TECHNICAL PROGRESS REPORT

DOE/PC/95154--T4

# PRECOMBUSTION REMOVAL OF HAZARDOUS AIR POLLUTANT PRECURSORS

Contract No.: DE-AC22-95PC95154

Technical Project Report for the Third Quarter
July 1, 1996 -- September 30, 1996


Prime Contractor:

Department of Mining and Minerals Engineering
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Blacksburg, Virginia 24061-0239

Subcontractors:

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Southern Illinois University at Carbondale
Electric Power Research Institute
Consol Inc.




Prepared for:

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Date Submitted: September 19, 1996

# DISCLAIMER

## ABSTRACT

This project involves the development of an optimized, bench-scale processing circuit capable of efficiently removing trace elements from run-of-mine coals. The optimized circuit will be developed using characterization data obtained from detailed washability studies and release analyses tests conducted with several eastern U.S. coals. The optimized circuit will incorporate a variety of conventional and advanced coal cleaning processes which are believed to be the most cost-effective and commercially viable. The coal products from the optimized circuit will be further treated with complexing agents specifically designed to extract organometallic trace elements that are difficult to remove by physical cleaning operations. Finally, innovative bioremediation schemes will be investigated as a means of controlling the release of trace elements from the process waste streams. Emphasis has been placed on the development of a processing circuit which (i) maximizes the rejection of trace elements, (ii) minimizes the production of coal fines which are costly to process and less marketable, and (iii) minimizes the downstream impacts of the process waste streams on the environment.

During the past quarter, several key subtasks were completed in accordance with the project work plan. Most of the characterization tests for the Pittsburgh No. 8 coal have now been concluded. These include all activities associated with Subtasks 3.2 - Washability Analysis, 3.3 - Flotation Release Analysis, and 3.4 - SEM/Image Analysis. The resultant coal products from these tests have been submitted for trace element analyses should be available during the next quarter. A large portion of the bench-scale test work was also completed during the past quarter for the Pittsburgh No. 8 coal under Subtask 4.1 - Heavy Media Testing. Additional bench-scale tests are underway as outlined in Subtask 4.2 - Froth Flotation and 4.3 - Enhanced Gravity Separation. The data from these tests should be completed by the end of the next quarter. Finally, experiments conducted under Subtasks 6.1 - Analysis of Pond Toxics and 6.2 - Control Method Evaluation using samples of refuse from the Pittsburgh No. 8 seam indicate that significant reductions (up to 90%) in trace element content can be achieved through the application of microbial mats. Follow-up tests are currently underway.

## BACKGROUND

Coal preparation is widely regarded a cost-effective method for reducing the amounts of potentially hazardous air pollutant precursors (HAPPs) which occur as trace elements in run-of-mine coals. Unfortunately, many existing coal preparation plants are inefficient in removing trace elements because of poor circuit design and inadequate liberation of coal and mineral matter. These shortcomings are often difficult to correct in the absence of characterization data regarding the mineralogical association and washability of trace elements in run-of-mine coals.

In the present work, detailed trace element characterization studies will be conducted using samples from three different coal producing regions in the U.S. Using the characterization data, size classes, density fractions, etc., will be identified that are capable of meeting the desired trace element cleanup levels using low-cost conventional technologies such as heavy media bath, cyclones, spirals, etc. Composite (middling) particles that do not meet these criteria will be pulverized to improve liberation and subjected to a second series of characterization studies. This information will be used to determine whether additional clean coal can be recovered from the middlings fractions.

Based on input provided by the industrial participants, one of the three base coal samples will be selected and subjected to a series of bench-scale tests using a wide variety of advanced physical separation processes. Processes evaluated in the bench-scale study will include column flotation cells and enhanced centrifugal gravity separators. These processes are believed to have the highest overall probability of gaining industrial acceptance. Data obtained from the bench-scale tests will be used to design optimum circuit configurations for the removal of trace elements. The various types of fine coal processing technologies may be combined in series to achieve high rejections of trace elements without ultrafine grinding.

To further enhance the removal of trace elements, the clean coal products from the bench-scale tests will be treated using complexing agents. These reagents are designed to combine with specific elements and increase their effective solubility range. This "polishing" step will allow for the incremental removal of organically bound or poorly liberated trace elements that cannot be rejected by physical cleaning. In addition, some of the waste streams from the bench-scale tests will be subjected to a variety of laboratory tests to formulate strategies for controlling the release of trace elements discarded into refuse impoundments. Finally, the data obtained from the characterization studies and bench-scale tests will be used to develop a conceptual design for a proof-of-concept (POC) plant which maximizes coal recovery and trace element rejection.

## PROJECT OBJECTIVES

The primary objective of this project is to develop and evaluate an advanced coal cleaning circuit that is capable of removing hazardous air pollutant precursors from run-of-mine coals in an efficient and cost-effective manner. Specific objectives of Phase I activities are (i) to determine the types and relative amounts of trace elements present in several eastern U.S. coals, (ii) to devise and test bench-scale circuits capable of maximizing the recovery of coal and the rejection of trace elements, (iii) to develop reliable performance data, operating guidelines and scale-up criteria for the proposed circuits, and (iv) to formulate strategies which minimize the downstream impact of trace elements on the effluent streams from the refuse impoundment.

## PROJECT TASKS

### Task 1 - Project Planning

#### *Subtask 1.2 - Project Reporting*

All status, management and technical reports for the project required during the past quarter have been submitted in a timely fashion to DOE. No delays are currently anticipated in meeting future reporting requirements.

Task 2 - Sample Acquisition

All activities related to coal acquisition have been completed. This includes the selection, procurement and preparation of run-of-mine coal samples from the Pittsburgh No. 8, Illinois No. 6 and Coalburg seams. Task 2 is now considered to be complete.

Task 3 - Characterization

*Subtask 3.1 - Preliminary Analyses*

Preliminary analyses (proximate and ultimate) of the various base coal samples were conducted at off-campus laboratories. The results of these analyses are still pending and will be reported after the data has been tabulated, mass balanced and reviewed.

*Subtask 3.2 - Washability Analyses*

Float-sink tests were completed for the coal sample from the Pittsburgh No. 8 seam during the past quarter. An overview of the particle size classes that were subjected to float-sink testing is provided in Figure 3.1. As shown, the feed coal was subdivided into 50 x 10 mm, 10 mm x 28 mesh, 28 x 100 mesh and 270 mesh x 0 size fractions. The 1.4 x 2.0 SG middlings product from the 50 x 10 mm size class was recovered and dried, crushed to below 10 mm, and wet-sieved into 10 mm x 28 mesh, 28 x 100 mesh, 100 x 270 mesh and 270 mesh x 0 size fractions. Figure 3.2 shows the mass percentages that were obtained by this procedure. Figure 3.3 shows the resultant particle size distributions for (i) the 50 mm x 0 run-of-mine feed coal, (ii) the crushed 1.4 x 2.0 SG middlings and (iii) the composite coal sample after the addition of the crushed middlings to the run-of-mine feed. The float-sink characterization data indicate that the Pittsburgh No. 8 coal is relatively well liberated since only about 5% of the feed coal reported as middlings in the 1.4 x 2.0 SG density class.

Tables 3.1 and 3.2 summarize the float-sink data for both the run-of-mine feed and crushed middlings samples, respectively. The data have been mathematically composited in Table 3.3 to illustrate the cleanability which may be achieved when these two products are combined. Only the ash and sulfur values have been included in this report since the pyritic sulfur analyses and heating value determinations were not fully completed at the time this document was prepared. The results of the ash and sulfur analyses cumulated as a function of particle size class are plotted in Figures 3.4-3.9. Performance curves which include the 270 mesh x 0 coal were not included since the evaluation of the 270 mesh x 0 release analysis data were not complete at this time. However, the float-sink data for the coarser size fractions (which represent the bulk of the coal tonnage) indicate that the cumulative clean coal yield (mass recovery) can be increased by up to approximately 1 percentage point via recrushing and retreatment of the middlings products. For a fully utilized 500 ton/hr processing circuit, this would correspond to approximately $675,000 (i.e., 500 ton/hr x 90% availability x 1% additional yield x $25/ton x 6000 hr/yr = $675,000/yr) of addition clean coal

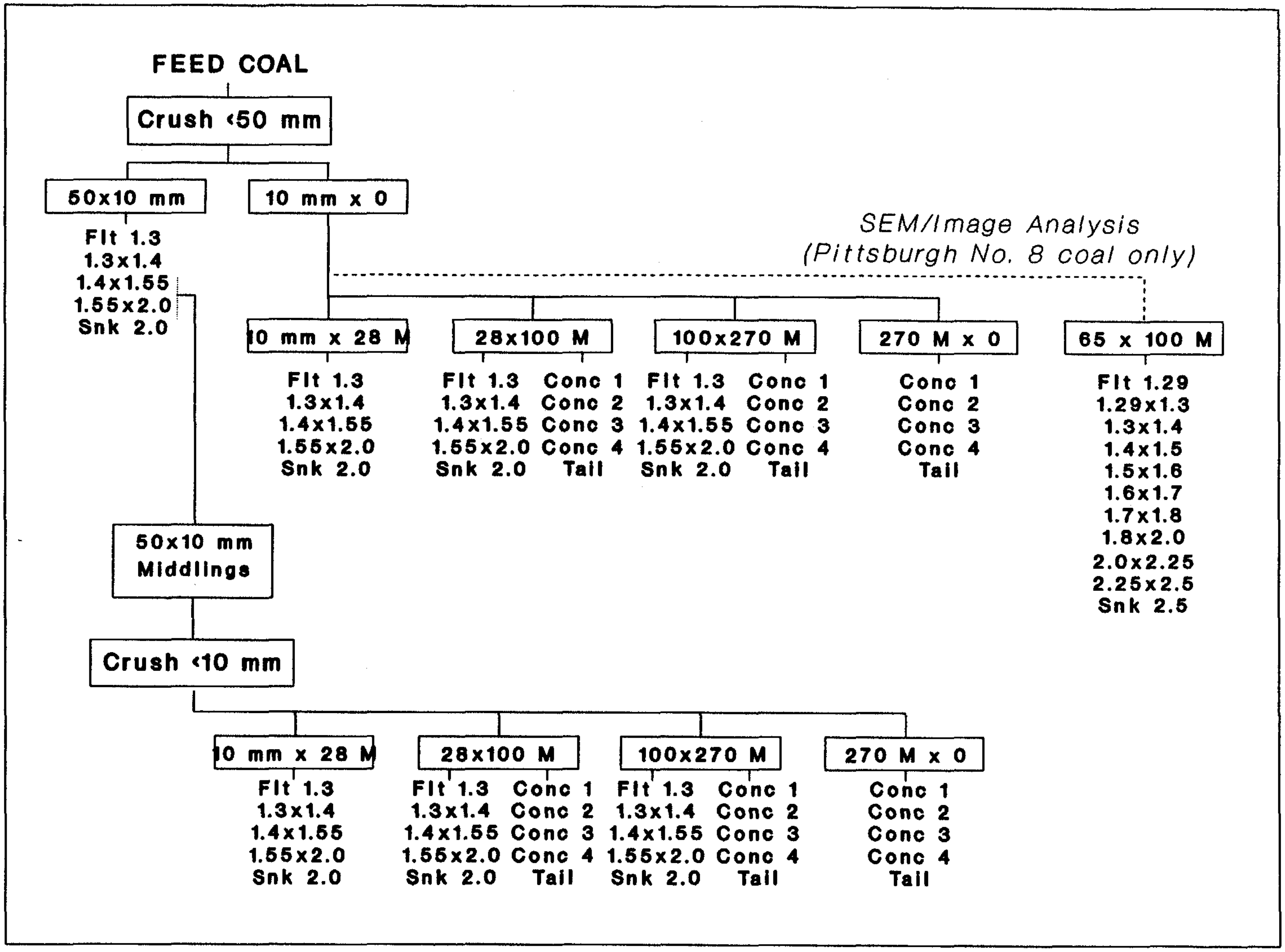



Figure 3.1 – Schematic overview of float-sink and release analysis test procedures.

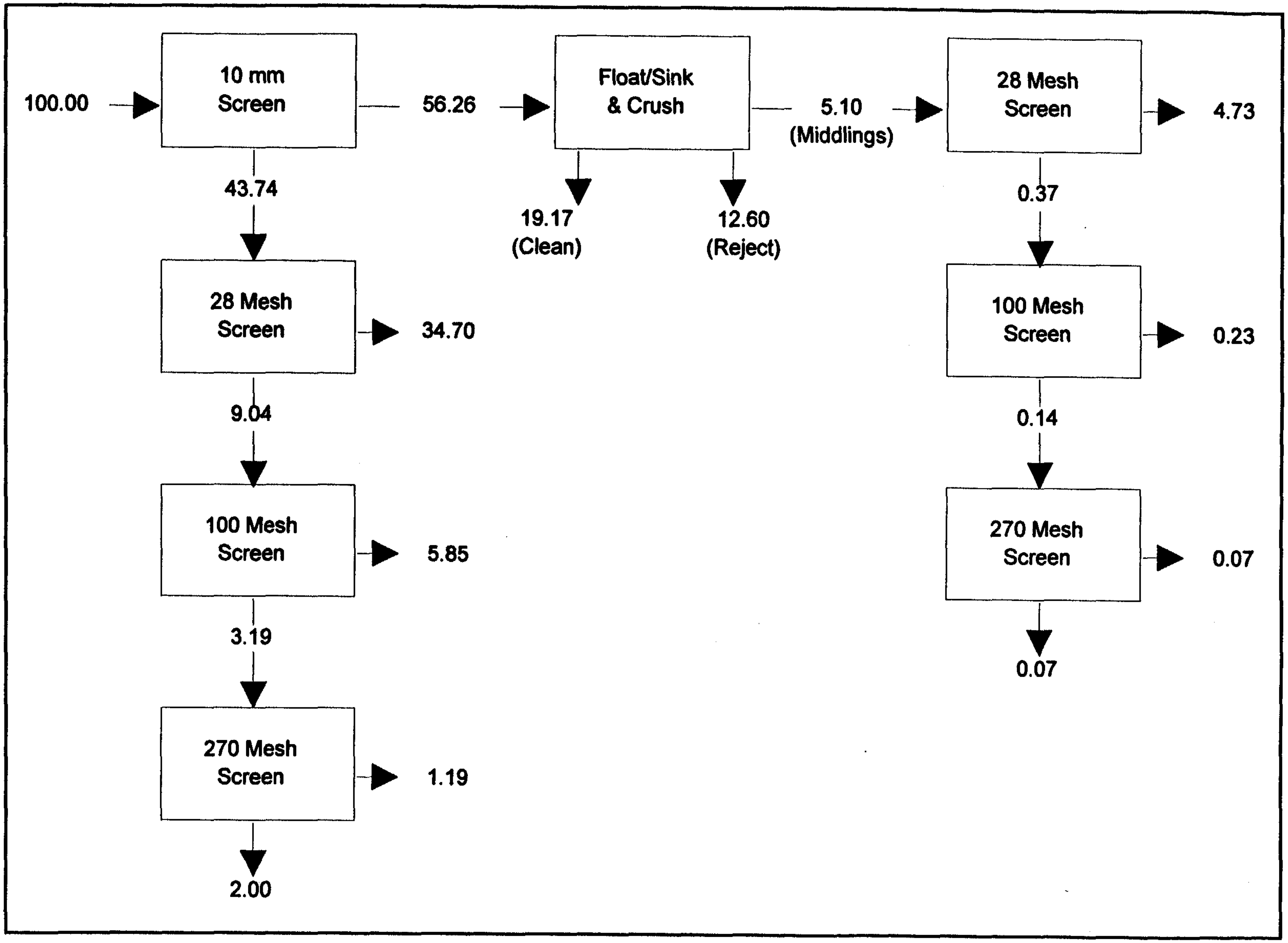



Figure 3.2 - Mass splits obtained during the characterization testing of the Pittsburgh No. 8 coal.

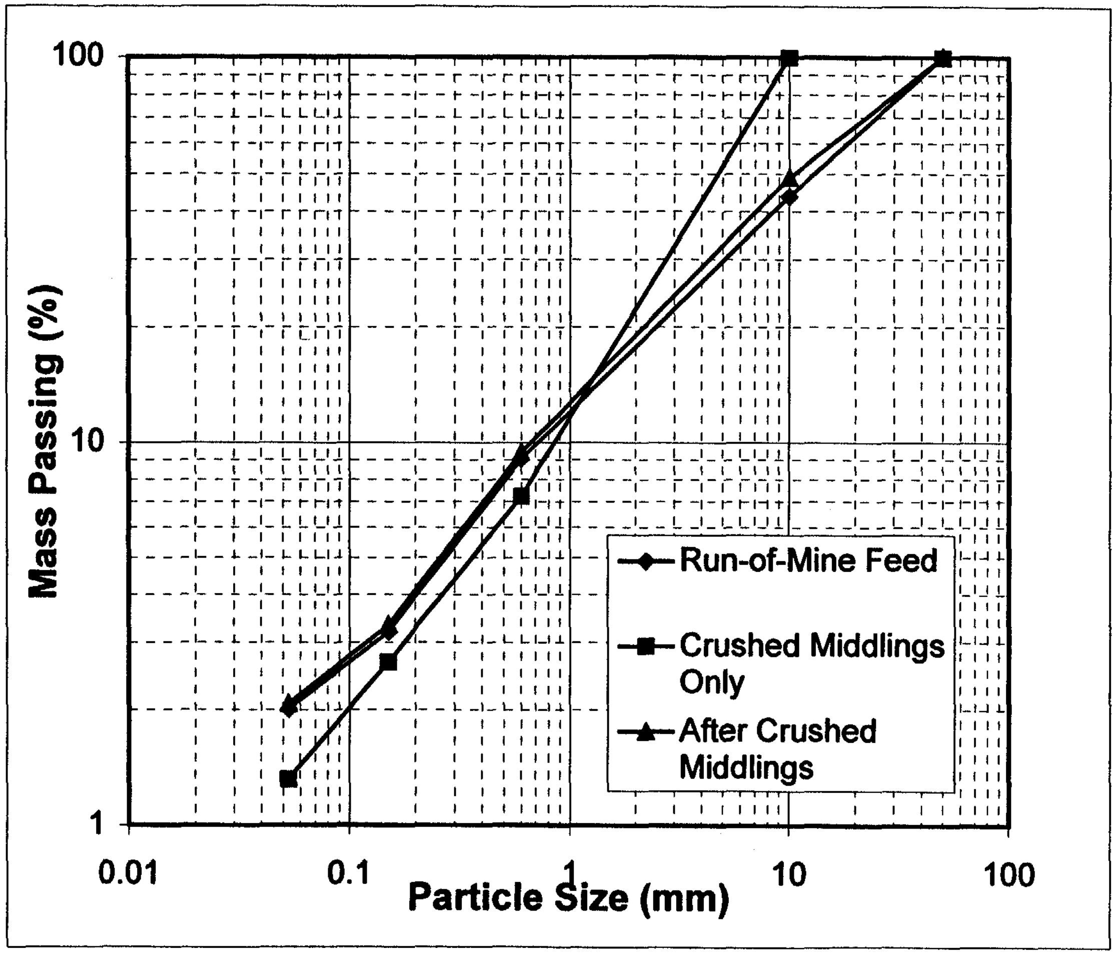



Figure 3.3 - Particle size distributions obtained using the Pittsburgh No. 8 coal.

Table 3.1 - Float-sink results for the run-of-mine Pittsburgh No. 8 coal.

**Class:** 50 x 10 mm **Mass (%):** 56.26

| | | Individual | | | | | |
|---|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Weight (Normal) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 34.07 | 19.17 | 4.52 | 1.96 | 0.00 | 0.00 |
| 1.30 | 1.40 | 34.47 | 19.39 | 8.03 | 3.16 | 0.00 | 0.00 |
| 1.40 | 1.55 | 5.57 | 3.13 | 20.43 | 4.66 | 0.00 | 0.00 |
| 1.55 | 2.00 | 3.50 | 1.97 | 41.88 | 5.59 | 0.00 | 0.00 |
| 2.00 | | 22.39 | 12.60 | 85.82 | 4.33 | 0.00 | 0.00 |
| | | 100.00 | 56.26 | 26.13 | 3.18 | 0.00 | 0.00 |

**Class:** 10 mm x 28 M **Mass (%):** 34.70

| | | Individual | | | | | |
|---|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Weight (Normal) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 47.89 | 16.62 | 3.42 | 1.57 | 0.00 | 0.00 |
| 1.30 | 1.40 | 32.93 | 11.43 | 7.24 | 2.74 | 0.00 | 0.00 |
| 1.40 | 1.55 | 3.63 | 1.26 | 17.99 | 6.36 | 0.00 | 0.00 |
| 1.55 | 2.00 | 2.97 | 1.03 | 37.09 | 8.55 | 0.00 | 0.00 |
| 2.00 | | 12.57 | 4.36 | 84.68 | 6.51 | 0.00 | 0.00 |
| | | 99.99 | 34.70 | 16.42 | 2.96 | 0.00 | 0.00 |

**Class:** 28 x 100 M **Mass (%):** 5.85

| | | Individual | | | | | |
|---|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Weight (Normal) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 39.32 | 2.30 | 2.79 | 1.45 | 0.00 | 0.00 |
| 1.30 | 1.40 | 36.70 | 2.15 | 7.01 | 1.84 | 0.00 | 0.00 |
| 1.40 | 1.55 | 9.03 | 0.53 | 13.83 | 3.62 | 0.00 | 0.00 |
| 1.55 | 2.00 | 4.56 | 0.27 | 32.48 | 6.92 | 0.00 | 0.00 |
| 2.00 | | 10.38 | 0.61 | 75.68 | 14.27 | 0.00 | 0.00 |
| | | 99.99 | 5.85 | 14.26 | 3.37 | 0.00 | 0.00 |

**Class:** 100 x 270 M **Mass (%):** 1.19

| | | Individual | | | | | |
|---|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Weight (Normal) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 2.77 | 0.03 | 5.49 | 1.64 | 0.00 | 0.00 |
| 1.30 | 1.40 | 59.04 | 0.70 | 6.85 | 1.53 | 0.00 | 0.00 |
| 1.40 | 1.55 | 12.49 | 0.15 | 13.40 | 2.15 | 0.00 | 0.00 |
| 1.55 | 2.00 | 9.72 | 0.12 | 26.61 | 3.29 | 0.00 | 0.00 |
| 2.00 | | 15.98 | 0.19 | 75.62 | 18.70 | 0.00 | 0.00 |
| | | 100.00 | 1.19 | 20.54 | 4.53 | 0.00 | 0.00 |

Table 3.2 - Float-sink results for the Pittsburgh No. 8 crushed middlings.

