	1.13	0.00
1.40	0.43	0.00	0.43	0.00	0.80	0.00	0.80	0.00
0.99	0.18	0.00	0.18	0.00	0.41	0.00	0.41	0.00
0.41	0.01	0.00	0.01	0.00	0.06	0.00	0.06	0.00
TOTAL	30.52	69.48	100.00		39.75	60.25	100.00	

Table 14.28

Mill Classifying Cyclone Performance Results

TEST NO.	93070701	93070701	93070701	93070701	93070702	93070702	93070702	93070702
ORIFICE	O'FLOW	U'FLOW	FEED	PART.	O'FLOW	U'FLOW	FEED	PART.
MEAN SIZE	WT %	WT %	WT %	VALUE	WT %	WT %	WT %	VALUE
252.65	0.01	0.89	0.90	98189	0.00	5.26	5.26	100.00
178.65	0.15	4.55	4.70	96.81	0.00	5.82	5.82	100.00
126.33	0.66	9.35	10.01	93.41	0.29	8.31	8.60	96.63
89.33	1.83	13.05	14.88	87.70	1.22	10.86	12.08	89.90
63.17	3.52	12.76	16.28	78.38	2.82	10.75	13.57	79.22
44.67	4.88	9.16	14.04	65.24	4.59	7.82	12.41	63.01
31.58	4.89	4.72	9.61	49.12	4.95	4.46	9.41	47.40
22.33	4.45	2.32	6.77	34.27	4.66	2.78	7.44	37.37
15.79	4.40	1.83	6.23	29.37	4.69	2.23	6.92	32.23
11.17	3.68	1.19	4.8	24.44	3.95	1.28	5.23	24.47
7.90	2.77	0.55	3.32	16.57	3.03	0.65	3.68	17.66
5.58	2.49	0.51	3.00	17.00	2.70	0.61	3.31	18.43
3.95	1.90	0.23	2.13	10.80	2.06	0.23	2.29	10.04
2.79	1.31	0.00	1.31	0.00	1.49	0.00	1.49	0.00
1.98	1.00	0.00	1.00	0.00	1.21	0.00	1.21	0.00
1.40	0.64	0.00	0.64	0.00	0.81	0.00	0.81	0.00
0.99	0.29	0.00	0.29	0.00	0.42	0.00	0.42	0.00
0.41	0.02	0.00	0.02	0.00	0.05	0.00	0.05	0.00
TOTAL	38.89	61.1	100.00		38.94	61.06	100.00	

Table 14.29

Size Variation with Time

TEST NUMBER		93070701	93070702	93070703	93070704	
COLUMN						AVERAGE
MICROTRAC	+200	100.00	100.00	100.00	100.00	100.00
	200 X 270	92.14	95.76	93.18	96.12	94.30
	270 X 325	82.93	87.28	84.12	88.89	85.81
	325 X 0	76.88	81.31	78.17	83.49	79.96
SCREEN ANALYSIS	+200	100.00	100.00	100.00	100.00	100.00
	200 X 270	88.02	91.76	91.63	91.70	90.78
	270 X 325	78.33	83.99	83.60	84.03	82.49
	325 X 0	73.81	79.47	79.12	79.23	77.91
BALL MILL FEED						
MICROTRAC	+200	100.00	100.00	100.00	100.00	100.00
	200 X 270	71.93	73.12	85.05	78.66	77.19
	270 X 325	54.39	55.78	70.24	63.69	61.03
	325 X 0	46.20	50.19	62.13	56.07	53.65
SCREEN ANALYSIS	+200	100.00	100.00	100.00	100.00	100.00
	200 X 270	77.81	73.12	70.56	69.20	72.67
	270 X 325	61.79	55.78	55.32	54.48	56.84
	325 X 0	54.60	50.19	50.40	49.46	51.16
BALL MISS DISCHARGE						
MICROTRAC	+200	100.00	100.00	100.00	100.00	100.00
	200 X 270	53.23	56.97	54.44	50.46	53.78
	270 X 325	31.45	36.19	33.56	32.86	33.52
	325 X 0	23.20	27.72	25.12	25.72	25.44
SCREEN ANALYSIS	+200	100.00	100.00	100.00	100.00	100.00
	200 X 270	38.47	36.00	31.92	30.49	34.22
	270 X 325	23.35	23.10	23.89	21.37	22.93
	325 X 0	20.32	19.62	18.36	18.58	19.22

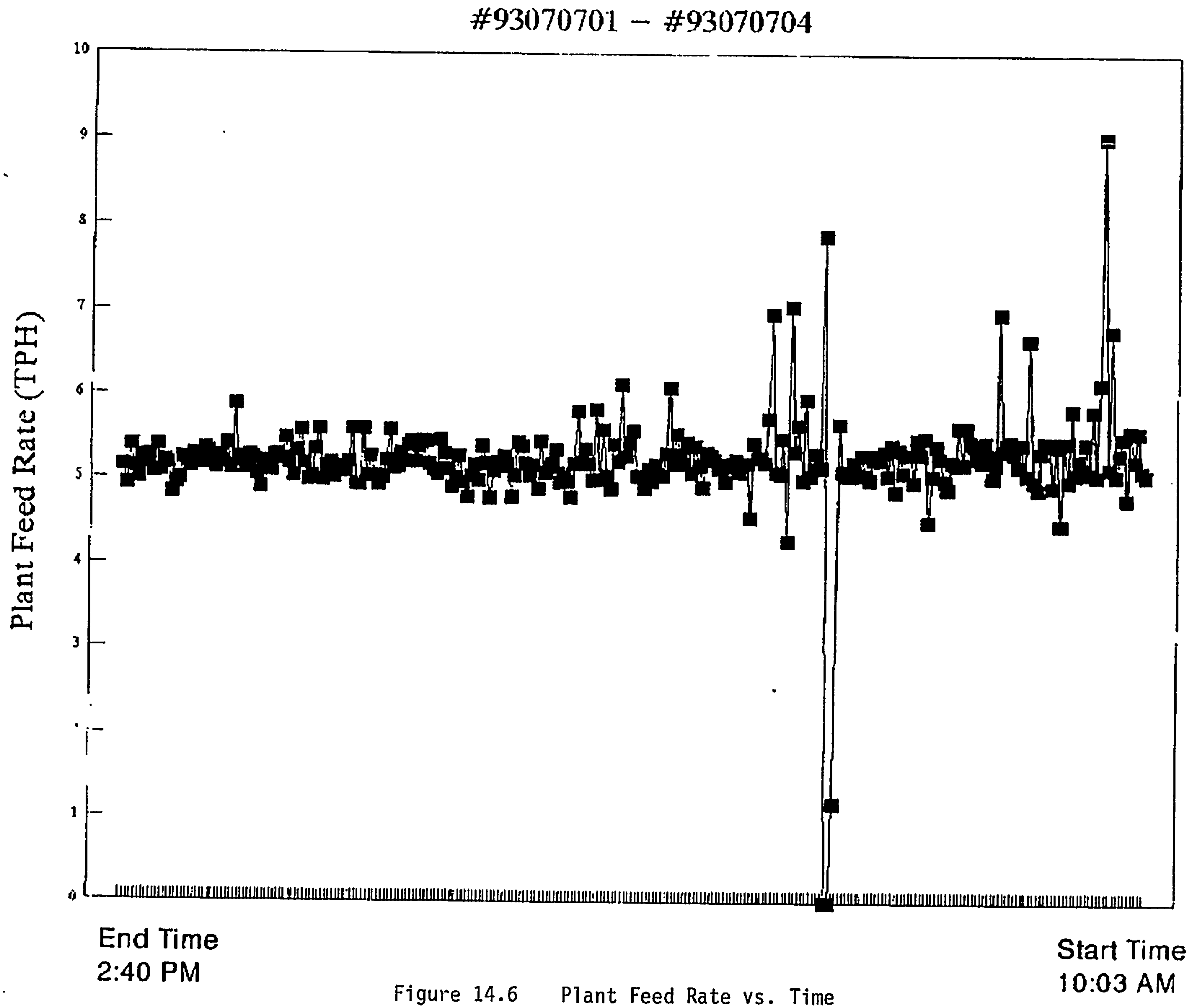


Figure 14.6 Plant Feed Rate vs. Time

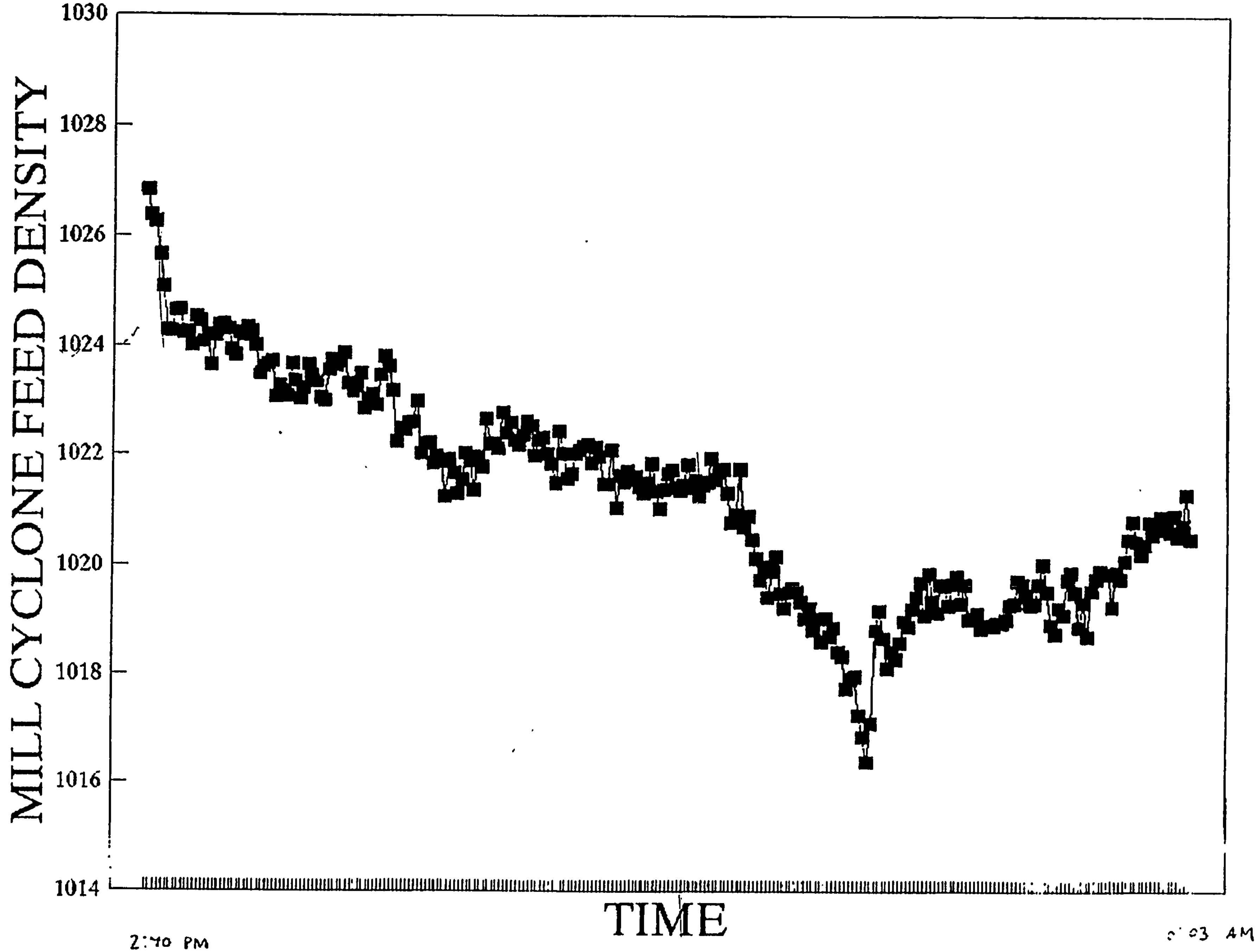


Figure 14.7 Mill Cyclone Feed Density vs. Time

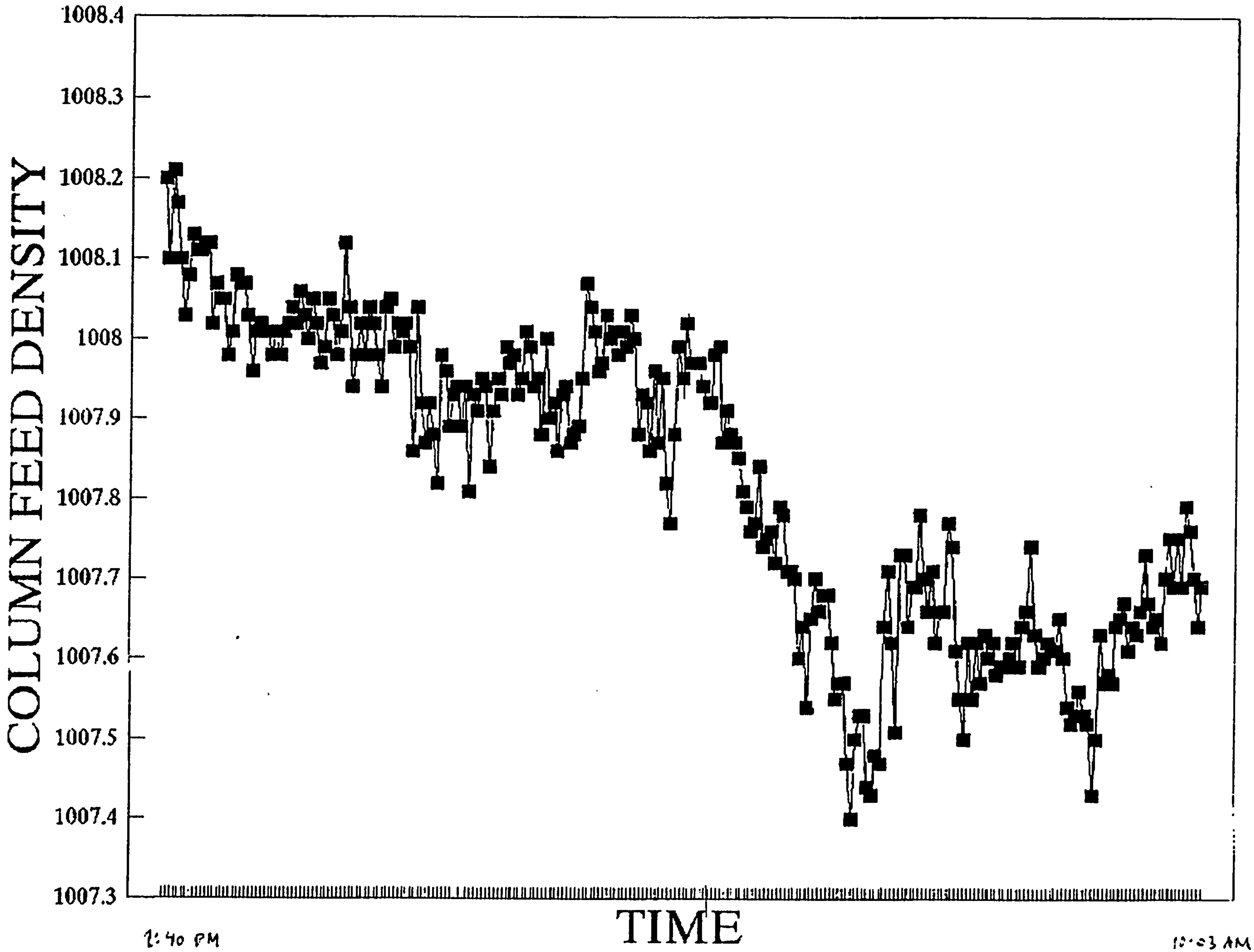


Figure 14.8 Column Feed Density vs. Time

Table 14.30

Statistical Comparison of Hour 3 and Hour 4 for Cyclone Feed Density, Column Feed Density, and Plant Feed Rate

	Classifying Cyclone Feed Density				Column Flotation Feed Density				Plant Feed Rate Tons per Hour	
	Hour 4		Hour 3		Hour 4		Hour 3			
Obs #	Sg.Gr.	% Sol.	Sg.Gr.	% Sol.	Sg.Gr.	% Sol.	Sg.Gr.	% Sol.	Hour 4	Hour 3
1	1.0269	11.33%	1.0232	9.82%	1.0082	3.52%	1.0080	3.45%	5.15	5.20
2	1.0264	11.14%	1.0234	9.92%	1.0081	3.48%	1.0080	3.43%	4.94	5.59
3	1.0263	11.09%	1.0228	9.67%	1.0082	3.53%	1.0080	3.43%	5.39	4.95
4	1.0257	10.85%	1.0230	9.75%	1.0082	3.51%	1.0080	3.45%	5.13	4.94
5	1.0251	10.61%	1.0231	9.78%	1.0081	3.48%	1.0080	3.43%	5.01	5.59
6	1.0243	10.28%	1.0227	9.62%	1.0080	3.45%	1.0078	3.36%	5.26	5.04
7	1.0243	10.27%	1.0222	9.43%	1.0081	3.47%	1.0078	3.37%	5.18	5.26
8	1.0247	10.43%	1.0225	9.53%	1.0081	3.49%	1.0079	3.38%	5.27	5.03
9	1.0247	10.44%	1.0225	9.51%	1.0081	3.49%	1.0080	3.46%	5.08	4.94
10	1.0243	10.26%	1.0226	9.57%	1.0081	3.49%	1.0079	3.41%	5.39	5.01
11	1.0243	10.27%	1.0226	9.58%	1.0081	3.49%	1.0079	3.38%	5.09	5.22
12	1.0240	10.16%	1.0230	9.74%	1.0081	3.49%	1.0079	3.41%	5.21	5.58
13	1.0246	10.39%	1.0220	9.34%	1.0080	3.45%	1.0079	3.39%	5.18	5.12
14	1.0245	10.35%	1.0222	9.42%	1.0081	3.47%	1.0078	3.36%	4.84	5.14
15	1.0241	10.19%	1.0222	9.42%	1.0081	3.46%	1.0080	3.43%	4.95	5.31
16	1.0242	10.25%	1.0218	9.26%	1.0081	3.46%	1.0080	3.42%	5.00	5.20
17	1.0237	10.02%	1.0220	9.32%	1.0080	3.43%	1.0079	3.39%	5.24	5.39
18	1.0242	10.24%	1.0219	9.27%	1.0080	3.44%	1.0079	3.41%	5.21	5.44
19	1.0244	10.32%	1.0212	9.01%	1.0081	3.47%	1.0079	3.41%	5.14	5.20
20	1.0244	10.33%	1.0219	9.29%	1.0081	3.47%	1.0079	3.39%	5.28	5.37
21	1.0243	10.29%	1.0217	9.19%	1.0081	3.47%	1.0079	3.41%	5.20	5.45
22	1.0239	10.13%	1.0213	9.03%	1.0080	3.45%	1.0078	3.36%	5.18	5.44
23	1.0238	10.09%	1.0215	9.14%	1.0080	3.42%	1.0079	3.41%	5.35	5.18
24	1.0243	10.26%	1.0220	9.34%	1.0080	3.44%	1.0079	3.40%	5.32	5.11
25	1.0242	10.24%	1.0219	9.28%	1.0080	3.45%	1.0080	3.42%	5.21	5.06
26	1.0244	10.30%	1.0214	9.06%	1.0080	3.44%	1.0079	3.41%	5.13	5.46
27	1.0243	10.27%	1.0220	9.31%	1.0080	3.44%	1.0078	3.37%	5.26	5.30
28	1.0240	10.16%	1.0218	9.23%	1.0080	3.43%	1.0079	3.40%	5.19	5.11
29	1.0235	9.95%	1.0227	9.60%	1.0080	3.44%	1.0079	3.41%	5.41	4.91
30	1.0236	10.00%	1.0222	9.41%	1.0080	3.43%	1.0080	3.43%	5.12	5.01
31	1.0237	10.02%	1.0222	9.41%	1.0080	3.44%	1.0080	3.43%	5.88	5.26
32	1.0237	10.04%	1.0221	9.37%	1.0080	3.45%	1.0080	3.43%	5.25	4.96
33	1.0231	9.77%	1.0228	9.64%	1.0080	3.46%	1.0079	3.41%	5.22	4.78
34	1.0233	9.86%	1.0224	9.49%	1.0080	3.45%	1.0080	3.42%	5.12	5.03
35	1.0232	9.82%	1.0226	9.57%	1.0081	3.46%	1.0080	3.44%	5.27	5.16
36	1.0231	9.78%	1.0223	9.43%	1.0080	3.45%	1.0080	3.43%	5.24	4.98
37	1.0237	10.02%	1.0222	9.40%	1.0080	3.44%	1.0079	3.41%	5.06	5.38
38	1.0234	9.89%	1.0224	9.48%	1.0081	3.46%	1.0080	3.42%	4.91	5.18
39	1.0230	9.76%	1.0226	9.58%	1.0080	3.45%	1.0079	3.39%	5.21	4.77
40	1.0232	9.84%	1.0225	9.54%	1.0080	3.43%	1.0080	3.44%	5.18	5.09
41	1.0237	10.02%	1.0220	9.32%	1.0080	3.43%	1.0079	3.40%	5.10	5.20
42	1.0235	9.93%	1.0223	9.44%	1.0081	3.46%	1.0079	3.41%	5.27	5.14
43	1.0234	9.89%	1.0223	9.46%	1.0080	3.45%	1.0079	3.38%	5.28	5.26
44	1.0231	9.76%	1.0220	9.33%	1.0080	3.43%	1.0079	3.41%	5.23	5.16
45	1.0230	9.74%	1.0218	9.25%	1.0080	3.44%	1.0079	3.41%	5.48	4.79
46	1.0236	9.97%	1.0215	9.11%	1.0081	3.49%	1.0079	3.38%	5.19	5.03
47	1.0238	10.06%	1.0224	9.50%	1.0080	3.46%	1.0079	3.39%	5.03	5.43
48	1.0236	10.01%	1.0220	9.33%	1.0079	3.41%	1.0079	3.39%	5.33	5.38
49	1.0237	10.03%	1.0216	9.15%	1.0080	3.43%	1.0080	3.42%	5.57	5.18
50	1.0239	10.11%	1.0217	9.18%	1.0080	3.45%	1.0081	3.47%	5.19	5.03
51	1.0233	9.87%	1.0220	9.33%	1.0080	3.43%	1.0080	3.46%	4.99	5.15
52	1.0232	9.81%	1.0221	9.36%	1.0080	3.43%	1.0080	3.44%	5.03	4.88
53	1.0233	9.85%	1.0221	9.38%	1.0080	3.46%	1.0080	3.42%	5.35	5.44
54	1.0235	9.95%	1.0222	9.40%	1.0080	3.45%	1.0080	3.45%	5.59	5.07
55	1.0229	9.68%	1.0218	9.26%	1.0080	3.43%	1.0080	3.44%	4.99	5.13
56	1.0230	9.76%	1.0221	9.38%	1.0079	3.41%	1.0080	3.44%	5.14	5.18
57	1.0231	9.80%	1.0220	9.31%	1.0080	3.46%	1.0080	3.43%	5.19	5.34
58	1.0229	9.71%	1.0215	9.10%	1.0081	3.46%	1.0080	3.44%	5.02	4.96
59	1.0235	9.93%	1.0215	9.10%	1.0080	3.43%	1.0080	3.43%	5.14	5.07
60	1.0238	10.08%	1.0221	9.36%	1.0080	3.45%	1.0080	3.44%	5.09	4.97
61	1.0236	10.00%	1.0210	8.93%	1.0080	3.44%	1.0080	3.43%	5.10	4.78
Maximum		11.33%		9.92%		3.53%		3.47%	5.88	5.59
Minimum		9.68%		8.93%		3.41%		3.36%	4.84	4.77
Average		10.13%		9.39%		3.46%		3.41%	5.20	5.16
Std. Dev.		0.37%		0.22%		0.03%		0.03%	0.1925	0.2110
No. of Obs.		61		61		61		61	61	61
Calculated Z		13.5208				8.4226			1.0042	

Table 14.31

Comparison of WOC Analysis with Column Flotation Feed Analysis

	HYDROCYCLONE OVERFLOW				COLUMN FLOTATION FEED			
	ASH	SULFUR	PYRITIC	BTU/LB	ASH	SULFUR	PYRITIC	BTU/LB
RUN #								
93070701	16.37	2.95	1.60	12385	18.66	3.32	2.16	11938
93070702	20.52	2.58	1.45	11338	21.91	2.81	1.63	11304
93070703	20.93	2.66	1.41	11549	22.91	2.42	1.30	11166
93070704	21.84	2.68	1.51	11484	21.24	2.23	1.07	11459

In an attempt to further establish why the pyritic sulfur was changing in the column flotation feed, a series of size analyses were conducted on the mill feed, mill product, and the column-flotation feed. These data are also shown on Table 14.32. The data indicates that pyritic sulfur at first increased, and with time, finally decreased below the WOC analysis in the column flotation feed.

An explanation of this phenomena is that, upon startup, pyrite that was retained in the ball mill from the previous day's operation was released to the column flotation. As time passed, the previous day's pyrite was depleted, indicated by the decrease in the column flotation feed. As time further passed, the column flotation feed continued to indicate a decrease in pyritic sulfur. All indications point to the condition that the ball-mill circuit was concentrating pyritic sulfur as the test period increased in time.

The unit operation that appears to be causing this concentration was the ball-mill-classifying-cyclone. The unit operation made a size split based upon particle size and specific gravity. The difference is the specific gravity of coal and pyrite is about 4. Therefore, if the coal was being sized at a d_{50} of 74 microns, then the pyrite was being sized at a d_{50} of 18-20 micron. This appears to be what was happening in the ball mill circuit. The pyrite was liberated from the coal, and because of the fineness of the pyrite, was recycled back to the ball mill. This means this closed circuit became a holding tank for liberated pyritic sulfur.

The problem was solved by changing the unit operation utilized to close the ball mill circuit. ICF KE arranged to install a Krebs Varisieve to make the 200 mesh sizing of the ball-mill product before the column flotation cell.

Five (5) plots of pyritic sulfur versus time are shown in Figures 14.9 - 14.13. These plots further prove that the precleaning unit operations were at steady state through the WOC unit operation. From the WOC unit operation, there was a strong indication that even though the size consist and rates were at steady state, the pyritic

Table 14.32

Comparison of Size Analysis for Coal-Mill Feed, Coal-Mill Discharge, and Column Flotation Feed

RUN # : 93070701

SIZE	COAL MILL FEED			COAL MILL DISCHARGE			COLUMN FLOTATION FEED		
	% WEIGHT	%ASH	%PYRITIC	% WEIGHT	%ASH	%PYRITIC	% WEIGHT	%ASH	%PYRITIC
+ 200M	61.53	6.44	0.92	22.19	5.87	0.87	11.98	8.23	0.88
200M X 270M	15.12	8.91	1.41	16.02	6.41	0.84	9.69	6.46	0.90
270M X 325M	3.03	11.64	1.96	7.19	8.13	1.09	4.52	6.73	0.92
325M X 0	20.32	31.92	9.29	54.60	12.85	2.39	73.81	21.18	2.60

RUN # : 93070702

SIZE	COAL MILL FEED			COAL MILL DISCHARGE			COLUMN FLOTATION FEED		
	% WEIGHT	%ASH	%PYRITIC	% WEIGHT	%ASH	%PYRITIC	% WEIGHT	%ASH	%PYRITIC
+ 200M	64.02	6.87	1.04	26.88	8.68	1.33	8.24	6.85	0.96
200M X 270M	12.90	9.56	1.56	17.34	9.89	1.67	7.77	5.75	0.72
270M X 325M	3.48	12.14	2.05	5.59	11.55	2.16	4.52	5.92	0.71
325M X 0	19.62	34.61	8.12	50.19	20.69	5.08	79.47	21.93	1.75

RUN # : 93070703

SIZE	COAL MILL FEED			COAL MILL DISCHARGE			COLUMN FLOTATION FEED		
	% WEIGHT	%ASH	%PYRITIC	% WEIGHT	%ASH	%PYRITIC	% WEIGHT	%ASH	%PYRITIC
+ 200M	68.08	7.30	1.09	29.44	9.06	1.34	8.37	7.11	0.98
200M X 270M	11.03	10.03	1.56	15.24	10.33	1.61	8.03	6.16	0.75
270M X 325M	2.53	13.14	2.00	4.92	12.04	2.09	4.48	6.70	0.80
325M X 0	18.36	36.98	6.00	50.40	20.53	4.38	79.12	23.28	1.50

RUN # : 93070704

SIZE	COAL MILL FEED			COAL MILL DISCHARGE			COLUMN FLOTATION FEED		
	% WEIGHT	%ASH	%PYRITIC	% WEIGHT	%ASH	%PYRITIC	% WEIGHT	%ASH	%PYRITIC
+ 200M	69.51	10.75	1.57	30.80	9.62	1.47	8.30	7.50	0.98
200M X 270M	9.12	16.02	2.65	14.72	11.12	1.89	7.67	5.85	0.73
270M X 325M	2.79	20.23	3.57	5.02	13.06	2.33	4.80	6.13	0.70
325M X 0	18.58	47.29	9.54	49.46	23.28	4.62	79.23	22.54	1.25

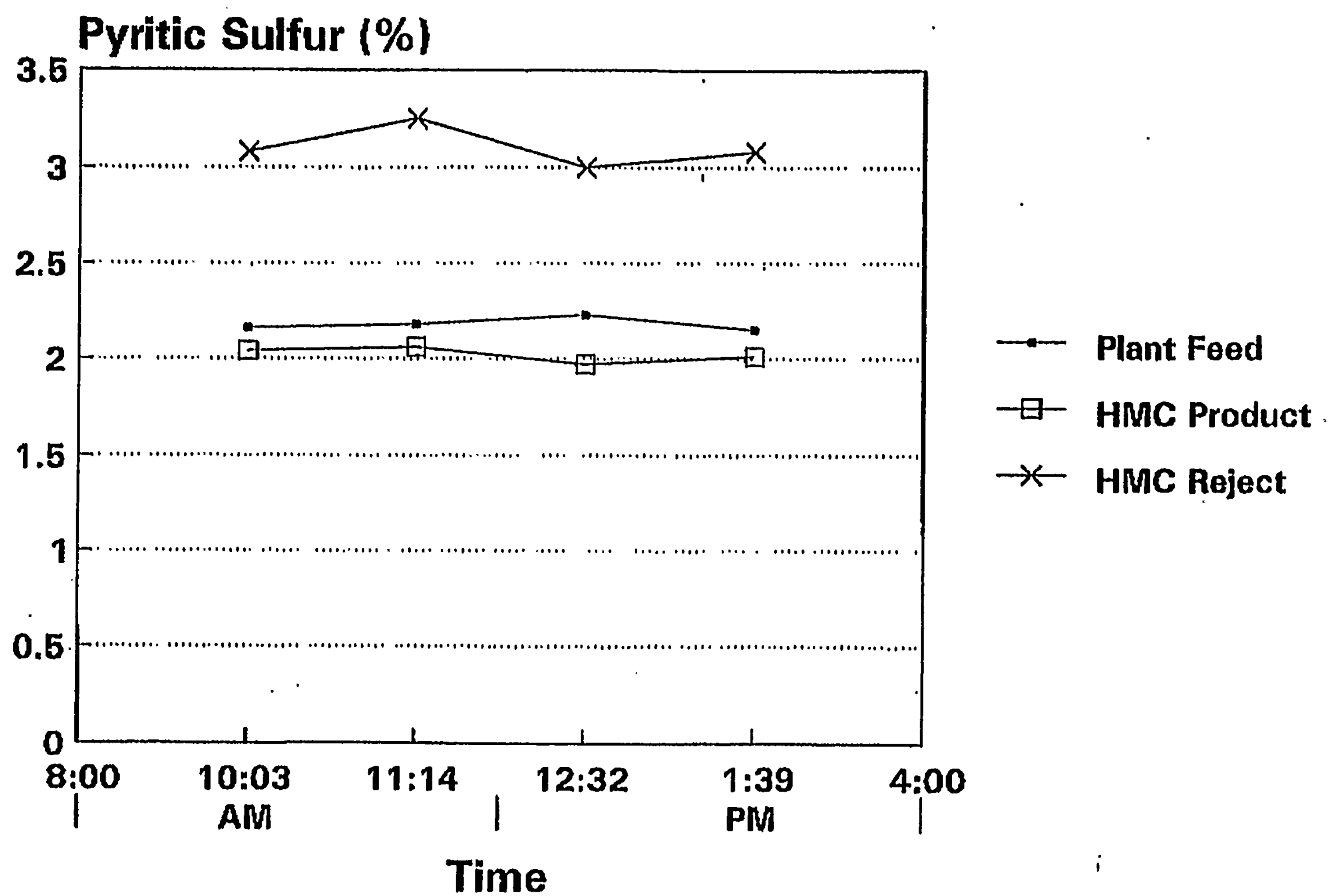


Figure 14.9

Pyritic Sulfur vs. Time for Plant Feed, HMC Product, HMC Reject

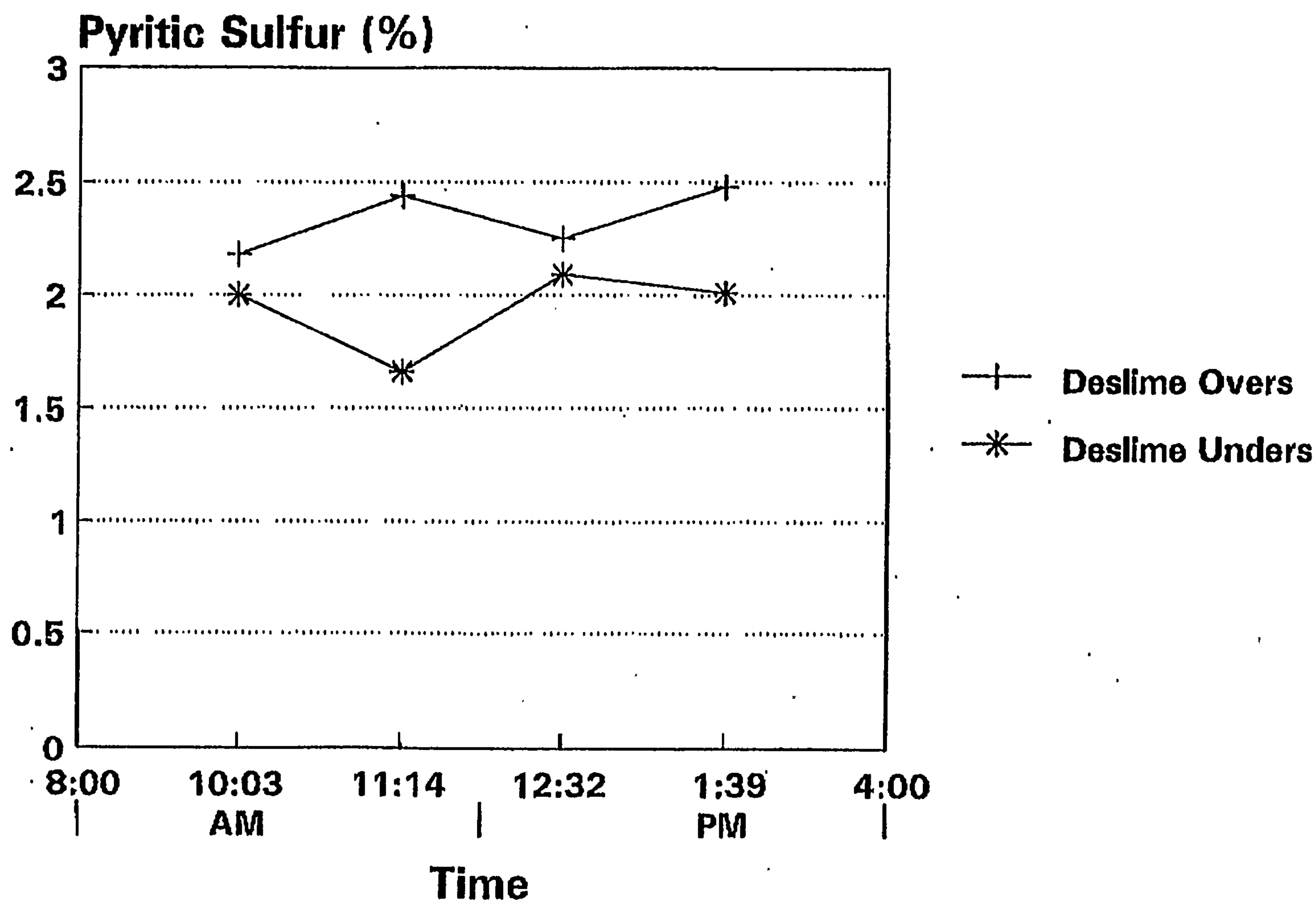


Figure 14.10
Pyritic Sulfur vs. Time for Deslime Overs and Deslime Unders

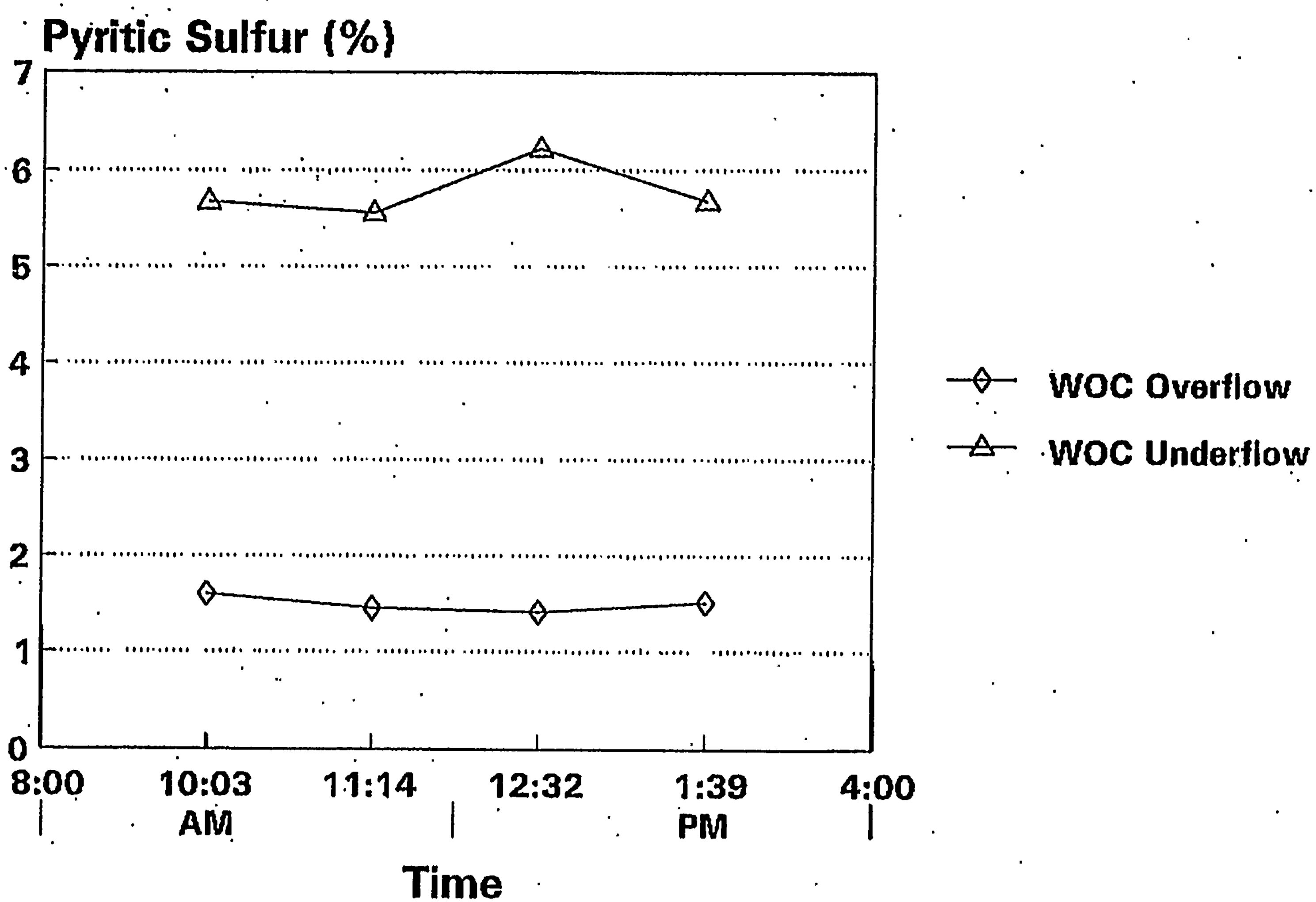


Figure 14.11

Pyritic Sulfur vs. Time for WOC Overflow and WOC Underflow

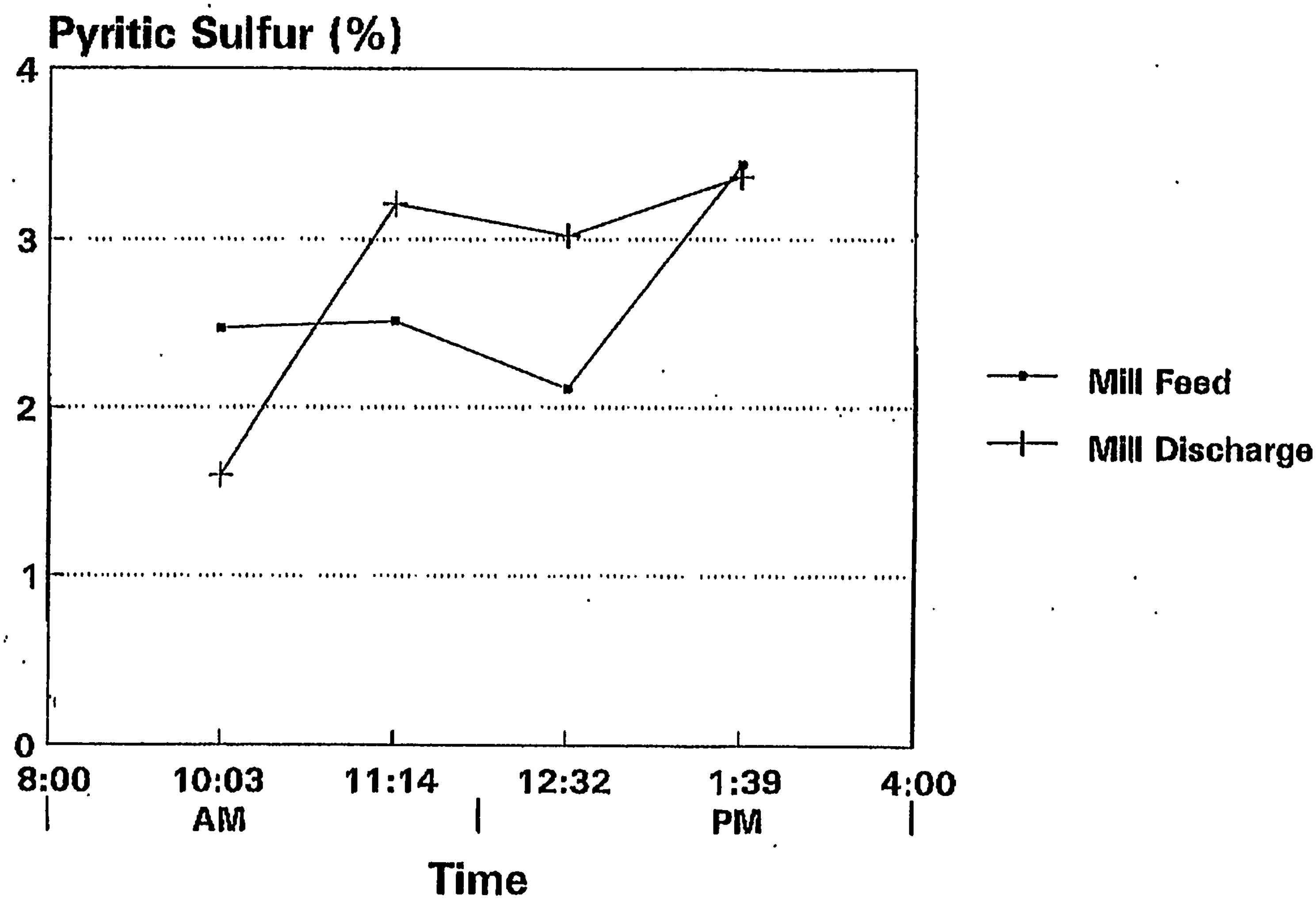


Figure 14.12

Pyritic Sulfur vs. Time for Mill Feed and Mill Discharge

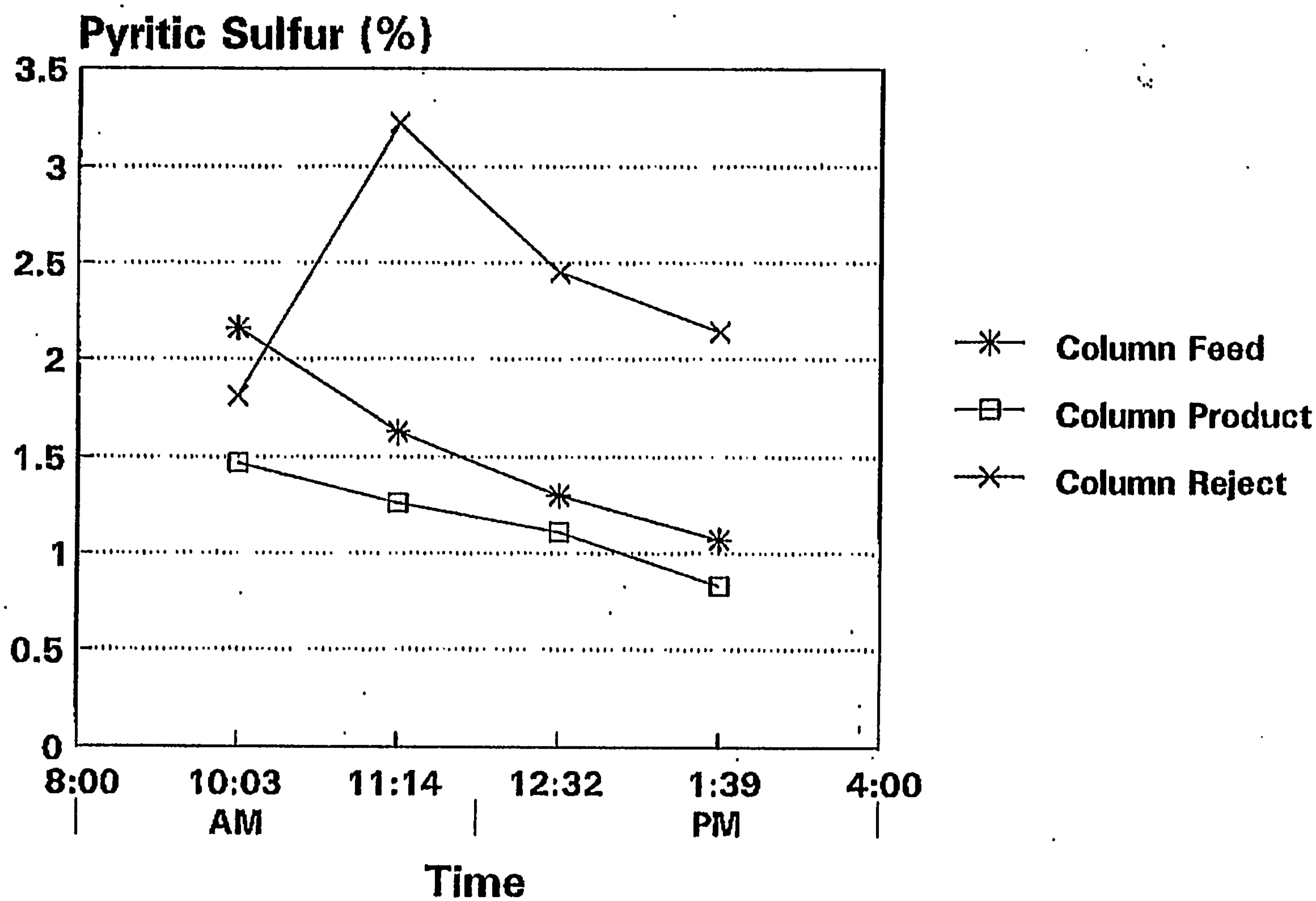


Figure 14.13

Pyritic Sulfur vs. Time for Column Feed, Column Product, and Column Reject sulfur was definitely not at steady state. This problem was solved by means of replacing the mill classifying cyclone with a Krebs' Varisieve screen.

The plot of specific gravity versus time for the column flotation feed is shown in Figure 14.8. There was every indication that, with increasing time, the feed rate to the column increased. At no time during any of the previous test work did the feed rate exceed the operating parameters of the column flotation cell. Therefore, all tests conducted on the Pittsburgh No. 8 coal were valid tests. The increasing feed rate to the column flotation was traced to the operation of the weigh feeder.

The weigh feeder was operated in automatic mode. The automatic mode required a set point tonnage input, and the electronics of the weigh feeder controlled the feeder output by matching load cell tonnage to the set point. The existing load cell accuracy was marginal at the low feed rates the POC was operating. As a result of observation and physical sampling, it was determined that indeed the feed rate increased with time.

To remedy this condition, the scale manufacturer was contacted and a new control system was installed that permitted the feed rate to be accurately measured and controlled. After this change the feed rate control was quite accurate.

In conclusion, it has been determined that all of the precleaning circuit operations were operating at steady-state conditions. The ball-mill circuit, including the classifying cyclones, were operating at steady state with regard to size, and pyrite analysis. The increase of percent solids to the column flotation cell was related to the weigh feeder operation. ICF KE concluded that a new size separation device be installed in the mill circuit to prevent pyrite build-up, and the operation of the weigh feeder was modified by changing the control system.

The operational procedure for testing continued to be observed. The plant was started up and operated for two (2) hours prior to any test work being conducted. After two (2) hours of operation at a test condition, sampling was conducted for one (1) hour. The testing conditions were changed. If reagents dosages and/or air rates were changed, one (1) additional hour was operated before testing again began. If a feed rate was changed, two (2) hours were operated before testing. This procedure insured steady-state conditions before testing.

In addition to steady-state testing an investigation of the necessity of the water-only cyclone was questioned. To answer this question a series of tests were conducted in an attempt to determine the practicability of the WOC inclusion in the POC.

Figure 14.14 shows the results of the performance of tests 609-627 which were the column flotation factorial tests indicated by the squares and the results of the four tests, 305-308, which were the

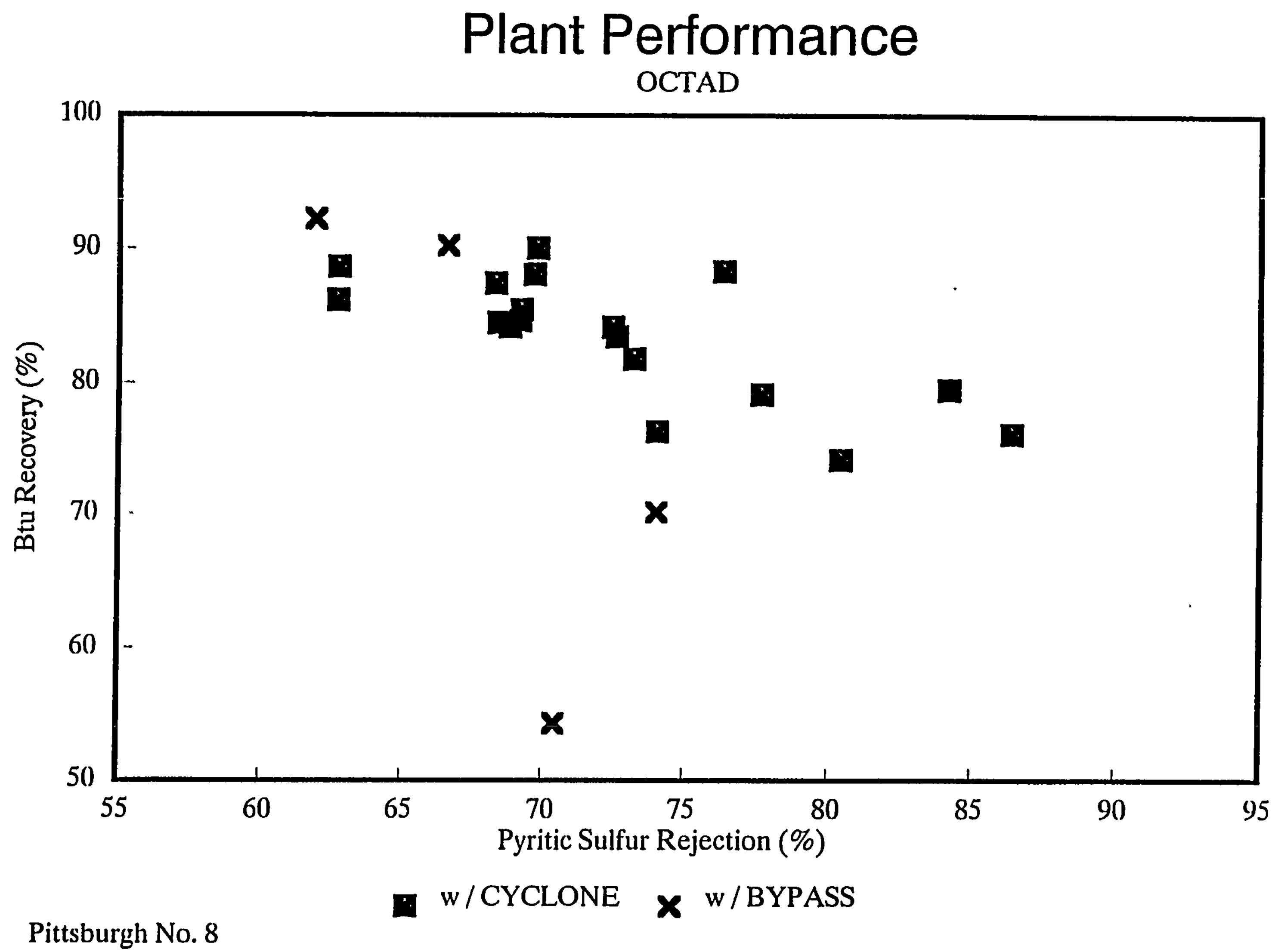


Figure 14.14

Performance of Tests 609 - 629 and Tests 305 - 308 tests without the WOC in the circuit, indicated by the "X". The two tests that show high Btu recovery were tests 305 and 306. One would note a decrease in the plant rejection of pyritic sulfur. This is the result of two conditions: 1) the increased Btu recovery as a result of greater weight recovery also resulted in more pyritic sulfur reporting to product because of increased weight recovery; and 2) free pyrite that would have been rejected by the WOC was not rejected, thus reducing pyrite rejection. Tests 306 and 308 were not representative tests because of a large recycle load from the clean-coal thickener. Test 308 was the operation of the POC at a high feed rate without the WOC and ball-mill circuit. Again, these results were inconclusive. The results show an increase in pyrite rejection, but this was a result of poor recovery. The results of the four (4) tests are shown on Tables 14.33 - 14.36.

The conclusion that can be drawn from these results was that the WOC should remain in the circuit to provide the potential of improving pyrite rejection. This was the original intention for installing this unit operation. The operation of the POC without the WOC and ball mill was inconclusive.

The results of the SEM analysis are shown in Figures 14.15 - 14.16. The concentrate indicates no free pyrite in the product. The only pyrite evident in the concentrate is locked within the coal particle. The reject shows free pyrite and locked pyrite in the tailings.

Factorial Column Flotation Test

The next step in the test plan was the 16-test resolution IV fractional factorial experiment of a 2^{6-2} experiment to determine major interaction of operating parameters. The column flotation independent variables are shown on Table 14.37 and the proposed test matrix is shown in Table. 14.38.

Table 14.33

Water-Only Cyclone Test 305 Results

ASSAYS:

STREAM	WEIGHT (tph)		ASH (%)		Btu/LB	
	EXP	CALC	EXP	CALC	EXP	CALC
1	3.45	2.85	38.63	38.57	85.89	8565
8	0.70	0.7562	82.23	82.24	1375	1370
11 - 17	1.81	2.09	22.72	22.78	11142	11165
19	0.63	0.4925	74.40	74.22	2755	2749
18	1.53	1.60	6.95	6.94	13761	13756

STREAM	WEIGHT (tph)		TOTAL SULFUR (%)		PYRITIC SULFUR (%)	
	EXP	CALC	EXP	CALC	EXP	CALC
1	3.45	2.85	3.30	2.85	2.37	1.97
8	0.70	0.7562	2.96	3.06	2.87	3.02
11 - 17	1.81	2.09	2.77	2.78	1.63	1.59
19	0.63	0.4925	3.16	3.23	2.83	2.95
18	1.53	1.60	2.50	2.64	1.11	1.17

RECOVERIES

STREAM	WEIGHT (%)		ASH		Btu/LB	
	EXP	CALC	EXP	CALC	EXP	CALC
1	121.12	100	100	100	100	100
8	24.58	26.55	56.51	56.61	4.25	4.25
11 - 17	63.54	73.45	43.20	43.39	95.29	95.75
19	22.12	17.29	33.30	33.27	5.55	5.55
18	53.71	56.16	10.10	10.11	89.98	90.20

STREAM	WEIGHT (%)		TOTAL SULFUR		PYRITIC SULFUR	
	EXP	CALC	EXP	CALC	EXP	CALC
1	121.12	100	100	100	1002	100
8	24.58	26.55	23.81	28.45	32.15	40.71
11 - 17	63.54	73.45	61.66	71.55	50.52	59.29
19	22.12	17.29	16.56	19.57	20.64	25.90
18	53.71	56.16	42.55	51.98	26.30	33.39

Table 14.34

Water-Only Cycloe Test 306 Results

ASSAYS:

STREAM	WEIGHT (tph)		ASH (%)		Btu/LB	
	EXP	CALC	EXP	CALC	EXP	CALC
1	5.81	5.16	39.58	39.63	8536	8274
8	1.50	1.51	79.35	79.26	1005	1001
11 - 17	3.46	3.65	23.18	23.24	11207	11283
19	0.86	0.7698	77.25	77.10	2361	2362
18	2.58	2.88	8.84	8.83	13440	13669

STREAM	WEIGHT (tph)		TOTAL SULFUR (%)		PYRITIC SULFUR (%)	
	EXP	CALC	EXP	CALC	EXP	CALC
1	5.81	5.16	3.13	2.87	2.12	1.99
8	1.50	1.51	3.14	3.22	2.79	2.86
11 - 17	3.46	3.65	2.63	2.72	1.54	1.63
19	0.86	0.7698	2.89	2.90	2.67	2.65
18	2.58	2.88	2.64	2.67	1.38	1.36

RECOVERIES

STREAM	WEIGHT (%)		ASH		Btu/LB	
	EXP	CALC	EXP	CALC	EXP	CALC
1	112.63	100	100	100	100	100
8	29.08	29.27	58.68	58.53	3.45	3.54
11 - 17	67.07	70.73	41.42	41.47	92.86	96.46
19	16.67	14.92	29.13	29.03	4.13	4.26
18	50.01	55.81	12.46	12.44	87.87	92.2

STREAM	WEIGHT (%)		TOTAL SULFUR		PYRITIC SULFUR	
	EXP	CALC	EXP	CALC	EXP	CALC
1	112.63	100	100	100	1002	100
8	29.08	29.27	29.36	32.86	38.52	42.07
11 - 17	67.07	70.73	59.43	67.14	51.38	57.93
19	16.67	14.92	13.78	15.10	18.79	19.86
18	50.01	55.81	47.07	52.04	36.33	38.06

Table 14.35

Water-Only Cyclone Test 307 Results

ASSAYS:

STREAM	WEIGHT (tph)		ASH (%)		Btu/LB	
	EXP	CALC	EXP	CALC	EXP	CALC
1	8	7.75	38.62	38.51	8833	8663
8	2.07	2.26	82.05	82.22	1496	1501
11 - 17	4.68	5.48	20.53	20.48	11549	11618
19	2.04	1.99	40.25	40.26	8358	8375
18	6.70	3.49	9.18	9.19	13445	13469

STREAM	WEIGHT (tph)		TOTAL SULFUR (%)		PYRITIC SULFUR (%)	
	EXP	CALC	EXP	CALC	EXP	CALC
1	8.00	7.75	3.22	2.90	2.23	1.94
8	2.07	2.26	3.07	3.16	2.91	3.06
11 - 17	4.68	5.48	2.74	2.79	1.43	1.48
19	2.04	1.99	3.06	3.11	2.08	2.11
18	6.70	3.49	2.54	2.60	1.10	1.11

RECOVERIES

STREAM	WEIGHT (%)		ASH		Btu/LB	
	EXP	CALC	EXP	CALC	EXP	CALC
1	121.12	103.28	100	100	100	100
8	24.58	26.72	62.06	62.36	4.95	5.06
11 - 17	63.54	60.42	37.63	37.64	92.55	94.94
19	22.12	26.34	26.81	26.89	24.34	24.87
18	53.71	86.49	10.71	10.75	68.68	70.07

STREAM	WEIGHT (%)		TOTAL SULFUR		PYRITIC SULFUR	
	EXP	CALC	EXP	CALC	EXP	CALC
1	103.28	100	100	100	100	100
8	26.72	29.21	27.85	31.83	38.12	46.07
11 - 17	60.42	70.79	60.24	68.17	45.39	53.93
19	26.34	25.72	24.44	27.65	23.99	28.01
18	86.49	45.07	35.55	40.52	22.23	25.93

Table 14.36

Water-Only Cyclone Test 308 Results

ASSAYS:

STREAM	WEIGHT (tph)		ASH (%)		Btu/LB	
	EXP	CALC	EXP	CALC	EXP	CALC
1	7.8	7.82	33.57	33.64	8628	9146
8	1.92	1.89	83.58	83.54	12.78	1277
11 - 17	5.62	5.93	17.88	17.88	11832	11652
19	2.52	2.95	26.85	26.80	10486	10269
18	6.83	2.98	8.61	8.61	13385	13018

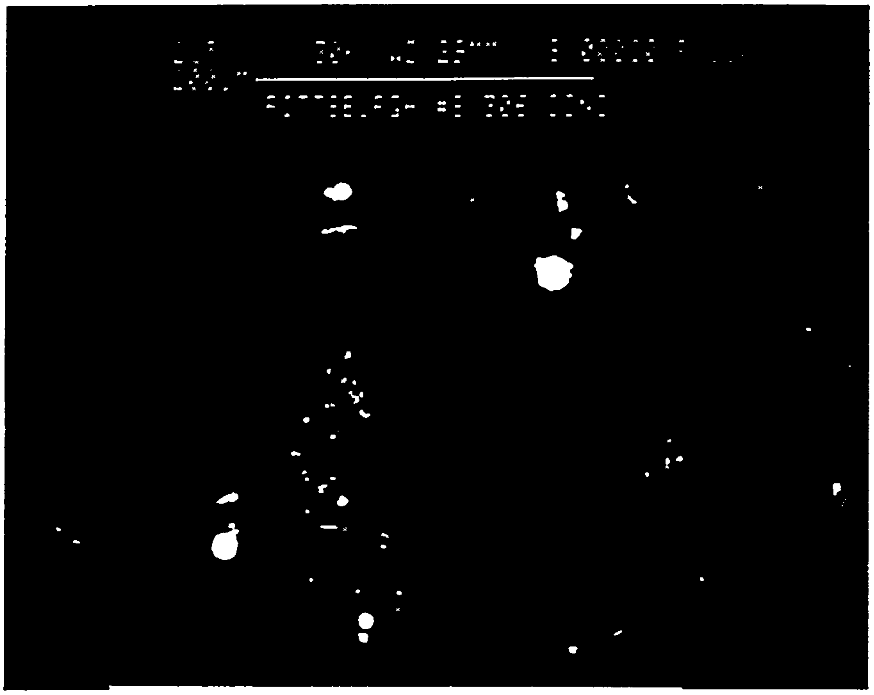
STREAM	WEIGHT (tph)		TOTAL SULFUR (%)		PYRITIC SULFUR (%)	
	EXP	CALC	EXP	CALC	EXP	CALC
1	7.80	7.82	3.31	3.16	2.44	2.13
8	1.92	1.89	3.03	3.06	2.98	3.09
11 - 17	5.62	5.93	3.37	3.19	1.93	1.83
19	2.52	2.95	3.08	3.20	1.89	2.01
18	6.83	2.98	3.05	3.17	1.57	1.65

RECOVERIES

STREAM	WEIGHT (%)		ASH		Btu/LB	
	EXP	CALC	EXP	CALC	EXP	CALC
1	99.73	100	100	100	100	100
8	24.54	24.15	60.14	59.99	3.58	3.37
11 - 17	71.83	75.85	40.40	40.01	104.01	96.63
19	32.21	37.70	30.10	30.22	45.82	42.33
18	87.30	38.15	9.78	9.78	59.18	54.30

STREAM	WEIGHT (%)		TOTAL SULFUR		PYRITIC SULFUR	
	EXP	CALC	EXP	CALC	EXP	CALC
1	99.70	100	100	100	100	100
8	24.54	24.15	22.11	23.41	29.50	34.99
11 - 17	71.83	75.85	77.22	76.59	59.99	65.01
19	32.21	37.70	35.08	38.25	29.20	35.47
18	87.30	38.15	35.15	38.34	24.55	29.54

Figure 14.15 SEM Results for Pittsburgh No. 8 Column Concentrate



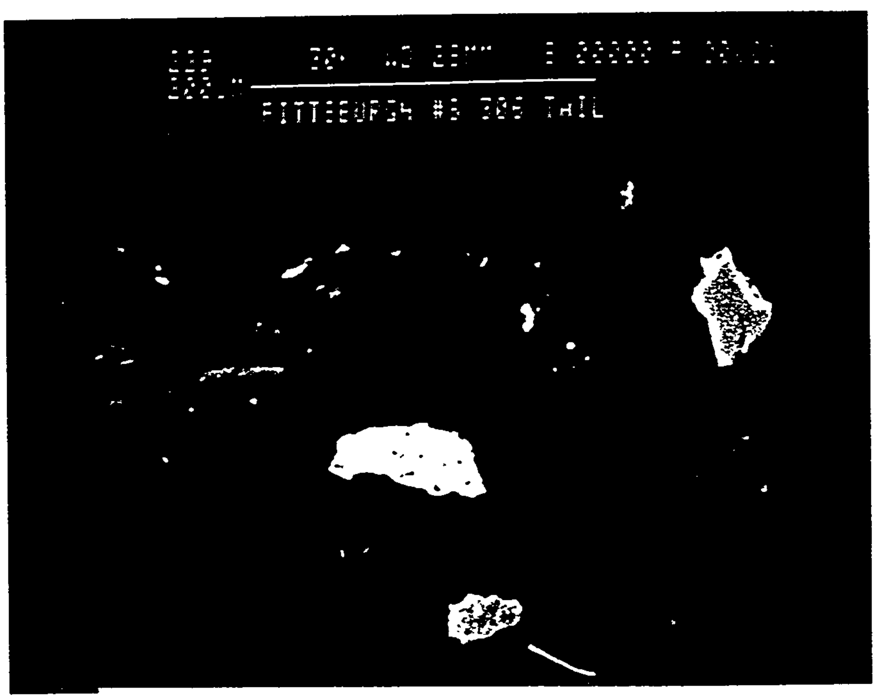


Figure 14.16 SEM Results for Pittsburgh No. 8 Column Reject

Table 14.37 Column Flotation Independent Variables			
Variable	Code Letter	(-) Factor	(+) Factor
Feed Rate (tph)	A	2	4
Air Rate (CM/SEC)	B	1.5	2.5
Frother Rate (LB/TON)	C	0.7	1.4
Water Rate (CM/SEC)	D	0.1	0.3
Frother Type	E	MIBC	Sherex 214
Collector Rate (LB/TON)	F	0.5	1.0

Table 14.38 Proposed Test Matrix						
	Variable					
Run No.	A	B	C	D	E	F
1	-	-	-	-	-	-
2	+	-	+	-	-	-
3	-	+	-	+	-	-
4	+	+	+	+	-	-
5	-	-	+	+	+	-
6	+	-	-	+	+	-
7	-	+	+	-	+	-
8	+	+	-	-	+	-
9	-	-	+	+	-	+
10	+	-	-	+	-	+
11	-	+	+	-	-	+
12	+	+	-	-	-	+
13	-	-	-	-	+	+
14	+	-	+	-	+	+
15	-	+	-	+	+	+
16	+	+	+	+	+	+

The test matrix was completed as outlined. In addition to the experimental data collected around the column flotation cell, enough data were collected to determine the operation of the heavy-media cyclone, water-only cyclone, the precleaning circuit, and the overall plant.

The data shown in Table 14.39 shows the Btu recovery and pyritic sulfur rejection for the heavy-media cyclone, the water-only cyclone, the column, the precleaning circuit, and the overall plant results. These tests were conducted to develop the parameters to perform the Box-Behnken design experiment. The test results indicate that 85% Btu recovery and 85% pyritic sulfur rejection were possible. The results of the unit operations and the different circuits are shown graphically in Figure 14.17 through Figure 14.21.

At the beginning of the experimental design, the first seven (7) tests were run. The results of these tests showed little or no beneficiation of the column flotation feed. This was of great concern and an investigation concluded that the feed to the column was being flocculated by excess flocculant in the recirculation water. This necessitated improving the way the flocculants were added to the refuse and clean coal thickeners and to control the amount of flocculant added to the refuse belt press.

The flocculant addition to both thickeners was reduced. An attempt to reduce the flocculant addition to the refuse belt press prevented optimum operation of the belt press. The conclusion made after several experimental runs was that the refuse belt press could not be operated if performance of the column flotation was to be improved. Therefore, a decision was made to eliminate the refuse belt press from the circuit in order to improve the performance of the column.