**Class:** 50 x 10 mm **Mass (%):** 0.00

| | | Individual | | | | | |
|---|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Weight (Normal) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1.30 | 1.40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1.40 | 1.55 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1.55 | 2.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.00 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**Class:** 10 mm x 28 M **Mass (%):** 4.73

| | | Individual | | | | | |
|---|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Weight (Normal) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 11.37 | 0.54 | 6.29 | 1.97 | 0.00 | 0.00 |
| 1.30 | 1.40 | 23.73 | 1.12 | 10.52 | 3.14 | 0.00 | 0.00 |
| 1.40 | 1.55 | 28.62 | 1.35 | 22.73 | 5.46 | 0.00 | 0.00 |
| 1.55 | 2.00 | 27.76 | 1.31 | 42.73 | 6.18 | 0.00 | 0.00 |
| 2.00 | | 8.52 | 0.40 | 63.64 | 12.40 | 0.00 | 0.00 |
| | | 100.00 | 4.73 | 27.00 | 5.30 | 0.00 | 0.00 |

**Class:** 28 x 100 M **Mass (%):** 0.23

| | | Individual | | | | | |
|---|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Weight (Normal) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 27.14 | 0.06 | 2.93 | 1.57 | 0.00 | 0.00 |
| 1.30 | 1.40 | 27.59 | 0.06 | 8.31 | 2.26 | 0.00 | 0.00 |
| 1.40 | 1.55 | 15.96 | 0.04 | 18.07 | 3.60 | 0.00 | 0.00 |
| 1.55 | 2.00 | 16.22 | 0.04 | 38.80 | 5.34 | 0.00 | 0.00 |
| 2.00 | | 13.09 | 0.03 | 65.89 | 19.60 | 0.00 | 0.00 |
| | | 100.00 | 0.23 | 20.89 | 5.06 | 0.00 | 0.00 |

**Class:** 100 x 270 M **Mass (%):** 0.07

| | | Individual | | | | | |
|---|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Weight (Normal) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 2.66 | 0.00 | 4.61 | 1.67 | 0.00 | 0.00 |
| 1.30 | 1.40 | 31.55 | 0.02 | 6.26 | 1.71 | 0.00 | 0.00 |
| 1.40 | 1.55 | 29.53 | 0.02 | 15.16 | 2.36 | 0.00 | 0.00 |
| 1.55 | 2.00 | 21.38 | 0.01 | 37.73 | 3.50 | 0.00 | 0.00 |
| 2.00 | | 14.89 | 0.01 | 70.65 | 22.57 | 0.00 | 0.00 |
| | | 100.01 | 0.07 | 25.16 | 5.39 | 0.00 | 0.00 |

Table 3.3 - Data obtained by adding crushed middlings to the run-of-mine feed.

**Class:** 50 x 10 mm **Mass (%):** 51.16

| | | Individual | | | | | |
|---|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Weight (Normal) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 37.47 | 19.17 | 4.52 | 1.96 | 0.00 | 0.00 |
| 1.30 | 1.40 | 37.91 | 19.39 | 8.03 | 3.16 | 0.00 | 0.00 |
| 1.40 | 1.55 | 0.00 | 0.00 | 20.43 | 4.66 | 0.00 | 0.00 |
| 1.55 | 2.00 | 0.00 | 0.00 | 41.88 | 5.59 | 0.00 | 0.00 |
| 2.00 | | 24.62 | 12.60 | 85.82 | 4.33 | 0.00 | 0.00 |
| | | 100.00 | 51.16 | 25.87 | 3.00 | 0.00 | 0.00 |

**Class:** 10 mm x 28 M **Mass (%):** 39.44

| | | Individual | | | | | |
|---|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Weight (Normal) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 33.54 | 17.16 | 3.51 | 1.58 | 0.00 | 0.00 |
| 1.30 | 1.40 | 24.53 | 12.55 | 7.53 | 2.78 | 0.00 | 0.00 |
| 1.40 | 1.55 | 5.11 | 2.61 | 20.45 | 5.89 | 0.00 | 0.00 |
| 1.55 | 2.00 | 4.58 | 2.34 | 40.25 | 7.22 | 0.00 | 0.00 |
| 2.00 | | 9.32 | 4.77 | 82.90 | 7.01 | 0.00 | 0.00 |
| | | 77.08 | 39.43 | 17.69 | 3.24 | 0.00 | 0.00 |

**Class:** 28 x 100 M **Mass (%):** 6.08

| | | Individual | | | | | |
|---|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Weight (Normal) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 4.62 | 2.36 | 2.79 | 1.45 | 0.00 | 0.00 |
| 1.30 | 1.40 | 4.32 | 2.21 | 7.05 | 1.85 | 0.00 | 0.00 |
| 1.40 | 1.55 | 1.11 | 0.57 | 14.11 | 3.62 | 0.00 | 0.00 |
| 1.55 | 2.00 | 0.60 | 0.30 | 33.26 | 6.72 | 0.00 | 0.00 |
| 2.00 | | 1.25 | 0.64 | 75.21 | 14.52 | 0.00 | 0.00 |
| | | 11.89 | 6.08 | 14.51 | 3.43 | 0.00 | 0.00 |

**Class:** 100 x 270 M **Mass (%):** 1.25

| | | Individual | | | | | |
|---|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Weight (Normal) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 0.07 | 0.03 | 5.44 | 1.64 | 0.00 | 0.00 |
| 1.30 | 1.40 | 1.41 | 0.72 | 6.83 | 1.54 | 0.00 | 0.00 |
| 1.40 | 1.55 | 0.33 | 0.17 | 13.61 | 2.18 | 0.00 | 0.00 |
| 1.55 | 2.00 | 0.25 | 0.13 | 27.86 | 3.31 | 0.00 | 0.00 |
| 2.00 | | 0.39 | 0.20 | 75.37 | 18.90 | 0.00 | 0.00 |
| | | 2.45 | 1.25 | 20.79 | 4.57 | 0.00 | 0.00 |

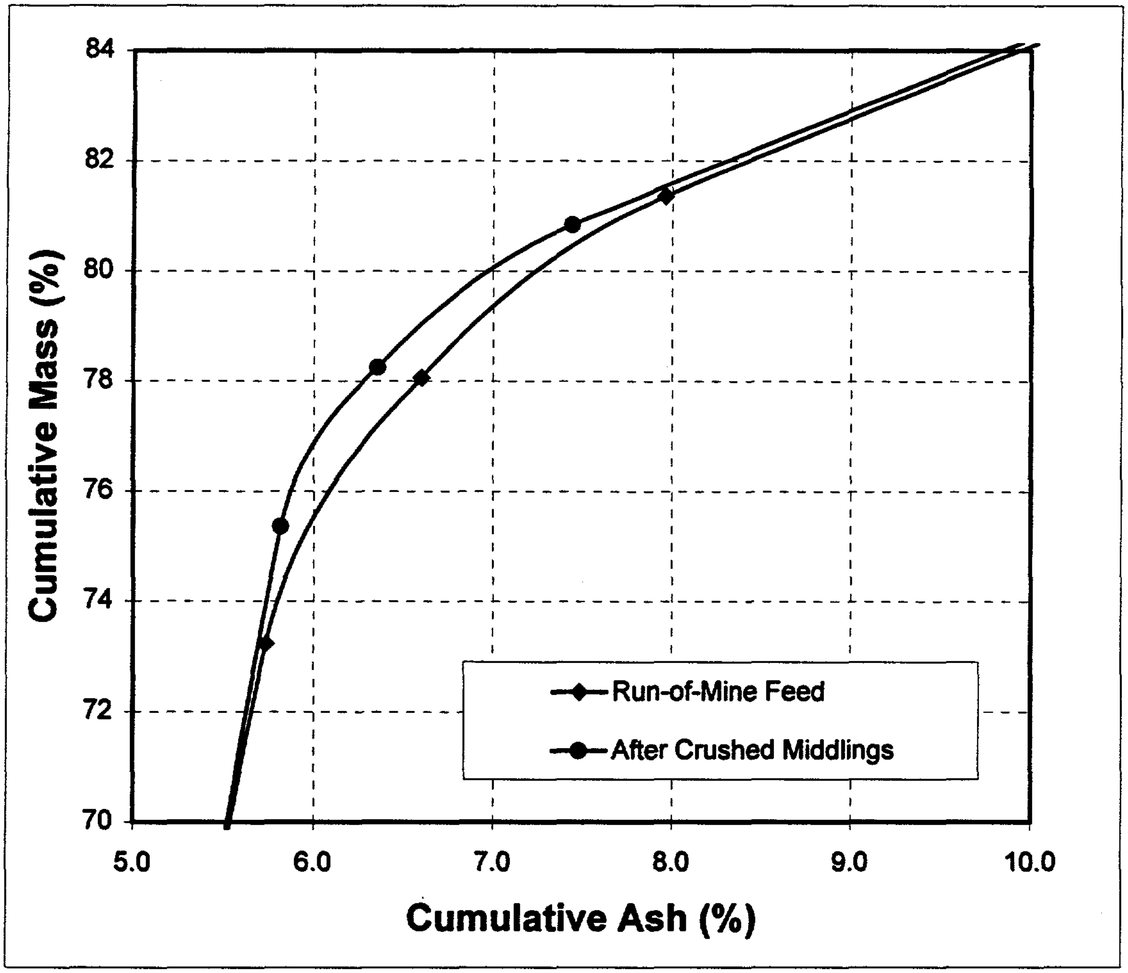



Figure 3.4 - Float-sink results for +28 mesh Pittsburgh No. 8 coal.

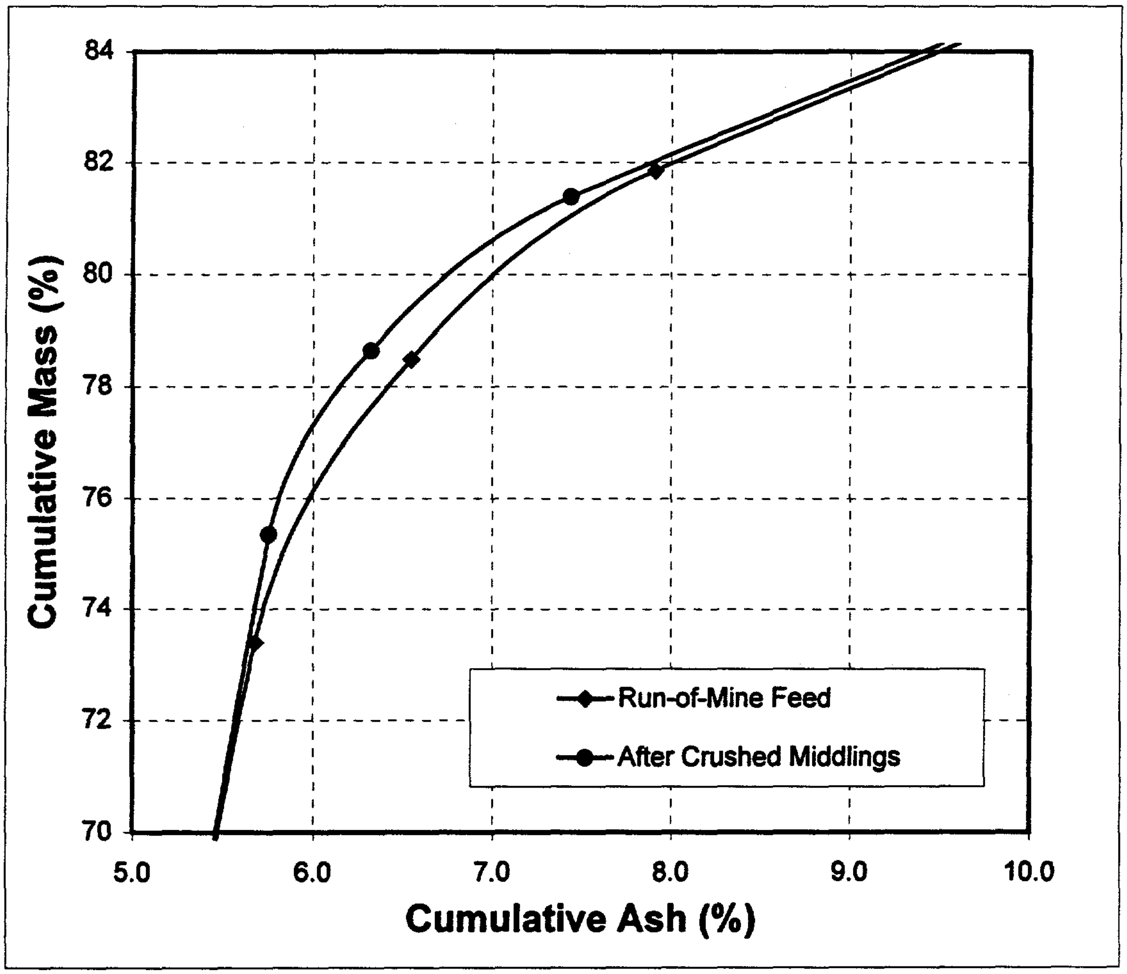



Figure 3.5 - Float-sink results for +100 mesh Pittsburgh No. 8 coal.

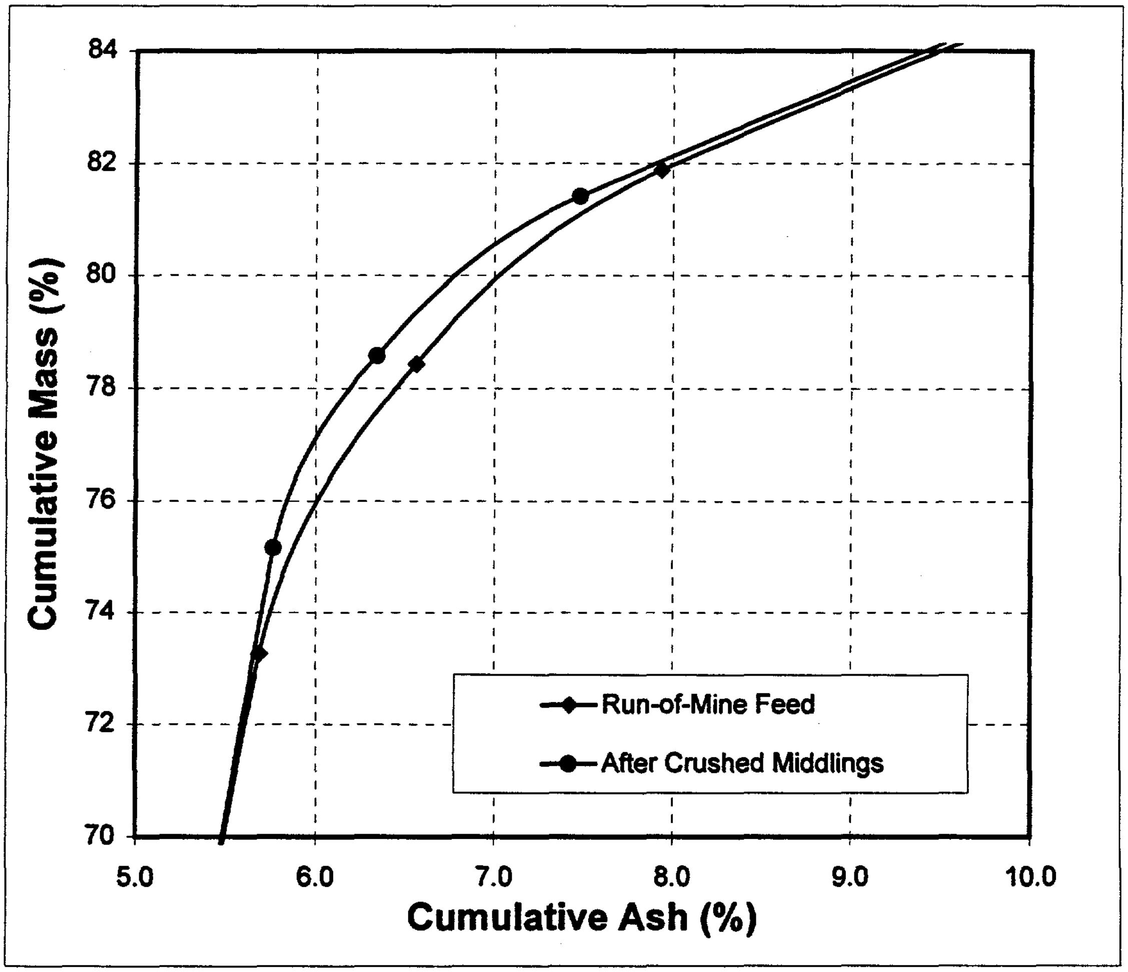



Figure 3.6 - Float-sink results for +270 mesh Pittsburgh No. 8 coal.

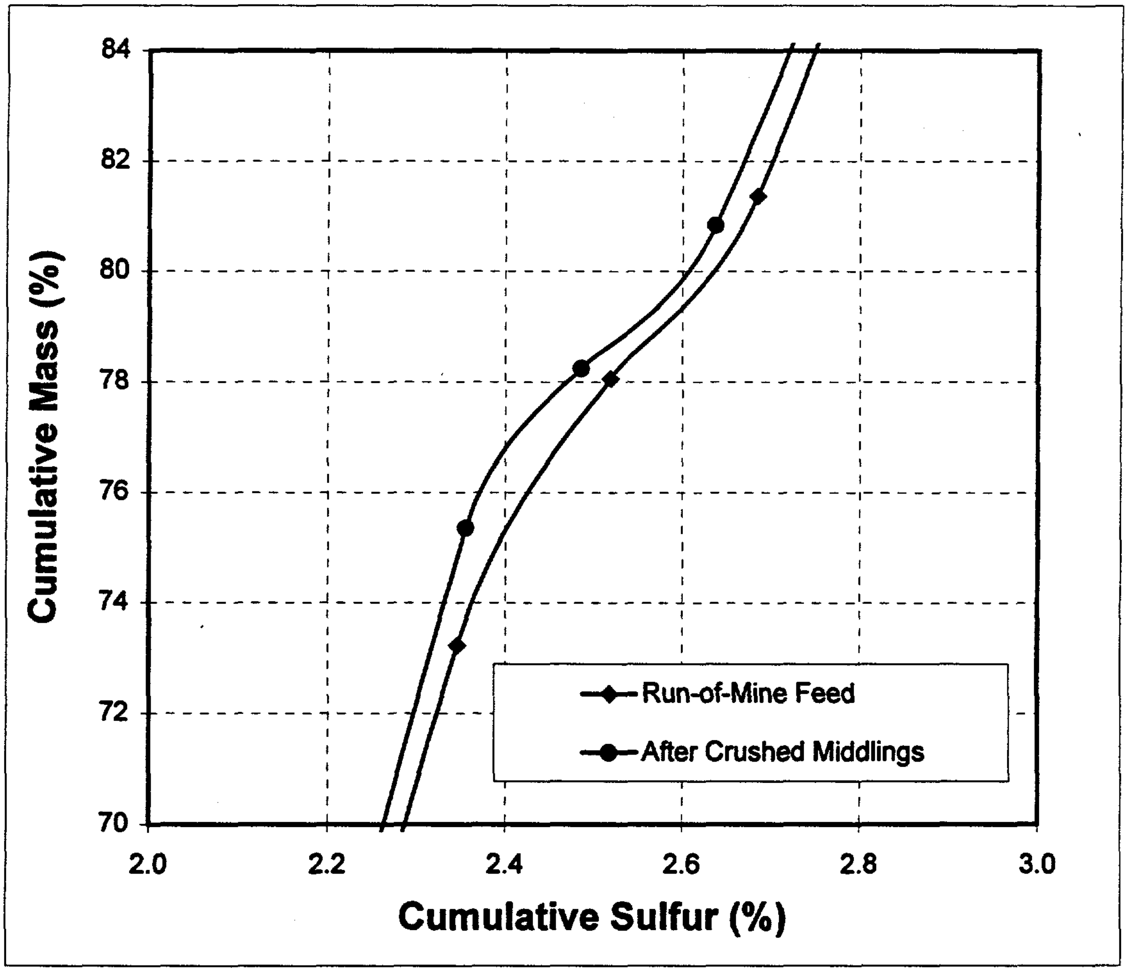



Figure 3.7 - Float-sink results for +28 mesh Pittsburgh No. 8 coal.