The decision did not affect the operation of the DOE POC. The thickener underflow now bypassed the refuse belt press and was disposed of in the Ohio Power's impoundment.

In light of these data, an attractive operating region occurred around test number 618 (i.e., 88% energy recovery and 70% pyritic sulfur rejection). On this basis, it was recommended that the following column operating parameters (Table 14.40) be examined in the Box-Behnken test program.

Table 14.40

Parameter	Low	Middle	High
Feed Rate	2.0	3.0	4.0
Frother	0.5	0.90	2.30
Collector	0.5	1.00	1.50

The wash water rate and aeration rate were maintained at 100 gpm and 140 scfm, respectively. MIBC was used as the frother for these tests.

Table 14.39

Feed Evaluation, Unit Operation Evaluation, and Plant Evaluation

			HMC		WOC		COLUMN		PRECLEAN		PLANT	
	FEED		BTU	PYR SUL	BTU	PYR SUL	BTU	PYR SUL	BTU	PYR SUL	BTU	PYR SUL
TEST NUMBER	ASH %	PYR SUL	REC %	REJ %	REC %	REJ %	REC %	REJ %	REC %	REJ %	REC %	REJ %
93050609	41.46	1.90	95.43	47.59	98.56	9.35	75.58	60.35	93.96	52.50	71.01	81.17
93050611	37.74	1.86	95.54	37.07	92.18	22.74	89.73	53.89	88.07	51.38	79.03	77.58
93050612	41.31	1.68	95.16	49.37	98.19	6.68	90.03	42.04	93.44	52.75	84.13	72.61
93050613	41.24	1.27	95.77	47.59	97.51	11.69	94.52	48.88	93.39	53.72	88.27	76.34
93050614	40.54	1.38	94.84	41.23	92.74	29.09	86.45	67.77	87.95	58.33	79.03	86.57
93050615	42.33	1.33	94.71	47.75	96.79	17.49	86.42	63.41	91.66	56.89	79.21	84.22
93050616	40.70	1.85	96.18	39.01	98.25	16.74	95.22	40.41	94.50	49.22	89.99	69.74
93050617	39.75	1.78	95.60	39.15	93.89	30.36	98.47	11.90	90.03	57.63	88.66	62.67
93050618	39.53	1.91	95.86	43.92	93.20	14.22	98.54	37.25	89.35	51.89	88.04	69.81
93050619	34.45	1.82	96.45	37.85	94.56	19.00	92.59	36.98	91.21	49.66	84.44	68.28
93050620	38.08	1.92	95.81	40.25	93.40	11.64	96.23	29.26	89.49	47.21	86.12	62.65
93050621	38.38	1.83	94.46	45.11	92.42	15.08	95.56	40.99	87.30	53.39	83.44	72.50
93050622	37.50	2.43	96.37	33.34	98.32	1.93	88.75	52.18	94.75	34.63	84.09	68.74
93050623	39.54	2.22	90.81	42.76	98.16	6.49	85.59	51.60	89.14	46.47	76.30	74.10
93050624	38.03	2.33	96.02	35.27	89.68	19.98	94.91	48.10	86.11	48.20	81.73	73.12
93050625	38.18	2.45	97.51	33.33	92.65	19.37	96.73	41.04	90.34	46.25	87.39	68.31
93050626	37.93	2.20	95.26	37.49	93.04	24.97	96.35	34.46	88.63	53.10	85.40	69.26
93050627	40.31	2.34	94.51	47.82	98.73	3.87	90.69	38.51	93.31	49.84	84.63	69.16
AVERAGE	39.28	1.92	95.35	41.44	95.13	15.59	91.80	44.39	90.70	50.73	83.38	72.60

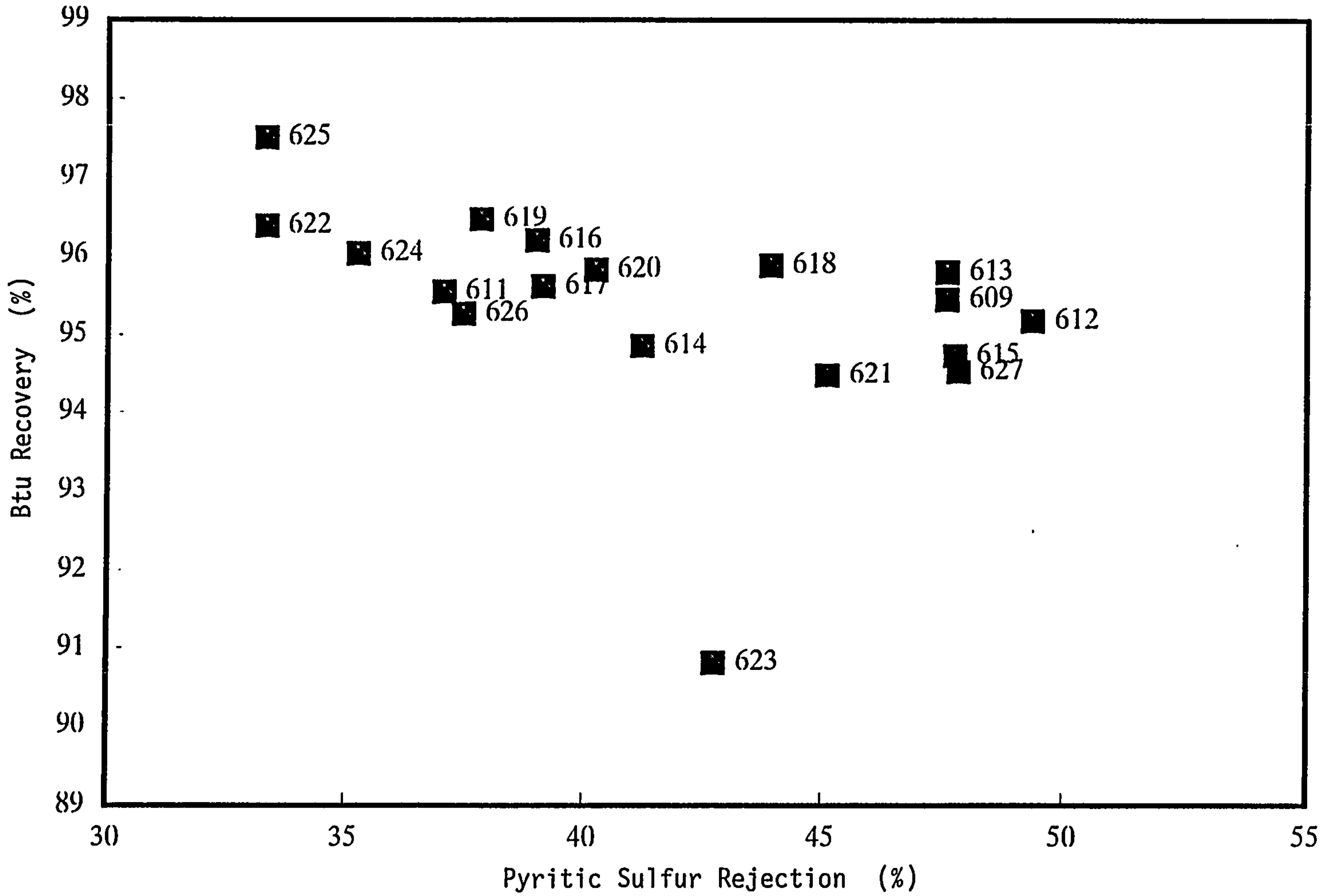


Figure 14.17

Btu Recovery vs. Pyritic Sulfur Rejection for HMC

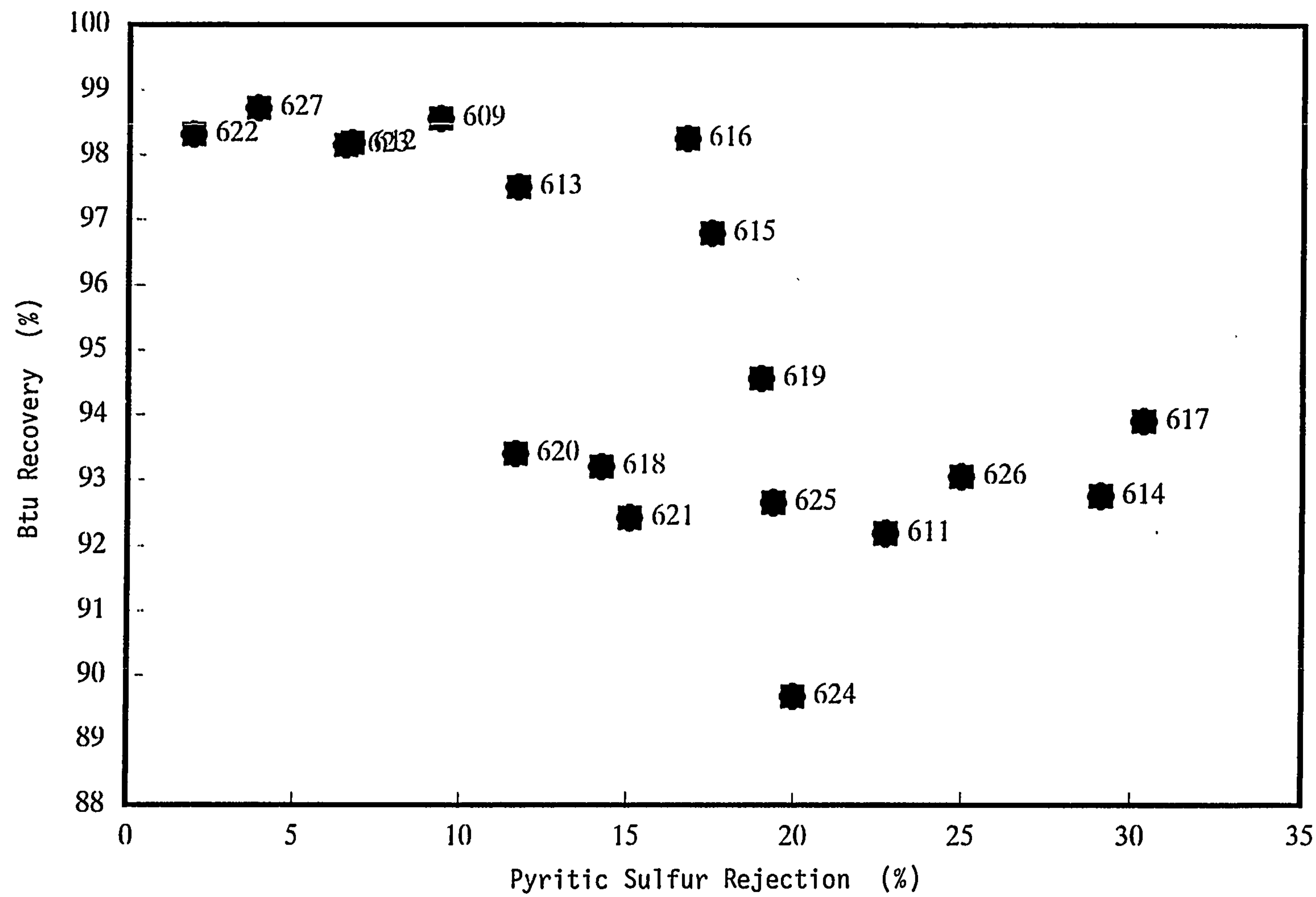


Figure 14.18

Btu Recovery vs. Pyritic Sulfur Rejection for WOC

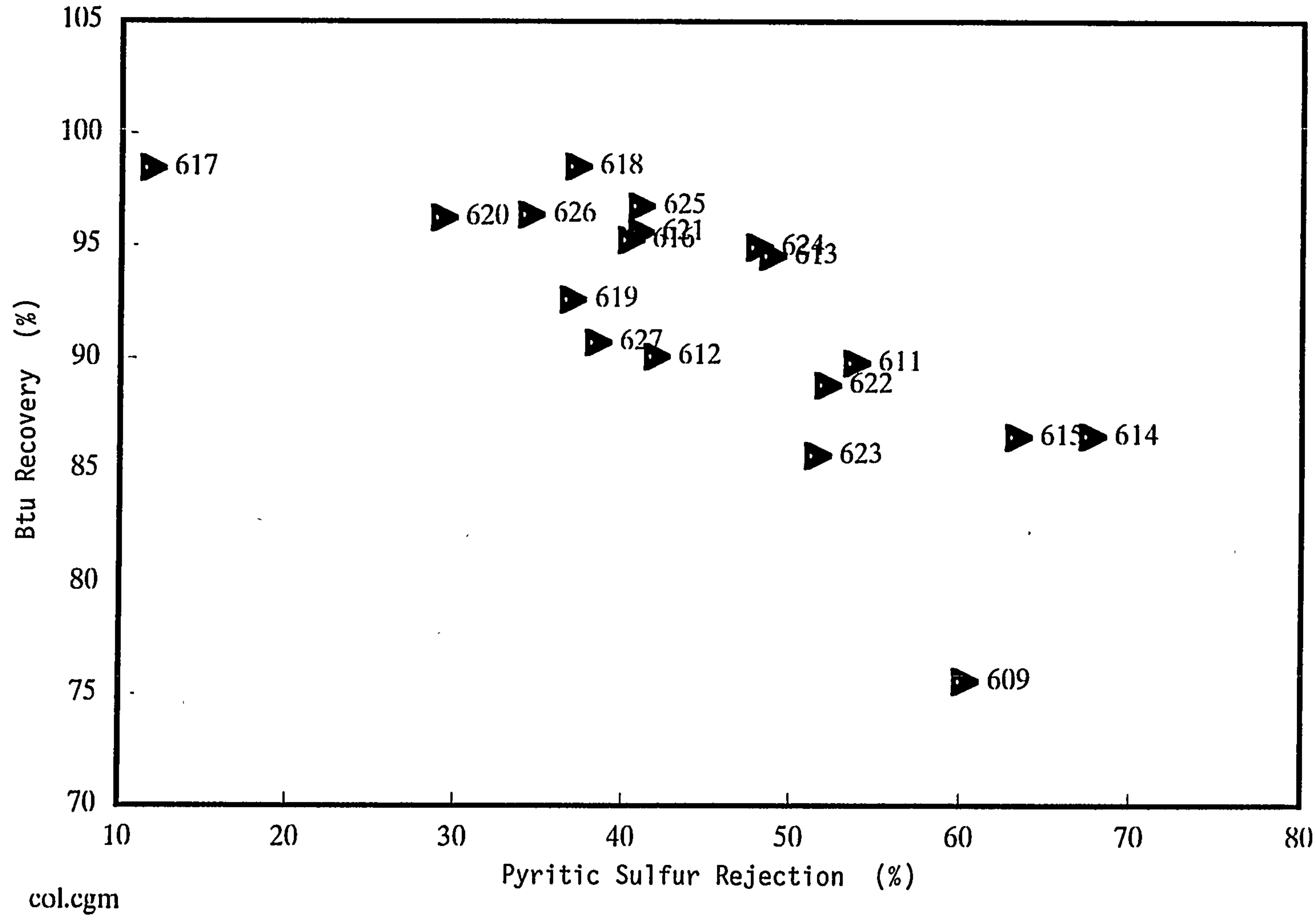


Figure 14.19

Btu Recovery vs. Pyritic Sulfur Rejection for Column Flotation

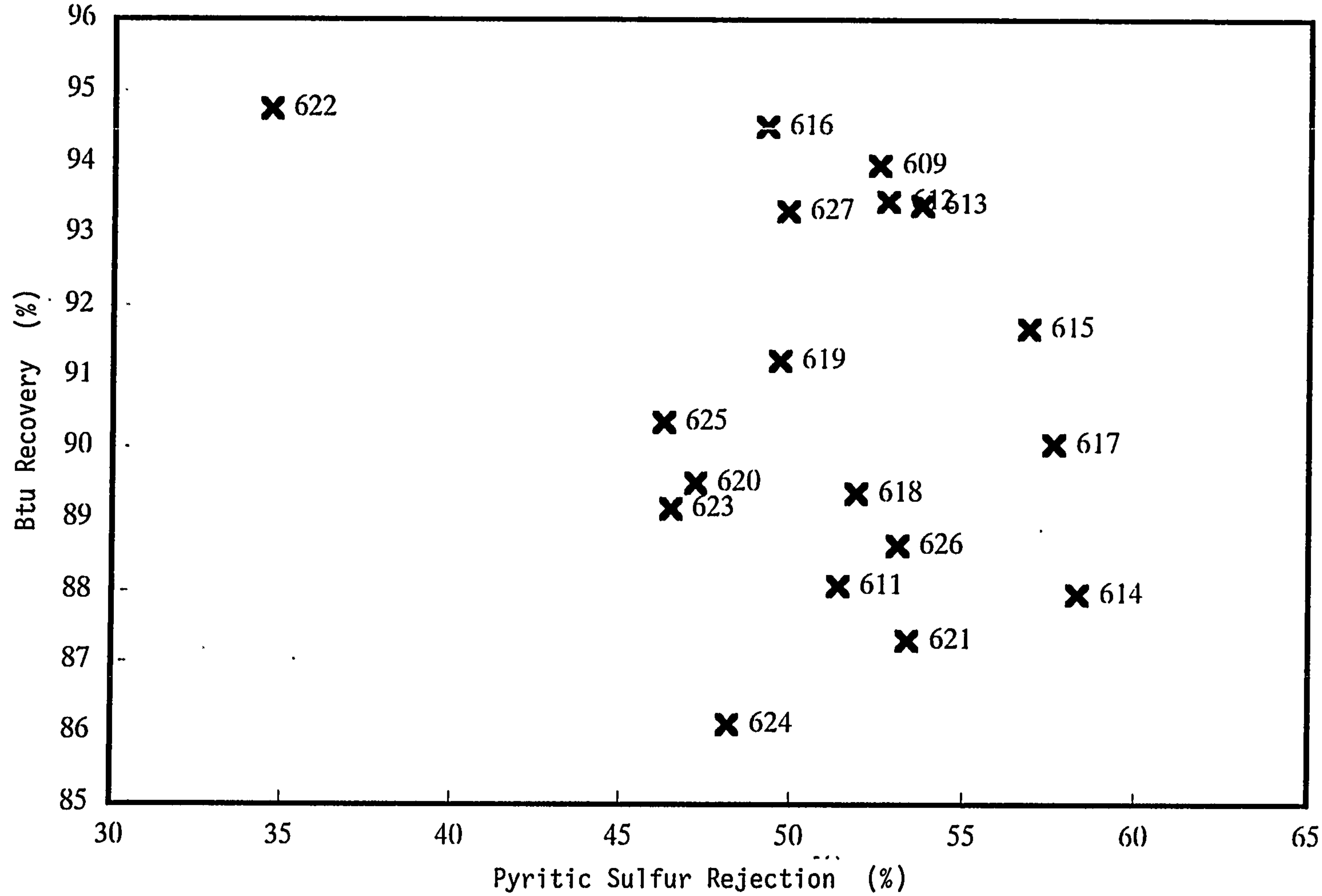


Figure 14.20

Btu Recovery vs. Pyritic Sulfur Rejection for Precleaning Circuit

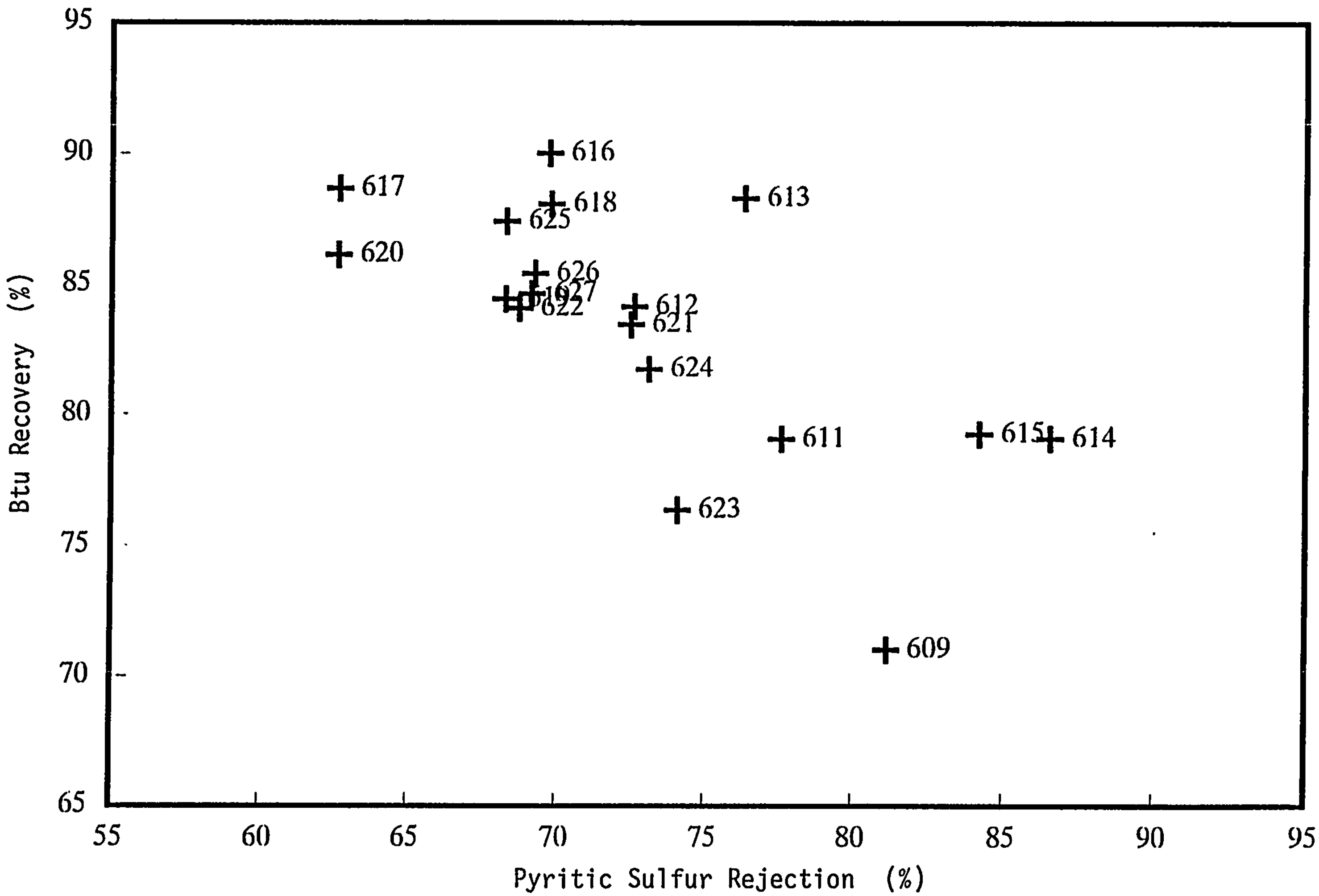


Figure 14.21

Btu Recovery vs. Pyritic Sulfur Rejection for Entire Plant

Box-Behnken Test Matrix

The Box-Behnken test matrix for the Pittsburgh No. 8 coal is given in Table 14.41. Three different operating variables were examined in the parametric test program, i.e., feed solids rate, collector dosage, and frother dosage. The results are included in Task 14 Report appendix.

The factorial test program recommended a series of feed rate tonnages of low - 2.0 TPH, middle - 3.0 TPH, and high - 4.0 TPH. It was determined that in order to produce a relatively fine grind and liberate the pyrite, it was necessary to modify the feed rate parameter. The feed tonnages for the Box-Behnken program would be low - 1.0 TPH, middle - 2.0 TPH, and high - 3.0 TPH.

Figure 14.22 shows the Btu recoveries as a function of ash rejection, pyritic sulfur rejection, and total sulfur rejection for the overall POC circuit. Although the flotation tests were conducted over a wide range of operating conditions, most of the experimental data points were found to fall within a single grouping of data. These results indicate that several different combinations of operating parameters can be used to achieve the same level of separation performance. This implies that other factors (e.g., column capacity, operating cost, maintenance considerations, etc.) should be used to select the preferred column operating point. In any case, the Box-Behnken test data indicate that a clean-coal concentrate can be readily obtained at a 75% ash rejection, 35% pyritic sulfur rejection, and 95% Bturecovery.

Table 14.41
Experimental Conditions Examined for the Pittsburgh No. 8 Seam Coal

Run Number	Feed Rate (tph)	Collector Dosage (lb/ton)	Frother Dosage (lb/ton)
1	1.0	1.00	1.12
2	2.0	0.50	1.92
3	2.0	1.50	1.12
4	3.0	1.50	1.52
5	3.0	1.00	1.12
6	2.0	1.00	1.52
7	1.0	1.00	1.92
8	2.0	1.00	1.52
9	1.0	1.50	1.52
10	1.0	0.50	1.52
11	3.0	0.50	1.52
12	2.0	1.50	1.92
13	3.0	1.00	1.92
14	2.0	0.50	1.12
15	2.0	1.00	1.52

Pittsburgh No. 8 - Column

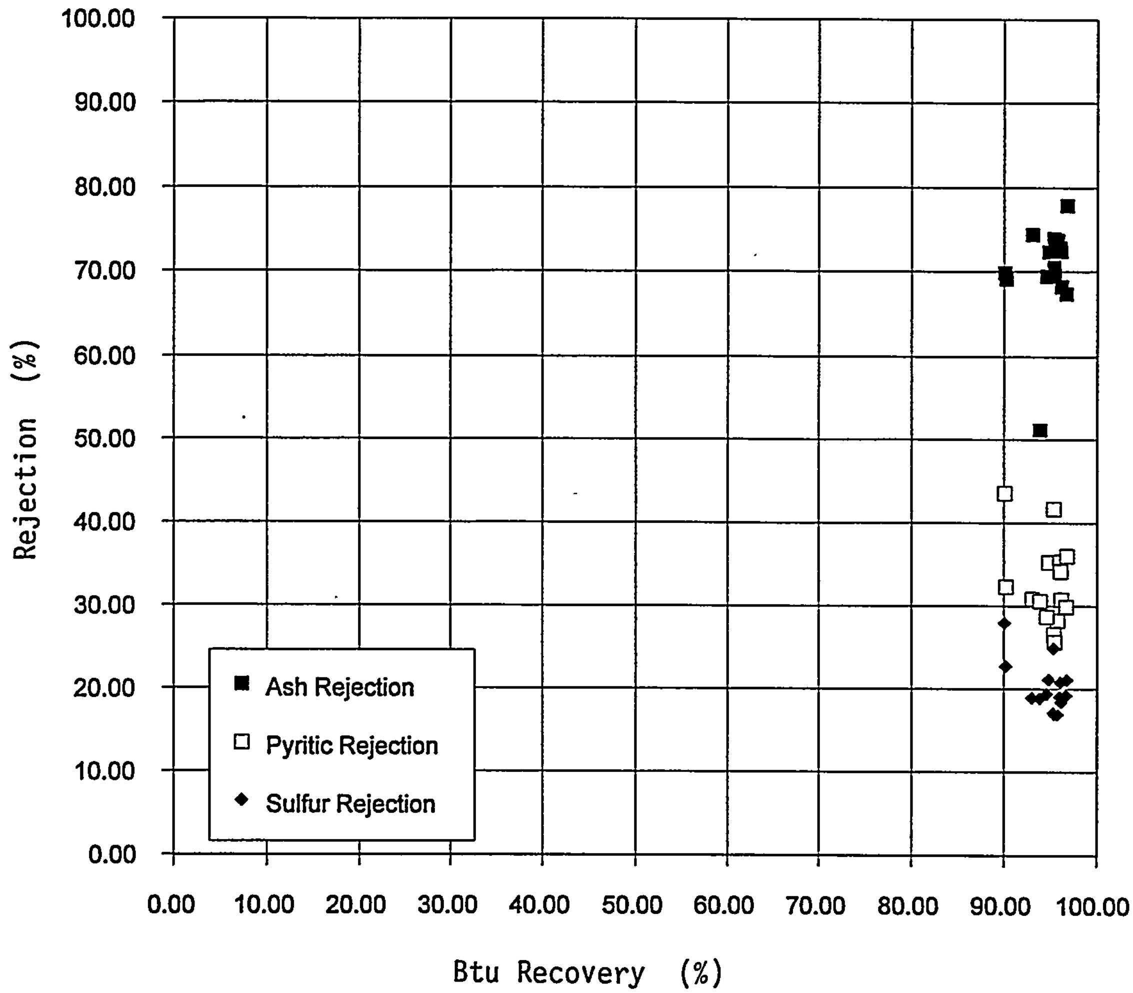


Figure 14.22

Column Circuit Results for the Testing of the Pittsburgh No. 8 Seam Coal

Table 14.42 is the result from the Box-Behnken test program that was utilized in the Demonstration Testing.

Table 14.42
Conditions for Column for Pittsburgh No. 8

Plant Feed Rate (tph)	Column Feed Rate (tph)	Collector Dosage (16/Ton)	Air Holdup (%)
3.1	2.0	1.0	2.4

The results of the net effect calculations for the Pittsburgh No. 8 tests are summarized in Table 14.43. As shown, Btu recovery was found to increase with feed rate and collector dosage, but decreased with frother dosage. In contrast, pyritic sulfur rejection increased with frother dosage, and decreased with feed rate and collector dosage. The results indicate that feed rate was the primary factor controlling column recovery, ash rejection, and pyritic sulfur rejection.

Response surface plots for the Pittsburgh No. 8 seam coal are provided in Figures 14.23 - 14.25 for Btu recovery, ash rejection, and sulfur rejection, respectively. In each case, the appropriate column response was plotted as a function of collector and frother dosage. Five separate plots were constructed representing feed rates of 1.0, 1.5, 2.0, 2.5, and 3.0 tph. The plots indicate that the relationship between the column response and the various operating parameters was non-linear and very complex.

Table 14.43
Net Effects Obtained for the Pittsburgh No. 8 Seam Coal

Test Variable	Units	Low Value	High Value	Btu Recovery	Ash Rejection	Pyritic Rejection
Main	***	***	***	+96.107	+68.42	+28.81
Feed Rate	tph	1.0	3.0	+1.516	+3.28	-2.68
Frother	lb/ton	1.12	1.92	+0.389	-1.04	+1.17
Collector	lb/ton	0.50	1.50	+1.055	+0.26	-1.49

UPPER FREEPORT TESTING

Unit Operations

The Upper Freeport coal was obtained from Camelot Coal Company, Somerset County, Pennsylvania. This is not the same Upper Freeport utilized for Tasks 5 and 6. At the time of procurement of the Upper Freeport coal, the mine where the Upper Freeport was obtained for Tasks 5 and 6 was no longer in operation. Therefore, Camelot Coal

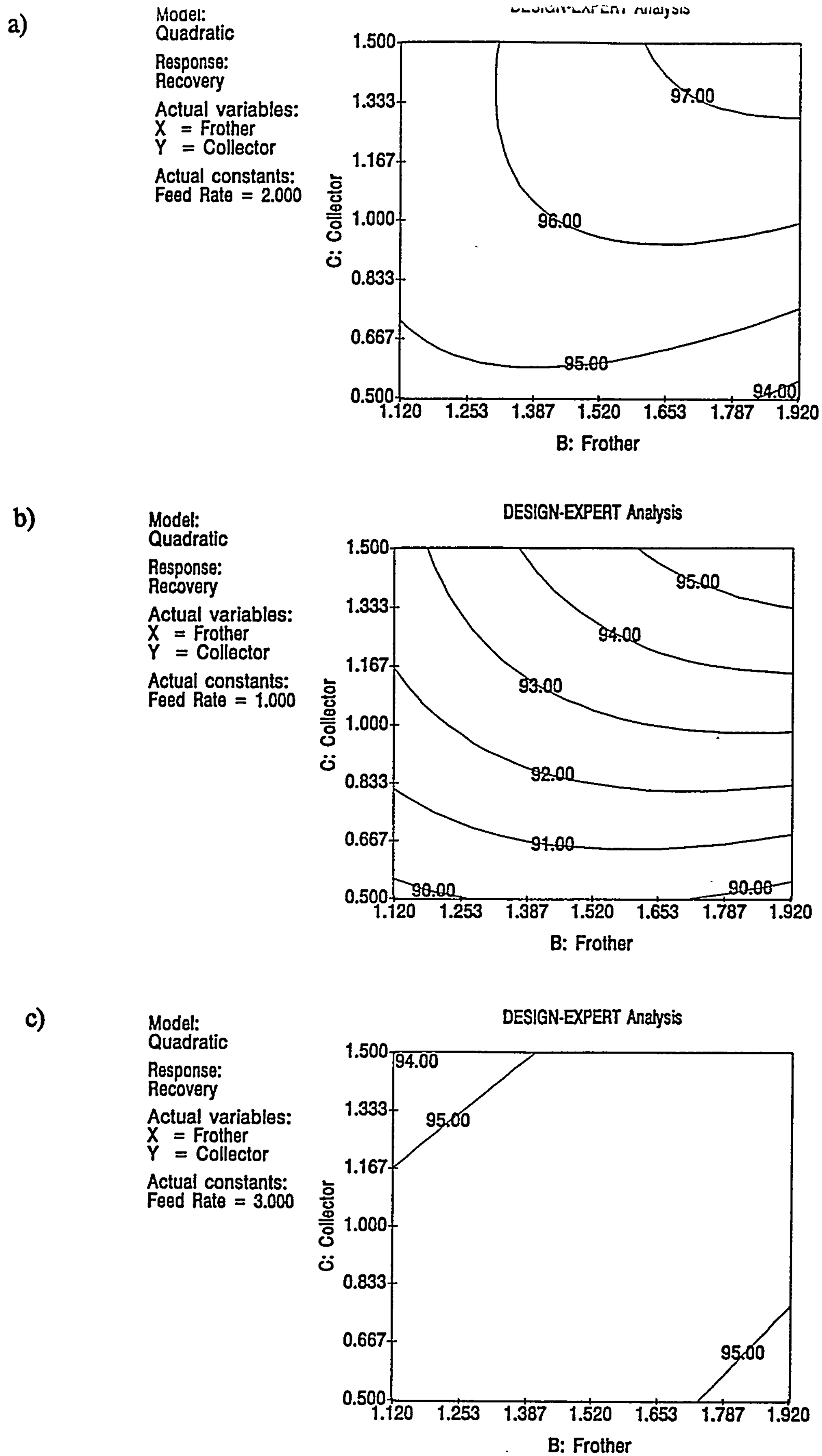


Figure 14.23

Effects of Collector Dosage and Frother Dosage on Btu Recovery for the Pittsburgh No. 8 Coal at Feed Rates of (a) 1.0, (b) 2.0, and (c) 3.0 tph

a) b) c)