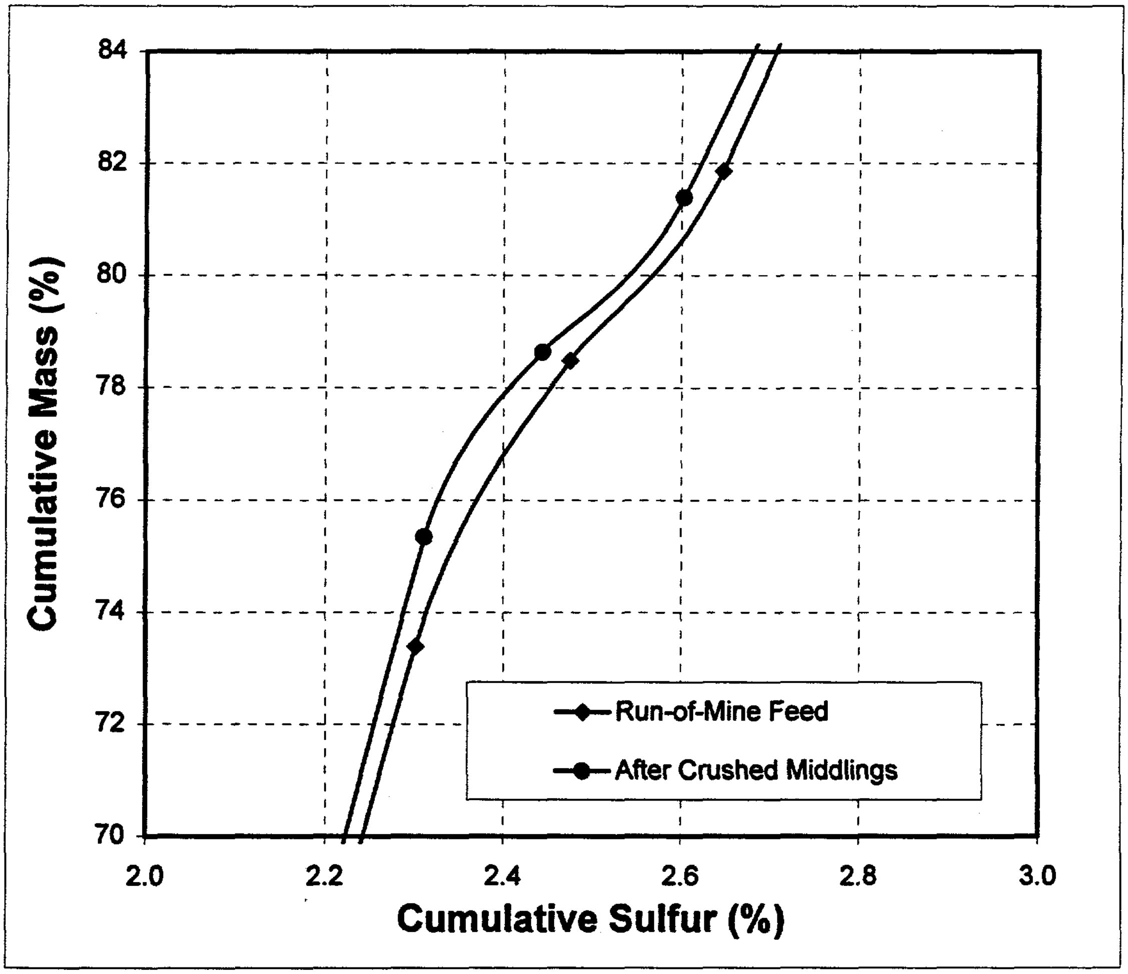



Figure 3.8 - Float-sink results for +100 mesh Pittsburgh No. 8 coal.

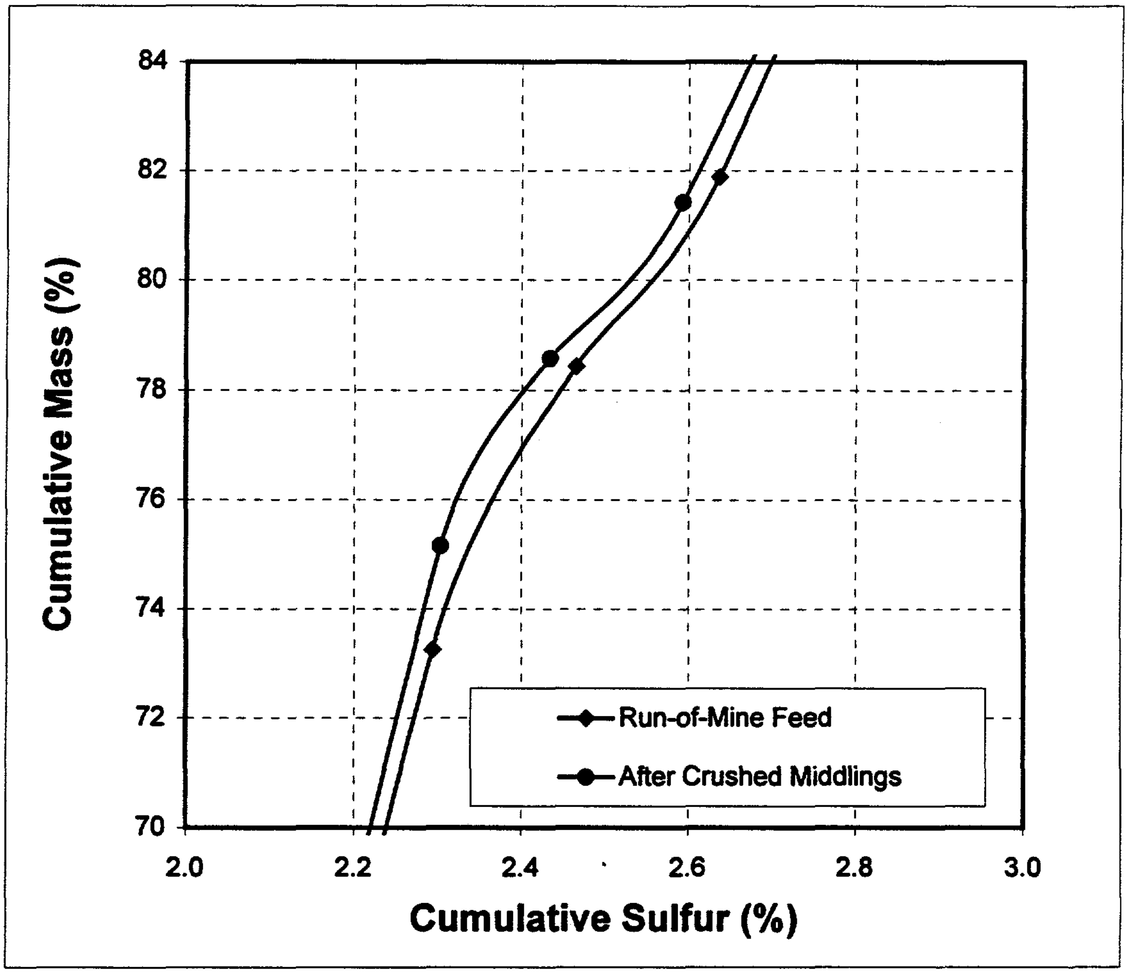



Figure 3.9 - Float-sink results for +270 mesh Pittsburgh No. 8 coal.

production at the same clean coal ash and sulfur. For reference, a summary of the particle size distribution data and density partitioning results are provided in Appendix I. Float-sink tests for the remaining base coal samples are continuing and should be completed prior to the submission of the next technical progress report. Trace element analyses are presently underway for all of the coal products.

*Subtask 3.3 - Release Analyses*

Flotation release analysis tests have now been completed for the Pittsburgh No. 8 coal. The test data are summarized in Appendix II. Figures 3.10 and 3.11 show the separation curves obtained for the run-of-mine feed sample as a function of particle size class (i.e., 28 x 100 mesh, 100 x 270 mesh and 270 mesh x 0 size fractions). In general, both the ash and sulfur rejections improved as particle size decreased due to enhanced liberation and an increase in the population of free mineral matter. Although the sulfur rejection curves for the 100 x 270 mesh and 270 mesh x 0 fractions did not follow this general trend, these curves are expected to be reversed once the sulfur values are converted to pyritic sulfur. For the finest size fraction, it was possible to achieve a combustible recovery of over 90% with corresponding ash and sulfur rejections of 95% and 55%, respectively.

The release analysis results for the fine coal fractions generated by the crushed middlings are provided in Figures 3.12 and 3.13. As with the run-of-mine samples, both the ash and sulfur rejections improved with a decrease in particle size. It should also be noted that the overall ash and sulfur rejections obtained for the crushed fines were generally inferior to those obtained with the run-of-mine feed. This difference may be largely attributed to the lower population of free mineral matter present in the recrushed middlings streams. It is encouraging to note that the test data obtained for the finest size fraction (270 mesh x 0) show that a combustible recovery of greater than 80% can be maintained at an ash and sulfur rejections of greater than 80% and 55%, respectively.

Computational procedures are presently underway to incorporate release analyses data with those obtained from the float-sink tests. These calculations are necessary to fully evaluate the benefits and adverse impacts of recrushing middlings on overall separation performance. It should also be noted that the laboratory release analysis tests and sample analyses are continuing for the remaining two base coal samples. The results of this work should be available prior to the completion of the next technical progress report. Trace element analyses are presently underway for all of the coal products.

*Subtask 3.4 - SEM/Image Analyses*

Characterization of the various density fractions obtained for narrowly-sized fractions of the Pittsburgh No. 8 coal was completed during the past quarter. The objective of this effort is to establish statistical correlations between trace element content and mineralogical composition. In this work, 65 x 100 mesh samples of the run-of-mine coal were subjected to float-sink testing using a Magstream separator. The resultant products were then analyzed by scanning electron spectroscopy (SEM) coupled with image analysis (IA).

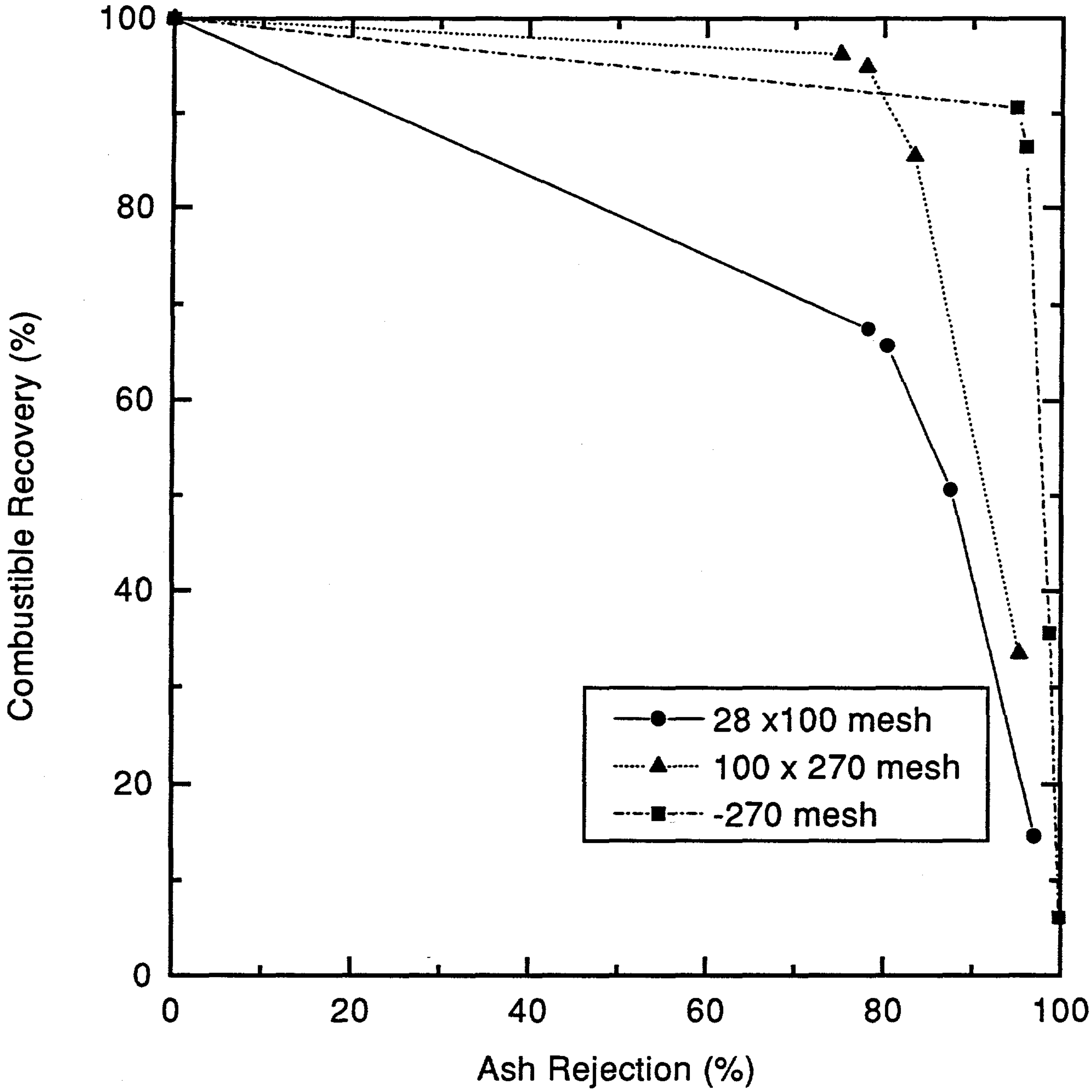



Figure 3.10 - Release analysis results for run-of-mine Pittsburgh No. 8 coal.

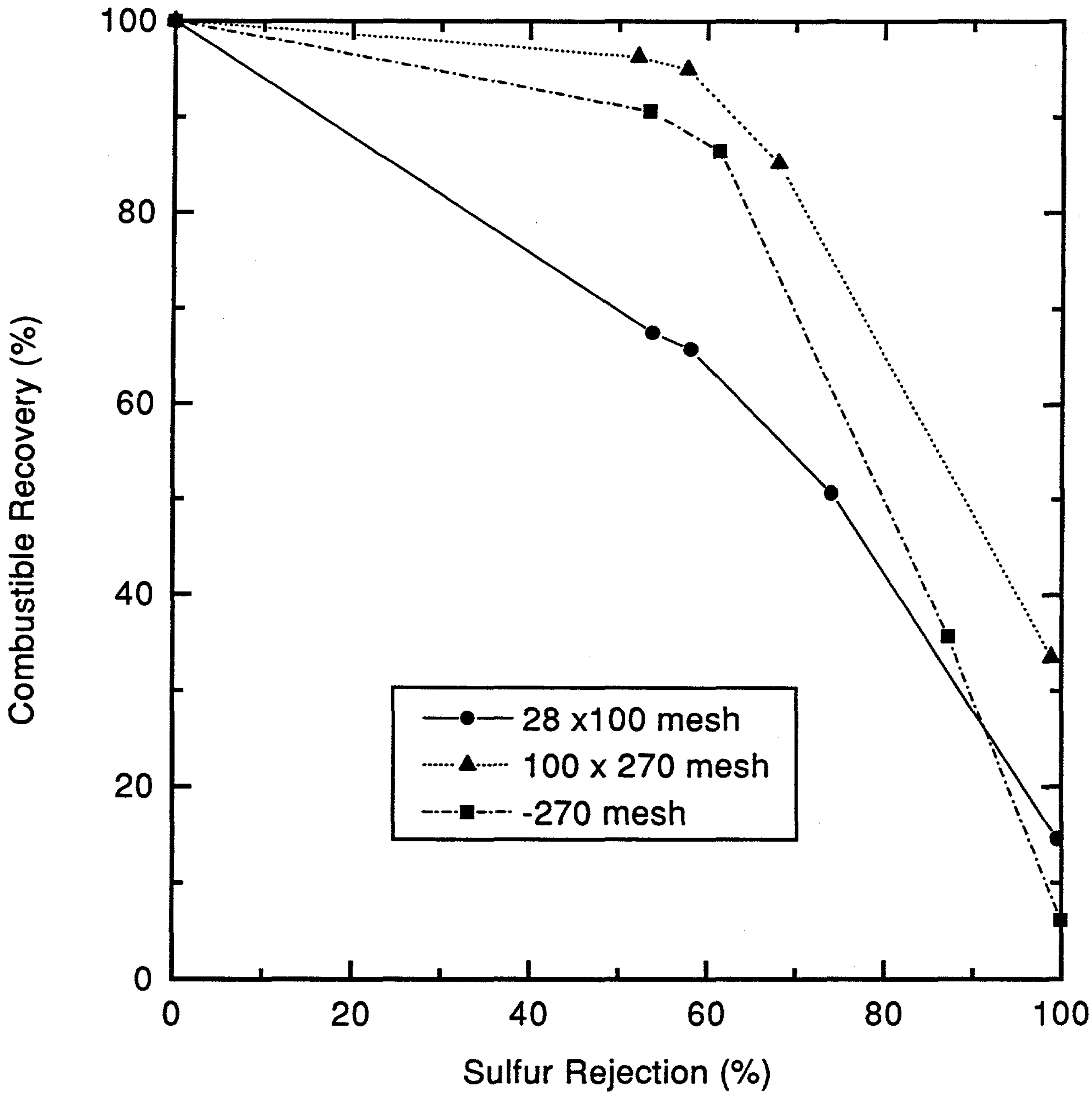



Figure 3.11 - Release analysis results for run-of-mine Pittsburgh No. 8 coal.

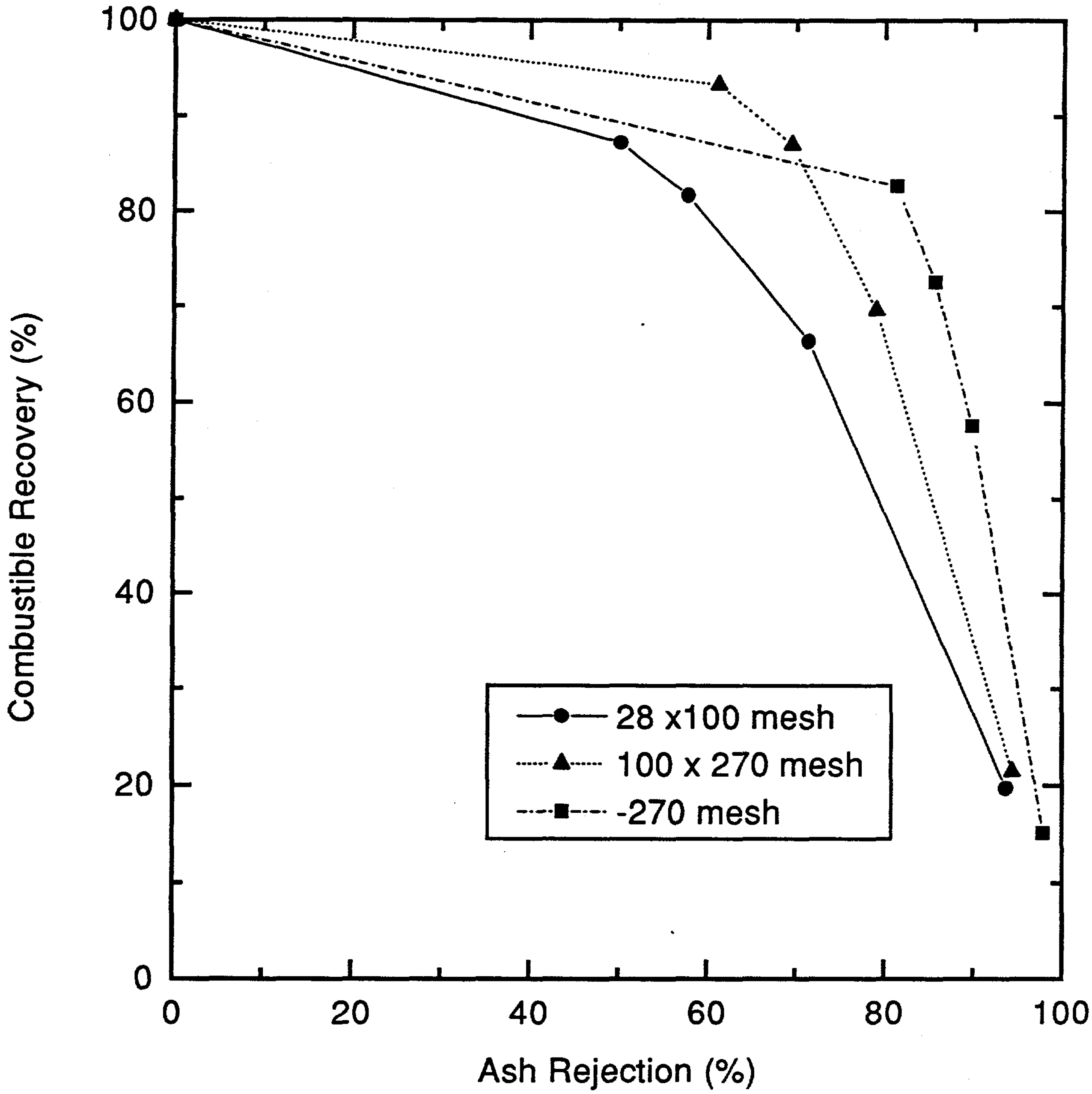



Figure 3.12 - Release analysis results for crushed middlings from the Pittsburgh No. 8 coal.

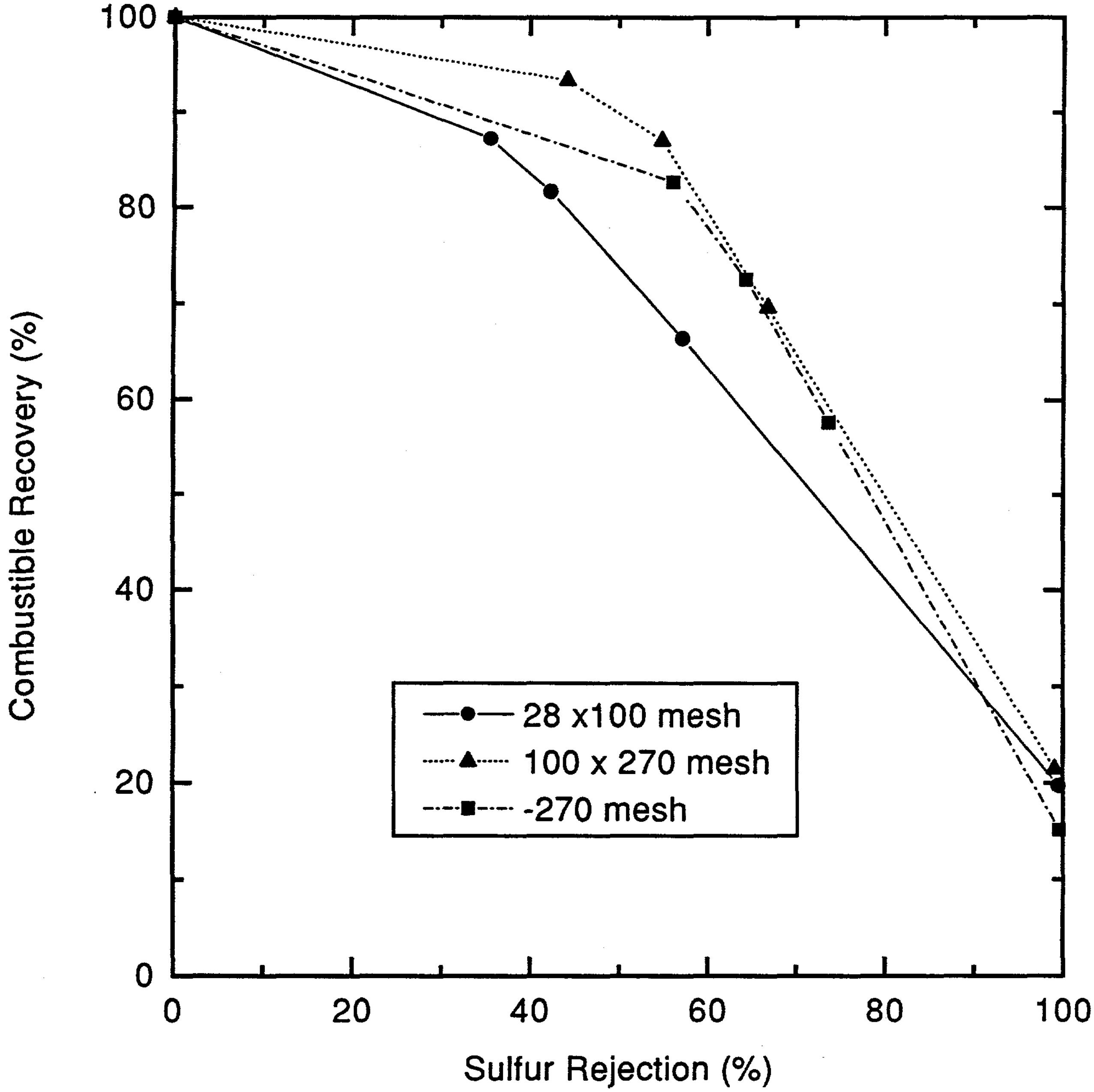



Figure 3.13 - Release analysis results for crushed middlings from the Pittsburgh No. 8 coal.

During the past quarter, mineralogical analyses were completed for the float 1.29, 1.29 x 1.30, 1.30 x 1.40, 1.40 x 1.50, 1.50 x 1.60, 1.60 x 1.70, 1.70 x 1.80, 1.80 x 2.00, 2.00 x 2.25, 2.25 x 2.50 and sink 2.50 specific gravity classes. Tables 3.4 and 3.5 show the breakdown of mineralogical components and coal quality indicators (i.e., ash, sulfur, etc.) for each of these specific gravity classes. As expected, the total mineral content increased as the specific gravity increased. In fact, Figure 3.14 shows that the well-known Parr formula (i.e., Mineral Matter = 1.08 (Ash) + 0.55 (Sulfur)) appears to be valid for this particular sample. Five primary mineral groups were identified during the mineralogical analyses, i.e., silicates, carbonates, phosphates, sulfides, sulfates and oxides. Of these, the dominant mineral group was the silicates (primarily quartz and clay). Analyses of the float-sink products for trace element content is presently under way. Detailed statistical evaluations of the mineralogical data will be conducted after completing the laboratory trace element analyses.

## Task 4 - Bench-Scale Testing

### *Subtask 4.1 - Dense Media*

The primary sizing step in the processing of the run-of-mine Pittsburgh No. 8 seam coal was completed during the past quarter. The screening of the sample was completed using a modified pilot-scale vibratory screen (see Figure 4.1). It was necessary to modify the screening system in order to allow for proper sampling and the simultaneous collection of the overflow and underflow streams. Rinse water was also introduced in order to clean the fines off of the oversized particles. All of the water was collected so that trace element balances could be completed. The screening procedure was carried out in accordance with guidelines outlined in the previous technical progress report. Figure 4.2 shows the results of the primary screening. As expected, slightly over half the sample mass reported to the oversize stream. The material balance data for this primary sizing unit operation are included in Appendix III.

Primary dense media work was also completed during the past quarter. Figure 4.3 shows the modified sand screw which served as the heavy media bath for the 50 x 10 mm and 10 mm x 28 mesh size fractions. This device required very little active media volume and provided for continuous removal of the coarse reject particles. The separator was operated in batch mode and used twice in series to generate a low-density clean coal product, a high-density reject product and a middlings product. As illustrated in Figure 4.4, the low-density product was generated from the 50 x 10 mm feed by adding sufficient magnetite to maintain a bath specific gravity of 1.35. The sink from the first stage of cleaning was collected and then fed into the second stage bath after adding sufficient magnetite to bring the specific gravity up to 2.0. From this second stage, both a reject (sink 2.0) and middlings (1.35 x 2.0 SG) fraction were produced. The test data show that a combustible recovery of approximately 96% was obtained when the clean coal and middling streams were combined. The material balance for this unit operation is provided in Appendix III. However, the material balance is incomplete pending the completion of the analysis of the magnetite stream to determine the amounts of coal and mineral matter that were lost during the magnetite drain and rinse steps.

Table 3.4 - Mineralogical data obtained by SEM analysis of 65 x 100 mesh Pittsburgh No. 8 coal.

| | Mass Percentage of Specific Gravity Fraction | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Float 1.29 | 1.29x1.30 | 1.30x1.40 | 1.40x1.50 | 1.50x1.60 | 1.60x1.70 | 1.70x1.80 | 1.80x2.00 | 2.00x2.25 | 2.25x2.50 | 2.50 Sink |
| SILICATES | | | | | | | | | | | |
| Quartz | 0.195 | 0.370 | 1.068 | 2.929 | 2.788 | 6.995 | 8.123 | 11.024 | 9.331 | 1.435 | 0.544 |
| Kaolinite | 0.326 | 0.465 | 2.099 | 5.356 | 2.973 | 4.985 | 3.849 | 2.897 | 1.273 | 1.420 | 0.534 |
| K-clay | 0.466 | 0.768 | 1.334 | 3.512 | 4.152 | 10.992 | 13.037 | 13.180 | 16.794 | 2.423 | 0.711 |
| Na-Clay | 0.014 | 0.041 | 0.046 | 0.201 | 0.173 | 0.519 | 0.605 | 0.438 | 0.019 | 0.358 | 0.094 |
| K-clay/apatite mix | 0.002 | 0.000 | 0.007 | 0.048 | 0.194 | 0.791 | 1.001 | 2.536 | 0.350 | 0.012 | 0.000 |
| Zircon | 0.000 | 0.007 | 0.004 | 0.000 | 0.000 | 0.000 | 0.000 | 0.015 | 0.000 | 0.000 | 0.000 |
| Other clays | 0.065 | 0.087 | 0.064 | 0.204 | 0.070 | 0.265 | 0.608 | 0.578 | 9.427 | 0.632 | 0.299 |
| Other silicates | 0.017 | 0.006 | 0.016 | 0.003 | 0.048 | 0.044 | 0.071 | 0.131 | 0.382 | 0.255 | 0.117 |
| CARBONATES | | | | | | | | | | | |
| Calcite | 0.026 | 0.008 | 0.032 | 0.284 | 1.087 | 0.758 | 2.275 | 3.773 | 41.272 | 2.139 | 0.883 |
| Dolomite | 0.046 | 0.049 | 0.053 | 0.000 | 0.194 | 0.486 | 0.897 | 1.617 | 0.082 | 0.000 | 0.012 |
| Ankerite | 0.000 | 0.000 | 0.002 | 0.000 | 0.016 | 0.058 | 0.020 | 0.000 | 1.128 | 7.627 | 2.567 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.172 | 0.000 |
| Sr-Ca carbonate | 0.002 | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.017 | 0.000 |
| Ba-Ca carbonate | 0.004 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| PHOSPHATES | | | | | | | | | | | |
| Apatite | 0.013 | 0.006 | 0.021 | 0.093 | 0.239 | 0.447 | 0.345 | 0.751 | 0.599 | 0.029 | 0.013 |
| Monazite | 0.000 | 0.000 | 0.013 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.144 | 0.000 | 0.000 |
| Fe-Ca phosphate | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.176 | 0.000 | 0.000 |
| Al-Sr-REE phosphate | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.050 | 0.000 | 0.000 |
| SULFIDES | | | | | | | | | | | |
| Pyrite | 0.169 | 0.245 | 0.624 | 2.547 | 1.344 | 7.321 | 9.917 | 12.955 | 9.668 | 79.839 | 91.618 |
| Sphalerite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.013 | 0.013 | 0.000 | 0.000 | 0.000 |
| Other sulfides | 0.004 | 0.000 | 0.008 | 0.000 | 0.000 | 0.000 | 0.030 | 0.000 | 0.000 | 0.021 | 0.000 |
| SULFATES | | | | | | | | | | | |
| Gypsum | 0.002 | 0.000 | 0.002 | 0.009 | 0.013 | 0.000 | 0.008 | 0.000 | 0.000 | 0.000 | 0.000 |
| Barite | 0.000 | 0.000 | 0.004 | 0.000 | 0.000 | 0.000 | 0.000 | 0.015 | 0.032 | 0.000 | 0.018 |
| OXIDES | | | | | | | | | | | |
| Rutile | 0.002 | 0.006 | 0.011 | 0.097 | 0.047 | 0.227 | 0.330 | 0.465 | 0.552 | 0.117 | 0.017 |
| Fe-Oxide | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.088 | 0.053 | 0.000 | 0.076 | 0.000 | 0.677 |
| Sphene | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.076 | 0.000 | 0.000 |
| Al2O3 | 0.002 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.018 | 0.000 |
| MINERAL MATTER | 1.355 | 2.065 | 5.408 | 15.283 | 13.338 | 33.976 | 41.182 | 50.388 | 91.431 | 96.514 | 98.104 |
| ORGANIC MATTER | 98.645 | 97.934 | 94.594 | 84.717 | 86.664 | 66.025 | 58.817 | 49.610 | 8.569 | 3.483 | 1.896 |
| TOTAL | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 |

Table 3.5 - Coal quality data for various density fractions of 65 x 100 mesh Pittsburgh No. 8 coal.

| SG Class | Float 1.29 | 1.29x1.30 | 1.30x1.40 | 1.40x1.50 | 1.50x1.60 | 1.60x1.70 | 1.70x1.80 | 1.80x2.00 | 2.00x2.25 | 2.25x2.50 | 2.50 Sink |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean SG | 1.29 | 1.30 | 1.35 | 1.45 | 1.55 | 1.65 | 1.75 | 1.90 | 2.13 | 2.38 | 2.63 |
| Moisture (%) | 1.79 | 1.84 | 1.85 | 1.84 | 1.62 | 1.50 | 1.42 | 1.52 | 1.05 | 0.38 | 0.18 |
| Ash (%) | 1.74 | 2.91 | 6.20 | 12.76 | 13.45 | 28.10 | 36.18 | 45.75 | 78.01 | 64.62 | 65.77 |
| Sulfur (%) | 1.35 | 1.34 | 1.50 | 2.14 | 2.18 | 4.45 | 5.59 | 6.97 | 3.96 | 40.20 | 47.45 |
| Parr Mineral Matter ( | 2.62 | 3.88 | 7.52 | 14.96 | 15.73 | 32.80 | 42.15 | 53.24 | 86.43 | 91.90 | 97.13 |

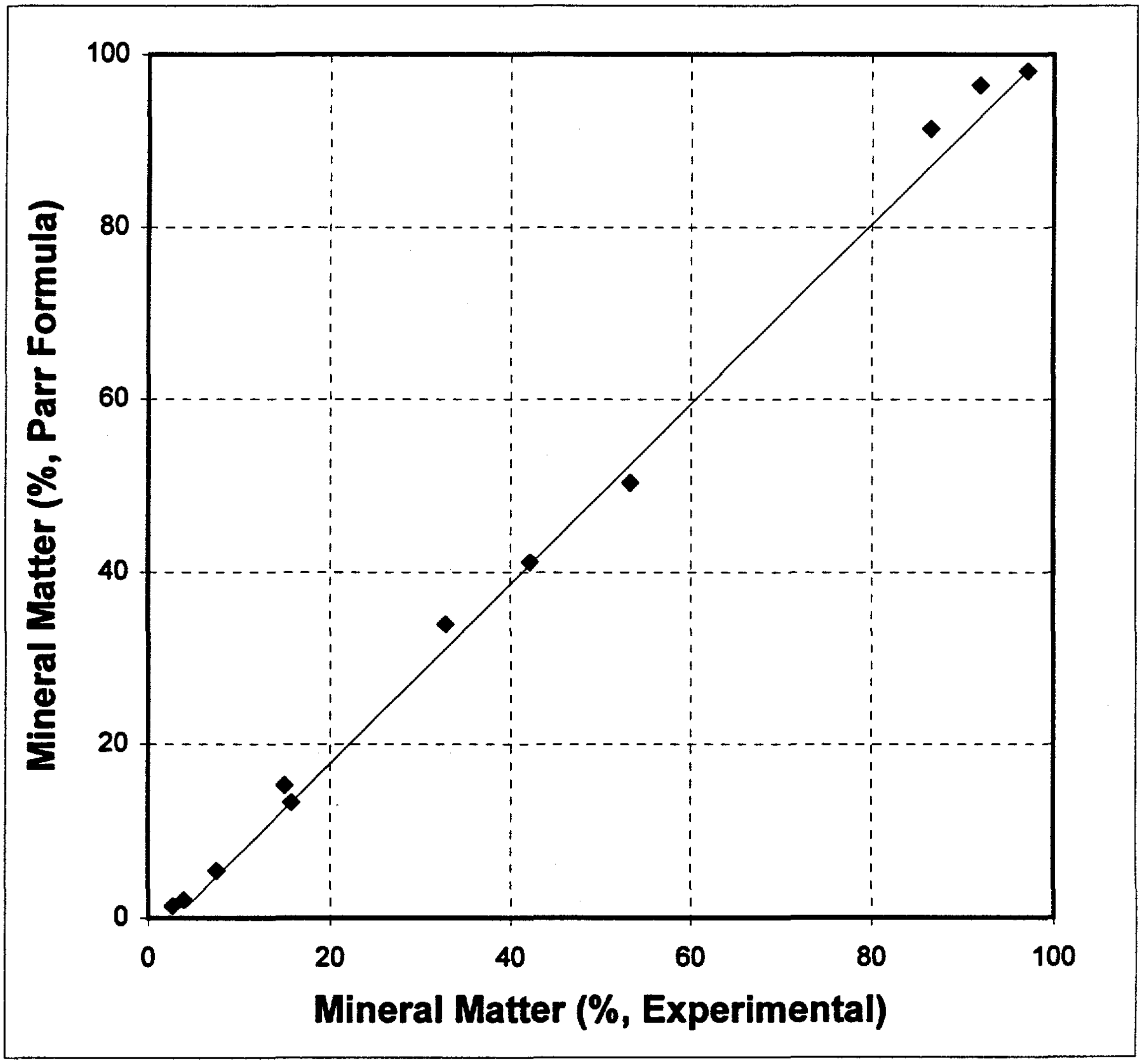



Figure 3.14 - Validation of the Parr formula for the Pittsburgh No. 8 coal.

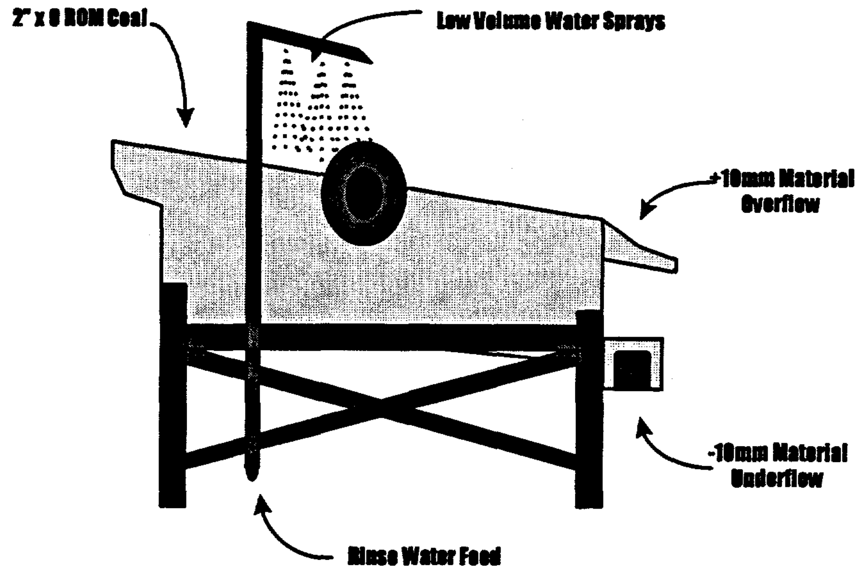



**Figure 4.1, Primary Sizing at 10mm Utilizing Vibratory Screen**

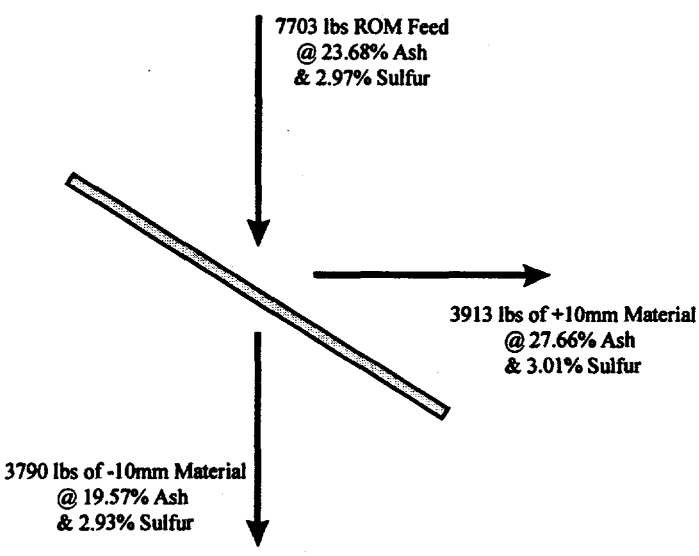



**Figure 4.2, Primary Sizing Flowsheet**

Blending of the crushed 50 x 10 mm middlings into the 10 mm x 28 mesh run-of-mine coal fraction has also been completed during the past quarter. The middlings produced from the primary dense media bath were first jaw crushed to pass 10 mm and then representatively blended into the underflow from the primary sizing unit operation. This process is illustrated in Figure 4.5. A material balance data for this blending step are summarized in Appendix III.

After blending, a secondary sizing step was completed. The blended stream (10mm x 0) was wet-screened at 28 mesh. The plus 28 mesh material was fed to the secondary dense media bath, while the passing 28 mesh material continued to a tertiary screening operation. Figures 4.6 and 4.7 show the secondary and tertiary screening results, respectively. Material balance data for these screening operations are also provided in Appendix III. The material balance for the tertiary screening operation is incomplete at this point; however, the sampling and analysis of this screening circuit is currently underway.

Finally, all work associated with the setup and operation of the secondary dense media bath operation has also been concluded. The plus 28 mesh material was fed into the modified dense media bath which operated at a specific gravity of 1.65. This step produced a clean coal product having 11.75% ash at a combustible recovery of 95%. The results obtained from the operation of the secondary dense media bath are provided in Figure 4.8. The material balance data are summarized in Appendix III. As noted previously, the material balance for the bath is incomplete pending the analysis of the magnetite slurry from the drain and rinse steps.

*Subtask 4.2 - Froth Flotation*

Samples to be used in the froth flotation bench scale tests were prepared from the 28 x 100 mesh material that was obtained from the overflow stream of the tertiary screening operation. Samples were also obtained from the underflow stream of the tertiary screening (passing 100M). These samples were diluted to 6% solids in order to facilitate the column flotation tests. Shakedown tests of the column flotation circuit has been initiated and flotation tests are presently underway.

*Subtask 4.3 - Gravity Separation*

Fractions of the 28 x 100 mesh material and the 100 mesh x 0 slurry have been collected for use in the enhanced gravity separation test program. Approximately three full-barrels of 100 mesh x 0 slurry and several buckets of 28 x 100 mesh material have been shipped to and received by Southern Illinois University at Carbondale for use in the Falcon concentrator tests. The remaining fractions will be utilized in the Multi-Gravity Separator tests that are being conducted at Virginia Tech.