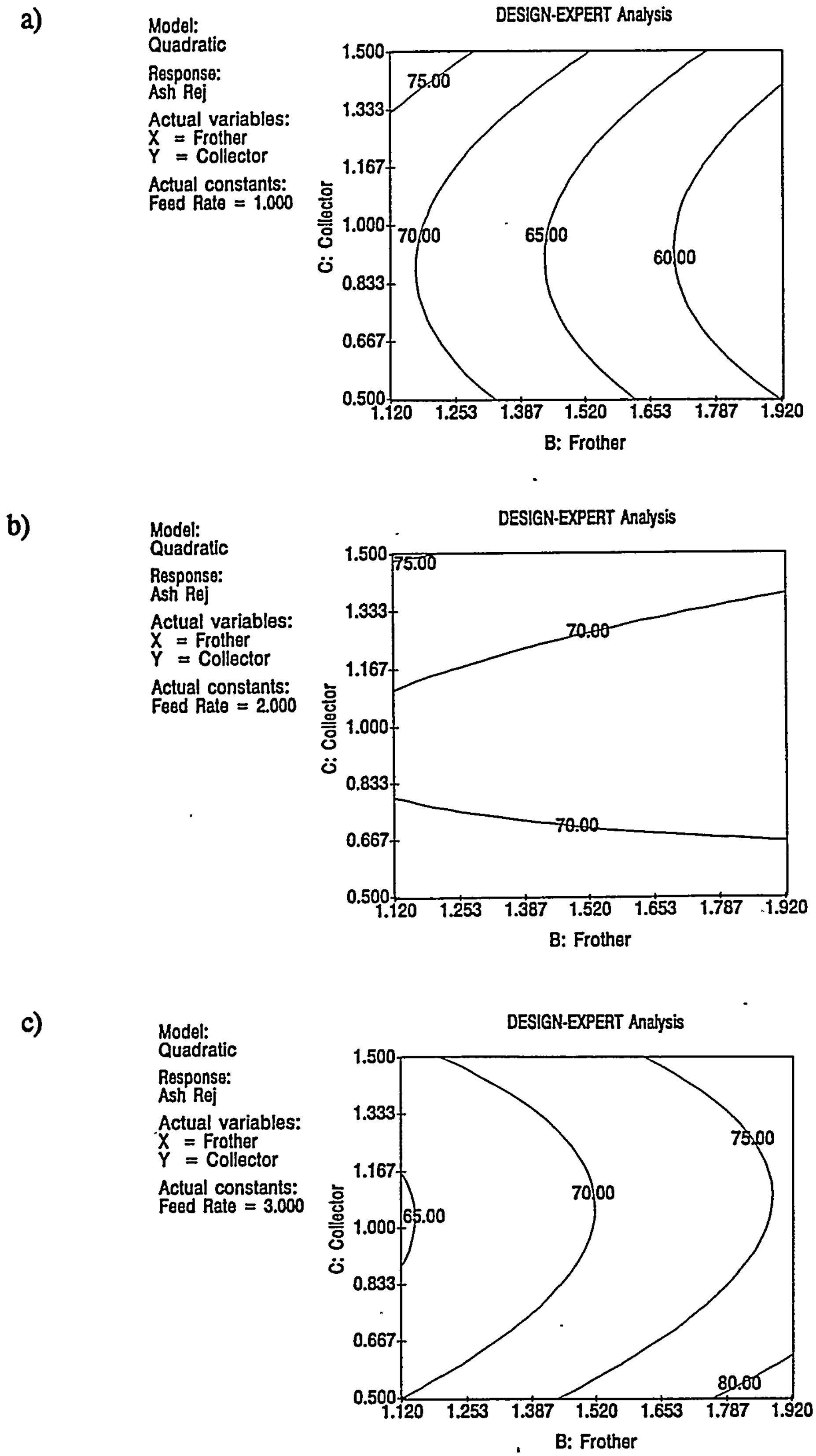


Figure 14.24

Effects of Collector Dosage and Frother Dosage on Ash Rejection for the Pittsburgh No. 8 Coal at Feed Rates of (a) 1.0, (b) 2.0, and (c) 3.0 tph

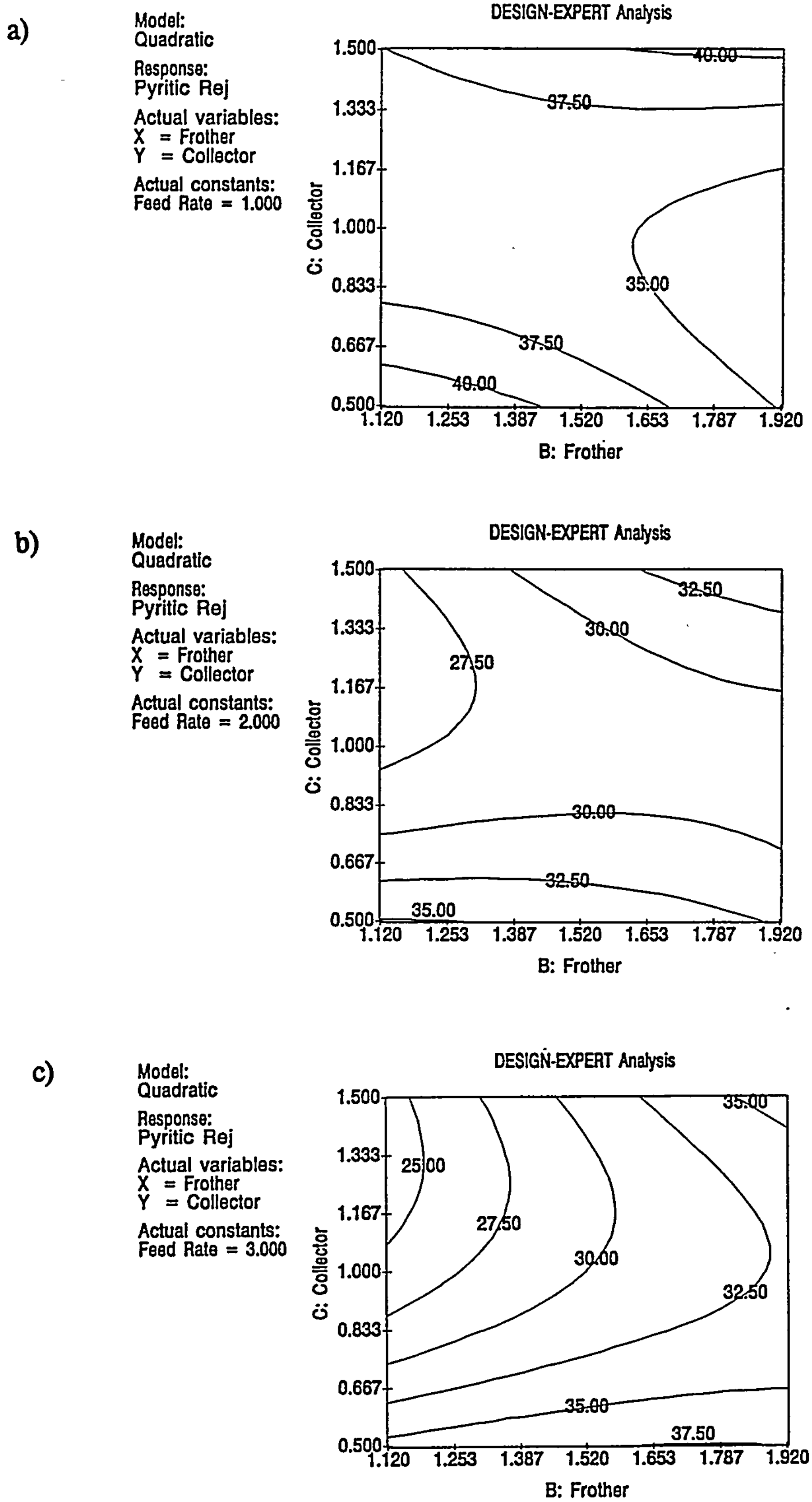


Figure 14.25

Effects of Collector Dosage and Frother Dosage on Pyritic Sulfur Rejection for the Pittsburgh No. 8 Coal at Feed Rates of (a) 1.0, (b) 2.0, and (c) 3.0 tph was selected as a substitute. The mine was a strip mine, and at times the raw coal contained oxidized material. The indication of oxidized material originally was suspected because the pH of the plant recirculation water became acidic. Subsequently, tests were conducted in the laboratory to confirm that indeed the coal was oxidized. The Upper Freeport coal required pH adjustment during processing. However, because of the crushing and grinding in both the precleaning and advanced circuits, the oxidation of the raw coal had little effect on the flotation results.

Heavy-Media Cyclone

The heavy-media cyclone was the first precleaning unit operation in the circuit. Four (4) tests were conducted on the heavy-media cyclone over a range of specific gravities of media from 1.70 - 1.85. The determining factor was the lowest specific gravity that produced 97% Btu recovery. The results are shown in Tables 14.44 - 14.47 "HMC Test Results - Upper Freeport." The results show that with 1.75 specific gravity, the Btu recovery of 97.5% was accomplished. This will be the specific gravity used in the remainder of the Upper Freeport test program.

Water-Only Cyclone

The product of the heavy-media cyclone was crushed in a closed circuit to minus-48 mesh and combined with the natural 48 mesh x zero and processed in a water-only cyclone. The water-only cyclone was used to remove high-ash, free-pyrite, and low-Btu-reject material. The performance of the hydrocyclone had been previously determined in the Pittsburgh No. 8 test program. However, two (2) tests were conducted to demonstrate the orifice size arrangements selected in the Pittsburgh test program were best for the Upper Freeport. The results for the two (2) tests are shown on Tables 14.48 and 14.49, "WOC Test Results - Upper Freeport." The arrangement of orifice for Test No. 93100401 resulted in a Btu recovery of 97.8%. This arrangement was used in the remainder of the Upper Freeport test program.

Conventional Flotation

The heavy-media cyclone and the water-only cyclone were operated at the determined conditions, and testing of the conventional flotation began. The Task 5 test work indicated the possibility of a grab-and-run product from conventional flotation. However, as shown in Tables 14.50 - 14.52, "Conventional Flotation Test Results - Upper Freeport", no grab-and-run product was produced, and the Btu recovery was too low to guarantee 85% Btu recovery in the final product. For this reason the conventional flotation was eliminated from the Upper Freeport test program.

Grinding

The first system to test in the advanced DOE POC was the grinding circuit. The grinding circuit consisted of the mill classifying

Table 14.44

HEAVY MEDIA CYCLONE TEST RESULTS - UPPER FREEPORT
TEST RUN NUMBER: 93092301

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME DISCHARGE	MANUAL	19.94	11852	3.67
HMC CLEAN COAL	705	15.12	12687	2.69
HMC REFUSE	706	62.63	4128	19.43
HMC WT% RECOVERY			89.85	
HMC BTU RECOVERY			96.19	

Table 14.45

HEAVY MEDIA CYCLONE TEST RESULTS - UPPER FREEPORT
TEST RUN NUMBER: 93092302

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME DISCHARGE	MANUAL	16.88	12335	3.17
HMC CLEAN COAL	705	15.65	12538	3.24
HMC REFUSE	706	63.92	3620	20.01
HMC WT% RECOVERY			97.45	
HMC BTU RECOVERY			99.06	

Table 14.46

HEAVY MEDIA CYCLONE TEST RESULTS - UPPER FREEPORT
TEST RUN NUMBER 93092303

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME DISCHARGE	MANUAL	16.88	12335	3.17
HMC CLEAN COAL	705	16.12	12500	2.89
HMC REFUSE	706	62.88	3994	21.70
HMC WT% RECOVERY			98.37	
HMC BTU RECOVERY			99.69	

Table 14.47

HEAVY MEDIA CYCLONE TEST RESULTS - UPPER FREEPORT
TEST RUN NUMBER: 93092304

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME DISCHARGE	MANUAL	18.60	12033	3.89
HMC CLEAN COAL	705	15.28	12591	2.79
HMC REFUSE	706	64.59	3776	21.36
HMC WT% RECOVERY			93.27	
HMC BTU RECOVERY			97.59	

Table 14.48

WATER ONLY CYCLONE TEST RESULTS - UPPER FREEPORT
TEST RUN NUMBER: 93100401

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME U'FLOW	702	15.62	12372	2.84
WOC CLEAN COAL	708	14.53	12562	2.55
WOC REFUSE	717B	43.84	7454	13.71
WOC WT% RECOVERY			96.28	
HMC BTU RECOVERY			97.76	

Table 14.49

WATER ONLY CYCLONE TEST RESULTS - UPPER FREEPORT
TEST RUN NUMBER: 93100402

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME U'FLOW	702	20.06	11699	4.45
HMC CLEAN COAL	708	15.08	12269	2.83
HMC REFUSE	717B	46.91	6769	17.71
HMC WT% RECOVERY			84.35	
HMC BTU RECOVERY			88.46	

Table 14.50

CONVENTIONAL FLOTATION TEST RESULTS - UPPER FREEPORT
TEST RUN NUMBER: 92092901 - BANK A

SAMPLER NAME	SAMPLER NUMBER	WT %	ASH %	% SOLIDS BY WT.	BTU
FEED	712A	100.00	18.17	8.27	11868
ROUGHER CONC.	715A	2.31	9.15	37.27	13583
SCAV. CONC.	713A	36.11	12.08	13.49	13111
TAILINGS	714A	61.58	22.08	4.12	11281
FLOT. WT % RECOVERY				38.42	
FLOT. BTU RECOVERY				42.54	

Table 14.51

CONVENTIONAL FLOTATION TEST RESULTS - UPPER FREEPORT
TEST RUN NUMBER: 92092902 - BANK A

SAMPLER NAME	SAMPLER NUMBER	WT %	ASH %	% SOLIDS BY WT.	BTU
FEED	712A	100.00	13.41	7.72	12730
ROUGHER CONC.	715A	-3.35	9.80	22.30	13531
SCAV. CONC.	713A	124.31	15.42	7.12	12547
TAILINGS	714A	-20.96	25.91	1.83	10691
FLOT. WT % RECOVERY				120.96	
FLOT. BTU RECOVERY				118.96	

Table 14.50

CONVENTIONAL FLOTATION TEST RESULTS - UPPER FREEPORT
TEST RUN NUMBER 92092901 - BANK B

SAMPLER NAME	SAMPLER NUMBER	WT %	ASH %	% SOLIDS BY WT.	BTU
FEED	712A	100.00	16.23	1.14	12263
ROUGHER CONC.	715A	90.86	7.95	5.05	13830
SCAV. CONC.	713A	-16.79	8.82	21.78	13665
TAILINGS	714A	25.93	40.45	0.80	8570
FLOT. WT % RECOVERY				74.07	
FLOT. BTU RECOVERY				83.76	

Table 14.51

CONVENTIONAL FLOTATION TEST RESULTS - UPPER FREEPORT
TEST RUN NUMBER: 92092902 - BANK B

SAMPLER NAME	SAMPLER NUMBER	WT %	ASH %	TOTAL SULFUR %	BTU
FEED	712A	100.00	17.31	2.62	12251
ROUGHER CONC.	715A	20.71	5.14	1.82	14321
SCAV. CONC.	713A	44.47	16.47	3.11	12095
TAILINGS	714A	34.82	25.62	2.47	10694
FLOT. WT. % RECOVERY				65.18	
FLOT. BTU RECOVERY				68.11	

Table 14.52

CONVENTIONAL FLOTATION RESULTS - UPPER FREEPORT
TEST RUN NUMBER: 93092903 - BANK A

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
FEED	712A	16.13	12365	3.44
ROUGHER CONC.	715A	12.31	13031	2.80
TAILINGS	714A	35.41	9058	2.07
FLOT. WT% RECOVERY			83.46	
FLOT. BTU RECOVERY			87.96	

Table 14.52

CONVENTIONAL FLOTATION RESULTS - UPPER FSREEPORT
TEST RUN NUMBER:93092903 - BANK B

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
FEED	712A	18.33	11900	1.90
ROUGHER CONC.	715A	16.19	12813	1.95
TAILINGS	714A	45.69	7278	1.76
FLOT. WT % RECOVERY			92.75	
FLOT. BTU RECOVERY			99.86	

cyclones in reversed closed circuit with the ball mill. Reversed closed circuit means the incoming feed and the ball mill product were sized in the mill classifying cyclones ahead of the mill. This permitted removal of natural-sized material and ground-sized material before recirculation through the ball mill.

During the testing of the Pittsburgh No. 8 coal, it was determined that experiments were needed to improve the product size from the mill and also improve the relationship in quality between the water-only cyclone overflow and the column flotation feed. An attempt to improve the size characteristics was made by installing smaller diameter grinding media and conducting speed changes to the ball mill. The quality relationship was improved with the addition of the Varisieve on the mill classifying cyclone underflow. This step eliminated recirculating pyrite in the mill circuit.

The test work done for the mill circuit for size distribution is shown on Table 14.53, "Mill Circuit Test Results - Upper Freeport." The mill was adjusted at two different speeds in an attempt to decrease the mean particle size. However, the results indicated little or no improvement. Therefore, the mill was operated at 27.7 rpm or the maximum rpm for operation. The data points out that the fineness of grind was influenced by the feed rate. The data are shown graphically in Figures 14.26 and 14.27.

The quality of the mill-circuit product was the feed to the advanced column, and this should have been of the same quality as the water-only cyclone overflow which was the feed to the mill circuit. Table 14.54, "Statistical Analysis of WOC Quality and Column Feed Quality - Upper Freeport," demonstrates that indeed the comparison of means shows a statistical similarity between the two streams for all parameters measured.

The conclusions that can be determined from the previous paragraphs about the mill circuit are that the fineness of grind was related to the feed rate, and that the quality of the mill circuit feed and mill circuit product were similar. The feed rate for obtaining 90% minus-200 mesh was 1 tph or less. This rate was too low to demonstrate the POC rate capability. Therefore, a feed rate of around 2.5 tph was selected to operate,resulting in a grind of 65-70% minus-200 mesh. This was a direct result of the size and horsepower of the ball mill. In this case, the ball mill was undersized, and the unit should have been larger in size in order to handle the larger than anticipated recirculated load to the mill.

The heavy-media cyclone, water-only cyclone, and the ball mill grinding circuit were operated at their respective best operating conditions, and a Box-Behnken test matrix was conducted on the advanced column flotation unit operation.

Table 14.53

Mill Circuit Test Results - Upper Freeport

TEST NUMBER	93100701	93100702	93100601	93100602	93100603	93100604	93100605	93100606
MILL SPEED – RPM	27.7	18.0	27.7	27.7	27.7	27.7	27.7	27.7
COL. FD. RATE – TPH	3.86	4.76	0.89	3.35	1.72	2.76	1.12	1.82
SIZE FRACTION MICRONS	WT% PASSING	WT% PASSING	WT% PASSING	WT% PASSING	WT% PASSING	WT% PASSING	WT% PASSING	WT% PASSING
296.00	92.56	98.78	100.00	98.94	99.79	99.24	99.92	100.00
248.90	87.32	96.16	100.00	97.04	99.22	98.46	99.61	99.89
209.30	81.10	91.52	99.60	94.00	97.98	96.57	98.73	98.99
176.00	74.02	85.01	98.93	90.04	96.24	93.63	97.41	97.33
148.00	66.31	76.80	98.07	85.46	94.20	89.66	95.76	94.81
124.45	57.47	67.40	96.84	80.24	91.53	84.68	93.54	91.33
104.65	51.02	57.42	95.02	74.42	87.89	78.73	90.49	86.77
88.00	44.06	47.51	92.47	68.06	83.17	72.08	86.53	81.16
74.00	37.71	38.30	89.00	61.20	77.22	65.00	81.52	74.51
62.23	31.99	30.32	84.57	54.23	70.41	57.81	75.75	67.19
52.33	26.88	24.09	79.17	47.53	63.14	50.83	69.53	59.56
44.00	22.49	19.26	73.00	41.30	55.78	44.32	63.01	52.04
37.00	18.88	15.51	66.26	35.72	48.67	38.47	56.34	45.02
31.11	15.96	12.66	59.54	31.00	42.27	33.45	50.01	38.85
26.16	13.64	10.52	53.45	27.36	37.01	29.41	44.51	33.91
22.00	11.65	8.78	47.67	24.14	32.39	25.88	39.44	29.60
18.50	9.73	7.19	41.91	20.73	27.93	22.41	34.46	25.39
15.56	7.95	5.75	36.32	17.41	23.73	19.10	29.65	21.39
13.08	6.37	4.46	31.00	14.41	19.80	15.98	25.01	17.66
11.00	5.02	3.39	26.26	11.82	16.38	13.28	20.91	14.47
9.25	3.97	2.64	22.40	9.79	13.71	11.23	17.70	12.11
7.78	3.12	2.06	19.12	8.13	11:51	9.56	15.02	10.21
6.54	2.40	1.55	16.19	6.71	9.53	8.06	12.58	8.48
5.50	1.74	1.08	13.42	5.37	7.69	6.59	10.26	6.86
4.62	1.06	0.58	10.59	3.90	5.85	4.96	7.86	5.25
3.89	0.52	0.19	8.15	2.64	4.29	3.54	5.80	3.88
3.27	0.27	0.04	6.52	1.92	3.30	2.72	4.50	3.01
2.75	0.15	0.00	5.27	1.49	2.58	2.18	3.57	2.35
2.31	0.06	0.00	4.05	1.17	1.87	1.71	2.68	1.68
1.94	0.00	0.00	2.95	0.89	1.26	1.28	1.90	1.09
1.64	0.00	0.00	2.06	0.59	0.80	0.87	1.27	0.67
1.38	0.00	0.00	1.31	0.32	0.45	0.50	0.74	0.37
1.16	0.00	0.00	0.65	0.12	0.17	0.19	0.29	0.14
0.97	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00
0.82	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00
SUMMARY DATA								
dv	0.1035	0.1346	0.1711	0.0790	0.2287	0.0672	0.1458	0.1831
5%	10.97	14.11	2.65	5.27	4.23	4.64	3.53	4.50
50%	102.12	91.99	23.60	55.85	38.26	51.23	31.10	41.90
95%	328.69	236.70	104.47	220.34	157.75	189.50	138.66	149.70
mv	128.69	104.30	34.64	75.78	52.25	67.75	45.00	53.83
ma	43.43	49.38	10.62	21.64	16.25	18.99	13.33	17.61
cs	0.1380	0.1220	0.5650	0.2770	0.3690	0.3160	0.4500	0.3410
sd	97.53	67.06	27.29	63.17	39.88	54.40	36.01	41.83

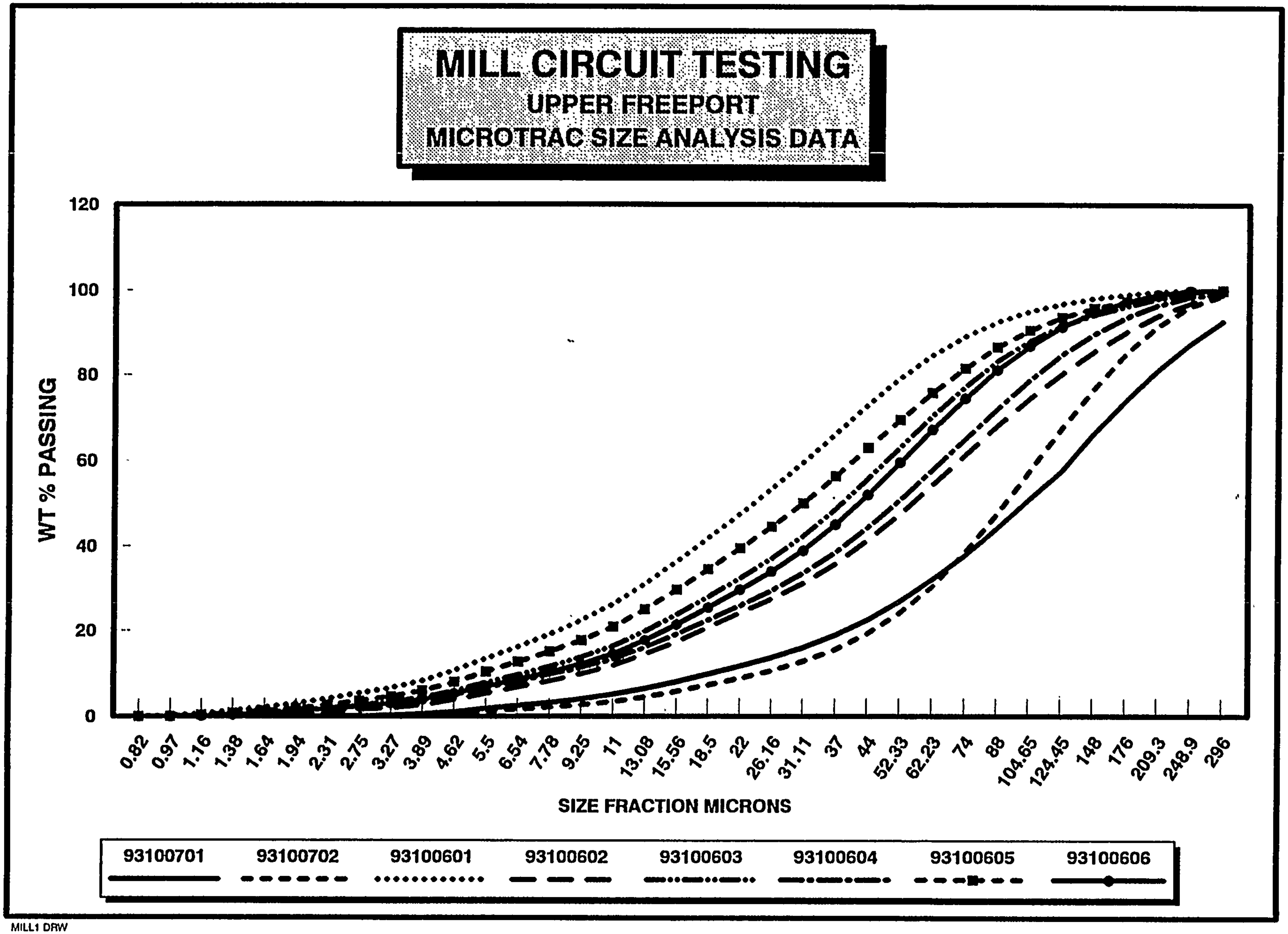


Figure 14.26
Mill Circuit Test Results Wt % Passing vs. Size Fractions

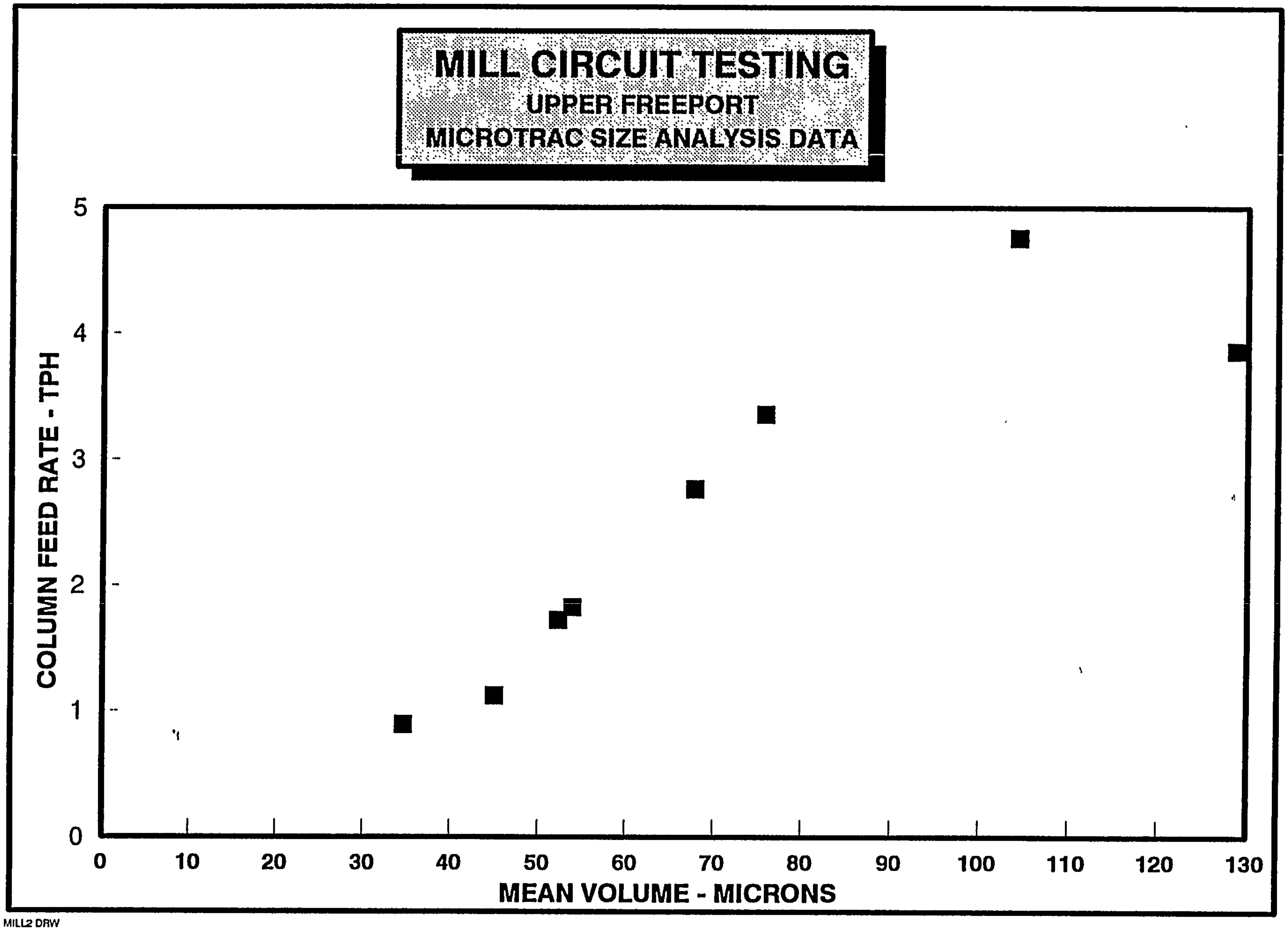


Figure 14.27
Mill Circuit Test Results Column Feed Rate vs. Mean Volume

Table 14.54

Statistical Analysis of WOC Quality and Column Feed Quality - Upper Freeport

	WOC	COLUMN	WOC	COLUMN	WOC	COLUMN	WOC	COLUMN
Obs #	% Ash	$ Ash	% Tot S	% Tot S	% Pyr	% Pyr	Btu/lb	Btu/lb
93100601	30.12	26.69	2.41	2.41	1.05	1.00	10345	10752
93100602	22.42	25.42	2.60	2.68	1.10	1.17	11490	11111
93100603	24.95	25.78	2.69	2.83	1.17	1.10	11123	10999
93100607	17.86	21.46	3.08	2.89	1.94	1.74	12147	11617
93100608	16.27	19.28	2.68	2.85	1.58	1.72	12394	11765
93100609	15.31	18.61	2.71	2.84	1.51	1.73	12474	11968
93100610	15.97	17.89	2.82	2.59	1.63	1.36	12414	12133
93100611	16.27	18.14	2.65	2.70	1.53	1.56	12364	12139
93100612	16.74	17.93	2.70	2.62	1.58	1.50	12434	12210
93100613	18.11	19.69	2.63	3.17	1.59	2.07	12213	11903
93100614	16.68	18.10	2.79	2.82	1.42	1.80	12525	12138
93100615	17.21	16.69	3.23	3.19	1.35	1.89	12240	12263
Maximum	30.12	26.69	3.23	3.19	1.94	2.07	12525	12263
Minimum	15.31	16.69	2.41	2.41	1.05	1.00	10345	10752
Average	18.99	20.47	2.75	2.80	1.45	1.55	12014	11750
Std. Dev.	4.32	3.37	0.21	0.22	0.24	0.32	648	498
No. of Obs	12	12	12	12	12	12	12	12
Calculated Z	-0.9359		-0.5783		-0.8541		1.1177	

Box-Behnken Test Matrix

Operational Data

The Box-Behnken test matrix for the Upper Freeport coal is given in Table 14.55. The three operating variables examined for this particular coal included feed solids rate, collector dosage, and air holdup.

Table 14.55
Experimental conditions examined for the Upper Freeport Seam Coal.

Run Number	Feed Rate (tph)	Collector Dosage (lb/ton)	Air Holdup (%)
1	2.50	0.20	18
2	2.50	1.00	24
3	1.00	0.60	24
4	1.00	0.20	21
5	1.00	0.60	18
6	1.00	1.00	21
7	4.00	0.60	18
8	2.50	0.20	18
9	2.50	1.00	24
10	2.50	0.20	24
11	2.50	0.60	21
12	2.50	1.00	18
13	2.50	0.20	18
14	2.50	1.00	24
15	2.50	0.20	24
16	2.50	0.60	21
17	4.00	0.20	21
18	4.00	1.00	21
19	2.50	1.00	18
20	2.50	0.60	21
21	4.00	0.60	24

Analytical Data

Figure 14.28 shows the test results obtained using the Upper Freeport coal. Btu recoveries were plotted as a function of ash rejection, pyritic sulfur rejection and total sulfur rejection for the circuit. All of the data points were found to fall along unique grade-recovery curves. The curves represent the trade-off between energy recovery and product quality. The "knee" or "elbow" in this curve was found to correspond to the point of maximum separation efficiency. When operating at this point, a 90% Btu recovery could be achieved at ash and pyritic sulfur rejections of approximately 50% and 38%, respectively.