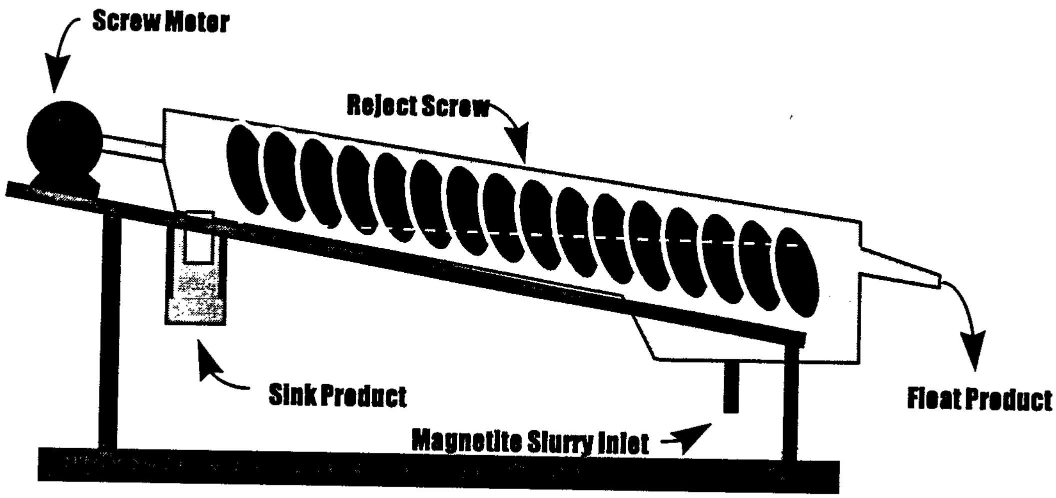



**Figure 4.3, Modified Dense Media Bath**

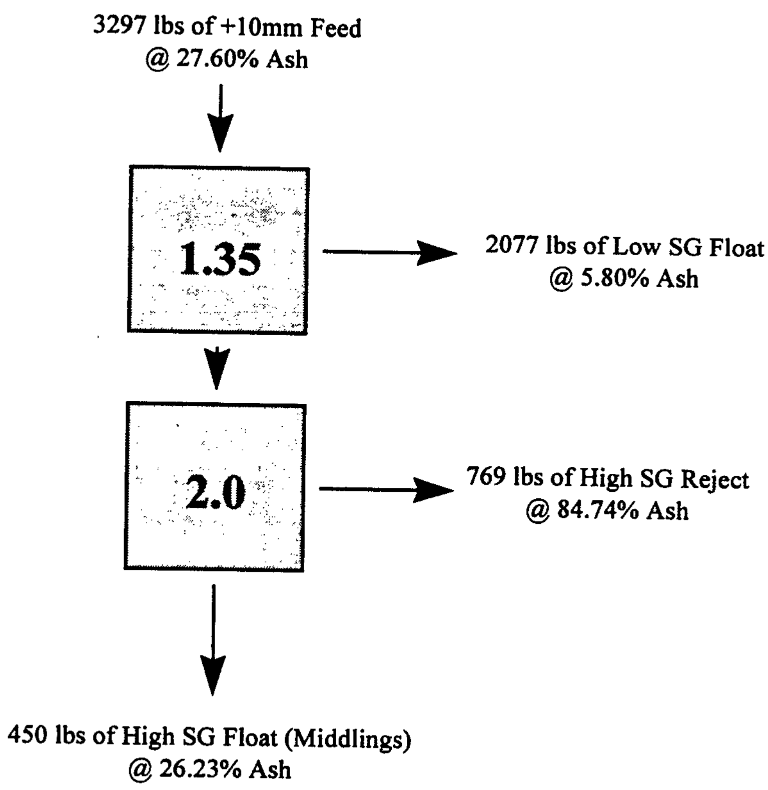



**Figure 4.4, Primary Dense Media Bath Flowsheet**

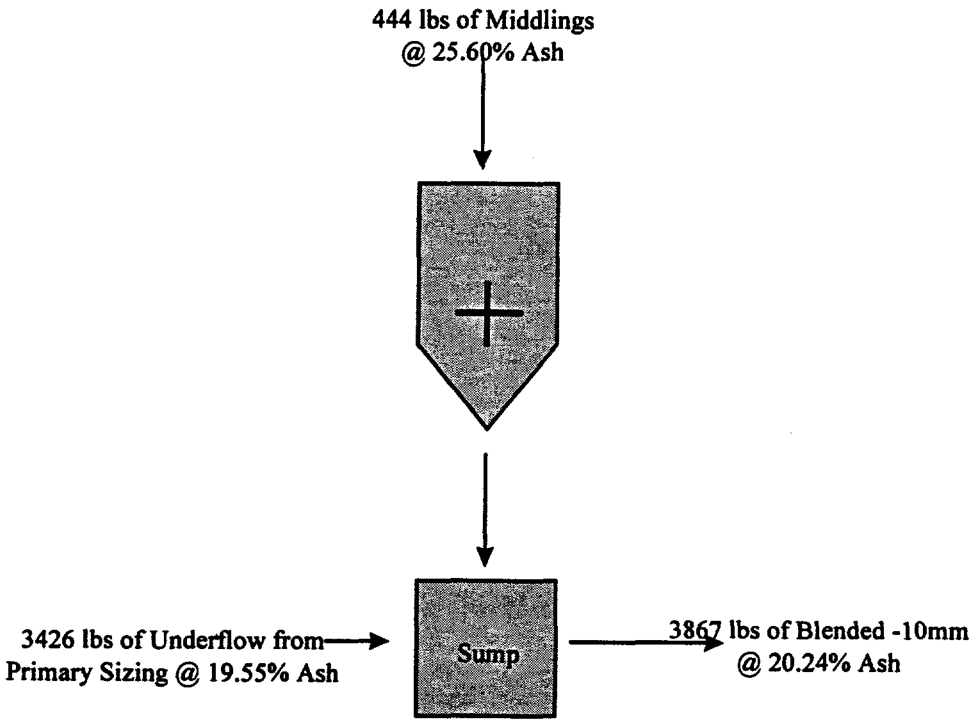



**Figure 4.5, Blending of Crushed Middlings and Primary Sizing Underflow**

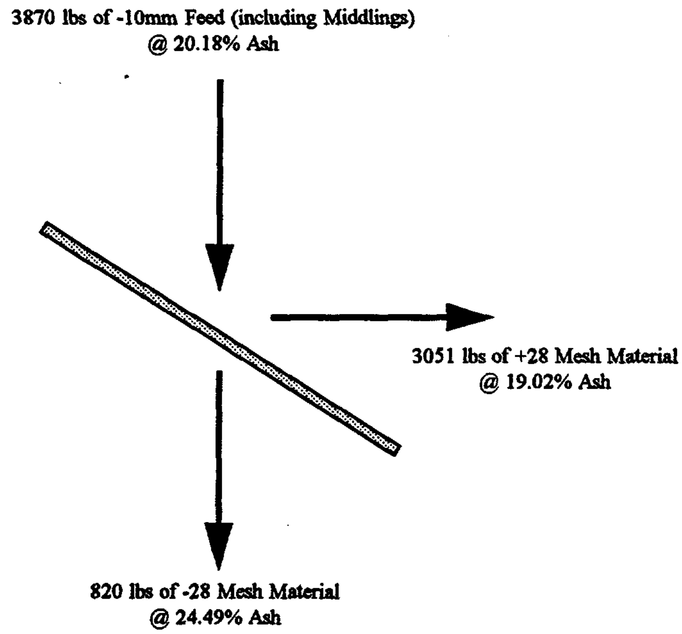



**Figure 4.6, Secondary Sizing Flowsheet at 28 Mesh**

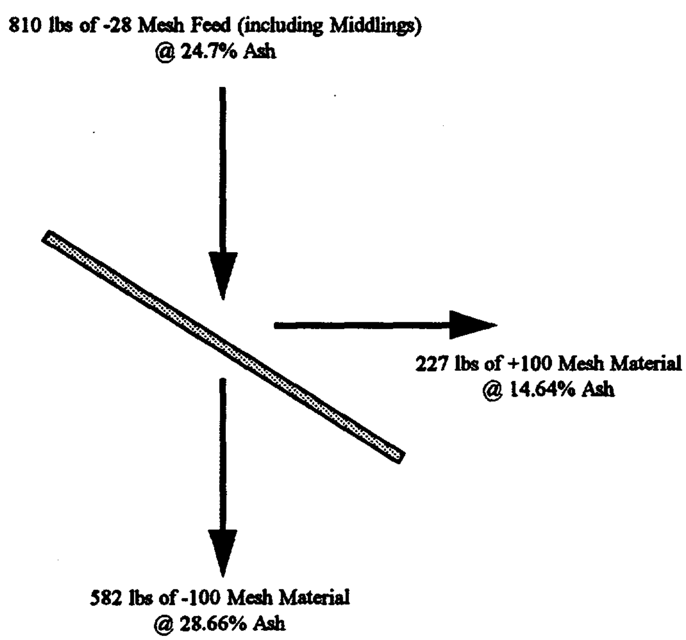



**Figure 4.7, Tertiary Sizing Flowsheet at 100 Mesh**

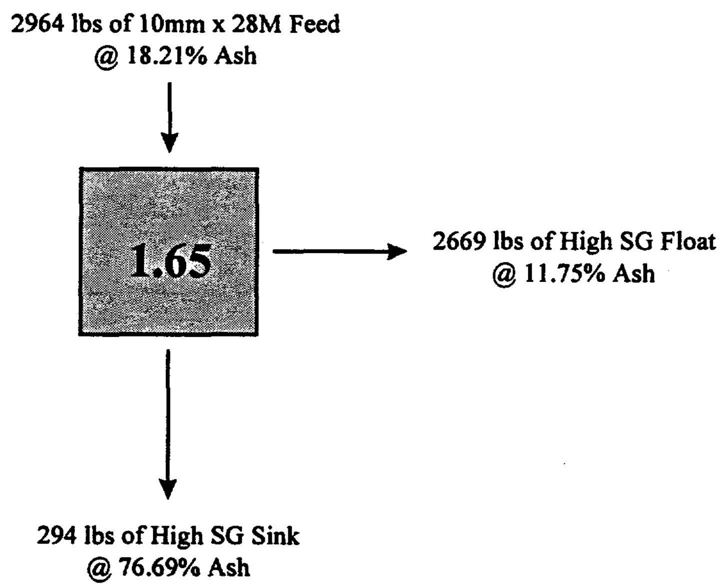



**Figure 4.8, Secondary Dense Media Bath Flowsheet**

Task 6 - Toxic Fate Studies

*Subtask 6.1 - Analysis of Pond Toxics*

As stated in the previous technical report, a sample of Pittsburgh No. 8 coal refuse was prepared at Virginia Tech and shipped to Clark Atlanta University (CAU) for use in their studies related to the release and control of trace metals from coal refuse impoundments. In the first part of this investigation, approximately 15 kg of the damp coal refuse (plus 28 mesh) was placed in a plastic container and allowed to stand for approximately one week during shipment to CAU. The aqueous run-off (i.e., leachate) from the coal refuse was drained off, acidified with concentrated ultrapure nitric acid in a 10:1 ratio, and hydrolyzed with a microwave digestor. The digested samples were placed in plastic vials and shipped to Virginia Tech for trace element determinations.

Although the trace element analyses are not yet completed, the concentrations of several important elements were determined including nickel, cobalt, chromium, manganese, lead and cadmium. The results of these analyses are discussed in the following section. Of the elements analyzed, the highest overall concentrations were observed for manganese (400-500 ppb), while the lowest were measured for cadmium (0.2-0.3 ppb). Analysis of the remaining trace metals of interest (including mercury) are presently underway.

*Subtask 6.2 - Control Method Evaluation*

One of the key objectives of the work carried out by Clark Atlanta University will be to determine whether microbial mats can be used to control the release of trace elements from refuse pond run-off. To evaluate this possibility, a series of mat sequestering experiments were conducted using the leachate from the Pittsburgh No. 8 coal refuse. Experiments were conducted using small baffle tanks (9 x 30 cm) constructed from plexiglass. The baffle tanks were filled with fine glass wool, inoculated with the microbial mat, and allowed to grow with Allen-Arnon media. Two identical series of tests were conducted so that the variability of the test procedures could be evaluated. In addition, a third series of otherwise identical control tests in which no microbial mats were added was also conducted for comparison. After three weeks of growth, the Allen-Arnon media was completely drained from the baffle tanks and 500 ml of coal leachate were poured into each tank. Small samples of the leachate were taken from the tanks immediately after contact (time 0) and after one week (7 days) of contact with the mats.

The results of the mat experiments are summarized in Table 6.1. For convenience, the data comparing the initial metal concentrations with those obtained after immediate contact (time 0) with the mats have been plotted in Figure 6.1. As shown, the metal content of the leachate samples treated by the mats were significantly reduced as compared to the concentrations obtained from the control tests. The calculated reductions in metal concentrations are shown in Figure 6.2. The calculations show that the concentration of manganese was reduced by greater than 90% in both series of mat sequestering tests. Reductions of greater than 80% were achieved for nickel and lead, while the cobalt and cadmium were reduced by about 65% and 75%, respectively. The smallest reductions were achieved for chromium (40-45%).

Table 6.1 - MAT treatment results for Pittsburgh No. 8 coal refuse.

| | Element Concentration | | | | | |
|---|---|---|---|---|---|---|
| Time (Days) | Ni (ppb) | Co (ppb) | Cr (ppb) | Mn (ppb) | Pb (ppb) | Cd (ppb) |
| *Control Tests* | | | | | | |
| 0 | 228.05 | 51.20 | 76.60 | 446.50 | 26.20 | 1.10 |
| 7 | 116.95 | 44.60 | 27.40 | 310.40 | 23.60 | 1.05 |
| *MAT Test #1* | | | | | | |
| 0 | 36.2 | 17.25 | 45.85 | 26.20 | 2.55 | 0.30 |
| 7 | 36.7 | 9.85 | 8.35 | 1.40 | <0.5 | 0.1 |
| *Mat Test #2* | | | | | | |
| 0 | 30.1 | 18.15 | 40.95 | 16.85 | 3.45 | 0.25 |
| 7 | 31.15 | 10.00 | 5.90 | 5.10 | 1.10 | <0.05 |

Table 6.2 - Reductions by MAT treatment for Pittsburgh No. 8 coal refuse.

| | Reduction in Element Concentration | | | | | |
|---|---|---|---|---|---|---|
| Time (Days) | Ni (%) | Co (%) | Cr (%) | Mn (%) | Pb (%) | Cd (%) |
| *Control Tests* | | | | | | |
| 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *MAT Test #1* | | | | | | |
| 0 | 84.1 | 66.3 | 40.1 | 94.1 | 90.3 | 72.7 |
| 7 | 68.6 | 77.9 | 69.5 | 99.5 | *** | 90.5 |
| *Mat Test #2* | | | | | | |
| 0 | 86.8 | 64.6 | 46.5 | 96.2 | 86.8 | 77.3 |
| 7 | 73.4 | 77.6 | 78.5 | 98.4 | 95.3 | *** |

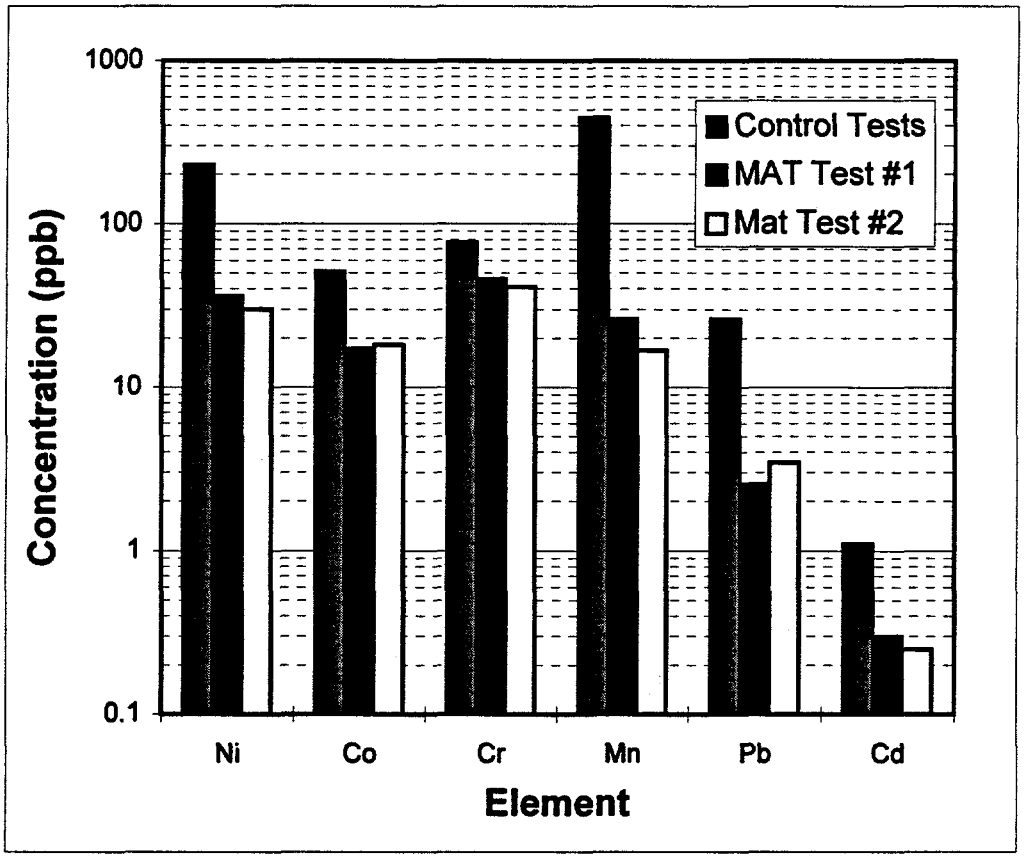



Figure 6.1 - Trace element concentration before and after MAT treatment.

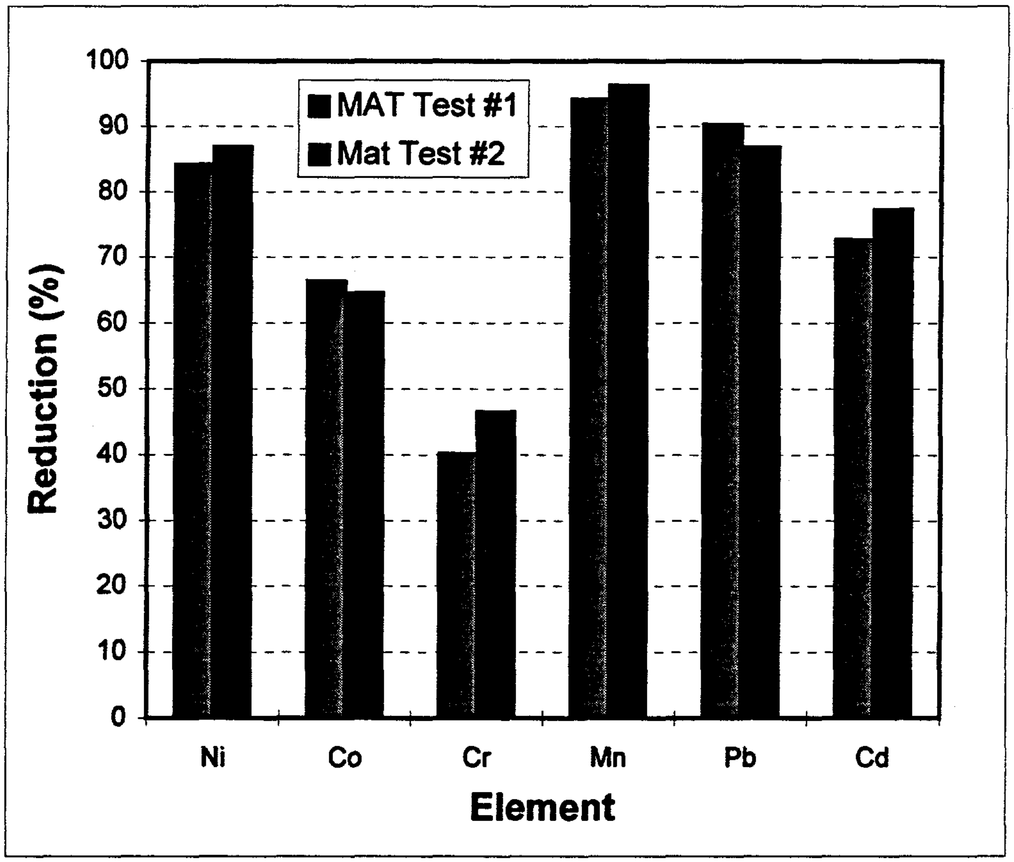



Figure 6.2 - Trace element reductions achieved after MAT treatment.

Task 9 - Sample Analyses

*Subtask 9.1 - Coal Analyses*

As indicated in the previous technical progress report, this subtask is presently running behind schedule because of the large amounts of samples generated by the characterization studies and bench-scale test work. Effort is presently underway to clear the backlog of samples.

*Subtask 9.2 - Trace Element Analyses*

Although the trace element analyses are running behind schedule, work is now progressing at an acceptable pace to ensure that the project goals will be met in a timely fashion. All technical and contractual problems associated with the trace element analyses have now been resolved. No additional delays are anticipated for the completion of this subtask.

## SUMMARY, STATUS AND PLANNED WORK

During the past quarter, several key subtasks were completed in accordance with the project work plan. In Subtasks 3.2 (Washability Analysis) and 3.3 (Flotation Release Analysis), characterization tests were completed for the Pittsburgh No. 8 coal using float-sink and release analysis procedures. All coal products have been submitted for trace element analyses and the complete data set should be available during the next quarter. Preliminary results indicate that recrushing of coarse middlings isolated by heavy media can improve coal yield and/or quality, despite the fact that the Pittsburgh No. 8 coal contains relatively few middlings particles. Float-sink and release analysis tests for the remaining two coal samples are behind schedule and will continue. Characterization studies conducted under Subtask 3.4 (SEM/Image Analysis) were completed during the past quarter. These detailed analyses were designed to investigate the mineralogical association of trace elements in the Pittsburgh No. 8 coal. A few follow-up examinations may be required before closing this subtask in order to resolve ambiguities which may arise after completing the trace element analyses and corresponding statistical analyses.

In Subtask 4.1 (Heavy Media Testing), a significant part of the bench-scale test work was completed during the past quarter for the Pittsburgh No. 8 coal. Preliminary material balances have been performed and a detailed analysis of the test data is presently underway. Additional bench-scale tests are also being conducted as outlined in Subtask 4.2 (Froth Flotation) and 4.3 (Enhanced Gravity Separation). The bench-scale tests should be completed by the end of the next quarter. Finally, in Subtasks 6.1 (Analysis of Pond Toxics) and 6.2 (Control Method Evaluation), samples of coal refuse run-off were analyzed for trace element content and subjected to treatment by microbial mats. Initial results indicate that significant reductions (up to 90%) in trace element content can be achieved through the application of microbial mats. As a final note, the trace element analyses continue to run behind schedule (Subtask 9.2 - Trace Element Analysis) due to early delays in obtaining equipment access and the resultant backlog of liquid and solid samples. Additional manpower has been allocated to bring this project activity back on schedule and no future delays are presently anticipated.

═════ APPENDIX I ═════

**Float-Sink Characterization Data**
Pittsburgh No. 8 Seam

**Seam:** Pittsburgh No. 8

**Sample:** Run-of-Mine Feed **Mass (%):** 100.00

| Particle Size | | | | | Mass | | | |
|---|---|---|---|---|---|---|---|---|
| Individual Designation | Retained Designation | Passing (mm) | Retained (mm) | Mean (mm) | Individual (kg) | Individual (%) | Passing (%) | Retained (%) |
| +50 mm | +50 mm | | 50 | | 0.0 | 0.00 | 100.00 | 0.00 |
| 50 x 10 mm | +10 mm | 50 | 10 | 22.4 | 502.9 | 56.26 | 100.00 | 56.26 |
| 10 mm x 28 M | +28 M | 10 | 0.6 | 2.45 | 310.2 | 34.70 | 43.74 | 90.96 |
| 28 x 100 M | +100 M | 0.6 | 0.15 | 0.30 | 52.3 | 5.85 | 9.04 | 96.81 |
| 100 x 270 M | +270 M | 0.15 | 0.053 | 0.089 | 10.6 | 1.19 | 3.19 | 98.00 |
| -270 M | | 0.053 | | | 17.9 | 2.00 | 2.00 | 100.00 |
| | | | | | 893.9 | 100.00 | | |

**Sample:** Crushed Middlings Only **Mass (%):** 100.00

| Particle Size | | | | | Mass | | | |
|---|---|---|---|---|---|---|---|---|
| Individual Designation | Retained Designation | Passing (mm) | Retained (mm) | Mean (mm) | Individual (kg) | Individual (%) | Passing (%) | Retained (%) |
| +50 mm | +50 mm | | 50 | | 0.000 | 0.00 | 100.00 | 0.00 |
| 50 x 10 mm | +10 mm | 50 | 10 | 22.4 | 0.000 | 0.00 | 100.00 | 0.00 |
| 10 mm x 28 M | +28 M | 10 | 0.6 | 2.45 | 29.80 | 92.78 | 100.00 | 92.78 |
| 28 x 100 M | +100 M | 0.6 | 0.15 | 0.30 | 1.46 | 4.56 | 7.22 | 97.34 |
| 100 x 270 M | +270 M | 0.15 | 0.053 | 0.089 | 0.431 | 1.34 | 2.66 | 98.68 |
| -270 M | | 0.053 | | | 0.423 | 1.32 | 1.32 | 100.00 |
| | | | | | 32.1 | 100.00 | | |

**Seam:** Pittsburgh No. 8

**Sample:** Crushed Middlings Only (Normalized to Feed) **Mass (%):** 5.10

| Particle Size | | | | | Mass | | | |
|---|---|---|---|---|---|---|---|---|
| Individual Designation | Retained Designation | Passing (mm) | Retained (mm) | Mean (mm) | Individual (kg) | Individual (%) | Passing (%) | Retained (%) |
| +50 mm | +50 mm | | 50 | | 0.00 | 0.00 | 5.10 | 0.00 |
| 50 x 10 mm | +10 mm | 50 | 10 | 22.4 | 0.00 | 0.00 | 5.10 | 0.00 |
| 10 mm x 28 M | +28 M | 10 | 0.6 | 2.45 | 1.52 | 4.73 | 5.10 | 4.73 |
| 28 x 100 M | +100 M | 0.6 | 0.15 | 0.30 | 0.07 | 0.23 | 0.37 | 4.97 |
| 100 x 270 M | +270 M | 0.15 | 0.053 | 0.089 | 0.02 | 0.07 | 0.14 | 5.04 |
| -270 M | | 0.053 | | | 0.02 | 0.07 | 0.07 | 5.10 |
| | | | | | 1.64 | 5.10 | | |

**Sample:** After Crushed Middlings **Mass (%):** 100.00

| Particle Size | | | | | Mass | | | |
|---|---|---|---|---|---|---|---|---|
| Individual Designation | Retained Designation | Passing (mm) | Retained (mm) | Mean (mm) | Individual (kg) | Individual (%) | Passing (%) | Retained (%) |
| +50 mm | +50 mm | | 50 | | *** | 0.00 | 100.00 | 0.00 |
| 50 x 10 mm | +10 mm | 50 | 10 | 22.4 | *** | 51.16 | 100.00 | 51.16 |
| 10 mm x 28 M | +28 M | 10 | 0.6 | 2.45 | *** | 39.44 | 48.84 | 90.59 |
| 28 x 100 M | +100 M | 0.6 | 0.15 | 0.30 | *** | 6.08 | 9.41 | 96.68 |
| 100 x 270 M | +270 M | 0.15 | 0.053 | 0.089 | *** | 1.25 | 3.32 | 97.93 |
| -270 M | | 0.053 | | | *** | 2.07 | 2.07 | 100.00 |
| | | | | | *** | 100.00 | | |

Seam: Pittsburgh No. 8
Sample: Run-of-Mine Feed
Class: 50 x 10 mm
Mass (%): 56.26

| | | Individual | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Mass (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 34.07 | 4.52 | 1.96 | 0.00 | 0.00 |
| 1.30 | 1.40 | 34.47 | 8.03 | 3.16 | 0.00 | 0.00 |
| 1.40 | 1.55 | 5.57 | 20.43 | 4.66 | 0.00 | 0.00 |
| 1.55 | 2.00 | 3.50 | 41.88 | 5.59 | 0.00 | 0.00 |
| 2.00 | | 22.39 | 85.82 | 4.33 | 0.00 | 0.00 |
| | | 100.00 | 26.13 | 3.18 | 0.00 | 0.00 |

| | | Cumulative Float | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 34.07 | 4.52 | 1.96 | 0.00 | 0.00 |
| 1.30 | 1.40 | 68.54 | 6.29 | 2.56 | 0.00 | 0.00 |
| 1.40 | 1.55 | 74.11 | 7.35 | 2.72 | 0.00 | 0.00 |
| 1.55 | 2.00 | 77.61 | 8.91 | 2.85 | 0.00 | 0.00 |
| 2.00 | | 100.00 | 26.13 | 3.18 | 0.00 | 0.00 |

| | | Cumulative Sink | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 100.00 | 26.13 | 3.18 | 0.00 | 0.00 |
| 1.30 | 1.40 | 65.93 | 37.29 | 3.81 | 0.00 | 0.00 |
| 1.40 | 1.55 | 31.46 | 69.35 | 4.53 | 0.00 | 0.00 |
| 1.55 | 2.00 | 25.89 | 79.88 | 4.50 | 0.00 | 0.00 |
| 2.00 | | 22.39 | 85.82 | 4.33 | 0.00 | 0.00 |

Seam: Pittsburgh No. 8
Sample: Run-of-Mine Feed
Class: 10 mm x 28 M
Mass (%): 34.70

| | | Individual | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Mass (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 47.89 | 3.42 | 1.57 | 0.00 | 0.00 |
| 1.30 | 1.40 | 32.93 | 7.24 | 2.74 | 0.00 | 0.00 |
| 1.40 | 1.55 | 3.63 | 17.99 | 6.36 | 0.00 | 0.00 |
| 1.55 | 2.00 | 2.97 | 37.09 | 8.55 | 0.00 | 0.00 |
| 2.00 | | 12.57 | 84.68 | 6.51 | 0.00 | 0.00 |
| | | 99.99 | 16.42 | 2.96 | 0.00 | 0.00 |

| | | Cumulative Float | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 47.89 | 3.42 | 1.57 | 0.00 | 0.00 |
| 1.30 | 1.40 | 80.82 | 4.98 | 2.05 | 0.00 | 0.00 |
| 1.40 | 1.55 | 84.45 | 5.54 | 2.23 | 0.00 | 0.00 |
| 1.55 | 2.00 | 87.42 | 6.61 | 2.45 | 0.00 | 0.00 |
| 2.00 | | 99.99 | 16.42 | 2.96 | 0.00 | 0.00 |

| | | Cumulative Sink | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 100.00 | 16.42 | 2.96 | 0.00 | 0.00 |
| 1.30 | 1.40 | 52.11 | 28.37 | 4.23 | 0.00 | 0.00 |
| 1.40 | 1.55 | 19.18 | 64.65 | 6.80 | 0.00 | 0.00 |
| 1.55 | 2.00 | 15.55 | 75.55 | 6.90 | 0.00 | 0.00 |
| 2.00 | | 12.58 | 84.63 | 6.51 | 0.00 | 0.00 |

Seam: Pittsburgh No. 8
Sample: Run-of-Mine Feed
Class: 28 x 100 M
Mass (%): 5.85

| Sink SG | Float SG | Individual Mass (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
|---|---|---|---|---|---|---|
| | 1.30 | 39.32 | 2.79 | 1.45 | 0.00 | 0.00 |
| 1.30 | 1.40 | 36.70 | 7.01 | 1.84 | 0.00 | 0.00 |
| 1.40 | 1.55 | 9.03 | 13.83 | 3.62 | 0.00 | 0.00 |
| 1.55 | 2.00 | 4.56 | 32.48 | 6.92 | 0.00 | 0.00 |
| 2.00 | | 10.38 | 75.68 | 14.27 | 0.00 | 0.00 |
| | | 99.99 | 14.26 | 3.37 | 0.00 | 0.00 |

| Sink SG | Float SG | Cumulative Float Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
|---|---|---|---|---|---|---|
| | 1.30 | 39.32 | 2.79 | 1.45 | 0.00 | 0.00 |
| 1.30 | 1.40 | 76.02 | 4.83 | 1.64 | 0.00 | 0.00 |
| 1.40 | 1.55 | 85.05 | 5.78 | 1.85 | 0.00 | 0.00 |
| 1.55 | 2.00 | 89.61 | 7.14 | 2.11 | 0.00 | 0.00 |
| 2.00 | | 99.99 | 14.26 | 3.37 | 0.00 | 0.00 |

| Sink SG | Float SG | Cumulative Sink Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
|---|---|---|---|---|---|---|
| | 1.30 | 100.00 | 14.26 | 3.37 | 0.00 | 0.00 |
| 1.30 | 1.40 | 60.68 | 21.69 | 4.61 | 0.00 | 0.00 |
| 1.40 | 1.55 | 23.98 | 44.15 | 8.86 | 0.00 | 0.00 |
| 1.55 | 2.00 | 14.95 | 62.46 | 12.02 | 0.00 | 0.00 |
| 2.00 | | 10.39 | 75.62 | 14.26 | 0.00 | 0.00 |

Seam: Pittsburgh No. 8
Sample: Run-of-Mine Feed
Class: 100 x 270 M
Mass (%): 1.19

| | | Individual | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Mass (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 2.77 | 5.49 | 1.64 | 0.00 | 0.00 |
| 1.30 | 1.40 | 59.04 | 6.85 | 1.53 | 0.00 | 0.00 |
| 1.40 | 1.55 | 12.49 | 13.40 | 2.15 | 0.00 | 0.00 |
| 1.55 | 2.00 | 9.72 | 26.61 | 3.29 | 0.00 | 0.00 |
| 2.00 | | 15.98 | 75.62 | 18.70 | 0.00 | 0.00 |
| | | 100.00 | 20.54 | 4.53 | 0.00 | 0.00 |

| | | Cumulative Float | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 2.77 | 5.49 | 1.64 | 0.00 | 0.00 |
| 1.30 | 1.40 | 61.81 | 6.79 | 1.53 | 0.00 | 0.00 |
| 1.40 | 1.55 | 74.30 | 7.90 | 1.64 | 0.00 | 0.00 |
| 1.55 | 2.00 | 84.02 | 10.06 | 1.83 | 0.00 | 0.00 |
| 2.00 | | 100.00 | 20.54 | 4.53 | 0.00 | 0.00 |

| | | Cumulative Sink | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 100.00 | 20.54 | 4.53 | 0.00 | 0.00 |
| 1.30 | 1.40 | 97.23 | 20.97 | 4.61 | 0.00 | 0.00 |
| 1.40 | 1.55 | 38.19 | 42.80 | 9.37 | 0.00 | 0.00 |
| 1.55 | 2.00 | 25.70 | 57.08 | 12.87 | 0.00 | 0.00 |
| 2.00 | | 15.98 | 75.62 | 18.70 | 0.00 | 0.00 |

Seam: Pittsburgh No. 8
Sample: Run-of-Mine Feed
Class: +10 mm
Mass (%): 56.3

| | | Individual | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Mass (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 34.07 | 4.52 | 1.96 | 0.00 | 0.00 |
| 1.30 | 1.40 | 34.47 | 8.03 | 3.16 | 0.00 | 0.00 |
| 1.40 | 1.55 | 5.57 | 20.43 | 4.66 | 0.00 | 0.00 |
| 1.55 | 2.00 | 3.50 | 41.88 | 5.59 | 0.00 | 0.00 |
| 2.00 | | 22.39 | 85.82 | 4.33 | 0.00 | 0.00 |
| | | 100.00 | 26.13 | 3.18 | 0.00 | 0.00 |

| | | Cumulative Float | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 34.07 | 4.52 | 1.96 | 0.00 | 0.00 |
| 1.30 | 1.40 | 68.54 | 6.29 | 2.56 | 0.00 | 0.00 |
| 1.40 | 1.55 | 74.11 | 7.35 | 2.72 | 0.00 | 0.00 |
| 1.55 | 2.00 | 77.61 | 8.91 | 2.85 | 0.00 | 0.00 |
| 2.00 | | 100.00 | 26.13 | 3.18 | 0.00 | 0.00 |

| | | Cumulative Sink | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 100.00 | 26.13 | 3.18 | 0.00 | 0.00 |
| 1.30 | 1.40 | 65.93 | 37.29 | 3.81 | 0.00 | 0.00 |
| 1.40 | 1.55 | 31.46 | 69.35 | 4.53 | 0.00 | 0.00 |
| 1.55 | 2.00 | 25.89 | 79.88 | 4.50 | 0.00 | 0.00 |
| 2.00 | | 22.39 | 85.82 | 4.33 | 0.00 | 0.00 |

Seam: Pittsburgh No. 8
Sample: Run-of-Mine Feed
Class: +28 M
Mass (%): 91.0

| | | Individual | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Mass (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 39.34 | 4.01 | 1.78 | 0.00 | 0.00 |
| 1.30 | 1.40 | 33.88 | 7.74 | 3.00 | 0.00 | 0.00 |
| 1.40 | 1.55 | 4.83 | 19.73 | 5.15 | 0.00 | 0.00 |
| 1.55 | 2.00 | 3.30 | 40.23 | 6.61 | 0.00 | 0.00 |
| 2.00 | | 18.64 | 85.53 | 4.89 | 0.00 | 0.00 |
| | | 100.00 | 22.42 | 3.10 | 0.00 | 0.00 |

| | | Cumulative Float | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 39.34 | 4.01 | 1.78 | 0.00 | 0.00 |
| 1.30 | 1.40 | 73.22 | 5.73 | 2.35 | 0.00 | 0.00 |
| 1.40 | 1.55 | 78.05 | 6.60 | 2.52 | 0.00 | 0.00 |
| 1.55 | 2.00 | 81.35 | 7.96 | 2.68 | 0.00 | 0.00 |
| 2.00 | | 100.00 | 22.42 | 3.10 | 0.00 | 0.00 |

| | | Cumulative Sink | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 100.00 | 22.42 | 3.10 | 0.00 | 0.00 |
| 1.30 | 1.40 | 60.66 | 34.37 | 3.95 | 0.00 | 0.00 |
| 1.40 | 1.55 | 26.78 | 68.07 | 5.15 | 0.00 | 0.00 |
| 1.55 | 2.00 | 21.95 | 78.71 | 5.15 | 0.00 | 0.00 |
| 2.00 | | 18.65 | 85.51 | 4.89 | 0.00 | 0.00 |

Seam: Pittsburgh No. 8
Sample: Run-of-Mine Feed
Class: +100 M
Mass (%): 96.8

| | | Individual | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Mass (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 39.34 | 3.94 | 1.76 | 0.00 | 0.00 |
| 1.30 | 1.40 | 34.05 | 7.69 | 2.93 | 0.00 | 0.00 |
| 1.40 | 1.55 | 5.08 | 19.10 | 4.98 | 0.00 | 0.00 |
| 1.55 | 2.00 | 3.37 | 39.60 | 6.63 | 0.00 | 0.00 |
| 2.00 | | 18.14 | 85.19 | 5.22 | 0.00 | 0.00 |
| | | 100.00 | 21.93 | 3.11 | 0.00 | 0.00 |

| | | Cumulative Float | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 39.34 | 3.94 | 1.76 | 0.00 | 0.00 |
| 1.30 | 1.40 | 73.39 | 5.68 | 2.30 | 0.00 | 0.00 |
| 1.40 | 1.55 | 78.48 | 6.55 | 2.48 | 0.00 | 0.00 |
| 1.55 | 2.00 | 81.85 | 7.91 | 2.65 | 0.00 | 0.00 |
| 2.00 | | 100.00 | 21.93 | 3.11 | 0.00 | 0.00 |

| | | Cumulative Sink | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 100.00 | 21.93 | 3.11 | 0.00 | 0.00 |
| 1.30 | 1.40 | 60.66 | 33.60 | 3.99 | 0.00 | 0.00 |
| 1.40 | 1.55 | 26.61 | 66.77 | 5.35 | 0.00 | 0.00 |
| 1.55 | 2.00 | 21.52 | 78.03 | 5.44 | 0.00 | 0.00 |
| 2.00 | | 18.15 | 85.17 | 5.21 | 0.00 | 0.00 |

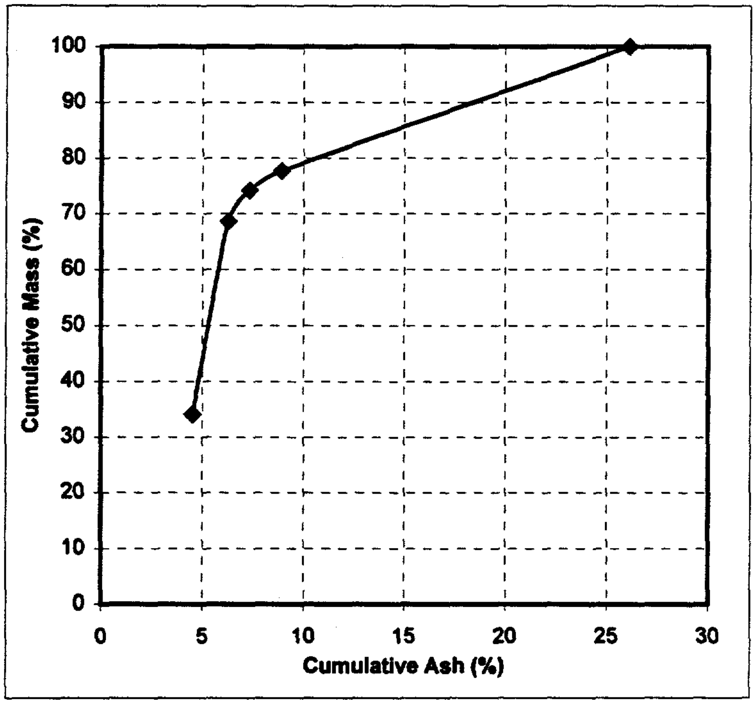
Seam: Pittsburgh No. 8
Sample: Run-of-Mine Feed
Class: +270 M
Mass (%): 98.0

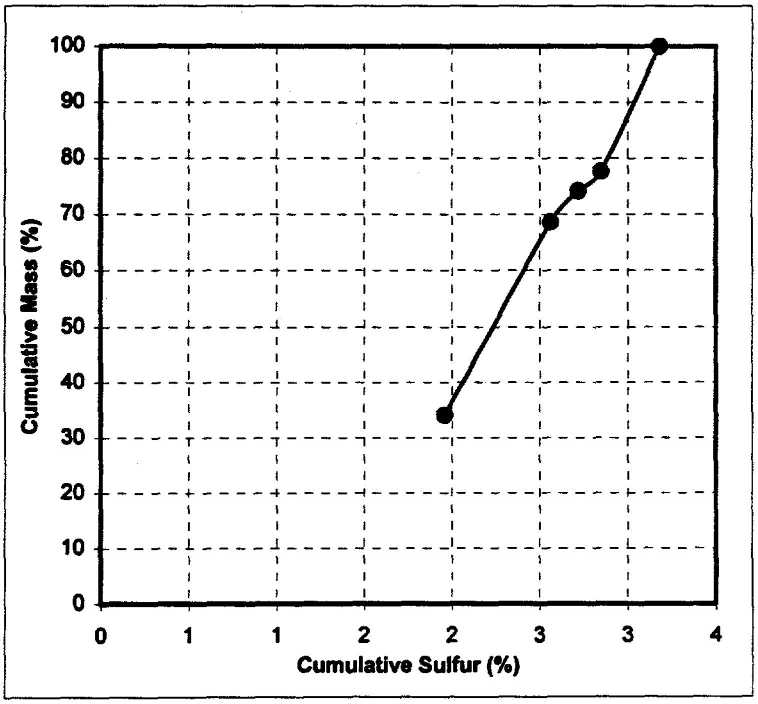
| | | Individual | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Mass (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 38.90 | 3.94 | 1.76 | 0.00 | 0.00 |
| 1.30 | 1.40 | 34.36 | 7.67 | 2.90 | 0.00 | 0.00 |
| 1.40 | 1.55 | 5.17 | 18.93 | 4.90 | 0.00 | 0.00 |
| 1.55 | 2.00 | 3.45 | 39.16 | 6.52 | 0.00 | 0.00 |
| 2.00 | | 18.12 | 85.08 | 5.36 | 0.00 | 0.00 |
| | | 100.00 | 21.91 | 3.13 | 0.00 | 0.00 |

| | | Cumulative Float | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 38.90 | 3.94 | 1.76 | 0.00 | 0.00 |
| 1.30 | 1.40 | 73.25 | 5.69 | 2.29 | 0.00 | 0.00 |
| 1.40 | 1.55 | 78.43 | 6.56 | 2.47 | 0.00 | 0.00 |
| 1.55 | 2.00 | 81.88 | 7.94 | 2.64 | 0.00 | 0.00 |
| 2.00 | | 100.00 | 21.91 | 3.13 | 0.00 | 0.00 |