Conclusions

The net effect calculations for the Upper Freeport tests are provided in Table 14.56. In this case, Btu recovery was found to decrease with feed rate, and increase with air holdup and collector dosage. Ash rejection increased with feed rate, and decreased with

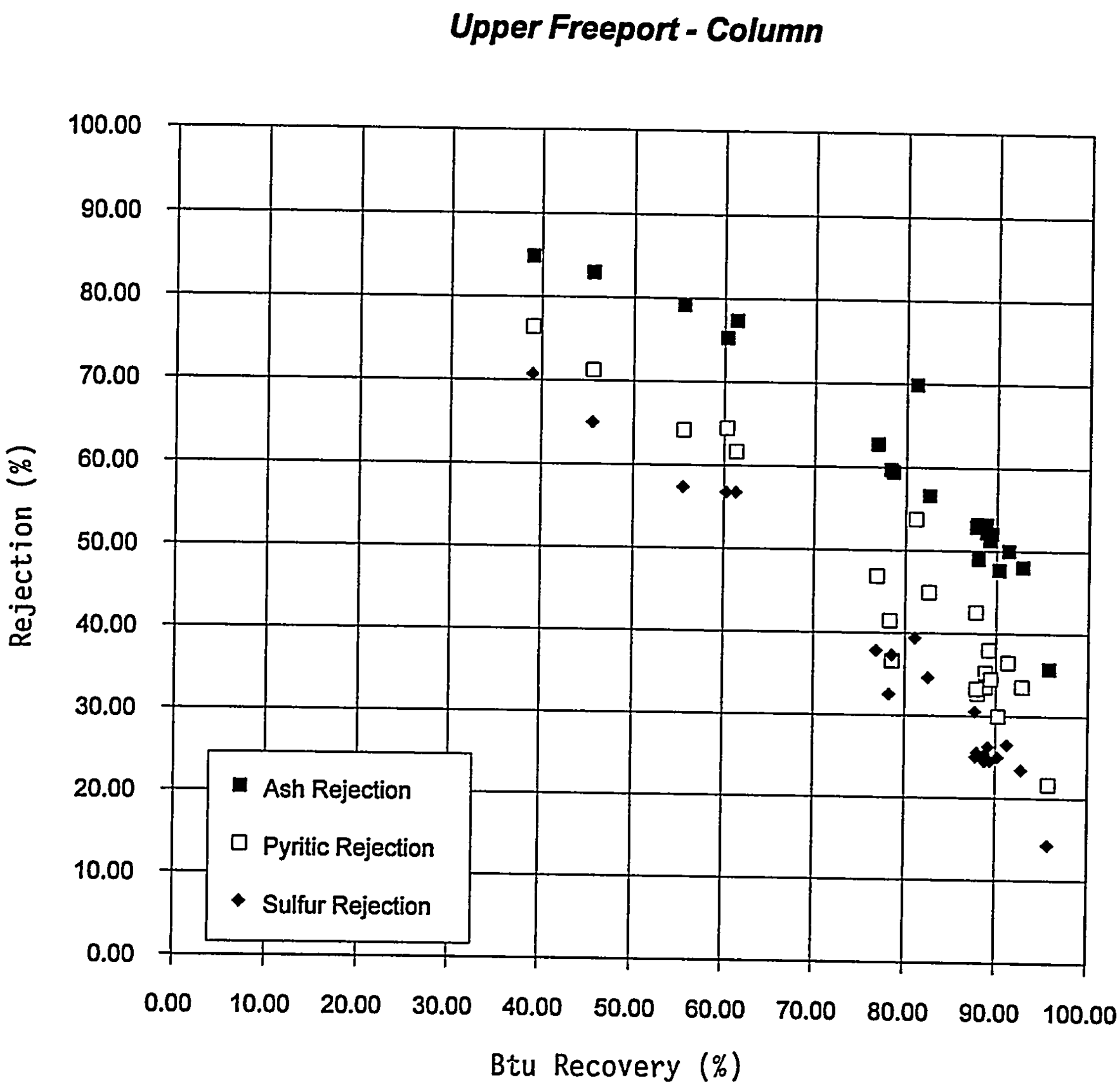


Figure 14.28

Column Circuit Results for the Testing of THe Upper Freeport Seam Coal air holdup and collector dosage. Pyritic sulfur rejection followed the same trend. These trends are in good agreement with those typically observed for the column flotation of fine coal. The statistical analyses also indicate that air holdup is the dominant factor controlling column recovery, ash rejection, and pyritic sulfur rejection. Feed solids rate was found to have only a small impact on column performance for this coal.

Response surface plots for the Upper Freeport coal are provided in Figures 14.29 - 14.31. As before, separate plots were constructed for Btu recovery, ash rejection, and pyritic sulfur rejection as functions of collector dosage, air holdup, and feed rate. The plots again suggest that the relationship between the column response and the various operating parameters is very complex.

Table 14.56
Net Effects Obtained for the Upper Freeport Seam Coal

Test Variable	Units	Low Value	High Value	Btu Recovery	Ash Rejection	Pyritic Rejection
Main	***	***	***	+84.97	+55.463	+40.09
Feed Rate	tph	1.0	4.0	-3.28	+2.22	+0.46
Air Holdup	%	18	24	+13.84	-12.62	-13.14
Collector	lb/ton	0.20	1.00	+6.22	-4.98	-6.72

The following Table 14.57 shows the results from the Box-Behnken test program that were utilized in the demonstration testing.

Table 14.57
Operating Conditions for Column for Upper Freeport

Plant Feed Rate (tph)	Column Feed Rate (tph)	Collector Dosage (lb/ton)	Air Holdup (%)
2.3	2.0	1.0	21

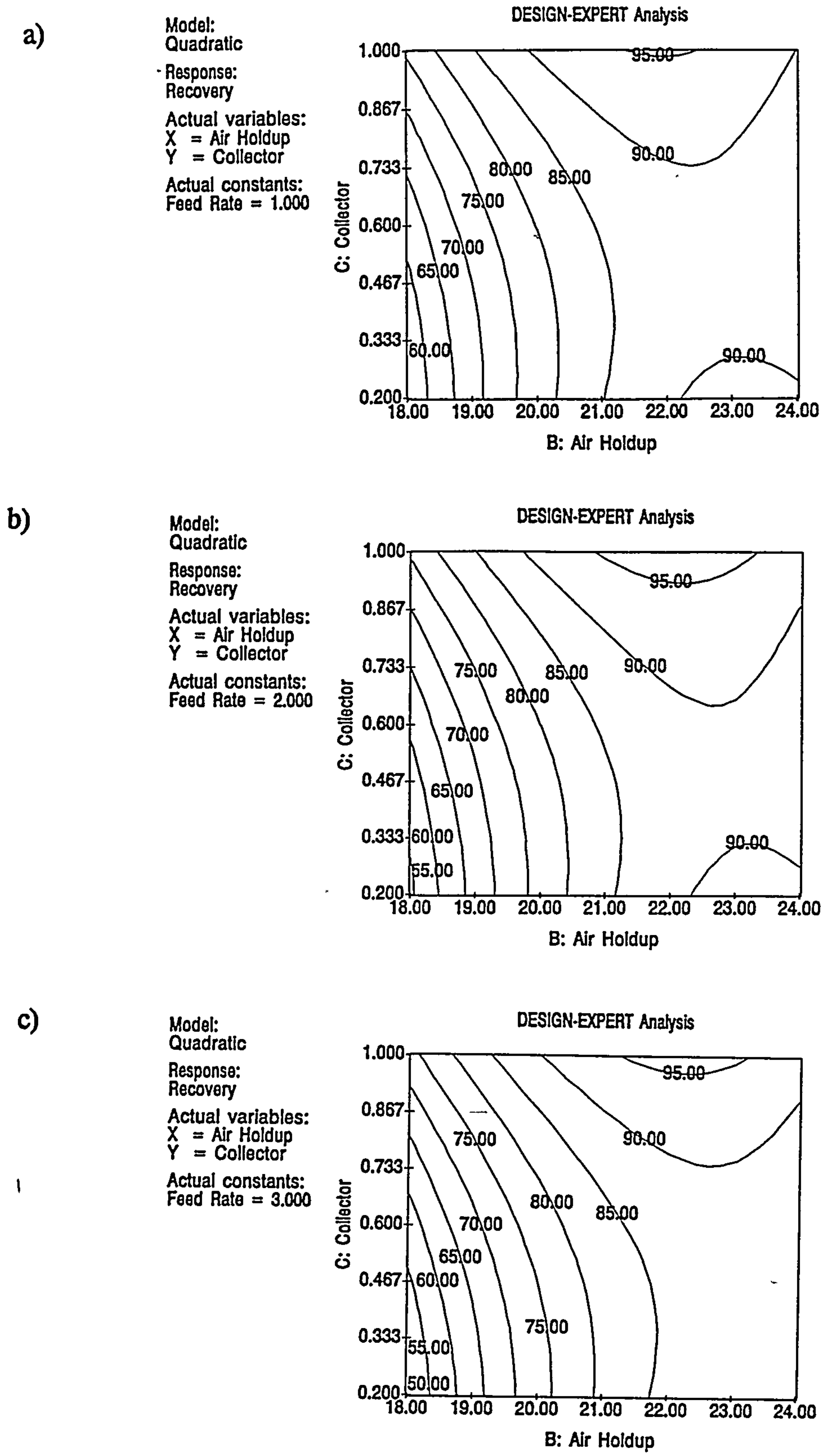


Figure 14.29

Effects of Collector Dosage and Air Holdup on Btu Recovery for the Upper Freeport Coal at Feed Rates of (a) 1.0, (b) 2.0, and (c) 3.0 tph

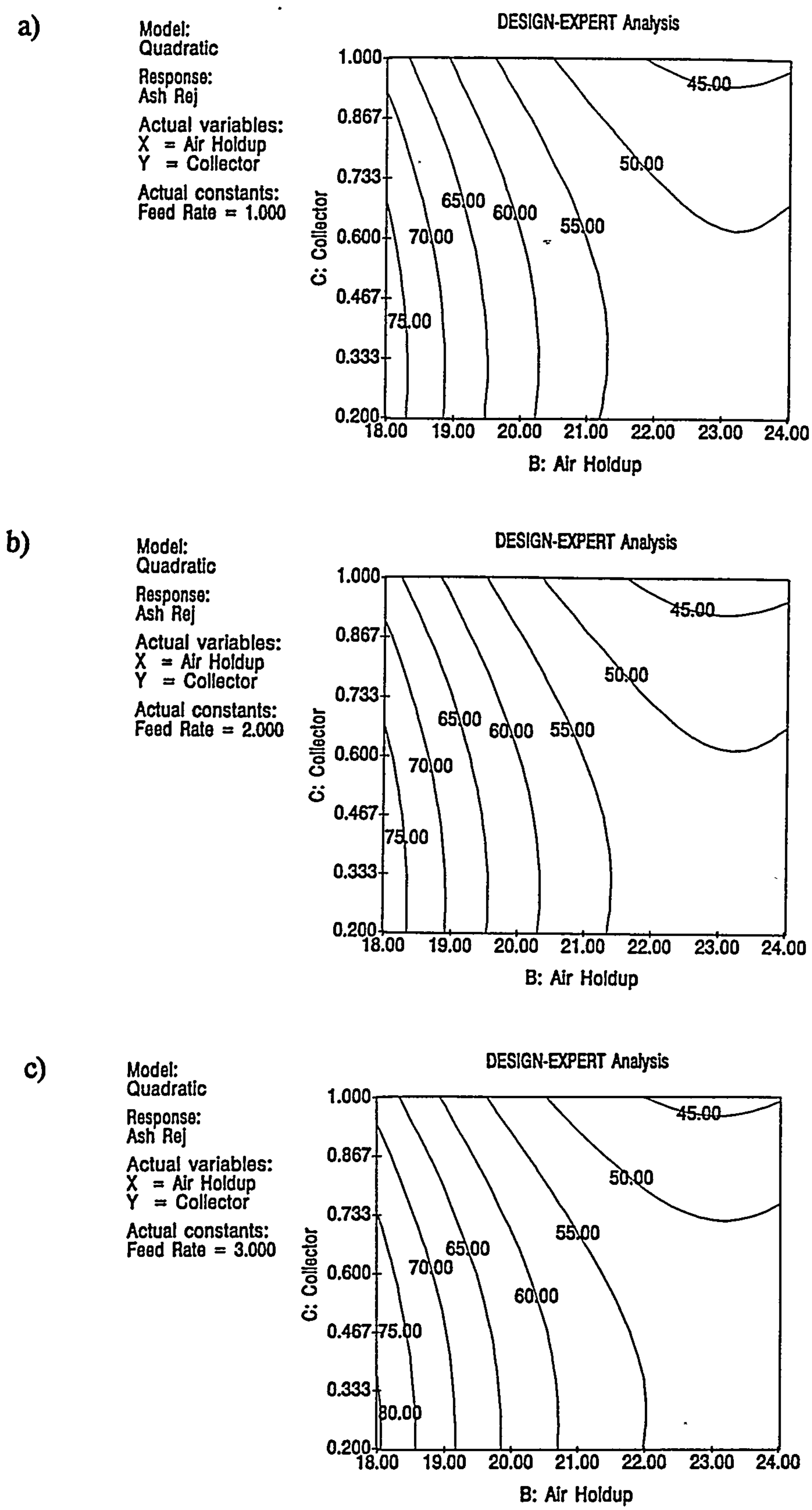


Figure 14.30

Effects of Collector Dosage and Air Holdup on Ash Rejection for the Upper Freeport Coal at Feed Rates of (a) 1.0, (b) 2.0, and (c) 3.0 tph

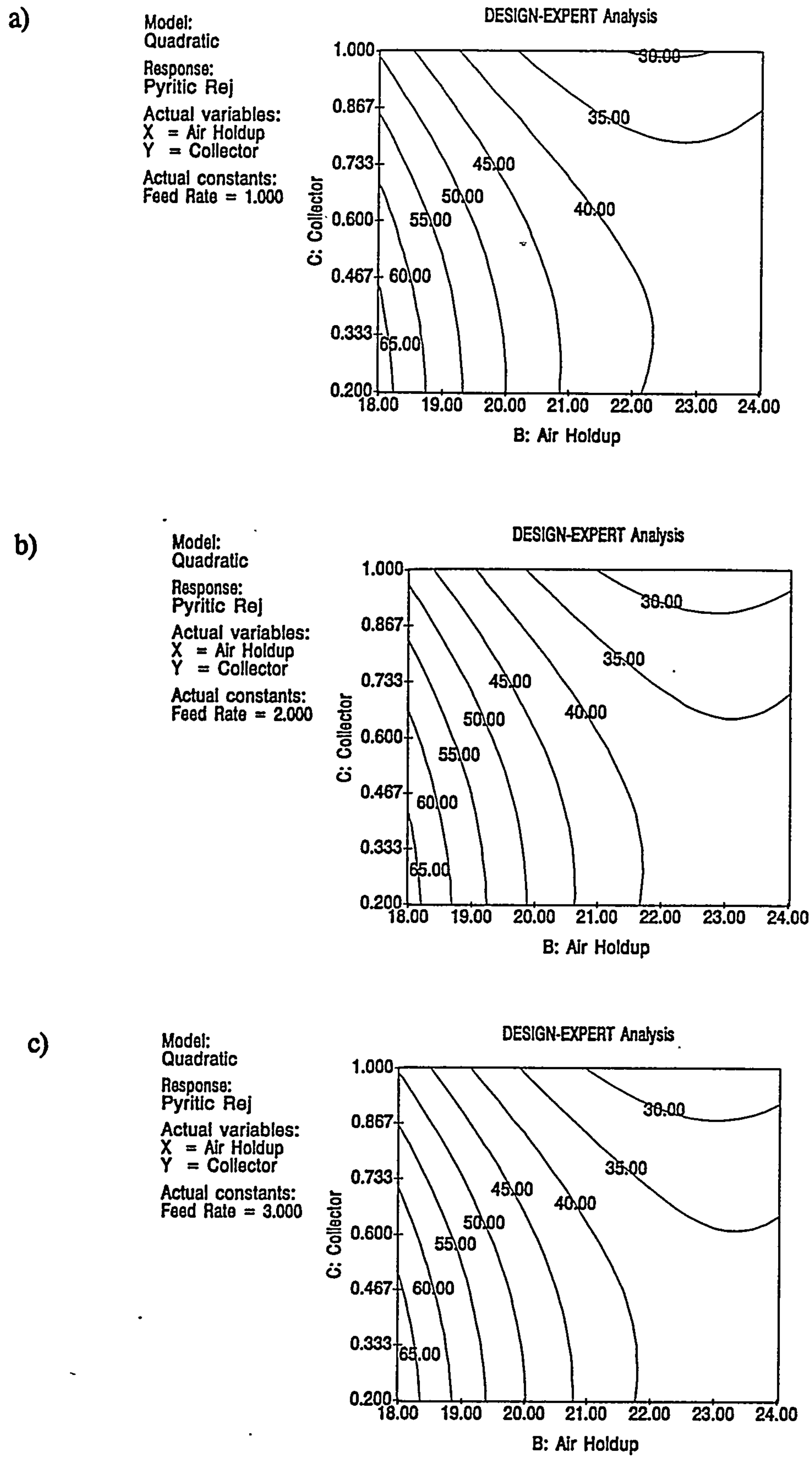


Figure 14.31

Effects of Collector Dosage and Air Holdup on Pyritic Sulfur Rejection for the Upper Freeport Coal at Feed Rates of (a) 1.0, (b) 2.0, and (c) 3.0 tph

ILLINOIS NO. 6 TESTING

Unit Operations

The Illinois No. 6 coal was supplied by Kerr-McGee Coal Corporation, Saline County, Illinois. This was not the same Illinois No. 6 utilized in Tasks 5 and 6. At the time of the procurement of the Illinois No. 6 coal, the mine where the Illinois No. 6 was obtained for Tasks 5 and 6 was experiencing a prolonged contract dispute. Therefore, the Kerr-McGee coal was selected as a substitute.

The testing procedure for Illinois No. 6 was the same procedure as the two previous coals. The precleaning equipment was first tested and then operated at selected conditions and then the advanced circuit unit operations were tested.

The precleaning unit operations were tested to establish the best operating conditions for each unit operation. The heavy-media cyclone, the water-only cyclone and the conventional flotation unit operations were tested. The procedure was altered because of experience gained during the testing of the previous two coals. The change was a result of not being able to produce adequate Btu recovery from conventional flotation. Therefore, the Illinois No. 6 conventional flotation was tested simultaneously with the water-only cyclone testing program in an attempt to limit the time required to set up the precleaning circuit.

Heavy-Media Cyclone

The heavy-media cyclone was tested at three (3) specific gravities from 1.70 - 1.80. Again, the determining factor was the lowest specific gravity that produced 97% Btu recovery. The results of the test program are shown in Tables 14.58 - 14.60 - HMC Test Results - Illinois No. 6. Although 97% Btu recovery was not obtained in any of the test work, the test results from 902 were selected to operate the HMC.

Water-only Cyclone/Conventional Flotation

The water-only cyclone and conventional flotation tests were combined in order to save time and expense of separate testing programs. It was anticipated that the conventional flotation would be eliminated from the precleaning circuit. However, testing was conducted to confirm this. Based on past experience only two tests were conducted. The water-only cyclone results are shown in Tables 14.61 - 14.62 - WOC Test Results - Illinois No. 6. The conventional flotation test results are shown in Tables 14.63 - 14.64 - Conventional Flotation Test Results - Illinois No. 6. The 202 test results and set up were selected for the WOC. The conventional flotation results indicated adequate Btu recovery. However, the amount of reagent necessary to obtain the results resulted in heavy concentrations of frother in the recirculation water. The operation problem and the economic expense made operation of the conventional flotation impractical. Although no measurement of flotation reagents in the recirculated water were obtained, visual problems -

Table 14.58

HEAVY-MEDIA CYCLONE TEST RESULTS - ILLINOIS NO. 6 AT 1.70
TEST RUN NUMBER: 93112901

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME DISCH.	MANUAL	26.49	10626	4.43
HMC CLEAN COAL	705	11.90	13020	3.74
HMC REFUSE	706	76.77	2268	8.02
HMC WT% RECOVERY			77.51	
HMC BTU RECOVERY			94.97	

Table 14.59

HEAVY-MEDIA CYCLONE TEST RESULTS - ILLINOIS NO. 6 AT 1.75
TEST RUN NUMBER: 93112902

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME DISCH.	MANUAL	23.70	11074	3.95
HMC CLEAN COAL	705	11.34	13006	3.59
HMC REFUSE	706	76.34	2315	7.71
HMC WT% RECOVERY			80.98	
HMC BTU RECOVERY			95.11	

Table 14.60
HEAVY-MEDIA CYCLONE TEST RESULTS - ILLINOIS NO. 6 AT 1.80
TEST RUN NUMBER: 93112903

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME DISCH.	MANUAL	28.31	10508	3.98
HMC CLEAN COAL	705	11.69	13003	3.46
HMC REFUSE	706	73.96	2762	7.32
HMC WT % RECOVERY			73.31	
HMC BTU RECOVERY			90.72	

Table 14.61

WATER-ONLY CYCLONE TEST RESULTS - ILLINOIS NO. 6
TEST RUN NUMBER: 93120201

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME U'FLOW	702	26.96	10490	3.49
WOC CLEAN COAL	708	22.13	11349	3.21
WOC REFUSE	717B	56.40	4915	12.01
WOC WT% RECOVERY			85.91	
WOC BTU RECOVERY			92.94	

Table 14.62

WATER-ONLY CYCLONE TEST RESULTS - ILLINOIS NO. 6
TEST RUN NUMBER: 93120202

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
DESLIME U'FLOW	702	21.15	11175	3.17
WOC CLEAN COAL	708	18.82	11844	3.01
WOC REFUSE	717B	52.43	5621	9.33
WOC WT % RECOVERY			93.07	
WOC BTU RECOVERY			98.64	

Table 14.63

CONVENTIONAL FLOTATION TEST RESULTS - ILLINOIS NO. 6
TEST RUN NUMBER: 93120201 - BANK A

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
FEED	712a	16.39	12093	3.41
ROUGHER CONC.	715A	15.03	12393	3.70
TAILINGS	714A	64.94	4705	3.08
FLOT. WT% RECOVERY			97.28	
FLOT. BTU RECOVERY			99.69	

BANK B

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
FEED	712A	34.68	9282	2.60
ROUGHER CONC.	715A	13.30	12711	2.88
TAILINGS	714A	79.07	2510	1.72
FLOT. WT% RECOVERY			67.49	
FLOT. BTU RECOVERY			92.4399.69	

Table 14.64

CONVENTIONAL FLOTATION TEST RESULTS - ILLINOIS NO. 6
TEST RUN NUMBER: 93120202 - BANK A

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
FEED	712A	14.61	12382	3.40
ROUCHER CONC.	715A	12.45	12754	3.42
TAILINGS	714A	71.84	3203	3.20
FLOT. WT% RECOVERY			96.36	
FLOT. BTU RECOVERY			99.26	

BANK B

SAMPLER NAME	SAMPLER NUMBER	ASH %	BTU	TOTAL SULFUR
FEED	712A	31.13	9993	2.44
ROUGHER CONC.	715A	8.79	13354	3.01
TAILINGS	714A	82.85	1781	1.47
FLOT. WT% RECOVERY			69.84	
FLOT. BTU RECOVERY			93.32	

such as the heavy-media circuit frothing - centrifugal pumps cavitating, and the inability to control reagent to the advanced column were clear indications of heavy frother concentration in the recirculated water. This was enough to discontinue conventional flotation.

Grinding

The data collected in the previous testing programs had determined that the mill circuit was limited by feed rate in producing a given grind size analysis. Therefore, no formal testing for this circuit was conducted. Data were collected during the Box-Behnken test series. These data are partially presented in Table 14.65 and shown graphically in Figures 14.32 and 14.33.

The data demonstrated the same characteristics as the previous two coals in that the higher the feed rate, the coarser the grind. This was true except for Test 93120313 which was somewhat suspect. The mill again needed to operate at a feed rate of 2.5 tph producing a 90% passing 88 microns. This was somewhat finer than the Upper Freeport. The quality of the mill circuit product was the feed to the advanced column, and this should have been the same quality as the water-only cyclone overflow which was the feed to the mill circuit. Table 14.66 shows the comparison of the quality of these two streams, and the comparison of means shows a statistical similarity between the two streams for all parameters measured.

Box-Behnken Test Matrix

The heavy-media cyclone and the water-only cyclone circuit were operated at their respective best operating conditions, and a Box-Behnken test matrix was conducted on the advanced column flotation unit operation.

Operational Data

The Box-Behnken test matrix for the Illinois No. 6 coal is given in Table 14.67. The same operating variables were examined in this series of tests as examined for the Upper Freeport coal, i.e,, feed solids rate, collector dosage and air holdup.

Table 14.65

Mill Circuit Test Results - Illinois No. 6

TEST NUMBER	93120301	93120302	93120306	93120307	93120308	93120311	93120312	93120313
MILL SPEED – RPM	27.7	27.7	27.7	27.7	27.7	27.7	27.7	27.7
MILL FD. RATE – TPH	2.54	2.26	1.59	3.07	3.42	4.06	1.31	4.43
SIZE FRACTION MICRONS	WT% PASSING	WT% PASSING	WT% PASSING	WT% PASSING	WT% PASSING	WT% PASSING	WT% PASSING	WT% PASSING
296.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
248.90	100.00	100.00	99.91	98.84	99.09	98.57	99.63	99.40
209.30	99.51	99.65	99.46	97.01	97.37	96.17	98.71	98.63
176.00	98.76	99.09	98.76	94.65	95.03	93.05	97.52	97.68
148.00	97.96	98.40	97.91	91.93	92.29	89.51	96.32	96.53
124.45	96.75	97.38	96.80	88.46	88.88	85.46	94.93	95.17
104.65	94.75	95.81	95.31	83.87	84.54	80.89	93.18	93.63
88.00	91.77	93.39	93.09	78.04	79.15	75.62	90.79	91.72
74.00	87.56	89.73	86.57	70.82	72.52	69.45	87.41	89.22
62.23	82.36	85.02	85.22	62.66	65.22	62.84	83.10	86.41
52.33	76.74	79.47	79.92	54.07	57.85	56.24	77.91	83.85
44.00	69.98	73.19	73.88	45.51	50.74	49.90	71.94	80.65
37.00	62.98	66.27	67.22	37.42	44.23	44.04	65.27	77.55
31.11	56.17	59.43	60.46	30.37	38.56	38.83	58.52	74.39
26.16	50.24	53.41	54.17	24.90	33.99	34.46	52.33	71.27
22.00	44.73	47.80	48.05	20.45	29.99	30.53	46.32	67.97
18.50	39.26	42.26	41.84	16.51	26.07	26.64	40.13	64.28
15.56	33.91	36.85	35.69	13.06	22.29	22.86	34.04	60.25
13.08	28.70	31.54	29.69	10.02	18.65	19.21	28.24	55.89
11.00	24.04	26.78	24.35	7.56	15.44	15.96	23.14	51.50
9.25	20.34	23.01	20.15	5.87	12.94	13.40	19.14	47.41
7.78	17.26	19.84	16.73	4.64	10.89	11.29	15.88	43.42
6.54	14.53	16.95	13.81	3.62	9.08	9.45	13.07	39.39
5.50	12.00	14.21	11.19	2.73	7.41	7.74	10.55	35.13
4.62	9.46	11.45	8.61	1.86	5.75	5.98	8.12	30.39
3.89	7.27	9.05	6.43	1.17	4.33	4.46	6.07	25.76
3.27	5.78	7.37	4.98	0.81	3.37	3.45	4.70	21.83
2.75	4.62	6.01	3.89	0.59	2.62	2.68	3.66	18.12
2.31	3.49	4.62	2.84	0.36	1.86	1.92	2.67	14.15
1.94	2.48	3.35	1.94	0.17	1.20	1.27	1.82	10.50
1.64	1.68	2.35	1.26	0.06	0.74	0.80	1.18	7.70
1.38	1.01	1.52	0.73	0.00	0.41	0.45	0.68	5.39
1.16	0.42	0.78	0.28	0.00	0.15	0.17	0.26	3.27
0.97	0.04	0.26	0.00	0.00	0.00	0.00	0.00	1.59
0.82	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.54
SUMMARY DATA								
dv	0.1462	0.1966	0.1477	0.2689	0.2109	0.1846	0.1858	0.1176
5%	2.92	2.42	3.28	8.22	4.24	4.16	3.43	1.34
50%	25.97	23.57	23.25	48.23	43.19	44.14	24.47	10.34
95%	106.67	97.99	101.71	180.34	175.67	195.53	125.49	121.95
mv	36.84	33.79	34.49	63.03	58.01	62.68	38.26	28.32
ma	11.59	10.14	11.89	27.03	17.07	16.87	12.41	5.04
cs	0.5180	0.5920	0.5050	0.2220	0.3520	0.3560	0.4840	1.1890
sd	29.18	27.01	26.09	43.54	45.68	53.25	28.25	25.61

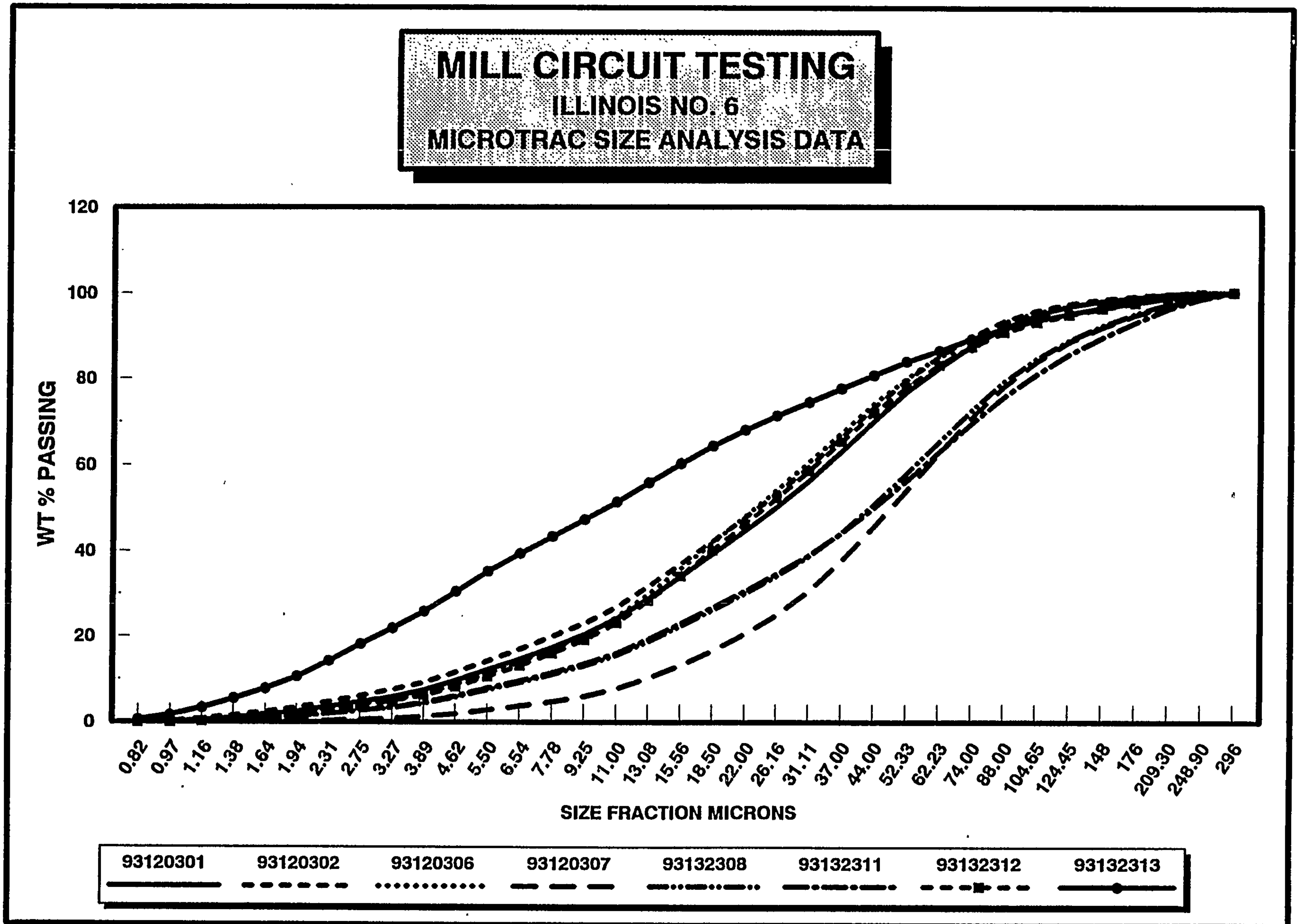


Figure 14.32
Mill Circuit Testing Wt % Passing vs. Size Fractions

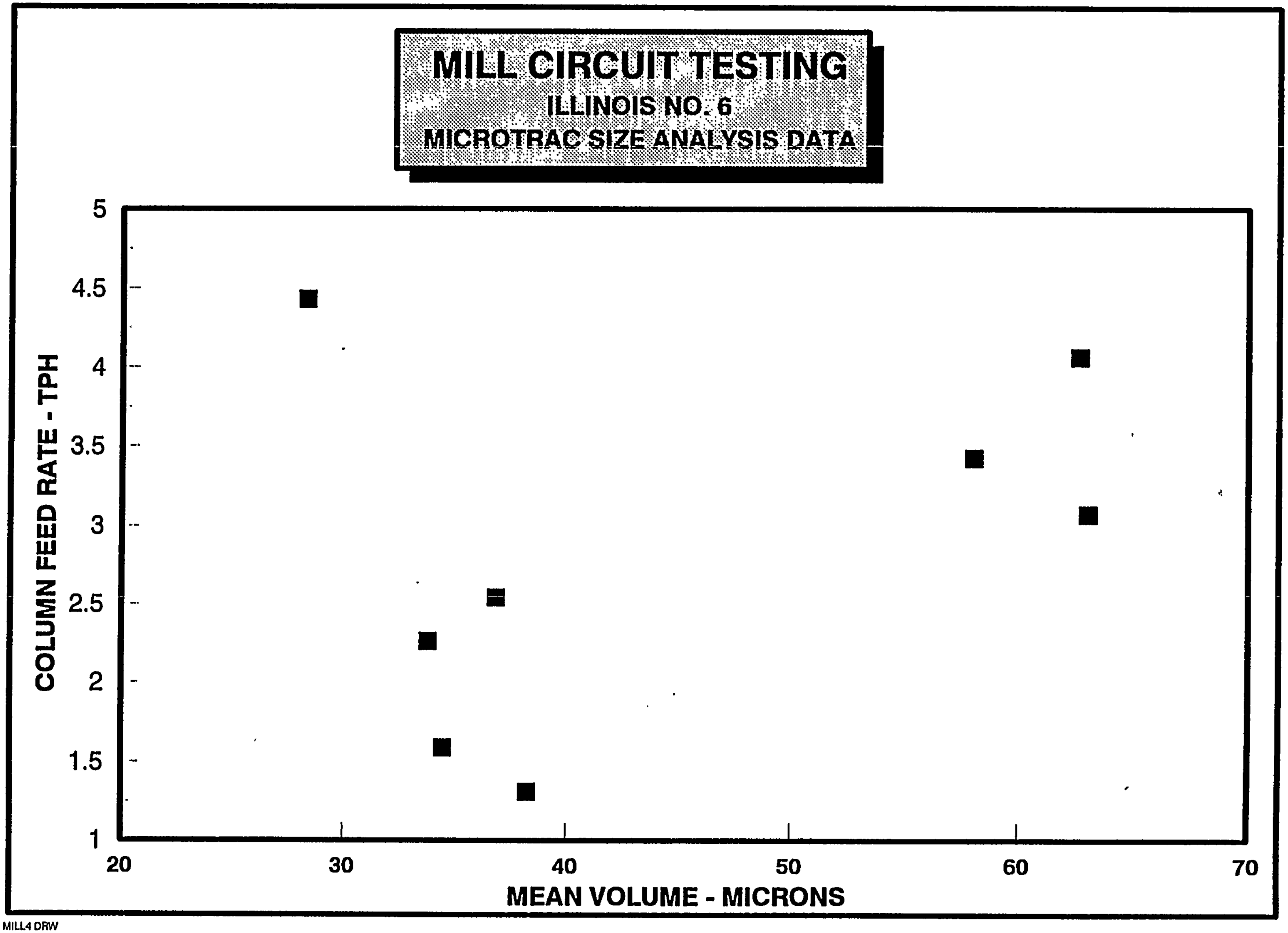


Figure 14.33
Mill Circuit Testing Column Feed Rate vs. Mean Volume

Table 14.66

Statistical Analysis of WOC Quality and Column Feed Quality - Illinois No. 6

	WOC	COLUMN	WOC	COLUMN	WOC	COLUMN	WOC	COLUMN
Obs #	% Ash	$ Ash	% Tot S	% Tot S	% Pyr	% Pyr	Btu/lb	Btu/lb
93120301	19.63	20.23	3.14	2.89	1.35	1.15	11442	11500
93120302	20.19	21.27	2.95	2.97	1.29	1.02	11457	11317
93120303	18.28	22.61	3.06	2.86	1.34	1.35	11845	11226
93120304	21.93	23.46	3.12	3.35	1.34	1.67	11286	11130
93120305	13.66	21.92	3.23	2.83	1.24	1.13	12494	11306
93230306	20.43	21.30	2.97	2.90	1.17	1.10	111493	11378
93120307	22.45	22.25	3.14	3.17	1.33	1.33	11209	11171
93120308	18.42	19.05	3.09	3.17	1.21	1.32	12007	11740
93120309	20.33	22.81	2.89	2.86	1.11	1.16	11316	11090
93120310	22.75	22.42	2.96	2.79	1.21	1.02	11189	11234
93120311	20.38	19.66	3.08	3.06	1.18	1.18	11488	11703
93120312	20.98	21.09	2.94	2.89	1.16	1.16	11418	11445
Maximum	22.75	23.46	3.23	3.35	1.35	1.67	12494	11740
Minimum	13.66	19.05	2.89	2.79	1.11	1.02	11189	11090
		1.25						
Average	19.0.08	21.51	3.05	2.98	1.25	1.22	11554	11353
Std. Dev.	2.32	1.28	0.10	0.16	0.08	0.17	365	202
No. of Obs	12	12	12	12	12	12	12	12
Calculated Z	-2.0323		1.2459		0.5647		1.6623	

Table 14.67
Experimental Conditions Examined for the Illinois No. 6 Seam Coal

Run Number	Feed Rate (tph)	Collector Dosage (lb/ton)	Air Holdup (%)
1	2.00	1.50	24
2	2.00	1.00	21
3	2.00	0.50	18
4	2.00	1.50	24
5	2.00	0.50	18
6	1.00	1.00	24
7	3.00	1.00	24
8	3.00	1.50	21
9	2.00	1.00	21
10	2.00	0.50	24
11	3.00	1.00	18
12	1.00	0.50	21
13	3.00	0.50	21
14	2.00	1.50	18
15	2.00	1.00	21
16	1.00	1.50	21
17	1.00	1.00	18
18	2.00	1.50	18
19	2.00	0.50	24

Analytical Data

Btu recoveries as a function of ash rejection, pyritic sulfur rejection and total sulfur rejection for the column circuit are plotted in Figure 14.34. The results again fall along unique grade-recovery curves. The maximum separation efficiency was observed to fall at a Btu recovery of approximately 90-95%. The corresponding ash and pyritic sulfur rejections were approximately 75% and 35%, respectively. These results could be obtained under several different combinations of operating conditions. This again suggested that other factors such as column capacity, maintenance considerations, etc., should have been considered in the selection of the preferred operating point for the advanced flotation column circuit.