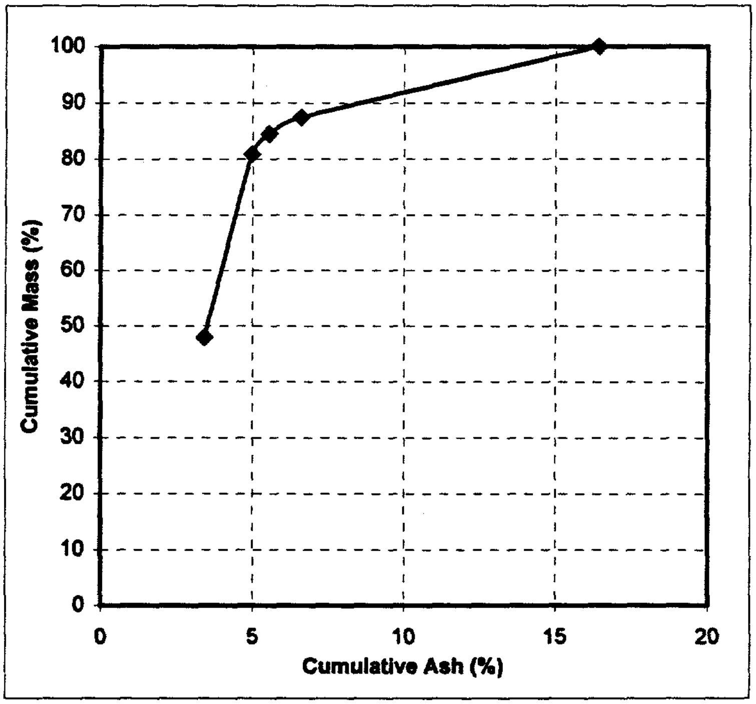
| | | Cumulative Sink | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 100.00 | 21.91 | 3.13 | 0.00 | 0.00 |
| 1.30 | 1.40 | 61.10 | 33.36 | 4.00 | 0.00 | 0.00 |
| 1.40 | 1.55 | 26.75 | 66.35 | 5.42 | 0.00 | 0.00 |
| 1.55 | 2.00 | 21.57 | 77.73 | 5.54 | 0.00 | 0.00 |
| 2.00 | | 18.12 | 85.07 | 5.36 | 0.00 | 0.00 |

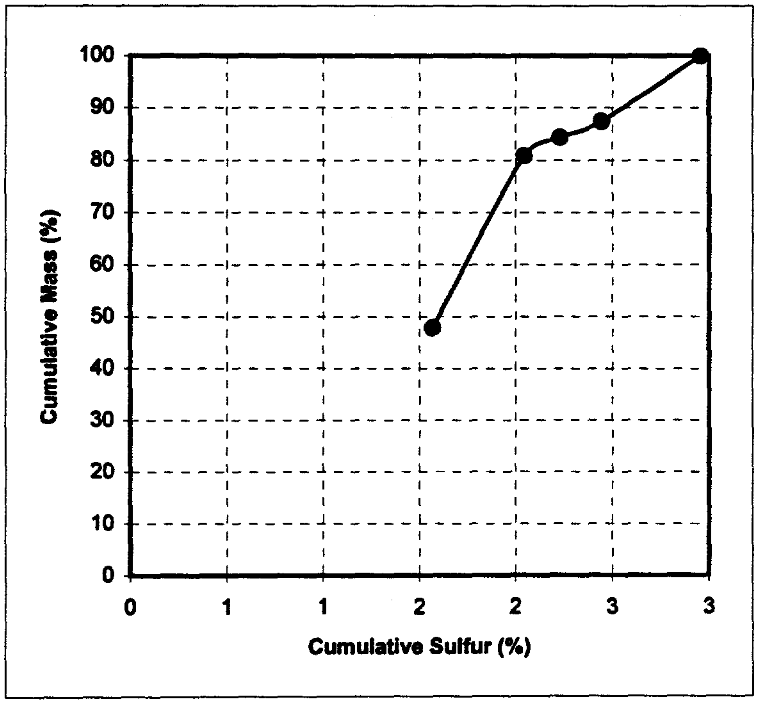
Seam: Pittsburgh No. 8
Sample: Run-of-Mine Feed
Class: 50 x 10 mm
Mass (%): 56.26



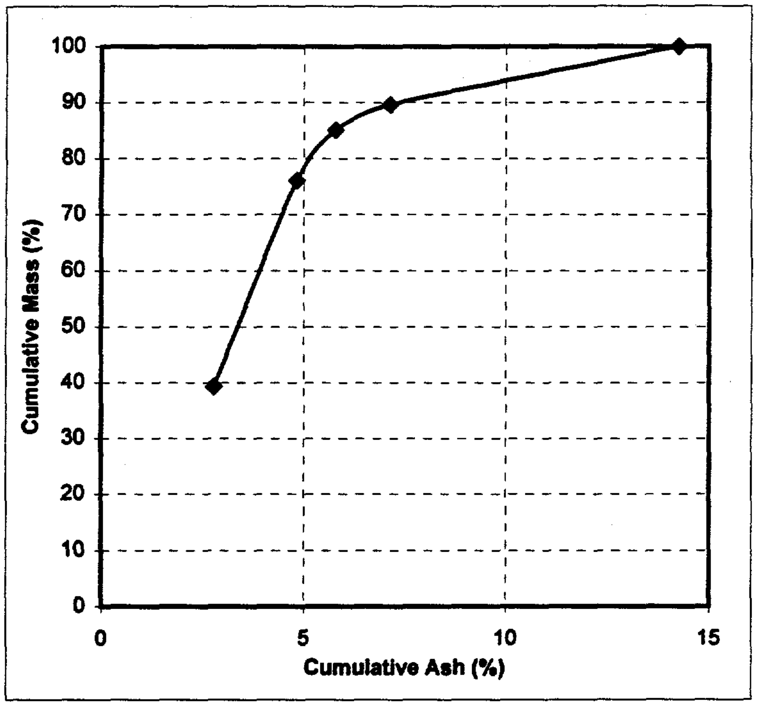



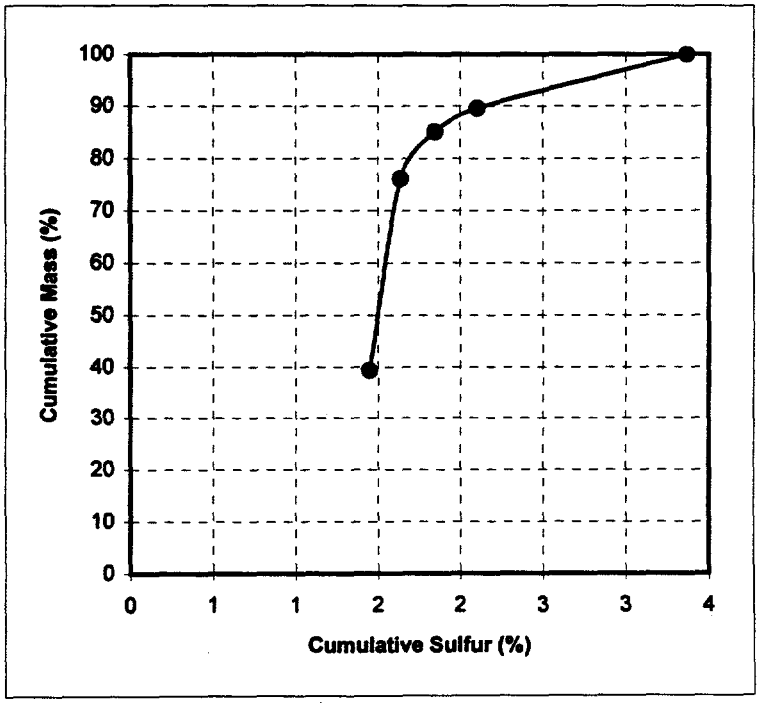
Seam: Pittsburgh No. 8
Sample: Run-of-Mine Feed
Class: 10 mm x 28 M
Mass (%): 34.70



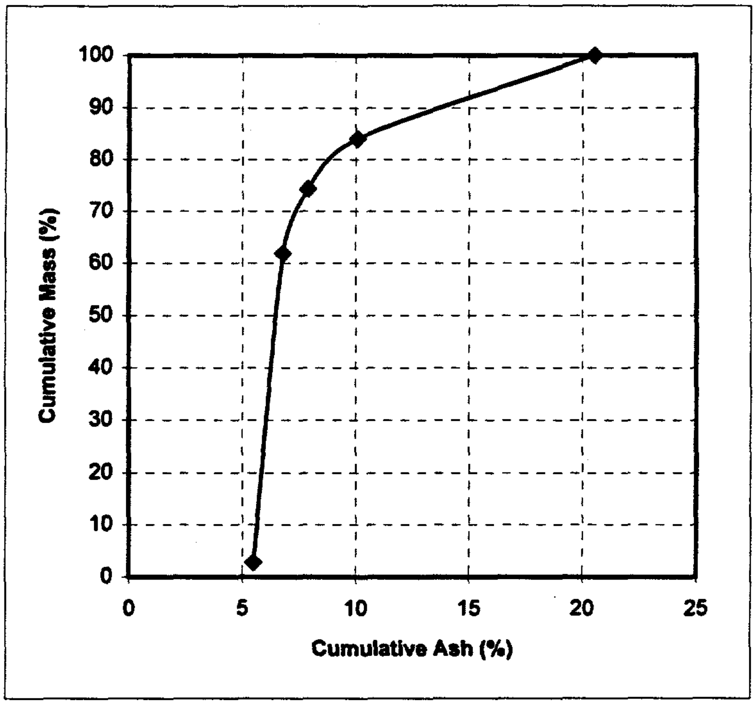



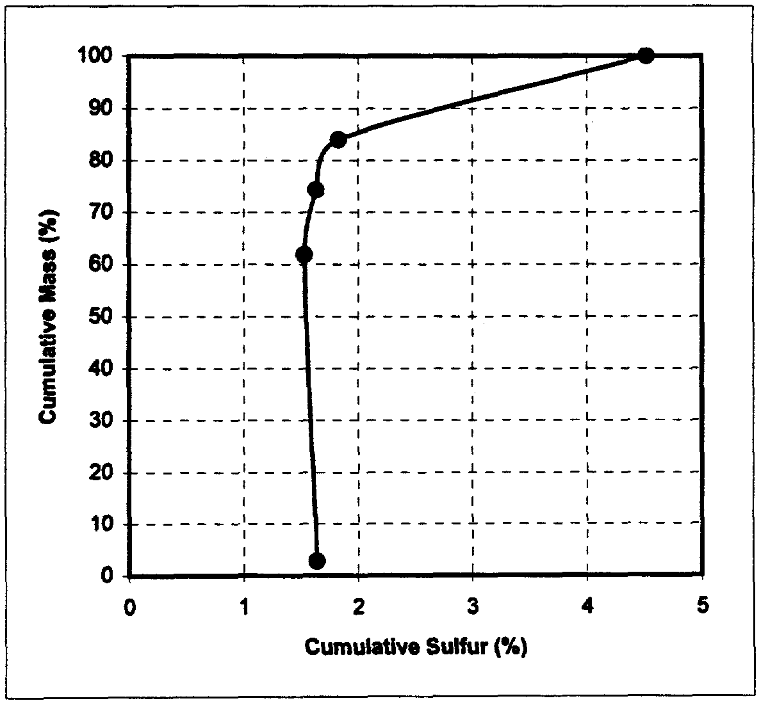
Seam: Pittsburgh No. 8
Sample: Run-of-Mine Feed
Class: 28 x 100 M
Mass (%): 5.85



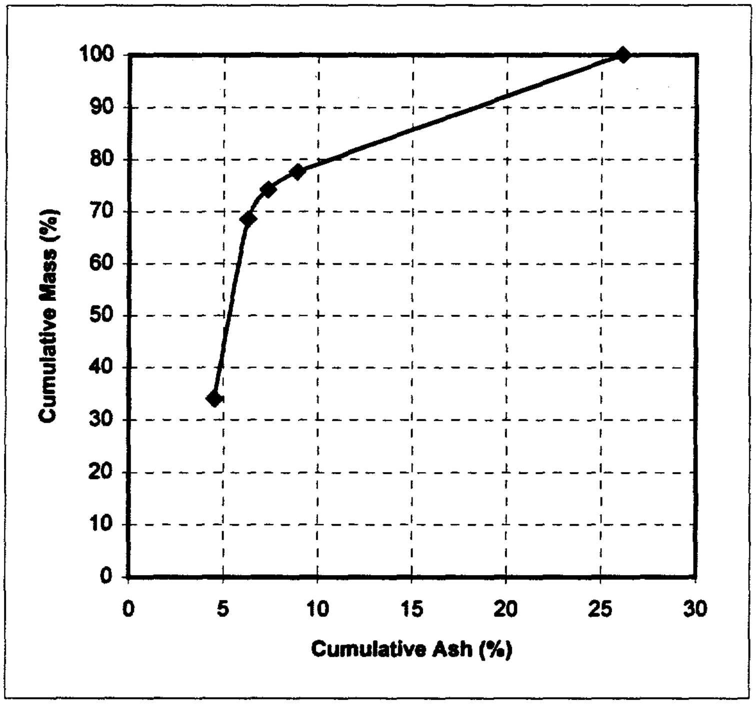



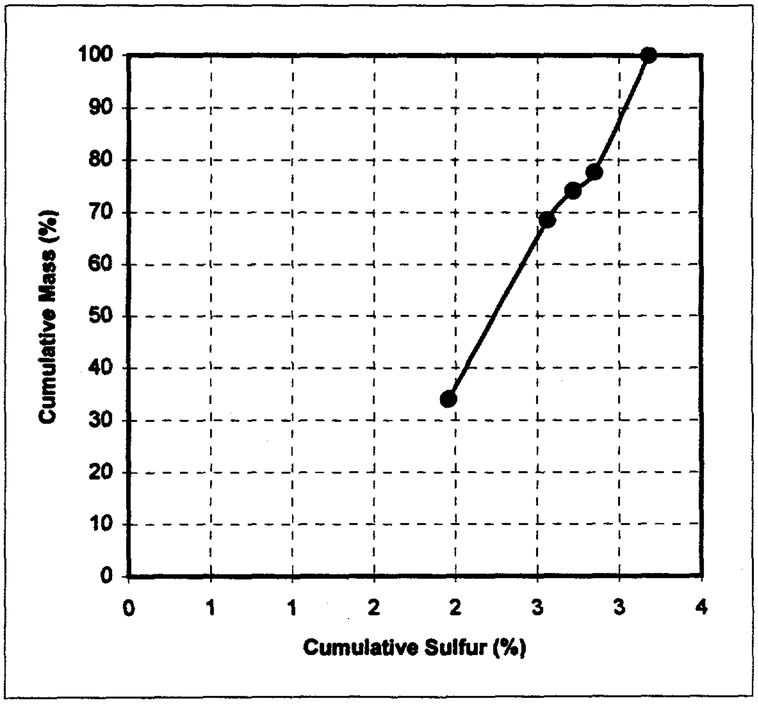
Seam: Pittsburgh No. 8
Sample: Run-of-Mine Feed
Class: 100 x 270 M
Mass (%): 1.19



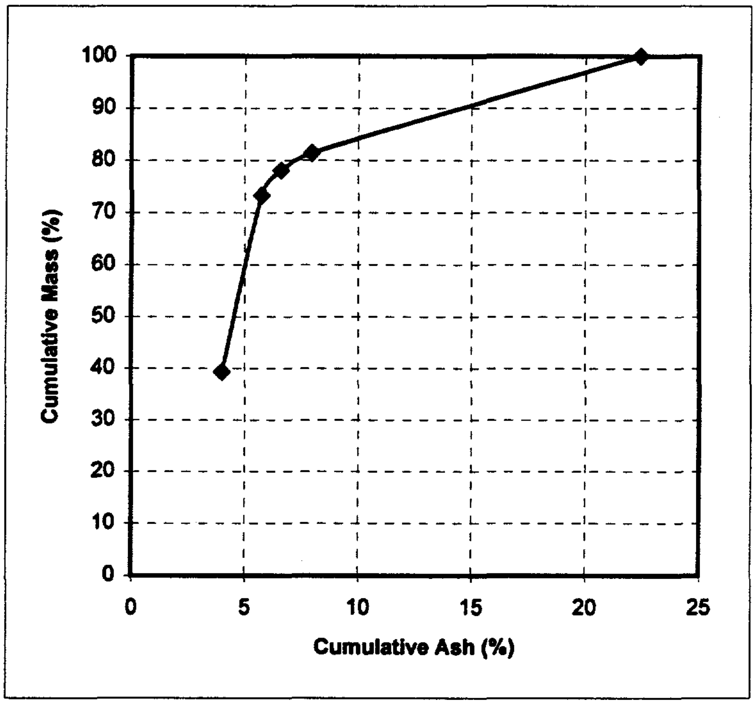



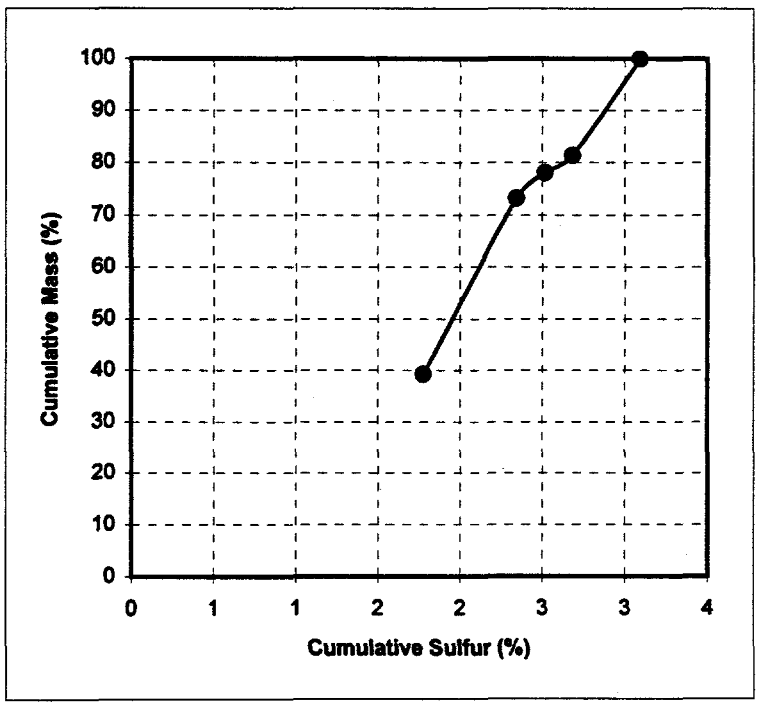
Seam: Pittsburgh No. 8
Sample: Run-of-Mine Feed
Class: +10 mm
Mass (%): 56.26



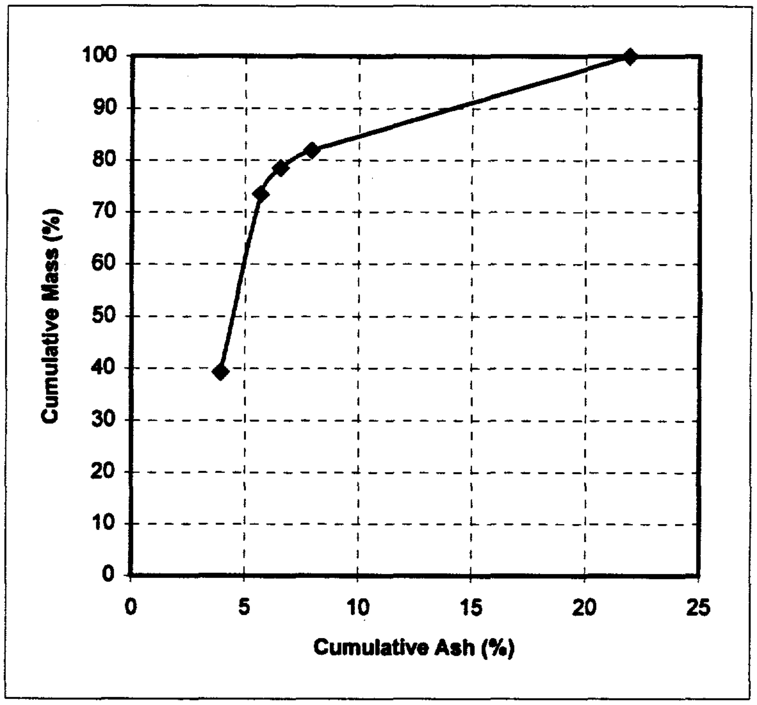



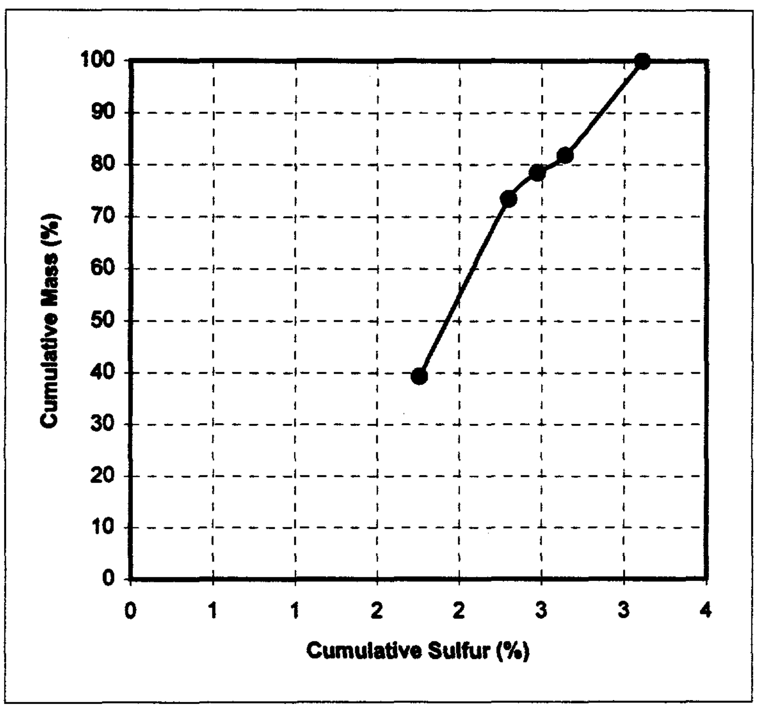
Seam: Pittsburgh No. 8
Sample: Run-of-Mine Feed
Class: +28 M
Mass (%): 90.96