Conclusions

Table 14.68 provides the results of the net effect calculations for the Illinois No. 6 tests. Btu recovery was again found to decrease with feed rate, and increase with frother dosage and collector dosage. However, all of the operating parameters were found to have a negative impact on the rejection of ash and pyritic sulfur. Air holdup was found to be the primary factor controlling column recovery and pyritic sulfur rejection. While this variable was also found to have a large influence on ash rejection, collector dosage was found to have a slightly larger influence. These unexpected trends may be related to variations in the population of middlings

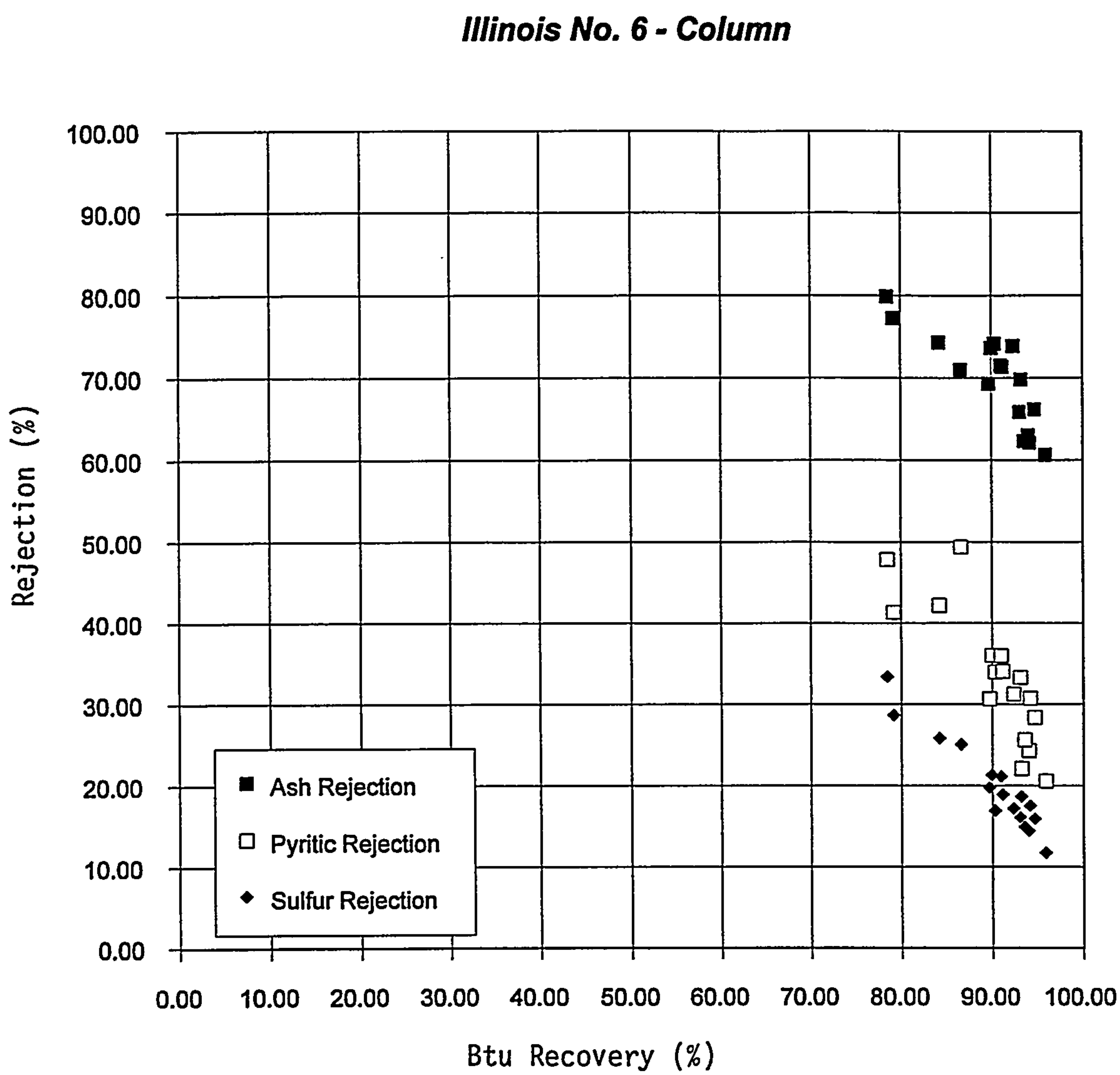


Figure 14.34

Column Circuit Results for the Testing of the Illinois No. 6 Seam Coal particles for each coal brought on by difference in their liberation characteristics.

Table 14.68
Net Effects Obtained for the Illinois No. 6 Seam Coal

Test Variable	Units	Low Value	High Value	Btu Recovery	Ash Rejection	Pyritic Rejection
Main	***	***	***	+91.33	+74.04	+32.62
Feed Rate	tph	1.0	3.0	-0.30	-0.14	-2.67
Air Holdup	%	18	24	+3.91	-2.68	-7.29
Collector	lb/ton	0.50	1.50	+3.32	-4.02	-3.90

Response surface plots for the Illinois No. 6 seam are provided in Figures 14.35 - 14.37. The plots again indicate that the relationship between column response and operating parameters is difficult to predict from simple cause-effect analyses.

The following Table 14.69 shows the results from the Box-Behnken test program that were utilized in the demonstration testing.

Table 14.69
Operating Conditions for Column for Illinois No. 6

Plant Feed Rate (TpH)	Column Feed Rate (TpH)	Collector Dosage (lb/ton)	Air Holdup (%)
2.6	2.0	1.0	21

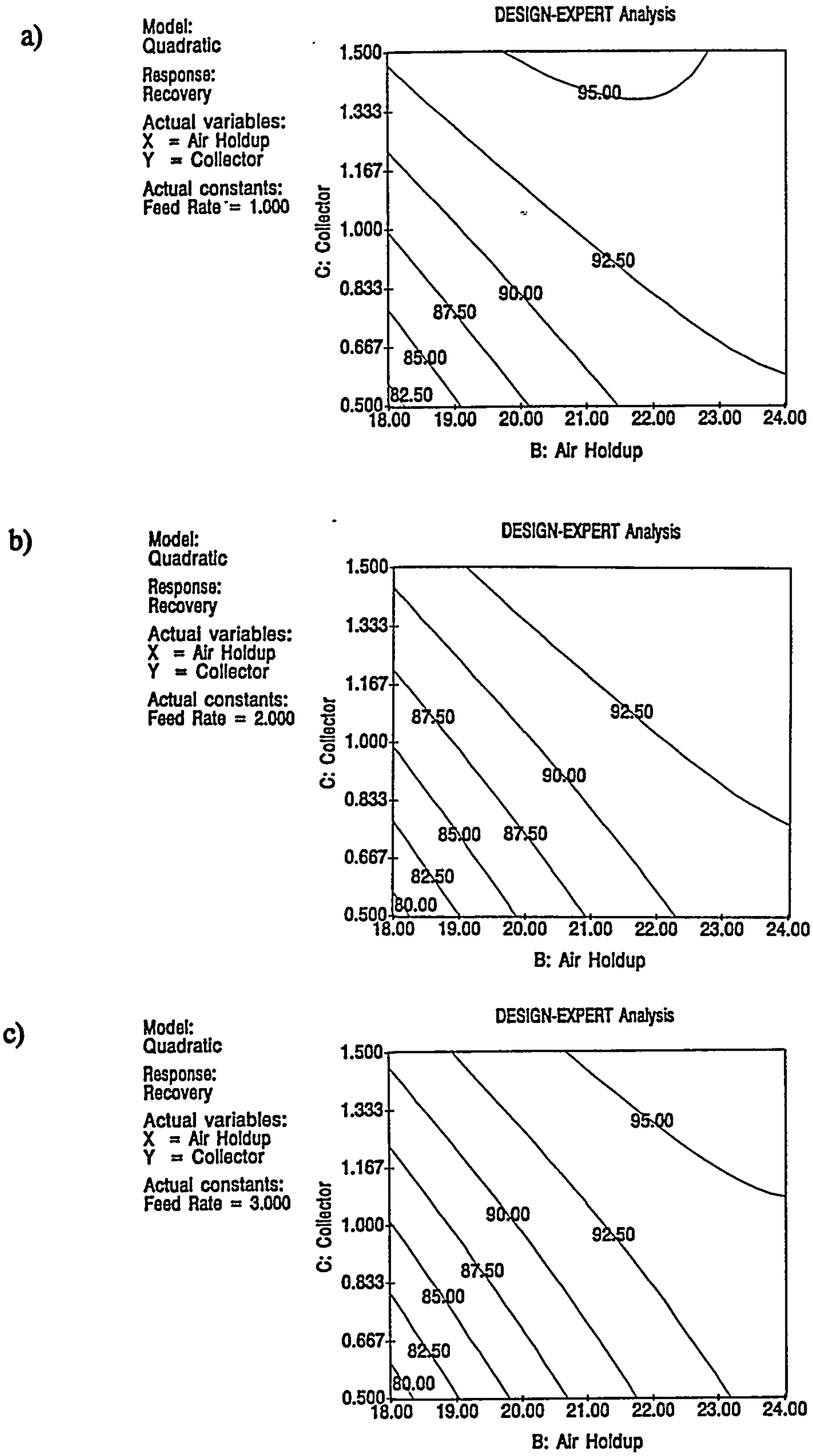


Figure 14.35

Effects of Collector Dosage and Air Holdup on Btu Recovery
For the Illinois No. 6 Coal at Feed Rates of (a) 1.0, (b) 2.0, and (c) 3.0 tph

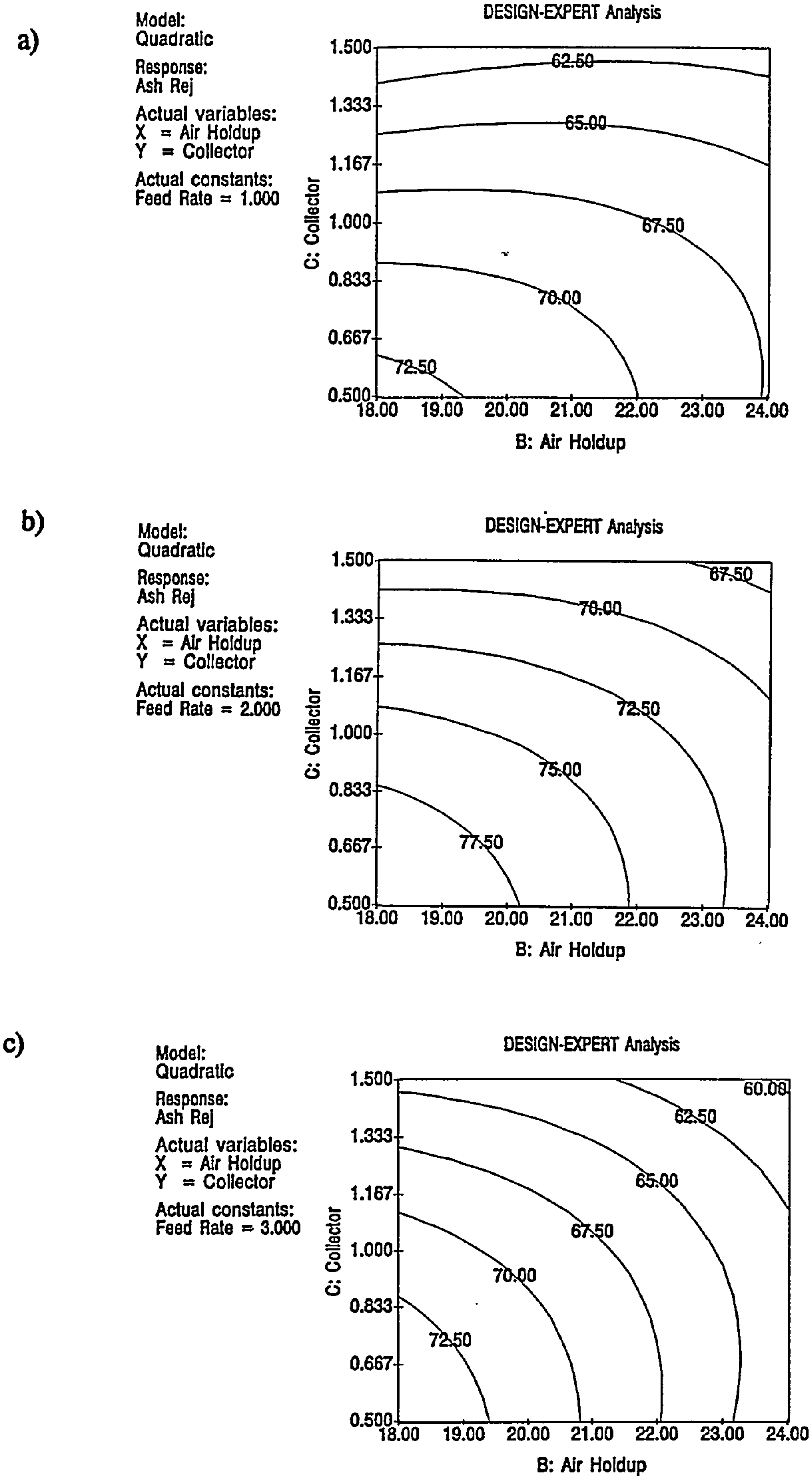


Figure 14.36

Effects of Collector Dosage and Air Holdup on Ash Rejection for the Illinois No. 6 Coal at Feed Rates of (a) 1.0, (b) 2.0, and (C) 3.0 tph

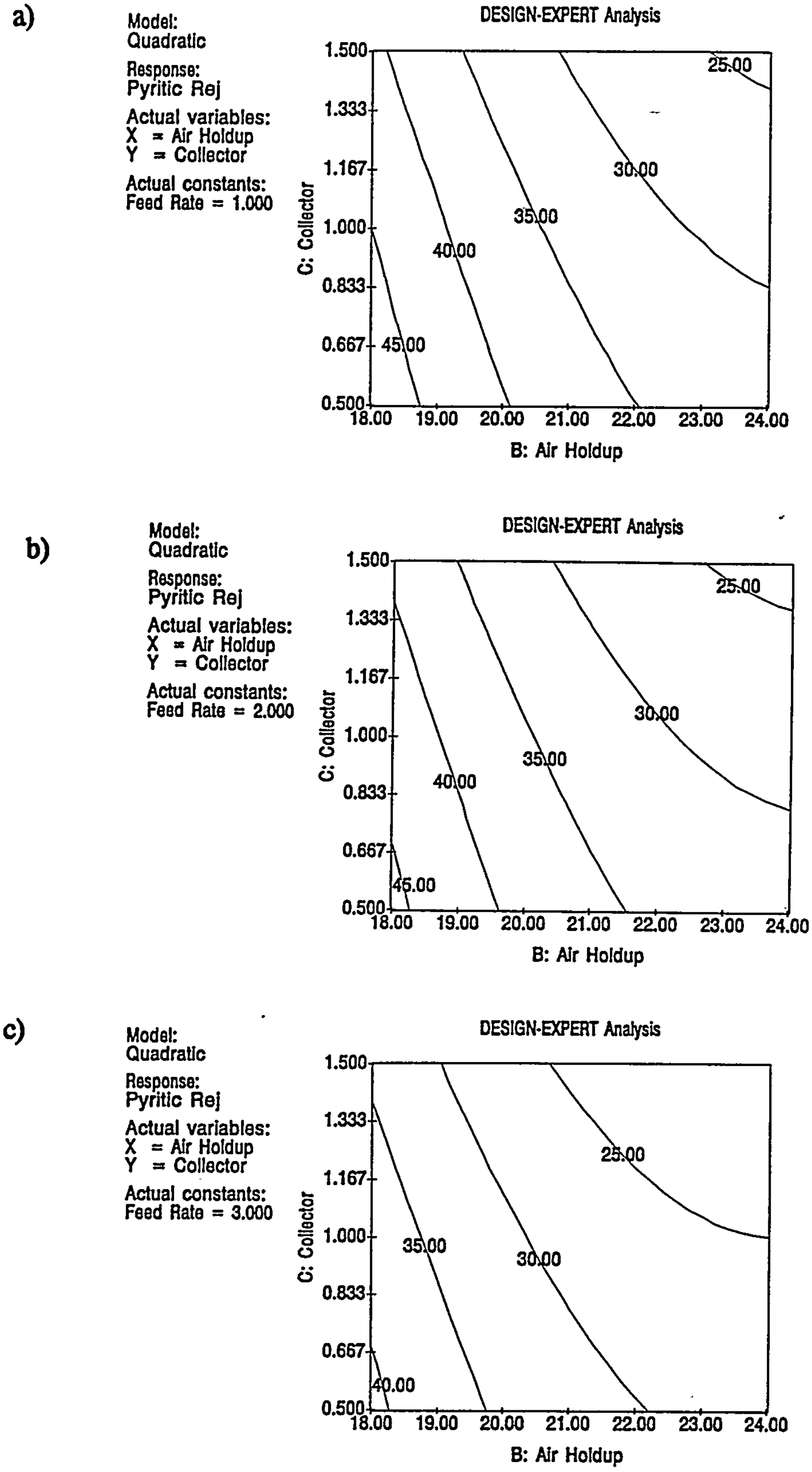


Figure 14.37

Effects of Collector Dosage and Air Holdup on Pyritic Sulfur Rejection for the Illinois No. 6 Coal at Feed Rates of (a) 1.0, (b) 2.0, and (c) 3.0 tph

15.0 TASK 15 FINAL SEMI-WORKS CONCEPTUAL DESIGN

15.1 Overview and Scope

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

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

15.2 Review of Work Completed This Quarter

During this quarter, work was initiated on the Task 15 Final Report. Based on the information from Task 13, a revised 20 TPH Semi-works flowsheet for each coal seam was calculated. In addition, a material balance for each coal seam was also produced. The flowsheets and material balances are shown in Figures 15.1 - 15.6.

Once the flowsheets were completed, a mechanical layout of the plant could proceed. This mechanical layout is the first step in a complete engineering design of the 20 TPH Semi-Works preparation plant.

During this quarter, the following engineering was completed on this project by the end of the quarter. The results are shown in Table 15.1.

Table 15.1
Engineering Table

DISCIPLINE	# OF DWGS.	% COMPLETE	PREDICTED FINISH
20 - Foundations	4	70.0	July 6
30 - Structural	6	96.3	July 6
40 - Architectural	6	99.3	July 6
50 - Mechanical	6	100.0	Completed
55 - HVAC	3	96.0	July 15
60 - Piping	12	71.7	July 15
70 - Electrical	15	84.7	July 15
TOTAL PROJECT	52	86.0	July 15

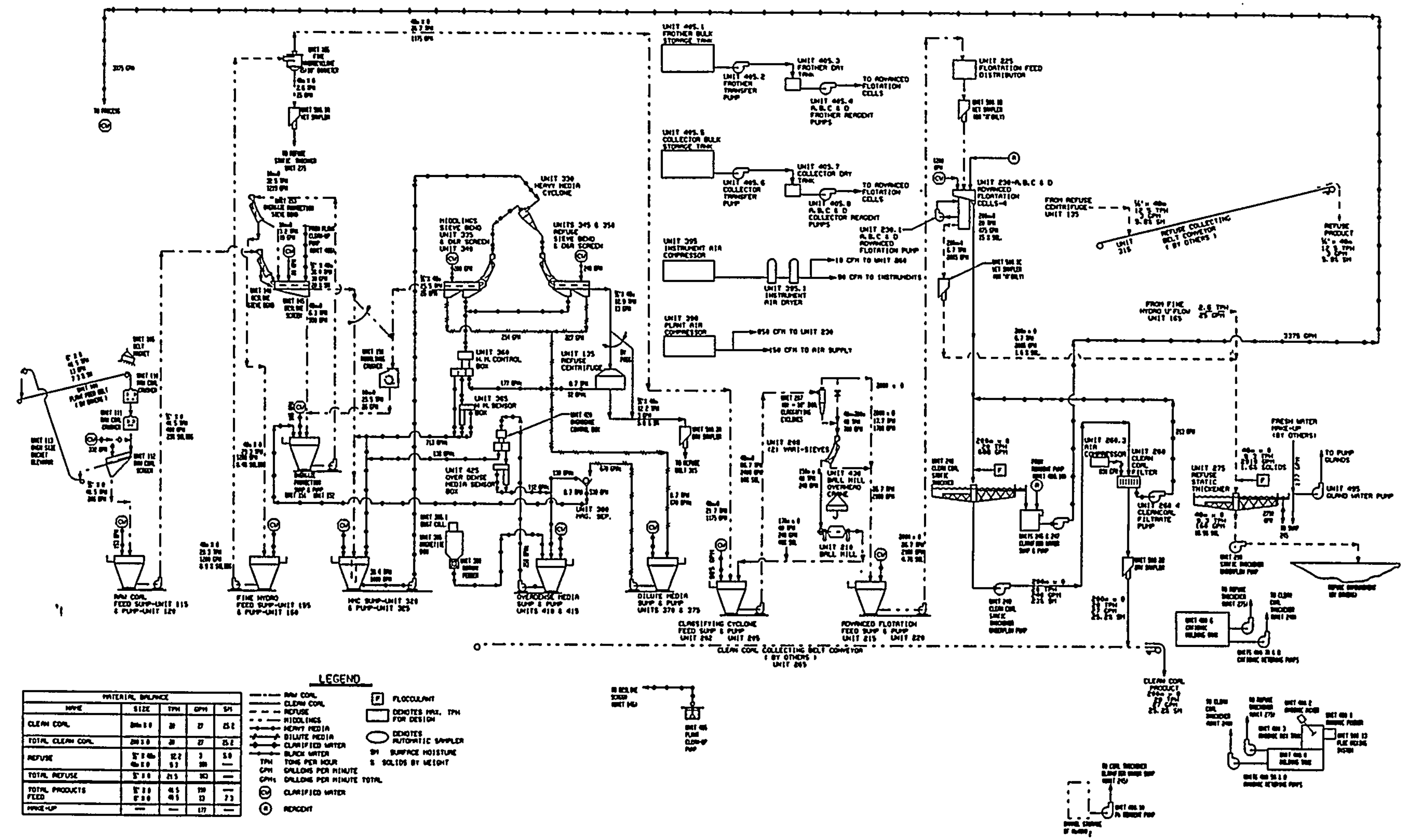


Figure 15.1

ICF KAISER
UNITED STATES DEPARTMENT OF ENERGY
ADVANCED FROTH FLOATATION
PROCESS FLOW DIAGRAM
PITTSBURGH No. 8

JOB NO 88107-240 DWG NO 10-50-0101

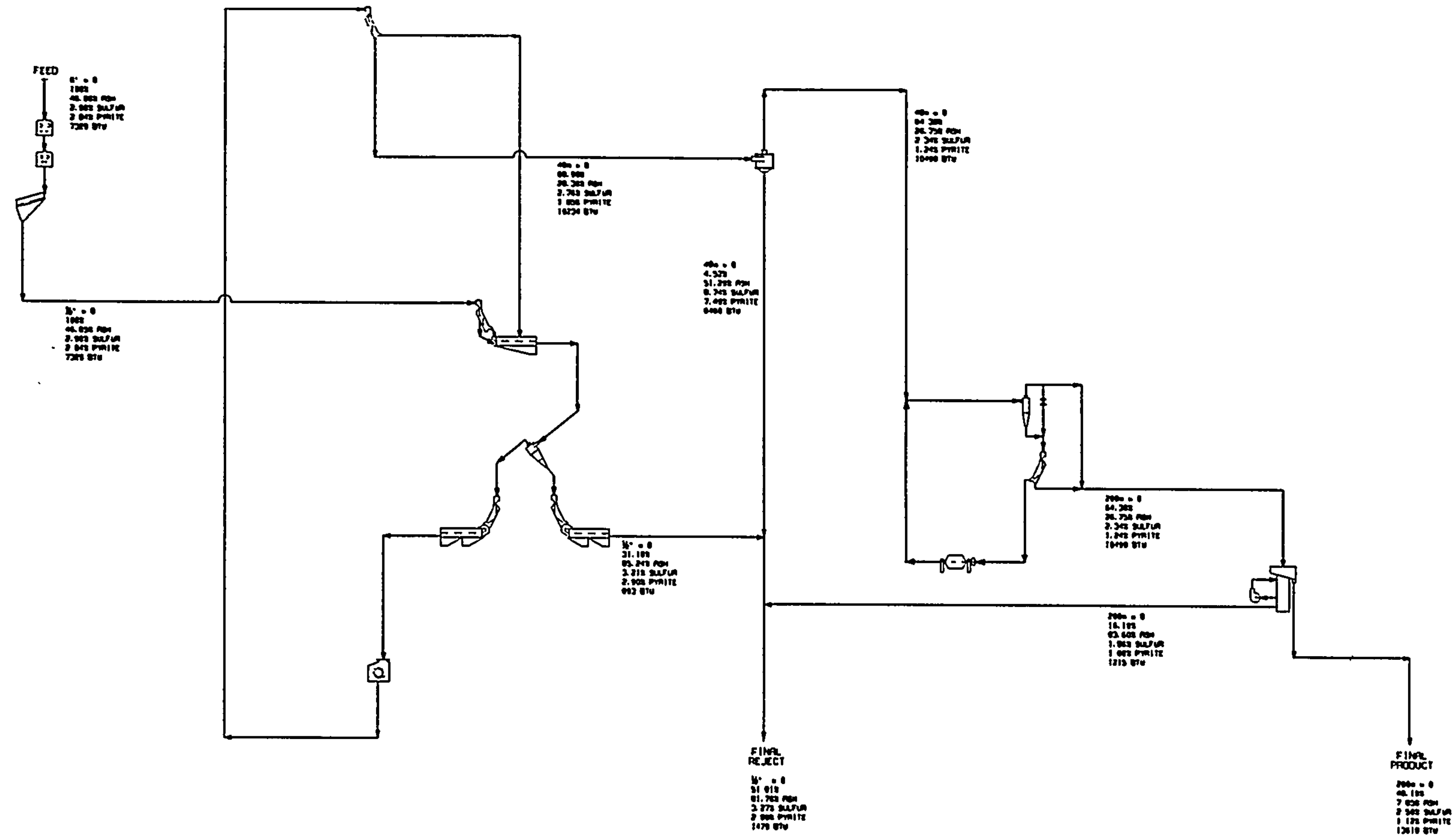


Figure 15.2

ICF KAISER

UNITED STATES DEPARTMENT OF ENERGY
ADVANCED FROTH FLOATATION
MATERIAL BALANCE
PITTSBURGH No. 8

JOB NO. 88107-240 | DWG. NO. 10-50-0201 | R-

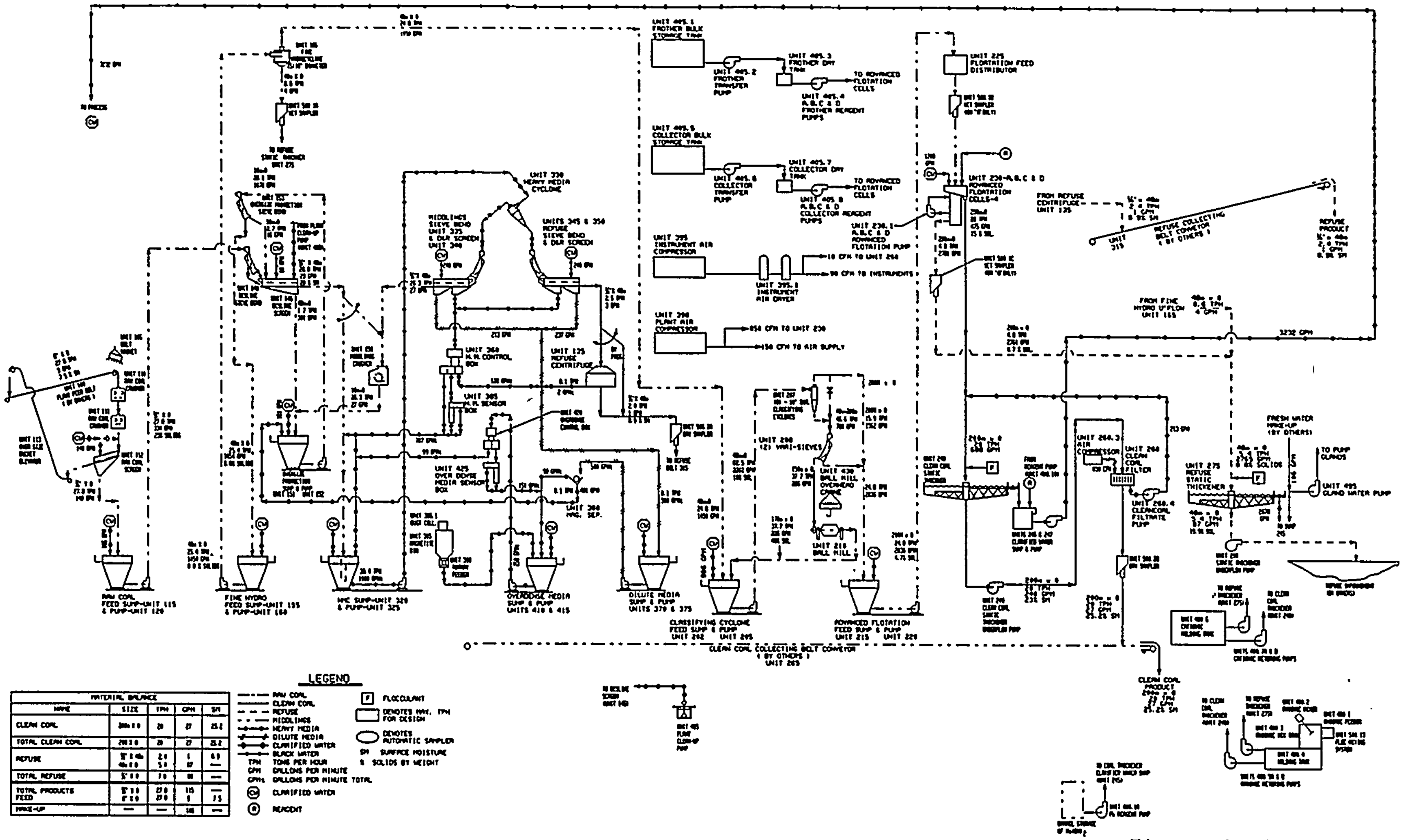


Figure 15.3

ICF KAISER

UNITED STATES DEPARTMENT OF ENERGY
ADVANCED FROTH FLOTATION
PROCESS FLOW DIAGRAM
UPPER FREEPORT

JOB NO. 88107-240 DWG. NO. 10500102 R-

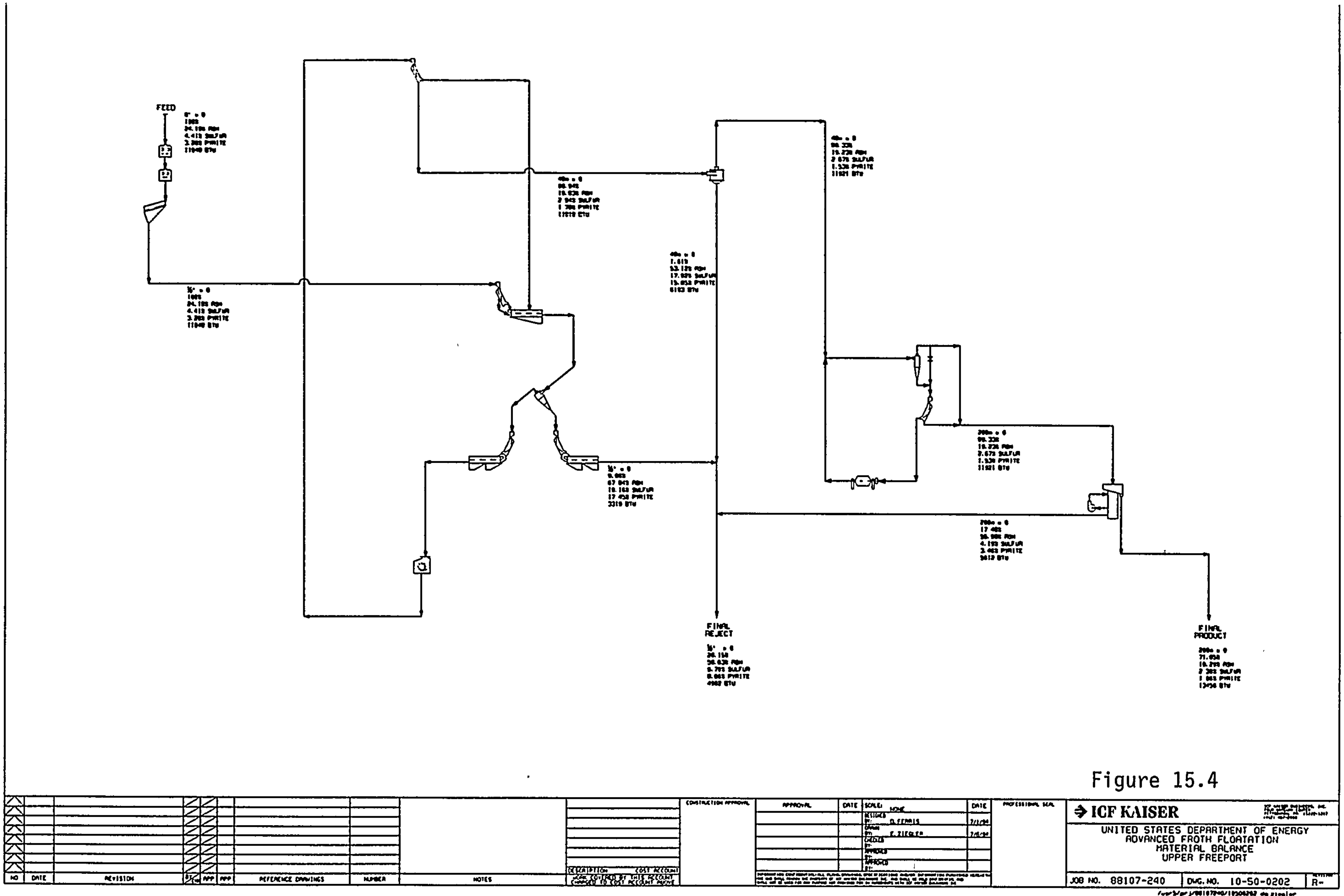

FEED
FINAL REJECT
FINAL PRODUCT
ICF KAISER
UNITED STATES DEPARTMENT OF ENERGY
ADVANCED FROTH FLOATATION
MATERIAL BALANCE
UPPER FREEPORT
JOB NO. 88107-240
DWG. NO. 10-50-0202
R-
NO
DATE
REVISION
APP
REFERENCE DRAWINGS
NUMBER
NOTES
DESCRIPTION
COST ACCOUNT
CONSTRUCTION APPROVAL
APPROVAL
DATE
SCALE: NONE
PROFESSIONAL SEAL

Figure 15.4

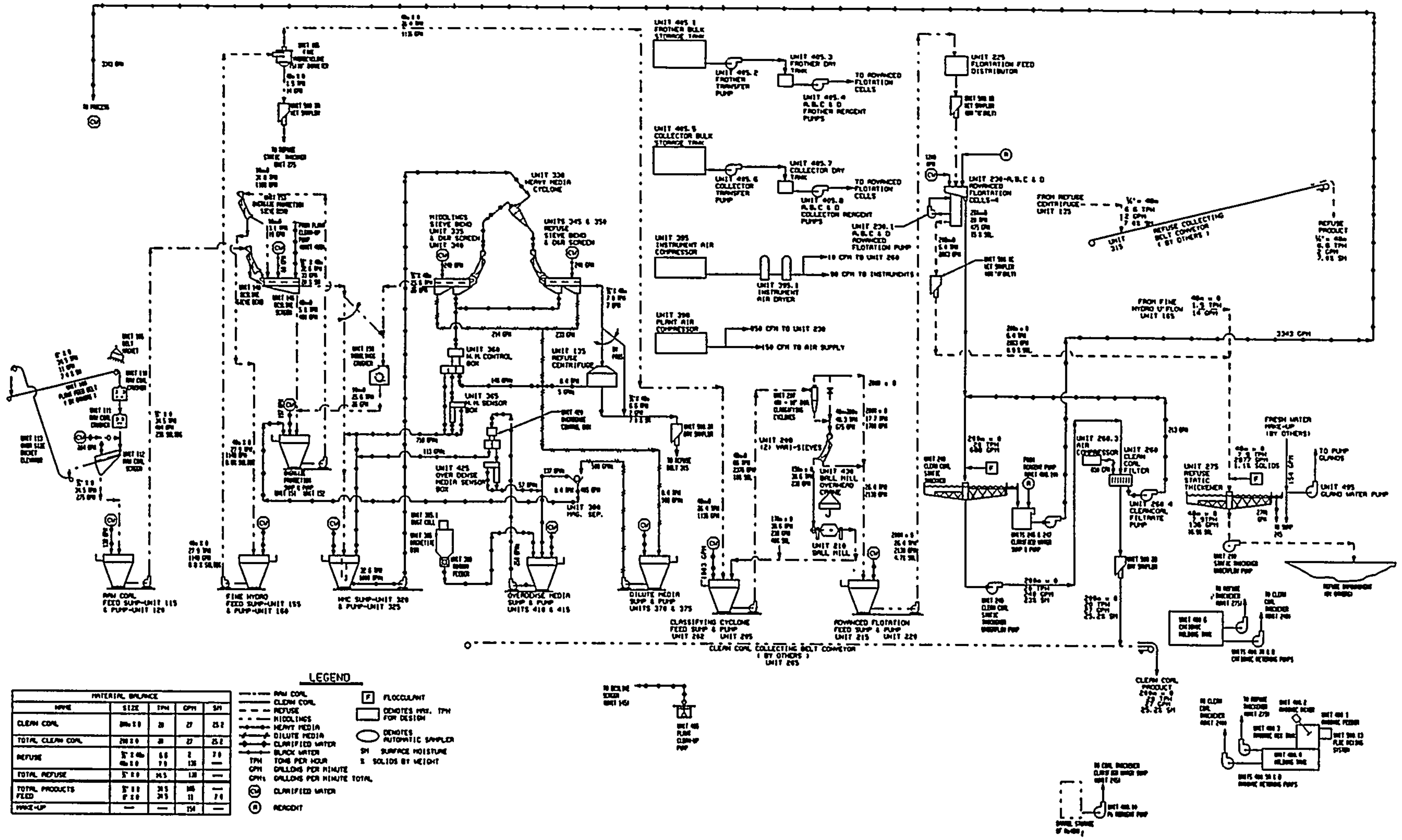


Figure 15.5

ICF KAISER

UNITED STATES DEPARTMENT OF ENERGY
ADVANCED FROTH FLOTATION
PROCESS FLOW DIAGRAM
ILLINOIS No. 6

JOB NO. 88107-240 | DWG. NO. 10-50-0103 | R-

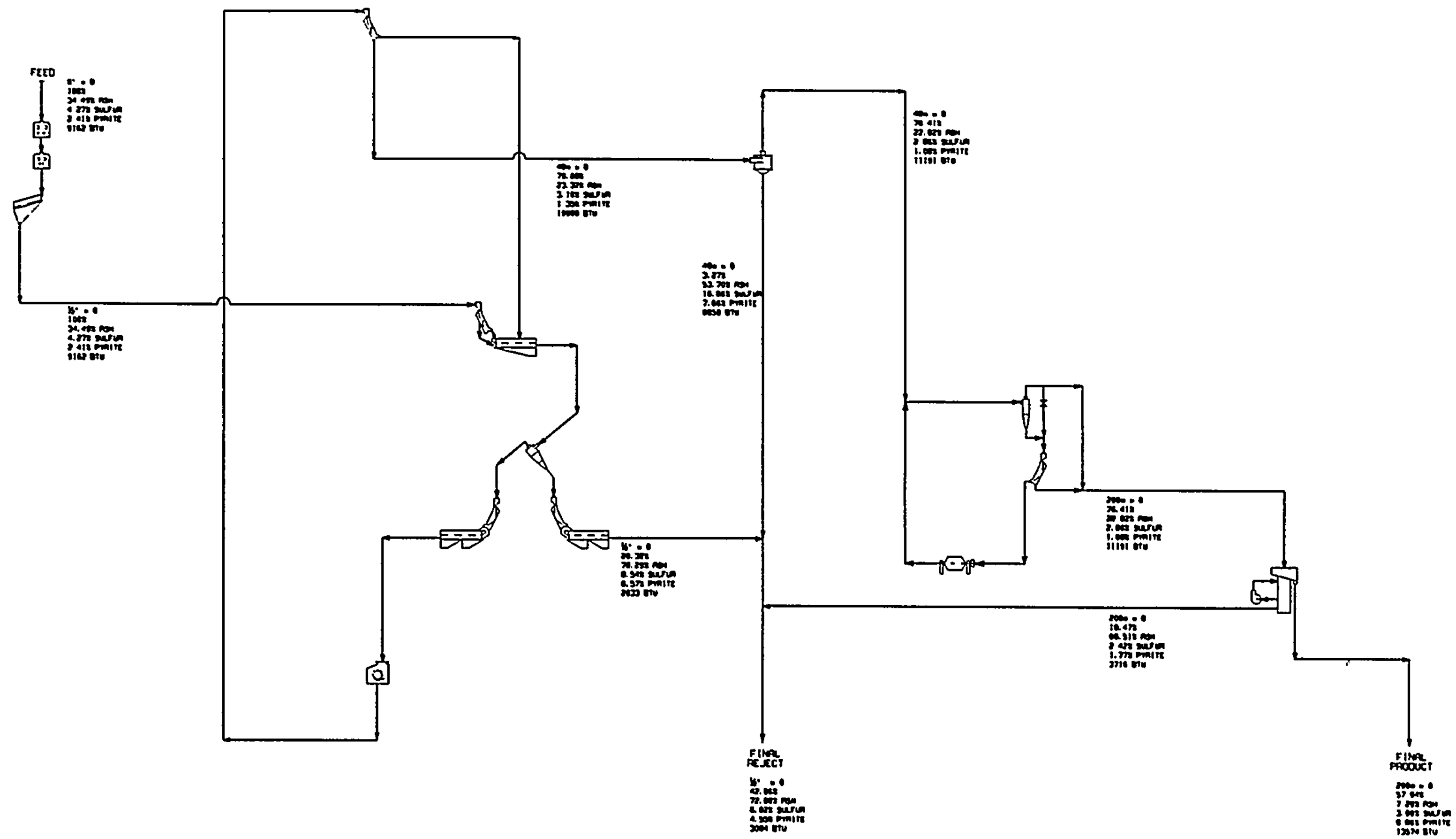


Figure 15.6

ICF KAISER

UNITED STATES DEPARTMENT OF ENERGY
ADVANCED FROTH FLOATATION
MATERIAL BALANCE
ILLINOIS No. 6

JOB NO. 88107-240 DWG. NO. 10-50-0203 R-

16.0 TASK 16 POC MODULE REMOVAL

16.1 Overview and Scope

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

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

16.2 Review of Work Completed This Quarter

During this quarter, work was conducted to convert the DOE POC flowscheme back to the OCTAD flowscheme. Piping was rerouted, screen decking was changed, instruments reinstalled, and plant interlocking was completed. The plant modifications were completed, and the facility was operated under the DOE contract to process excess Illinois No. 6 and Pittsburgh No. 8 raw coal. The excess inventory was processed by the end of May and the DOE POC equipment was properly stored.

The negotiations between DOE, OCDO, AEP, and ICF Kaiser continued regarding the possibility of retaining the DOE equipment at the OCTAD facility.

APPENDIX A

TRACE ELEMENT ANALYSIS

PITTSBURGH NO. 8

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS PLANT FEED* — #701

SAMPLE NUMBER CWK-299 Pitts. #8 Seam

DATE LOGGED 10/07/93
DATE COMPLETED 11/12/93
PROJECT NUMBER 1621-013-013
ANALYTICAL NUMBER 936668

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	45.61
VOLATILE MATTER	25.79
FIXED CARBON	28.60
SULFUR, TOTAL	3.03
BTU	7550
MAF BTU	13881

ULTIMATE	(Dry)%
CHLORINE	0.072
SULFUR	3.03
ASH	45.61

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	56.81
Al_2O_3	22.06
TiO_2	0.87
Fe_2O_3	8.96
CaO	3.95
MgO	1.38
Na_2O	0.51
K_2O	2.94
P_2O_5	0.29
SO_3	1.34
UND	0.89

SULFUR FORMS	(Dry)%
PYRITIC	2.40
SULFATE	0.11
ORGANIC	0.52
SULFUR, TOTAL	3.03

OTHERS	As determined
HG	0.15 ppm

AS DETERMINED MOISTURE: 1.94 %

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cc: CWK
GEW

Trace Element Report

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4000 Brownsville Road
Library, PA 15129

12/14/93

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Project No. : 1621- 13- 13

Description : DOE/ICF KE 24 HR CONT. TESTS PLANT FEED – #701 Pitts. #8 Seam

Anal. No. : 936668

	VAL1	VAL2	Average
As	30.8	31.5	31.2
Ba	182	179	181
Be	2.41	2.69	2.55
Cd	0.38	0.40	0.39
Co	10.8	11.6	11.2
Cr	53.2	56.8	55.0
Cu	29.7	30.1	29.9
F	488	483	486
Hg	0.10	0.10	0.10
Li	42.3	48.3	45.3
Mn	143	154	149
Mo	3.28	3.45	3.37
Ni	42.1	41.4	41.8
Pb	19.1	18.9	19.0
Sb	1.87	1.86	1.87
Se	2.94	3.23	3.09
Sn	2.24	2.19	2.22
Th	7.72	7.56	7.64
Tl	1.84	2.03	1.94
U	2.63	2.60	2.62
V	69.5	76.3	72.9
Zn	58.6	51.1	54.9

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS PLANT CLEAN COAL* – #727

SAMPLE NUMBER CWK-300 Pitts. #8 Seam

DATE LOGGED 10/07/93
DATE COMPLETED 11/12/93
PROJECT NUMBER 1621-013-013
ANALYTICAL NUMBER 936669

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	7.74
VOLATILE MATTER	38.68
FIXED CARBON	53.58
SULFUR, TOTAL	2.51
BTU	13732
MAF BTU	14884

SULFUR FORMS	(Dry)%
PYRITIC	1.26
SULFATE	0.06
ORGANIC	1.19
SULFUR, TOTAL	2.51

OTHERS	As Determined
HG	0.10 ppm

ULTIMATE	(Dry)%
CHLORINE	0.126
SULFUR	2.51
ASH	7.74

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	44.81
Al_2O_3	21.41
TiO_2	1.21
Fe_2O_3	23.23
CaO	1.91
MgO	0.97
Na_2O	0.89
K_2O	2.02
P_2O_5	0.21
SO_3	2.09
UND	1.25

AS DETERMINED MOISTURE: 2.01 %

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Anal. No. : 936669

	VAL1	VAL2	Average
As	9.53	9.71	9.62
Ba	24.8	25.5	25.2
Be	1.44	1.47	1.46
Cd	0.12	0.13	0.13
Co	3.85	3.91	3.88
Cr	16.9	17.1	17.0
Cu	7.96	8.07	8.02
F	84.6	78.5	81.6
Hg	0.12	0.10	0.11
Li	10.2	10.5	10.4
Mn	18.9	19.6	19.3
Mo	2.13	2.25	2.19
Ni	12.0	12.4	12.2
Pb	5.02	5.09	5.06
Sb	1.08	1.12	1.10
Se	1.80	1.68	1.74
Sn	1.01	0.91	0.96
Th	1.71	1.78	1.75
Tl	0.47	0.47	0.47
U	0.97	0.99	0.98
V	24.3	25.2	24.8
Zn	14.3	14.3	14.3

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS REFUSE THICKENER FEED* #728

SAMPLE NUMBER CWK-301 Pitts. #8 Seam

DATE LOGGED 10/07/93
DATE COMPLETED 11/12/93
PROJECT NUMBER 1621-013-013
ANALYTICAL NUMBER 936670

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	73.58
VOLATILE MATTER	15.30
FIXED CARBON	11.12
SULFUR, TOTAL	2.88
BTU	2835
MAF BTU	10731

SULFUR FORMS	(Dry)%
PYRITIC	2.68
SULFATE	0.11
ORGANIC	0.09
SULFUR, TOTAL	2.88

OTHERS	As determined (ppm)
HG	0.12

ULTIMATE	(Dry)%
CHLORINE	0.035
SULFUR	2.88
ASH	73.58

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	57.27
Al_2O_3	21.44
TiO_2	0.72
Fe_2O_3	11.05
CaO	2.29
MgO	1.29
Na_2O	0.33
K_2O	3.02
P_2O_5	0.25
SO_3	0.95
UND	1.39

AS DETERMINED MOISTURE: 2.33 %
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Description : DOE/ICF KE 24 HR CONT. TESTS REFUSE THICKENER
FEED- #728
Anal. No. : 936670 PITTS. #8 SEAM

	VAL1	VAL2	Average
As	35.3	34.4	34.8
Ba	302	304	303
Be	3.61	3.63	3.62
Cd	0.60	0.58	0.59
Co	17.2	18.1	17.7
Cr	98.9	99.5	99.2
Cu	49.5	50.1	49.8
F	822	864	843
Hg	0.12	0.13	0.13
Li	74.5	74.4	74.5
Mn	212	217	215
Mo	5.30	5.45	5.38
Ni	54.8	54.8	54.8
Pb	28.6	26.5	27.6
Sb	2.76	2.79	2.78
Se	3.27	3.87	3.57
Sn	3.98	4.17	4.08
Th	11.1	10.7	10.9
Tl	2.37	2.30	2.34
U	3.47	3.42	3.45
V	151	151	151
Zn	79.3	80.7	80.0

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS* ~~COAL~~ BALL *MILL FEED*

SAMPLE NUMBER CWK-302 – #2733 Pitts. #8 Seam

DATE LOGGED *10/07/93*
DATE COMPLETED 11/12/93
PROJECT NUMBER 1621-013-013
ANALYTICAL NUMBER 936671

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	15.77
VOLATILE MATTER	36.49
FIXED CARBON	47.74
SULFUR, TOTAL	3.50
BTU	12387
MAF BTU	14706

SULFUR FORMS	(Dry)%
PYRITIC	2.23
SULFATE	0.06
ORGANIC	1.21
SULFUR, TOTAL	3.50

OTHERS	
HG	0.13 ug/g

ULTIMATE	(Dry)%
CHLORINE	0.106
SULFUR	3.50
ASH	15.77

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	50.16
Al_2O_3	18.88
TiO_2	0.80
Fe_2O_3	21.76
CaO	2.09
MgO	0.89
Na_2O	0.53
K_2O	2.04
P_2O_5	0.18
SO_3	1.51
UND	1.16

AS DETERMINED MOISTURE: 1.69 %

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Description : DOE/ICF KE 24 HR CONT. TESTS ~~COAL~~ BALL MILL FEED - #2733 Pitts. #8 Seam

Anal. No. : 936671

	VAL1	VAL2	Average
As	19.4	19.0	19.2
Ba	50.5	50.4	50.5
Be	1.75	1.67	1.71
Cd	0.20	0.21	0.21
Co	5.79	5.68	5.73
Cr	23.5	23.3	23.4
Cu	14.3	13.9	14.1
F	131	108	120
Hg	0.12	0.13	0.13
Li	17.5	17.3	17.4
Mn	44.0	44.6	44.3
Mo	2.79	2.73	2.76
Ni	18.7	18.2	18.5
Pb	8.58	8.76	8.67
Sb	1.20	1.24	1.22
Se	2.89	2.81	2.85
Sn	1.19	1.17	1.18
Th	2.42	2.51	2.47
Tl	0.90	0.91	0.91
U	1.23	1.24	1.24
V	35.5	34.6	35.1
Zn	23.6	23.6	23.6

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS BALL MILL DISCHARGE*

SAMPLE NUMBER CWK-303 — #2734 Pitts #8 seam

DATE LOGGED *10/07/93*
DATE COMPLETED *11/12/93*
PROJECT NUMBER *1621-013-013*
ANALYTICAL NUMBER *936672*

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	16.61
VOLATILE MATTER	36.31
FIXED CARBON	47.08
SULFUR, TOTAL	3.60
BTU	12208
MAF BTU	14640

ULTIMATE	(Dry)%
CHLORINE	0.105
SULFUR	3.60
ASH	16.61

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	49.25
Al_2O_3	18.71
TiO_2	0.78
Fe_2O_3	22.37
CaO	1.98
MgO	0.92
Na_2O	0.49
K_2O	2.07
P_2O_5	0.18
SO_3	1.78
UND	1.47

SULFUR FORMS	(Dry)%
PYRITIC	2.24
SULFATE	0.14
ORGANIC	1.22
SULFUR, TOTAL	3.60

OTHERS

HG 0.12 µg/g

AS DETERMINED MOISTURE: 2.63 %

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Description : DOE/ICF KE 24 HR CONT. TESTS BALL MILL DISCHARGE
- #2734
Anal. No. : 936672 Pitts. #8 seam

	VAL1	VAL2	Average
As	20.2	20.1	20.2
Ba	50.2	51.1	50.7
Be	1.34	1.32	1.33
Cd	0.25	0.25	0.25
Co	5.34	5.41	5.38
Cr	21.6	21.7	21.7
Cu	14.3	14.3	14.3
F	110	110	110
Hg	0.12	0.12	0.12
Li	15.6	15.0	15.3
Mn	42.0	42.1	42.1
Mo	2.66	2.73	2.70
Ni	18.9	18.7	18.8
Pb	9.74	9.21	9.48
Sb	1.57	1.58	1.58
Se	3.00	2.53	2.77
Sn	1.18	1.22	1.20
Th	2.58	2.54	2.56
Tl	0.90	0.92	0.91
U	1.28	1.27	1.28
V	32.3	32.0	32.2
Zn	22.1	22.1	22.1

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS COLUMN FLOTATION FEED* – # 2735

SAMPLE NUMBER CWK-304 Pitts. #8 seam

DATE LOGGED 10/07/93
DATE COMPLETED 11/12/93
PROJECT NUMBER 1621-013-013
ANALYTICAL NUMBER 936673

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	26.35
VOLATILE MATTER	31.95
FIXED CARBON	41.70
SULFUR, TOTAL	2.42
BTU	10699
MAF BTU	14527

SULFUR FORMS	(Dry)%
PYRITIC	1.48
SULFATE	0.05
ORGANIC	0.89
SULFUR, TOTAL	2.42

OTHERS

HG	0.09 µg/g

ULTIMATE	(Dry)%
CHLORINE	0.088
SULFUR	2.42
ASH	26.35

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	55.90
Al_2O_3	22.15
TiO_2	0.84
Fe_2O_3	11.45
CaO	1.61
MgO	1.27
Na_2O	0.39
K_2O	3.02
P_2O_5	0.22
SO_3	1.12
UND	2.03

AS DETERMINED MOISTURE: 1.88 %
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Trace Element Report

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Project No. : 1621- 13- 13

Description : DOE/ICF KE 24 HR CONT. TESTS COLUMN FLOTATION
FEED – #2735
Anal. No. : 936673 PITTS. #8 SEAM

	VAL1	VAL2	Average
As	13.9	14.1	14.0
Ba	106	107	107
Be	1.71	1.72	1.72
Cd	0.31	0.31	0.31
Co	7.16	7.25	7.21
Cr	36.7	37.1	36.9
Cu	17.0	17.1	17.1
F	290	297	294
Hg	0.09	0.09	0.09
Li	24.7	25.6	25.2
Mn	59.1	60.0	59.6
Mo	2.62	2.68	2.65
Ni	22.7	23.1	22.9
Pb	10.4	10.3	10.4
Sb	1.91	1.94	1.93
Se	2.00	2.11	2.06
Sn	2.99	2.40	2.70
Th	4.29	4.35	4.32
Tl	0.86	0.87	0.87
U	1.70	1.72	1.71
V	53.1	54.3	53.7
Zn	31.4	32.0	31.7

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS COLUMN FLOTATION CONCENTRATE* — #2736

SAMPLE NUMBER CWK-305 Pitts. #8 Seam

DATE LOGGED *10/07/93*
DATE COMPLETED *11/12/93*
PROJECT NUMBER *1621-013-013*
ANALYTICAL NUMBER 936674

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	6.84
VOLATILE MATTER	39.24
FIXED CARBON	53.92
SULFUR, TOTAL	2.27
BTU	13821
MAF BTU	14836

SULFUR FORMS	(Dry)%
PYRITIC	0.90
SULFATE	0.13
ORGANIC	1.24
SULFUR, TOTAL	2.27

OTHERS

HG	0.08 µg/g

ULTIMATE	(Dry)%
CHLORINE	0.118
SULFUR	2.27
ASH	6.84

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	43.96
Al_2O_3	21.97
TiO_2	1.32
Fe_2O_3	23.90
CaO	1.86
MgO	1.01
Na_2O	0.84
K_2O	2.06
P_2O_5	0.22
SO_3	2.21
UND	0.65

AS DETERMINED MOISTURE: 3.26 %
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Description : DOE/ICF KE 24 HR CONT. TESTS COLUMN FLOTATION
CONCENTRATE — #2736

Anal. No. : 936674

PITTS. #8 SEAM

	VAL1	VAL2	Average
As	7.57	7.33	7.45
Ba	22.4	22.9	22.7
Be	1.28	1.22	1.25
Cd	0.14	0.14	0.14
Co	3.32	3.19	3.26
Cr	15.2	15.1	15.2
Cu	7.29	7.46	7.38
F	78.3	76.2	77.3
Hg	0.08	0.08	0.08
Li	8.33	7.90	8.12
Mn	17.1	17.4	17.3
Mo	1.93	1.98	1.96
Ni	10.6	10.5	10.6
Pb	4.30	4.35	4.32
Sb	1.14	1.13	1.14
Se	1.82	1.62	1.72
Sn	0.92	0.94	0.93
Th	1.71	1.65	1.68
Tl	0.39	0.40	0.40
U	0.98	0.97	0.98
V	23.4	22.7	23.1
Zn	13.0	12.7	12.9

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS COLUMN FLOTATION TAILINGS – #2737*

SAMPLE NUMBER CWK-306 Pitts. #8 seam

DATE LOGGED 10/07/93
DATE COMPLETED 11/12/93
PROJECT NUMBER 1621-013-013
ANALYTICAL NUMBER 936675

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	82.93
VOLATILE MATTER	11.48
FIXED CARBON	5.59
SULFUR, TOTAL	2.12
BTU	1392
MAF BTU	8155

SULFUR FORMS	(Dry)%
PYRITIC	2.00
SULFATE	0.07
ORGANIC	0.05
SULFUR, TOTAL	2.12

OTHERS

HG	0.10 µg/g

ULTIMATE	(Dry)%
CHLORINE	0.031
SULFUR	2.12
ASH	82.93

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	59.90
Al_2O_3	22.35
TiO_2	0.73
Fe_2O_3	8.07
CaO	1.59
MgO	1.37
Na_2O	0.36
K_2O	3.30
P_2O_5	0.22
SO_3	0.97
UND	1.14

AS DETERMINED MOISTURE: 2.47 %
DISTRIBUTION:
R. KOSKY C. KOCH

Approved for transmittal

Trace Element Report

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Library, PA 15129

12/14/93

Submitted By: DISTRIBUTION
Project No. : 1621- 13- 13

Description : DOE/ICF KE 24 HR CONT. TESTS COLUMN FLOTATION
TAILINGS - #2737
Anal. No. : 936675

PITTS. #8 SEAM

	VAL1	VAL2	Average
As	27.0	27.3	27.2
Ba	346	349	348
Be	3.67	3.65	3.66
Cd	0.77	0.78	0.78
Co	18.0	18.3	18.2
Cr	120	119	120
Cu	53.6	55.2	54.4
F	1059	1056	1058
Hg	0.10	0.09	0.10
Li	70.1	72.3	71.2
Mn	189	194	192
Mo	5.13	5.25	5.19
Ni	64.0	64.3	64.2
Pb	28.6	29.1	28.9
Sb	3.53	3.58	3.56
Se	2.56	2.54	2.55
Sn	5.74	6.44	6.09
Th	12.1	11.2	11.7
Tl	1.99	2.06	2.03
U	3.66	3.60	3.63
V	143	147	145
Zn	87.8	87.7	87.8

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS HEAVY MEDIA CYCLONE REJECT (COMP.) - #706*

SAMPLE NUMBER CWK-307 Pitts #8 Seam

DATE LOGGED *10/13/93*
DATE COMPLETED *11/17/93*
PROJECT NUMBER *1621-013-013*
ANALYTICAL NUMBER 936771

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	84.22
VOLATILE MATTER	12.87
FIXED CARBON	2.91
SULFUR, TOTAL	3.34
BTU	958
MAF BTU	6071

SULFUR FORMS	(Dry)%
PYRITIC	3.18
SULFATE	0.07
ORGANIC	0.09
SULFUR, TOTAL	3.34

OTHERS

HG	0.15

ULTIMATE	(Dry)%
CHLORINE	0.012
SULFUR	3.34
ASH	84.22

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	57.70
Al_2O_3	22.17
TiO_2	0.84
Fe_2O_3	7.26
CaO	4.91
MgO	1.46
Na_2O	0.35
K_2O	2.89
P_2O_5	0.32
SO_3	1.24
UND	0.86

AS DETERMINED MOISTURE: 1.96 %
DISTRIBUTION:
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Trace Element Report

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12/14/93

Submitted By: DISTRIBUTION
Project No. : 1621- 13- 13

Description : DOE/ICF KE 24 HR CONT. TESTS HEAVY MEDIA CYCLONE
REJECT (COMP.) - #706

Anal. No. : 936771

PITTS. #8 SEAM

	VAL1	VAL2	Average
As	47.0	47.9	47.5
Ba	320	320	320
Be	3.60	3.61	3.61
Cd	0.90	0.92	0.91
Co	18.5	18.6	18.6
Cr	92.6	96.4	94.5
Cu	55.9	57.1	56.5
F	990	992	991
Hg	0.15	0.15	0.15
Li	88.0	89.1	88.6
Mn	318	329	324
Mo	4.55	4.43	4.49
Ni	49.5	50.5	50.0
Pb	37.7	37.8	37.8
Sb	2.34	2.30	2.32
Se	4.00	4.03	4.02
Sn	20.1	16.6	18.4
Th	13.9	14.1	14.0
Tl	3.05	3.10	3.08
U	4.41	4.43	4.42
V	122	127	125
Zn	87.6	94.2	90.9

UPPER FREEPORT

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS PLANT FEED SL #701*

SAMPLE NUMBER CWK #402 U. Freeport Seam

DATE LOGGED *01/03/94*
DATE COMPLETED 01/27/94
PROJECT NUMBER *1621-013-013*
ANALYTICAL NUMBER 940012

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	22.15
VOLATILE MATTER	32.78
FIXED CARBON	45.07
SULFUR, TOTAL	3.67
BTU	11417
MAF BTU	14665

SULFUR FORMS	(Dry)%
PYRITIC	2.08
SULFATE	0.24
ORGANIC	1.35
SULFUR, TOTAL	3.67

OTHERS

HG µg/g	0.43

ULTIMATE	(Dry)%
CHLORINE	0.070
SULFUR	3.67
ASH	22.15

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	48.24
Al_2O_3	20.69
TiO_2	1.00
Fe_2O_3	20.47
CaO	1.59
MgO	0.86
Na_2O	0.23
K_2O	2.42
P_2O_5	0.27
SO_3	1.96
UND	2.27

AS DETERMINED MOISTURE: 2.16 %

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03/04/94

Submitted By: DISTRIBUTION
Project No. : 1621- 13- 13

Description : DOE/ICF KE 24 HR CONT. TESTS PLANT FEED SL #701

U. Freeport Seam

Anal. No. : 940012

	VAL1	VAL2	Average
As	13.9	14.1	14.0
Ba	203	198	201
Be	4.30	4.31	4.31
Cd	0.20	0.18	0.19
Co	7.61	7.96	7.79
Cr	28.5	29.2	28.9
Cu	28.5	29.4	29.0
F	121	124	123
Hg	0.42	0.43	0.43
Li	47.5	47.4	47.5
Mn	113	115	114
Mo	3.40	3.36	3.38
Ni	23.6	24.2	23.9
Pb	26.3	25.2	25.8
Sb	1.04	1.01	1.03
Se	3.94	3.81	3.88
Sn	1.39	1.39	1.39
Th	4.72	4.41	4.57
Tl	2.66	2.71	2.69
U	22.3	21.2	21.8
V	43.4	43.4	43.4
Zn	44.1	39.5	41.8

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DESCRIPTION *DOE/ICF KE 24 HR. CONT. TESTS HMC REFUSE SL #706*

SAMPLE NUMBER CWK #403 U. Freeport Seam

DATE LOGGED 01/03/94
DATE COMPLETED 01/27/94
PROJECT NUMBER 1621-013-013
ANALYTICAL NUMBER 940013

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	66.66
VOLATILE MATTER	19.22
FIXED CARBON	14.12
SULFUR, TOTAL	16.43
BTU	3263
MAF BTU	9787

SULFUR FORMS	(Dry)%
PYRITIC	14.72
SULFATE	0.14
ORGANIC	1.57
SULFUR, TOTAL	16.43

OTHERS

HG ug/g	1.37

ULTIMATE	(Dry)%
CHLORINE	0.086
SULFUR	16.43
ASH	66.66

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	40.13
Al_2O_3	12.14
TiO_2	0.45
Fe_2O_3	39.13
CaO	1.73
MgO	0.81
Na_2O	0.21
K_2O	1.77
P_2O_5	0.09
SO_3	1.19
UND	2.35

AS DETERMINED MOISTURE: 0.78 %

DISTRIBUTION:
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Trace Element Report

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03/04/94

Submitted By: DISTRIBUTION
Project No. : 1621- 13- 13

Description : DOE/ICF KE 24 HR CONT. TESTS HMC REFUSE SL #706

Anal. No. : 940013 U. Freeport Seam

	VAL1	VAL2	Average
As	90.7	91.8	91.3
Ba	282	272	277
Be	2.45	2.47	2.46
Cd	0.47	0.50	0.49
Co	17.7	18.0	17.9
Cr	35.6	35.8	35.7
Cu	73.5	71.4	72.5
F	195	196	196
Hg	1.31	1.42	1.37
Li	59.7	63.2	61.5
Mn	539	551	545
Mo	12.4	12.7	12.6
Ni	51.9	52.6	52.3
Pb	110	111	111
Sb	2.82	2.87	2.85
Se	9.82	9.30	9.56
Sn	1.58	1.62	1.60
Th	5.50	5.26	5.38
Tl	16.0	16.0	16.0
U	6.93	6.81	6.87
V	< 0.40	< 0.40	< 0.40
Zn	123	132	128

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS PLANT CLEAN COAL*
SL #727 U. Freeport Seam

SAMPLE NUMBER CWK #404

DATE LOGGED *01/03/94*
DATE COMPLETED 01/27/94
PROJECT NUMBER 1621-013-013
ANALYTICAL NUMBER 940014

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	10.07
VOLATILE MATTER	36.79
FIXED CARBON	53.14
SULFUR, TOTAL	2.15
BTU	13459
MAF BTU	14966

SULFUR FORMS	(Dry)%
PYRITIC	0.92
SULFATE	0.07
ORGANIC	1.16
SULFUR, TOTAL	2.15

OTHERS

HG ug/g	0.20

ULTIMATE	(Dry)%
CHLORINE	0.086
SULFUR	2.15
ASH	10.07

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	46.20
Al_2O_3	24.87
TiO_2	1.63
Fe_2O_3	18.75
CaO	1.35
MgO	0.89
Na_2O	0.74
K_2O	2.43
P_2O_5	0.46
SO_3	1.85
UND	0.83

AS DETERMINED MOISTURE: 1.49 %
DISTRIBUTION:
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Trace Element Report

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03/04/94

Submitted By: DISTRIBUTION
Project No. : 1621- 13- 13

Description : DOE/ICF KE 24 HR CONT. TESTS PLANT CLEAN COAL - #727
Anal. No. : 940014 U. Freeport Seam

	VAL1	VAL2	Average
As	3.81	3.74	3.78
Ba	79.0	76.7	77.8
Be	4.45	4.67	4.56
Cd	0.10	0.09	0.10
Co	5.33	5.40	5.37
Cr	25.3	25.8	25.6
Cu	18.8	19.0	18.9
F	78.0	82.0	80.0
Hg	0.21	0.19	0.20
Li	28.8	29.3	29.1
Mn	48.3	48.9	48.6
Mo	2.36	2.45	2.41
Ni	17.9	18.1	18.0
Pb	10.9	10.7	10.8
Sb	0.73	0.74	0.74
Se	2.57	2.37	2.47
Sn	2.20	2.24	2.22
Th	2.94	3.01	2.98
Tl	0.88	0.84	0.86
U	1.80	1.80	1.80
V	43.9	43.6	43.8
Zn	18.5	17.8	18.2

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS REFUSE THICKENER FEED SL #728*

SAMPLE NUMBER CWK #405 U. Freeport Seam

DATE LOGGED *01/03/94*
DATE COMPLETED *01/27/94*
PROJECT NUMBER *1621-013-013*
ANALYTICAL NUMBER 940015

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	51.71
VOLATILE MATTER	22.34
FIXED CARBON	25.95
SULFUR, TOTAL	4.28
BTU	6309
MAF BTU	13065

SULFUR FORMS	(Dry)%
PYRITIC	3.48
SULFATE	0.24
ORGANIC	0.56
SULFUR, TOTAL	4.28

OTHERS

HG ug/g	0.41

ULTIMATE	(Dry)%
CHLORINE	0.033
SULFUR	4.28
ASH	51.71

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	50.25
Al_2O_3	18.27
TiO_2	0.68
Fe_2O_3	24.97
CaO	0.74
MgO	0.87
Na_2O	0.27
K_2O	2.49
P_2O_5	0.14
SO_3	0.94
UND	0.38

AS DETERMINED MOISTURE: *1.65 %*
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03/04/94

Submitted By: DISTRIBUTION
Project No. : 1621- 13- 13

Description : DOE/ICF KE 24 HR CONT. TESTS REFUSE THICKENER
FEED - #728 U. Freeport Seam
Anal. No. : 940015

	VAL1	VAL2	Average
As	21.9	21.8	21.9
Ba	672	676	674
Be	3.74	3.66	3.70
Cd	0.56	0.58	0.57
Co	13.5	13.7	13.6
Cr	72.0	71.3	71.7
Cu	55.6	54.3	55.0
F	452	460	456
Hg	0.42	0.39	0.41
Li	94.5	88.0	91.3
Mn	376	378	377
Mo	6.01	5.97	5.99
Ni	47.1	47.0	47.1
Pb	49.3	51.0	50.2
Sb	1.59	1.63	1.61
Se	6.89	6.79	6.84
Sn	2.62	2.69	2.66
Th	7.46	7.10	7.28
Tl	4.09	4.16	4.13
U	3.24	3.21	3.23
V	76.3	73.8	75.1
Zn	109	114	112

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS BALL MILL FEED*
SL #2733 U. Freeport Seam

SAMPLE NUMBER CWK #406

DATE LOGGED *01/03/94*
DATE COMPLETED *01/27/94*
PROJECT NUMBER *1621-013-013*
ANALYTICAL NUMBER 940016

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	22.78
VOLATILE MATTER	33.49
FIXED CARBON	43.73
SULFUR, TOTAL	4.59
BTU	11320
MAF BTU	14659

ULTIMATE	(Dry)%
CHLORINE	0.058
SULFUR	4.59
ASH	22.78

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	47.45
Al_2O_3	18.47
TiO_2	0.96
Fe_2O_3	25.69
CaO	1.00
MgO	0.67
Na_2O	0.41
K_2O	2.06
P_2O_5	0.27
SO_3	1.55
UND	1.47

SULFUR FORMS	(Dry)%
PYRITIC	3.46
SULFATE	0.12
ORGANIC	1.01
SULFUR, TOTAL	4.59

OTHERS

HG µg/g	0.40

AS DETERMINED MOISTURE: 1.15 %
DISTRIBUTION:
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Trace Element Report

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03/04/94

Submitted By: DISTRIBUTION
Project No. : 1621- 13- 13

Description : DOE/ICF KE 24 HR CONT. TESTS BALL MILL FEED
- #2733 U. Freeport Seam
Anal. No. : 940016

	VAL1	VAL2	Average
As	10.4	11.0	10.7
Ba	249	275	262
Be	4.49	4.50	4.50
Cd	0.23	0.26	0.25
Co	7.78	8.49	8.14
Cr	30.0	31.5	30.8
Cu	39.4	41.5	40.5
F	96.0	95.0	95.5
Hg	0.40	0.39	0.40
Li	50.8	49.7	50.3
Mn	145	157	151
Mo	3.21	3.26	3.24
Ni	29.2	31.0	30.1
Pb	26.1	25.3	25.7
Sb	1.15	1.21	1.18
Se	4.32	4.90	4.61
Sn	1.96	1.94	1.95
Th	4.49	4.49	4.49
Tl	2.32	2.21	2.27
U	2.23	2.14	2.19
V	34.8	36.5	35.7
Zn	49.8	54.5	52.2

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS BALL MILL DISCHARGE*
SL #2734
U. Freeport Seam

SAMPLE NUMBER CWK #407

DATE LOGGED *01/03/94*
DATE COMPLETED 01/27/94
PROJECT NUMBER 1621-013-013
ANALYTICAL NUMBER 940017

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	22.15
VOLATILE MATTER	33.92
FIXED CARBON	43.93
SULFUR, TOTAL	4.37
BTU	11431
MAF BTU	14683

SULFUR FORMS	(Dry)%
PYRITIC	3.23
SULFATE	0.14
ORGANIC	1.00
SULFUR, TOTAL	4.37

OTHERS

HG µg/g	0.39

ULTIMATE	(Dry)%
CHLORINE	0.061
SULFUR	4.37
ASH	22.15

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	46.16
Al_2O_3	19.52
TiO_2	0.96
Fe_2O_3	24.99
CaO	1.12
MgO	0.67
Na_2O	0.47
K_2O	2.02
P_2O_5	0.27
SO_3	1.59
UND	2.23

AS DETERMINED MOISTURE: 1.38 %
DISTRIBUTION:
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Trace Element Report

CONSOL Inc.
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03/04/94

Submitted By: DISTRIBUTION
Project No. : 1621- 13- 13

Description : DOE/ICF KE 24 HR CONT. TESTS BALL MILL DISCHARGE
- #2734
Anal. No. : 940017 U. Freeport Seam

	VAL1	VAL2	Average
As	10.3	10.2	10.3
Ba	239	228	234
Be	4.23	4.48	4.36
Cd	0.23	0.23	0.23
Co	7.72	7.66	7.69
Cr	32.1	31.5	31.8
Cu	39.2	38.6	38.9
F	92.0	100.0	96.0
Hg	0.38	0.39	0.39
Li	47.2	48.1	47.7
Mn	149	150	150
Mo	3.15	3.10	3.13
Ni	29.4	28.9	29.2
Pb	24.1	23.7	23.9
Sb	1.10	1.11	1.11
Se	4.51	4.37	4.44
Sn	1.98	1.79	1.89
Th	4.32	4.27	4.30
Tl	2.14	2.16	2.15
U	2.08	2.05	2.07
V	32.5	31.6	32.1
Zn	47.4	48.2	47.8

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS COLUMN FLOTATION FEED SL #2735*

SAMPLE NUMBER CWK #408 U. Freeport Seam

DATE LOGGED *01/03/94*
DATE COMPLETED *01/27/94*
PROJECT NUMBER *1621-013-013*
ANALYTICAL NUMBER 940018

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	20.00
VOLATILE MATTER	33.81
FIXED CARBON	46.19
SULFUR, TOTAL	2.56
BTU	11774
MAF BTU	14718

ULTIMATE	(Dry)%
CHLORINE	0.071
SULFUR	2.56
ASH	20.00

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	49.58
Al_2O_3	22.14
TiO_2	1.07
Fe_2O_3	18.53
CaO	1.09
MgO	0.86
Na_2O	0.34
K_2O	2.50
P_2O_5	0.27
SO_3	1.39
UND	2.23

SULFUR FORMS	(Dry)%
PYRITIC	1.51
SULFATE	0.10
ORGANIC	0.95
SULFUR, TOTAL	2.56

OTHERS

HG µg/g 0.24

AS DETERMINED MOISTURE: 1.32 %
DISTRIBUTION:
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Trace Element Report

CONSOL Inc.
Research and Development
4000 Brownsville Road
Library, PA 15129

03/04/94

Submitted By: DISTRIBUTION
Project No. : 1621- 13- 13

Description : DOE/ICF KE 24 HR CONT. TESTS COLUMN FLOTATION
FEED - # 2735
Anal. No. : 940018 U. FREEPORT SEAM

	VAL1	VAL2	Average
As	7.29	7.11	7.20
Ba	234	214	224
Be	4.18	4.41	4.30
Cd	0.23	0.24	0.24
Co	6.95	6.91	6.93
Cr	34.4	34.5	34.5
Cu	27.0	26.9	27.0
F	121	127	124
Hg	0.23	0.24	0.24
Li	42.1	44.5	43.3
Mn	109	109	109
Mo	3.18	3.20	3.19
Ni	23.6	23.7	23.7
Pb	19.9	18.7	19.3
Sb	0.99	1.01	1.00
Se	3.68	3.52	3.60
Sn	3.80	3.56	3.68
Th	4.65	4.28	4.47
Tl	1.50	1.46	1.48
U	2.39	2.26	2.33
V	46.1	46.0	46.1
Zn	39.0	39.1	39.1

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS COLUMN FLOTATION CONCENTRATE SL #2736*

SAMPLE NUMBER CWK #409 U. Freeport Seam

DATE LOGGED *01/03/94*
DATE COMPLETED *01/27/94*
PROJECT NUMBER *1621-013-013*
ANALYTICAL NUMBER 940019

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	9.46
VOLATILE MATTER	37.04
FIXED CARBON	53.50
SULFUR, TOTAL	2.01
BTU	13577
MAF BTU	14996

SULFUR FORMS	(Dry)%
PYRITIC	0.86
SULFATE	0.07
ORGANIC	1.08
SULFUR, TOTAL	2.01

OTHERS

HG µg/g	0.18

ULTIMATE	(Dry)%
CHLORINE	0.082
SULFUR	2.01
ASH	9.46

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	46.72
Al_2O_3	25.38
TiO_2	1.75
Fe_2O_3	17.31
CaO	1.40
MgO	0.87
Na_2O	0.75
K_2O	2.46
P_2O_5	0.47
SO_3	1.46
UND	1.43

AS DETERMINED MOISTURE: 1.44 %
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Trace Element Report

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03/04/94

Submitted By: DISTRIBUTION
Project No. : 1621- 13- 13

Description : DOE/ICF KE 24 HR CONT. TESTS COLUMN FLOTATION
CONCENTRATE – #2736
Anal. No. : 940019 U. FREEPORT SEAM

	VAL1	VAL2	Average
As	3.06	3.08	3.07
Ba	66.5	68.9	67.7
Be	4.52	4.51	4.52
Cd	0.07	0.07	0.07
Co	4.96	4.91	4.94
Cr	24.8	24.7	24.8
Cu	17.0	17.4	17.2
F	80.0	77.0	78.5
Hg	0.18	0.17	0.18
Li	26.0	26.5	26.3
Mn	46.1	47.8	47.0
Mo	2.43	2.43	2.43
Ni	16.6	16.6	16.6
Pb	9.47	9.46	9.47
Sb	0.73	0.74	0.74
Se	2.35	2.37	2.36
Sn	1.17	1.18	1.18
Th	3.15	3.31	3.23
Tl	0.74	0.74	0.74
U	2.04	2.07	2.06
V	41.9	41.4	41.7
Zn	16.3	16.3	16.3

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS COLUMN FLOTATION TAILINGS SL #2737*

SAMPLE NUMBER CWK #410 U. Freeport Seam

DATE LOGGED *01/03/94*
DATE COMPLETED *01/27/94*
PROJECT NUMBER *1621-013-013*
ANALYTICAL NUMBER 940020

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	57.10
VOLATILE MATTER	19.79
FIXED CARBON	23.11
SULFUR, TOTAL	3.34
BTU	5389
MAF BTU	12562

ULTIMATE	(Dry)%
CHLORINE	0.033
SULFUR	3.34
ASH	57.10

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	52.71
Al_2O_3	19.91
TiO_2	0.65
Fe_2O_3	18.66
CaO	0.72
MgO	0.93
Na_2O	0.30
K_2O	2.75
P_2O_5	0.15
SO_3	0.90
UND	2.32

SULFUR FORMS	(Dry)%
PYRITIC	2.60
SULFATE	0.34
ORGANIC	0.40
SULFUR, TOTAL	3.34

OTHERS

HG µg/g 0.33

AS DETERMINED MOISTURE: 1.86 %
DISTRIBUTION:
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Trace Element Report

CONSOL Inc.
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03/04/94

Submitted By: DISTRIBUTION
Project No. : 1621- 13- 13

Description : DOE/ICF KE 24 HR CONT. TESTS COLUMN FLOTATION
TAILINGS - #2737
Anal. No. : 940020 U. Freeport Seam

	VAL1	VAL2	Average
As	21.1	20.7	20.9
Ba	791	806	799
Be	4.36	4.38	4.37
Cd	0.51	0.61	0.56
Co	12.9	12.8	12.9
Cr	82.0	81.7	81.8
Cu	55.4	55.6	55.5
F	538	554	546
Hg	0.34	0.32	0.33
Li	104	101	103
Mn	361	363	362
Mo	6.41	6.34	6.38
Ni	49.3	48.6	49.0
Pb	54.0	53.0	53.5
Sb	1.75	1.81	1.78
Se	7.93	8.33	8.13
Sn	11.3	10.6	11.0
Th	8.47	8.44	8.46
Tl	4.13	4.09	4.11
U	3.68	3.69	3.69
V	62.2	61.7	62.0
Zn	120	121	121

ILLINOIS NO. 6

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS PLANT FEED - 701*
ILL #6 Seam

SAMPLE NUMBER CWK #434

DATE LOGGED 02/14/94
DATE COMPLETED 04/08/94
PROJECT NUMBER 1621-013-013
ANALYTICAL NUMBER 940606

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	36.73
VOLATILE MATTER	29.14
FIXED CARBON	34.13
SULFUR, TOTAL	4.14
BTU	8789
MAF BTU	13891

SULFUR FORMS	(Dry)%
PYRITIC	3.22
SULFATE	0.12
ORGANIC	0.80
SULFUR, TOTAL	4.14

ULTIMATE	(Dry)%
CHLORINE	0.163
SULFUR	4.14
ASH	36.73

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	49.40
Al_2O_3	17.79
TiO_2	0.69
Fe_2O_3	13.77
CaO	6.92
MgO	1.65
Na_2O	0.76
K_2O	3.19
P_2O_5	0.51
SO_3	3.08
UND	2.24

AS DETERMINED MOISTURE: 1.35 %

DISTRIBUTION:
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Trace Element Report

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04/04/94

Submitted By: DISTRIBUTION
Project No. : 1621- 13- 13

Description : DOE/ICF KE 24 HR CONT. TESTS PLANT FEED - 701
ILL. #6 Seam

Anal. No. : 940606

	VAL1	VAL2	Average
As	9.47	9.67	9.57
Ba	164	160	162
Be	2.14	2.06	2.10
Cd	6.49	5.50	6.00
Co	9.29	9.36	9.32
Cr	96.3	87.7	92.0
Cu	38.9	33.2	36.1
F	588	582	585
Hg	0.17	0.16	0.17
Li	20.6	19.6	20.1
Mn	131	131	131
Mo	26.2	26.5	26.4
Ni	46.3	47.2	46.8
Pb	48.2	47.8	48.0
Sb	1.48	1.62	1.55
Se	10.1	9.06	9.58
Sn	2.59	3.18	2.89
Th	5.21	5.17	5.19
Tl	2.01	2.03	2.02
U	10.7	10.4	10.6
V	103	105	104
Zn	219	194	207

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS HMC REFUSE - 706*
ILL. #6 SEAM

SAMPLE NUMBER CWK #435

DATE LOGGED *02/14/94*
DATE COMPLETED 04/08/94
PROJECT NUMBER 1621-013-013
ANALYTICAL NUMBER 940607

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	81.62
VOLATILE MATTER	18.38
FIXED CARBON	0.00
SULFUR, TOTAL	7.50
BTU	1835
MAF BTU	9984

SULFUR FORMS	(Dry)%
PYRITIC	7.22
SULFATE	0.06
ORGANIC	0.22
SULFUR, TOTAL	7.50

ULTIMATE	(Dry)%
CHLORINE	<0.010
SULFUR	7.50
ASH	81.62

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	45.65
Al_2O_3	16.30
TiO_2	0.60
Fe_2O_3	13.92
CaO	11.06
MgO	2.41
Na_2O	0.65
K_2O	3.15
P_2O_5	1.73
SO_3	2.94
UND	1.59

AS DETERMINED MOISTURE: 0.76 %

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Trace Element Report

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04/04/94

Submitted By: DISTRIBUTION
Project No. : 1621- 13- 13

Description : DOE/ICF KE 24 HR CONT. TESTS HMC REFUSE - 706
IL.#6 Seam

Anal. No. : 940607

	VAL1	VAL2	Average
As	23.9	23.8	23.9
Ba	295	304	300
Be	3.15	3.37	3.26
Cd	8.41	9.11	8.76
Co	16.3	16.1	16.2
Cr	235	241	238
Cu	61.4	62.8	62.1
F	1495	1470	1483
Hg	0.26	0.27	0.27
Li	39.5	38.7	39.1
Mn	300	305	303
Mo	56.1	56.5	56.3
Ni	121	121	121
Pb	93.5	93.1	93.3
Sb	3.80	3.98	3.89
Se	28.2	30.1	29.2
Sn	2.25	2.20	2.23
Th	9.47	9.58	9.53
Tl	5.52	5.45	5.48
U	25.9	25.6	25.8
V	247	250	249
Zn	457	462	460

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS PLANT CLEAN COAL - 727*
ILL. #6 SEAM

SAMPLE NUMBER CWK #436

DATE LOGGED 02/14/94
DATE COMPLETED 04/08/94
PROJECT NUMBER 1621-013-013
ANALYTICAL NUMBER 940608

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	6.91
VOLATILE MATTER	38.08
FIXED CARBON	55.01
SULFUR, TOTAL	2.75
BTU	13596
MAF BTU	14605

SULFUR FORMS	(Dry)%
PYRITIC	0.98
SULFATE	0.05
ORGANIC	1.72
SULFUR, TOTAL	2.75

ULTIMATE	(Dry)%
CHLORINE	0.382
SULFUR	2.75
ASH	6.91

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	45.47
Al_2O_3	19.86
TiO_2	1.44
Fe_2O_3	20.73
CaO	2.60
MgO	1.27
Na_2O	0.98
K_2O	2.65
P_2O_5	0.18
SO_3	2.92
UND	1.90

AS DETERMINED MOISTURE: 1.68 %

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Trace Element Report

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04/04/94

Submitted By: DISTRIBUTION
Project No. : 1621- 13- 13

Description : DOE/ICF KE 24 HR CONT. TESTS PLANT CLEAN COAL - 727
ILL. #6 SEAM

Anal. No. : 940608

	VAL1	VAL2	Average
As	3.35	3.46	3.41
Ba	35.9	36.7	36.3
Be	1.43	1.44	1.44
Cd	0.27	0.25	0.26
Co	3.67	3.72	3.70
Cr	29.3	27.4	28.4
Cu	10.4	11.1	10.8
F	68.1	55.9	62.0
Hg	0.09	0.09	0.09
Li	7.34	7.29	7.32
Mn	21.4	22.0	21.7
Mo	15.7	15.5	15.6
Ni	18.3	19.0	18.7
Pb	19.2	19.3	19.3
Sb	0.53	0.60	0.56
Se	3.74	3.42	3.58
Sn	1.12	1.14	1.13
Th	1.95	1.98	1.97
Tl	0.70	0.69	0.70
U	8.34	8.08	8.21
V	46.5	48.1	47.3
Zn	25.8	24.9	25.4

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS REFUSE THICKENER FEED -728* Ill. #6 Seam

SAMPLE NUMBER CWK #437

DATE LOGGED 02/14/94
DATE COMPLETED 04/08/94
PROJECT NUMBER 1621-013-013
ANALYTICAL NUMBER 940609

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	65.34
VOLATILE MATTER	17.73
FIXED CARBON	16.93
SULFUR, TOTAL	3.03
BTU	4371
MAF BTU	12611

SULFUR FORMS	(Dry)%
PYRITIC	2.65
SULFATE	0.08
ORGANIC	0.30
SULFUR, TOTAL	3.03

ULTIMATE	(Dry)%
CHLORINE	0.073
SULFUR	3.03
ASH	65.34

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	56.93
Al_2O_3	19.52
TiO_2	0.69
Fe_2O_3	10.36
CaO	3.13
MgO	1.71
Na_2O	0.44
K_2O	3.66
P_2O_5	0.29
SO_3	1.64
UND	1.63

AS DETERMINED MOISTURE: 1.53 %
DISTRIBUTION:
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Trace Element Report

CONSOL Inc.
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04/04/94

Submitted By: DISTRIBUTION
Project No. : 1621- 13- 13

Description : DOE/ICF KE 24 HR CONT. TESTS REFUSE THICKENER
FEED - 728 ILL.#6 SEAM
Anal. No. : 940609

	VAL1	VAL2	Average
As	11.8	11.8	11.8
Ba	341	338	340
Be	2.51	2.35	2.43
Cd	2.07	2.14	2.11
Co	13.8	14.2	14.0
Cr	132	135	134
Cu	40.5	40.8	40.7
F	849	895	872
Hg	0.16	0.15	0.16
Li	34.1	33.3	33.7
Mn	228	229	229
Mo	19.4	20.4	19.9
Ni	66.4	68.7	67.6
Pb	52.8	50.8	51.8
Sb	1.87	1.86	1.87
Se	9.26	8.64	8.95
Sn	2.70	2.98	2.84
Th	8.46	8.18	8.32
Tl	2.02	2.04	2.03
U	7.78	7.55	7.67
V	152	154	153
Zn	186	184	185

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS ~~COAL~~ BALL MILL FEED - 2733* ILL. #6 SEAM

SAMPLE NUMBER CWK #438

DATE LOGGED 02/14/94
DATE COMPLETED 04/08/94
PROJECT NUMBER 1621-013-013
ANALYTICAL NUMBER 940610

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	20.27
VOLATILE MATTER	33.97
FIXED CARBON	45.76
SULFUR, TOTAL	4.19
BTU	11471
MAF BTU	14387

SULFUR FORMS	(Dry)%
PYRITIC	2.78
SULFATE	0.05
ORGANIC	1.36
SULFUR, TOTAL	4.19

ULTIMATE	(Dry)%
CHLORINE	0.294
SULFUR	4.19
ASH	20.27

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	53.50
Al_2O_3	16.05
TiO_2	0.72
Fe_2O_3	19.31
CaO	3.68
MgO	1.17
Na_2O	0.63
K_2O	2.34
P_2O_5	0.24
SO_3	1.86
UND	0.50

AS DETERMINED MOISTURE: 1.56 %
DISTRIBUTION:
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Trace Element Report

CONSOL Inc.
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04/04/94

Submitted By: DISTRIBUTION
Project No. : 1621- 13- 13
Description : DOE/ICF KE 24 HR CONT. TESTS ~~COAL~~ BALL MILL FEED
– 2733 ILL. #6 SEAM
Anal. No. : 940610

	VAL1	VAL2	Average
As	8.97	9.21	9.09
Ba	77.6	76.6	77.1
Be	1.61	1.57	1.59
Cd	1.22	1.18	1.20
Co	6.74	6.82	6.78
Cr	41.6	41.7	41.7
Cu	21.2	21.8	21.5
F	119	110	115
Hg	0.14	0.15	0.15
Li	13.9	13.5	13.7
Mn	74.8	76.9	75.8
Mo	19.5	19.6	19.6
Ni	33.6	34.2	33.9
Pb	56.4	55.9	56.2
Sb	1.15	1.22	1.19
Se	6.21	6.17	6.19
Sn	0.84	0.77	0.80
Th	3.18	3.02	3.10
Tl	1.72	1.65	1.69
U	10.0	9.23	9.62
V	59.0	58.9	59.0
Zn	97.1	95.7	96.4

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS BALL MILL DISCHARGE - 2734* ILL #6 Seam

SAMPLE NUMBER CWK #439

DATE LOGGED *02/14/94*
DATE COMPLETED 04/08/94
PROJECT NUMBER *1621-013-013*
ANALYTICAL NUMBER 940611

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	17.44
VOLATILE MATTER	35.27
FIXED CARBON	47.29
SULFUR, TOTAL	3.75
BTU	11966
MAF BTU	14494

ULTIMATE	(Dry)%
CHLORINE	0.321
SULFUR	3.75
ASH	17.44

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	54.40
Al_2O_3	17.18
TiO_2	0.79
Fe_2O_3	18.50
CaO	3.53
MgO	1.23
Na_2O	0.73
K_2O	2.49
P_2O_5	0.23
SO_3	2.33
UND	-1.41

SULFUR FORMS	(Dry)%
PYRITIC	2.03
SULFATE	0.07
ORGANIC	1.65
SULFUR, TOTAL	3.75

AS DETERMINED MOISTURE: 1.75 %
DISTRIBUTION:
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Trace Element Report

CONSOL Inc.
Research and Development
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04/04/94

Submitted By: DISTRIBUTION
Project No. : 1621- 13- 13

Description : DOE/ICF KE 24 HR CONT. TESTS BALL MILL DISCHARGE
- 2734
Anal. No. : 940611 ILL. #6 Sem

	VAL1	VAL2	Average
As	7.25	7.36	7.31
Ba	67.7	67.6	67.7
Be	1.51	1.51	1.51
Cd	0.94	0.87	0.91
Co	6.01	6.08	6.05
Cr	44.3	43.9	44.1
Cu	19.1	19.1	19.1
F	109	98.0	104
Hg	0.14	0.14	0.14
Li	13.3	12.4	12.9
Mn	64.7	65.4	65.1
Mo	19.3	19.1	19.2
Ni	32.3	32.2	32.3
Pb	42.2	42.4	42.3
Sb	1.06	1.29	1.18
Se	5.31	4.66	4.98
Sn	1.00	0.97	0.99
Th	2.70	2.70	2.70
Tl	1.35	1.36	1.36
U	9.27	9.25	9.26
V	57.4	59.1	58.3
Zn	72.5	73.4	73.0

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ANALYTICAL LABORATORY
4000 BROWNSVILLE ROAD, LIBRARY, PA 15129

DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS COLUMN FLOTATION*
FEED 2735 ILL. #6 seam

SAMPLE NUMBER CWK #440

DATE LOGGED *02/14/94*
DATE COMPLETED *04/08/94*
PROJECT NUMBER *1621-013-013*
ANALYTICAL NUMBER 940612

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	23.23
VOLATILE MATTER	32.49
FIXED CARBON	44.28
SULFUR, TOTAL	2.61
BTU	11041
MAF BTU	14382

SULFUR FORMS	(Dry)%
PYRITIC	1.11
SULFATE	0.04
ORGANIC	1.46
SULFUR, TOTAL	2.61

ULTIMATE	(Dry)%
CHLORINE	0.250
SULFUR	2.61
ASH	23.23

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	55.33
Al_2O_3	20.23
TiO_2	0.88
Fe_2O_3	11.24
CaO	2.66
MgO	1.75
Na_2O	0.53
K_2O	3.79
P_2O_5	0.19
SO_3	1.71
UND	1.69

AS DETERMINED MOISTURE: 1.89 %
DISTRIBUTION:
C. KOCH R. KOSKY

Approved for transmittal

Trace Element Report

CONSOL Inc.
Research and Development
4000 Brownsville Road
Library, PA 15129

04/04/94

Submitted By: DISTRIBUTION
Project No. : 1621- 13- 13

Description : DOE/ICF KE 24 HR CONT. TESTS COLUMN FLOTATION
FEED - 2735 ILL.#6 SEAM
Anal. No. : 940612

	VAL1	VAL2	Average
As	4.83	4.84	4.84
Ba	125	122	124
Be	1.85	1.74	1.80
Cd	0.48	0.50	0.49
Co	6.28	6.45	6.37
Cr	54.0	57.5	55.8
Cu	18.3	19.0	18.7
F	366	366	366
Hg	0.11	0.11	0.11
Li	14.4	14.6	14.5
Mn	70.1	72.2	71.2
Mo	16.1	17.2	16.7
Ni	29.7	31.1	30.4
Pb	23.8	23.2	23.5
Sb	0.82	0.81	0.81
Se	3.97	3.44	3.71
Sn	1.48	1.13	1.31
Th	3.88	3.83	3.86
Tl	0.95	0.96	0.96
U	7.87	7.64	7.76
V	67.7	72.1	69.9
Zn	51.4	51.7	51.6

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ANALYTICAL LABORATORY
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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS COLUMN FLOTATION CONCENTRATE 2736* ILL. #1 SEAM

SAMPLE NUMBER CWK #441

DATE LOGGED *02/14/94*
DATE COMPLETED 04/08/94
PROJECT NUMBER *1621-013-013*
ANALYTICAL NUMBER 940613

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	7.20
VOLATILE MATTER	38.42
FIXED CARBON	54.38
SULFUR, TOTAL	2.85
BTU	13544
MAF BTU	14595

SULFUR FORMS	(Dry)%
PYRITIC	0.99
SULFATE	0.04
ORGANIC	1.82
SULFUR, TOTAL	2.85

ULTIMATE	(Dry)%
CHLORINE	0.375
SULFUR	2.85
ASH	7.20

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	48.43
Al_2O_3	20.87
TiO_2	1.38
Fe_2O_3	19.70
CaO	2.59
MgO	1.27
Na_2O	0.84
K_2O	2.76
P_2O_5	0.16
SO_3	2.59
UND	-0.59

AS DETERMINED MOISTURE: 1.79 %
DISTRIBUTION:
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Trace Element Report

CONSOL Inc.
Research and Development
4000 Brownsville Road
Library, PA 15129

04/04/94

Submitted By: DISTRIBUTION
Project No. : 1621- 13- 13

Description : DOE/ICF KE 24 HR CONT. TESTS COLUMN FLOTATION
CONCENTRATE – 2736 ILL. #6 SEAM
Anal. No. : 940613

	VAL1	VAL2	Average
As	3.46	3.45	3.46
Ba	37.2	38.4	37.8
Be	1.52	1.48	1.50
Cd	0.24	0.25	0.25
Co	3.59	3.57	3.58
Cr	24.8	24.7	24.8
Cu	10.0	9.85	9.93
F	63.0	58.2	60.6
Hg	0.09	0.09	0.09
Li	7.63	7.75	7.69
Mn	20.9	20.8	20.9
Mo	15.5	15.7	15.6
Ni	17.2	17.0	17.1
Pb	20.1	20.1	20.1
Sb	0.55	0.54	0.55
Se	3.44	3.14	3.29
Sn	0.71	0.73	0.72
Th	2.16	2.11	2.14
Tl	0.72	0.72	0.72
U	8.75	8.71	8.73
V	43.6	43.6	43.6
Zn	22.9	22.8	22.9

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DESCRIPTION *DOE/ICF KE 24 HR CONT. TESTS COLUMN FLOTATION TAILINGS 2737* ILL. #6 SEAM

SAMPLE NUMBER CWK #442

DATE LOGGED *02/14/94*
DATE COMPLETED 04/08/94
PROJECT NUMBER 1621-013-013
ANALYTICAL NUMBER 940614

ANALYSIS REPORT

PROXIMATE	(Dry)%
ASH	71.34
VOLATILE MATTER	15.48
FIXED CARBON	13.18
SULFUR, TOTAL	2.84
BTU	3430
MAF BTU	11968

SULFUR FORMS	(Dry)%
PYRITIC	1.97
SULFATE	0.09
ORGANIC	0.78
SULFUR, TOTAL	2.84

ULTIMATE	(Dry)%
CHLORINE	0.048
SULFUR	2.84
ASH	71.34

MAJOR ASH ELEM IGNITED AT 750 C	%
SiO_2	60.64
Al_2O_3	19.96
TiO_2	0.65
Fe_2O_3	9.99
CaO	2.46
MgO	1.77
Na_2O	0.45
K_2O	3.72
P_2O_5	0.19
SO_3	1.33
UND	-1.16

AS DETERMINED MOISTURE: 1.46 %

DISTRIBUTION:

C. KOCH R. KOSKY

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Trace Element Report

CONSOL Inc.
Research and Development
4000 Brownsville Road
Library, PA 15129

04/04/94

Submitted By: DISTRIBUTION
Project No. : 1621- 13- 13

Description : DOE/ICF KE 24 HR CONT. TESTS COLUMN FLOTATION
TAILINGS - 2737

Anal. No. : 940614 ILL. #6 SEAM

	VAL1	VAL2	Average
As	10.6	10.2	10.4
Ba	395	393	394
Be	2.76	2.77	2.77
Cd	1.17	1.22	1.20
Co	14.0	14.1	14.1
Cr	140	146	143
Cu	40.4	41.1	40.8
F	855	870	863
Hg	0.15	0.15	0.15
Li	38.3	37.8	38.1
Mn	249	232	241
Mo	16.8	17.9	17.4
Ni	70.6	73.6	72.1
Pb	44.2	44.1	44.2
Sb	1.57	1.62	1.60
Se	6.83	6.99	6.91
Sn	2.98	3.58	3.28
Th	9.51	9.57	9.54
Tl	1.79	1.79	1.79
U	6.63	6.45	6.54
V	137	141	139
Zn	144	146	145