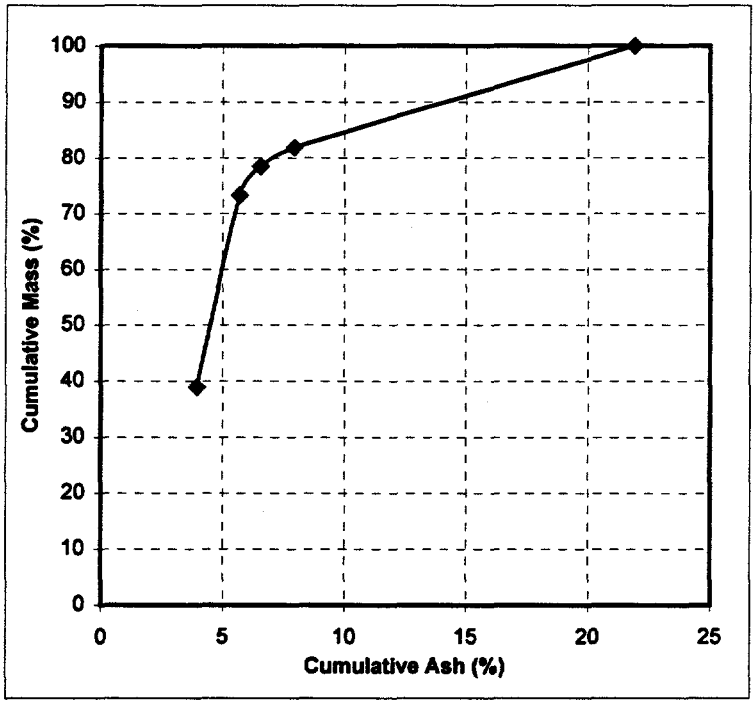



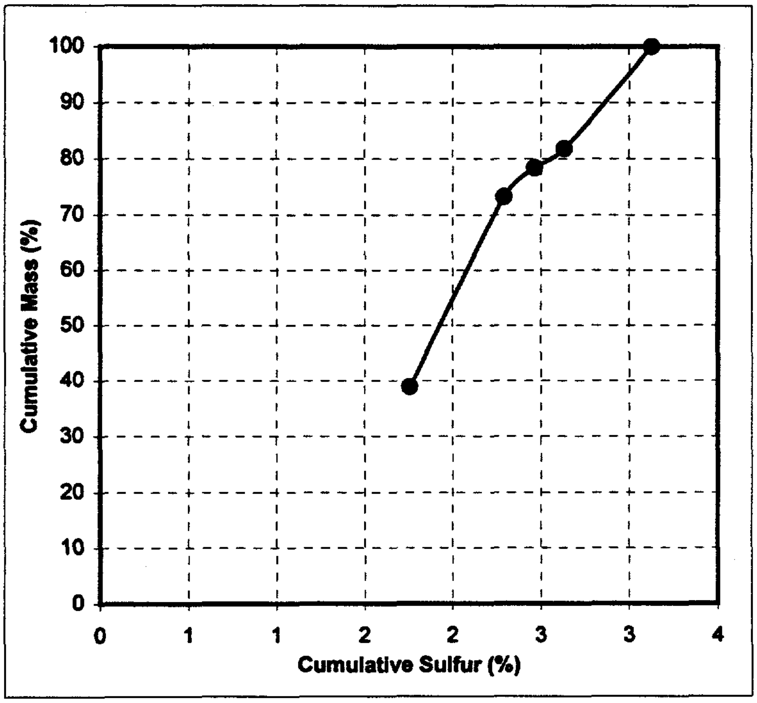
Seam: Pittsburgh No. 8
Sample: Run-of-Mine Feed
Class: +100 M
Mass (%): 96.81



Seam: Pittsburgh No. 8
Sample: Run-of-Mine Feed
Class: +270 M
Mass (%): 98.00



Seam: Pittsburgh No. 8
Sample: Crushed Middlings Only
Class: 10 mm x 28 M
Mass (%): 4.73

| | | Individual | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Mass (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 11.37 | 6.29 | 1.97 | 0.00 | 0.00 |
| 1.30 | 1.40 | 23.73 | 10.52 | 3.14 | 0.00 | 0.00 |
| 1.40 | 1.55 | 28.62 | 22.73 | 5.46 | 0.00 | 0.00 |
| 1.55 | 2.00 | 27.76 | 42.73 | 6.18 | 0.00 | 0.00 |
| 2.00 | | 8.52 | 63.64 | 12.40 | 0.00 | 0.00 |
| | | 100.00 | 27.00 | 5.30 | 0.00 | 0.00 |

| | | Cumulative Float | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 11.37 | 6.29 | 1.97 | 0.00 | 0.00 |
| 1.30 | 1.40 | 35.10 | 9.15 | 2.76 | 0.00 | 0.00 |
| 1.40 | 1.55 | 63.72 | 15.25 | 3.97 | 0.00 | 0.00 |
| 1.55 | 2.00 | 91.48 | 23.59 | 4.64 | 0.00 | 0.00 |
| 2.00 | | 100.00 | 27.00 | 5.30 | 0.00 | 0.00 |

| | | Cumulative Sink | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 100.00 | 27.00 | 5.30 | 0.00 | 0.00 |
| 1.30 | 1.40 | 88.63 | 29.66 | 5.73 | 0.00 | 0.00 |
| 1.40 | 1.55 | 64.90 | 36.66 | 6.68 | 0.00 | 0.00 |
| 1.55 | 2.00 | 36.28 | 47.64 | 7.64 | 0.00 | 0.00 |
| 2.00 | | 8.52 | 63.64 | 12.40 | 0.00 | 0.00 |

Seam: Pittsburgh No. 8
Sample: Crushed Middlings Only
Class: 28 x 100 M
Mass (%): 0.23

| | | Individual | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Mass (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 27.14 | 2.93 | 1.57 | 0.00 | 0.00 |
| 1.30 | 1.40 | 27.59 | 8.31 | 2.26 | 0.00 | 0.00 |
| 1.40 | 1.55 | 15.96 | 18.07 | 3.60 | 0.00 | 0.00 |
| 1.55 | 2.00 | 16.22 | 38.80 | 5.34 | 0.00 | 0.00 |
| 2.00 | | 13.09 | 65.89 | 19.60 | 0.00 | 0.00 |
| | | 100.00 | 20.89 | 5.06 | 0.00 | 0.00 |

| | | Cumulative Float | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 27.14 | 2.93 | 1.57 | 0.00 | 0.00 |
| 1.30 | 1.40 | 54.73 | 5.64 | 1.92 | 0.00 | 0.00 |
| 1.40 | 1.55 | 70.69 | 8.45 | 2.30 | 0.00 | 0.00 |
| 1.55 | 2.00 | 86.91 | 14.11 | 2.87 | 0.00 | 0.00 |
| 2.00 | | 100.00 | 20.89 | 5.06 | 0.00 | 0.00 |

| | | Cumulative Sink | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 100.00 | 20.89 | 5.06 | 0.00 | 0.00 |
| 1.30 | 1.40 | 72.86 | 27.58 | 6.35 | 0.00 | 0.00 |
| 1.40 | 1.55 | 45.27 | 39.32 | 8.85 | 0.00 | 0.00 |
| 1.55 | 2.00 | 29.31 | 50.90 | 11.71 | 0.00 | 0.00 |
| 2.00 | | 13.09 | 65.89 | 19.60 | 0.00 | 0.00 |

Seam: Pittsburgh No. 8
Sample: Crushed Middlings Only
Class: 100 x 270 M
Mass (%): 0.07

| | | Individual | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Mass (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 2.66 | 4.61 | 1.67 | 0.00 | 0.00 |
| 1.30 | 1.40 | 31.55 | 6.26 | 1.71 | 0.00 | 0.00 |
| 1.40 | 1.55 | 29.53 | 15.16 | 2.36 | 0.00 | 0.00 |
| 1.55 | 2.00 | 21.38 | 37.73 | 3.50 | 0.00 | 0.00 |
| 2.00 | | 14.89 | 70.65 | 22.57 | 0.00 | 0.00 |
| | | 100.01 | 25.16 | 5.39 | 0.00 | 0.00 |

| | | Cumulative Float | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 2.66 | 4.61 | 1.67 | 0.00 | 0.00 |
| 1.30 | 1.40 | 34.21 | 6.13 | 1.71 | 0.00 | 0.00 |
| 1.40 | 1.55 | 63.74 | 10.31 | 2.01 | 0.00 | 0.00 |
| 1.55 | 2.00 | 85.12 | 17.20 | 2.38 | 0.00 | 0.00 |
| 2.00 | | 100.01 | 25.16 | 5.39 | 0.00 | 0.00 |

| | | Cumulative Sink | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 100.00 | 25.16 | 5.39 | 0.00 | 0.00 |
| 1.30 | 1.40 | 97.34 | 25.72 | 5.49 | 0.00 | 0.00 |
| 1.40 | 1.55 | 65.79 | 35.05 | 7.30 | 0.00 | 0.00 |
| 1.55 | 2.00 | 36.26 | 51.25 | 11.33 | 0.00 | 0.00 |
| 2.00 | | 14.88 | 70.68 | 22.58 | 0.00 | 0.00 |

Seam: Pittsburgh No. 8
Sample: Crushed Middlings Only
Class: +28 M
Mass (%): 4.73

| | | Individual | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Mass (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 11.37 | 6.29 | 1.97 | 0.00 | 0.00 |
| 1.30 | 1.40 | 23.73 | 10.52 | 3.14 | 0.00 | 0.00 |
| 1.40 | 1.55 | 28.62 | 22.73 | 5.46 | 0.00 | 0.00 |
| 1.55 | 2.00 | 27.76 | 42.73 | 6.18 | 0.00 | 0.00 |
| 2.00 | | 8.52 | 63.64 | 12.40 | 0.00 | 0.00 |
| | | 100.00 | 27.00 | 5.30 | 0.00 | 0.00 |

| | | Cumulative Float | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 11.37 | 6.29 | 1.97 | 0.00 | 0.00 |
| 1.30 | 1.40 | 35.10 | 9.15 | 2.76 | 0.00 | 0.00 |
| 1.40 | 1.55 | 63.72 | 15.25 | 3.97 | 0.00 | 0.00 |
| 1.55 | 2.00 | 91.48 | 23.59 | 4.64 | 0.00 | 0.00 |
| 2.00 | | 100.00 | 27.00 | 5.30 | 0.00 | 0.00 |

| | | Cumulative Sink | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 100.00 | 27.00 | 5.30 | 0.00 | 0.00 |
| 1.30 | 1.40 | 88.63 | 29.66 | 5.73 | 0.00 | 0.00 |
| 1.40 | 1.55 | 64.90 | 36.66 | 6.68 | 0.00 | 0.00 |
| 1.55 | 2.00 | 36.28 | 47.64 | 7.64 | 0.00 | 0.00 |
| 2.00 | | 8.52 | 63.64 | 12.40 | 0.00 | 0.00 |

Seam: Pittsburgh No. 8
Sample: Crushed Middlings Only
Class: +100 M
Mass (%): 4.97

| | | Individual | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Mass (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 12.11 | 5.94 | 1.93 | 0.00 | 0.00 |
| 1.30 | 1.40 | 23.91 | 10.40 | 3.09 | 0.00 | 0.00 |
| 1.40 | 1.55 | 28.03 | 22.61 | 5.41 | 0.00 | 0.00 |
| 1.55 | 2.00 | 27.22 | 42.62 | 6.16 | 0.00 | 0.00 |
| 2.00 | | 8.73 | 63.80 | 12.91 | 0.00 | 0.00 |
| | | 100.00 | 26.71 | 5.29 | 0.00 | 0.00 |

| | | Cumulative Float | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 12.11 | 5.94 | 1.93 | 0.00 | 0.00 |
| 1.30 | 1.40 | 36.02 | 8.90 | 2.70 | 0.00 | 0.00 |
| 1.40 | 1.55 | 64.05 | 14.90 | 3.89 | 0.00 | 0.00 |
| 1.55 | 2.00 | 91.27 | 23.17 | 4.56 | 0.00 | 0.00 |
| 2.00 | | 100.00 | 26.71 | 5.29 | 0.00 | 0.00 |

| | | Cumulative Sink | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 100.00 | 26.71 | 5.29 | 0.00 | 0.00 |
| 1.30 | 1.40 | 87.89 | 29.58 | 5.76 | 0.00 | 0.00 |
| 1.40 | 1.55 | 63.98 | 36.74 | 6.75 | 0.00 | 0.00 |
| 1.55 | 2.00 | 35.95 | 47.76 | 7.80 | 0.00 | 0.00 |
| 2.00 | | 8.73 | 63.80 | 12.91 | 0.00 | 0.00 |

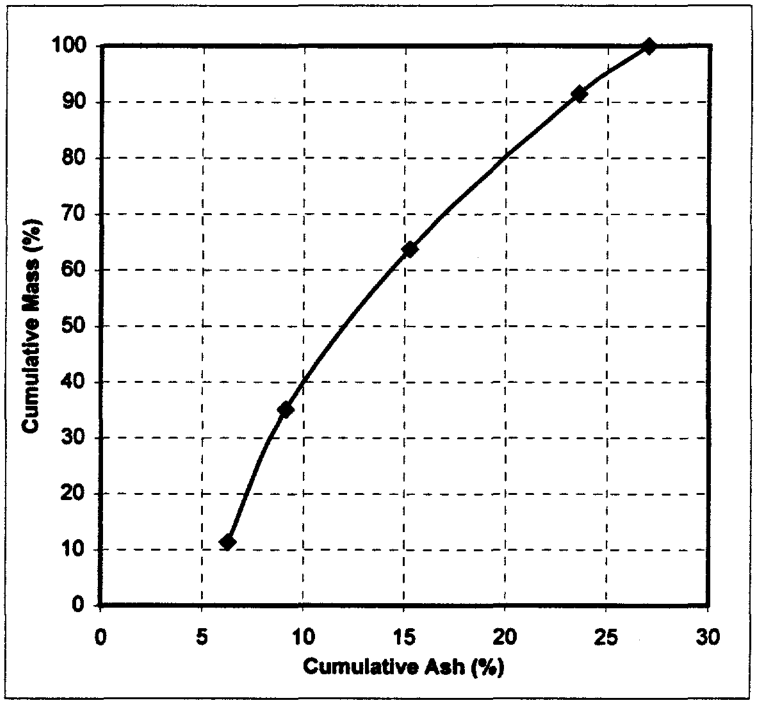
Seam: Pittsburgh No. 8
Sample: Crushed Middlings Only
Class: +270 M
Mass (%): 5.04

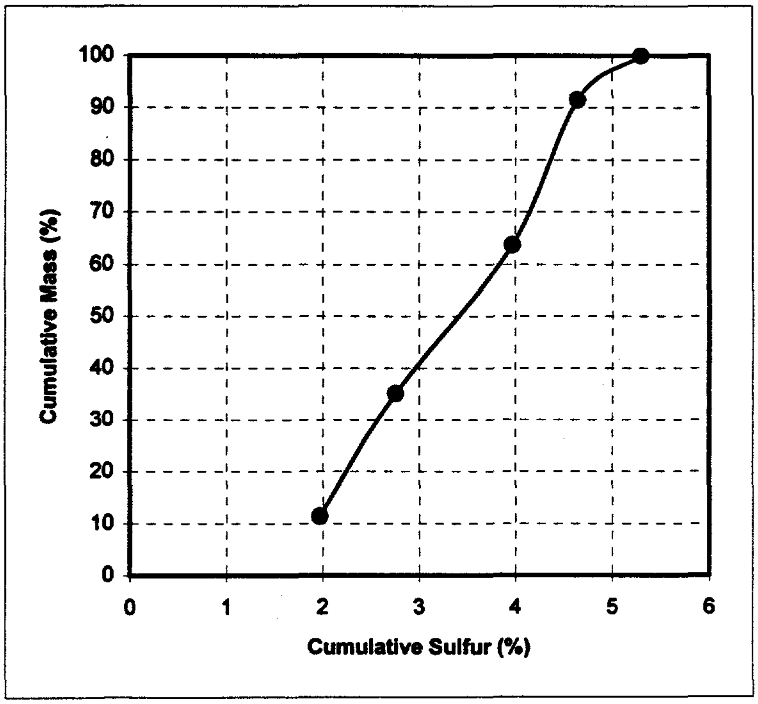
| | | Individual | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Mass (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 11.98 | 5.93 | 1.93 | 0.00 | 0.00 |
| 1.30 | 1.40 | 24.01 | 10.33 | 3.07 | 0.00 | 0.00 |
| 1.40 | 1.55 | 28.05 | 22.50 | 5.37 | 0.00 | 0.00 |
| 1.55 | 2.00 | 27.14 | 42.57 | 6.13 | 0.00 | 0.00 |
| 2.00 | | 8.82 | 63.96 | 13.13 | 0.00 | 0.00 |
| | | 100.00 | 26.69 | 5.29 | 0.00 | 0.00 |

| | | Cumulative Float | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 11.98 | 5.93 | 1.93 | 0.00 | 0.00 |
| 1.30 | 1.40 | 35.99 | 8.86 | 2.69 | 0.00 | 0.00 |
| 1.40 | 1.55 | 64.04 | 14.84 | 3.86 | 0.00 | 0.00 |
| 1.55 | 2.00 | 91.18 | 23.09 | 4.54 | 0.00 | 0.00 |
| 2.00 | | 100.00 | 26.69 | 5.29 | 0.00 | 0.00 |

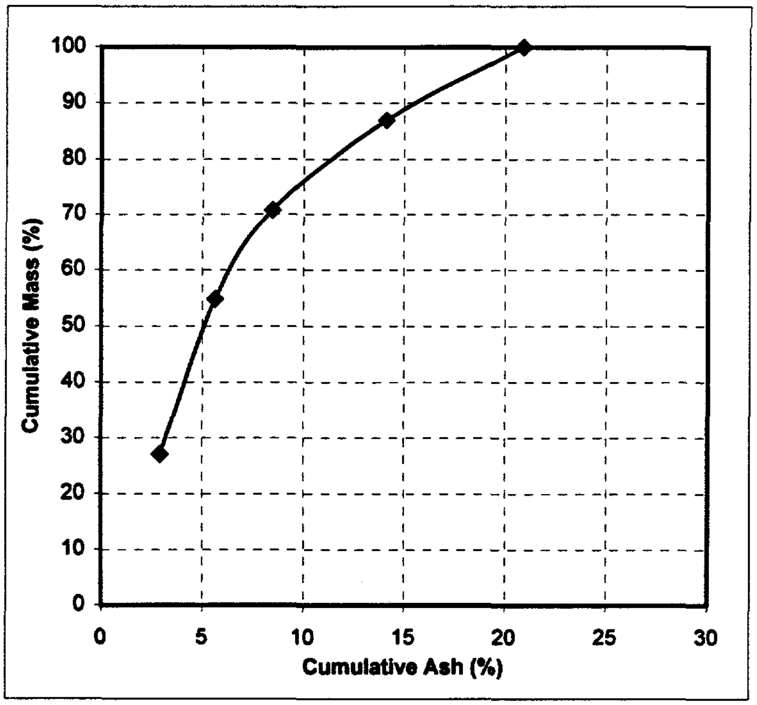
| | | Cumulative Sink | | | | |
|---|---|---|---|---|---|---|
| Sink SG | Float SG | Weight (%) | Ash (%) | Sulfur (%) | Pyritic (%) | Heat (Btu/lb) |
| | 1.30 | 100.00 | 26.69 | 5.29 | 0.00 | 0.00 |
| 1.30 | 1.40 | 88.02 | 29.52 | 5.75 | 0.00 | 0.00 |
| 1.40 | 1.55 | 64.01 | 36.72 | 6.76 | 0.00 | 0.00 |
| 1.55 | 2.00 | 35.96 | 47.81 | 7.84 | 0.00 | 0.00 |
| 2.00 | | 8.82 | 63.96 | 13.13 | 0.00 | 0.00 |

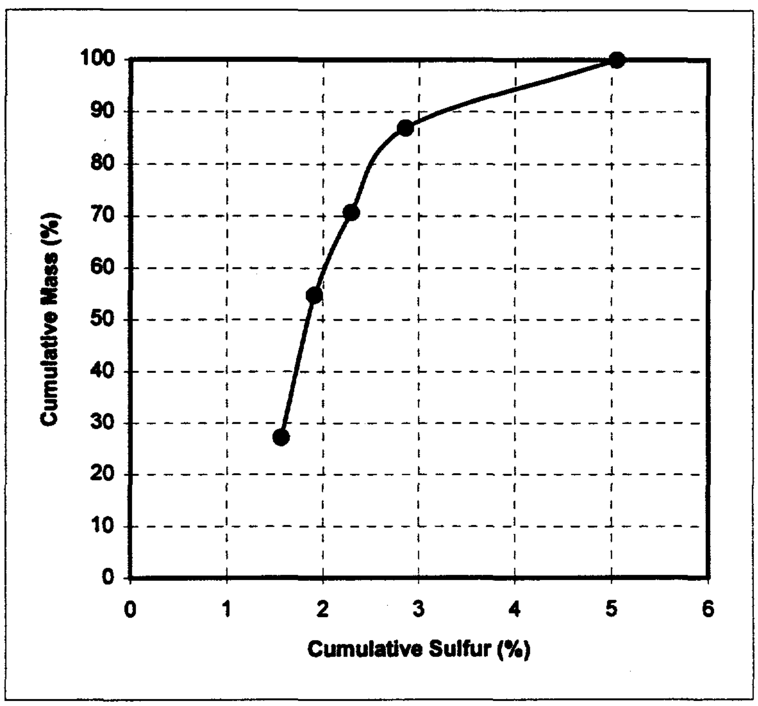
Seam: Pittsburgh No. 8
Sample: Crushed Middlings Only
Class: 10 mm x 28 M
Mass (%): 4.73



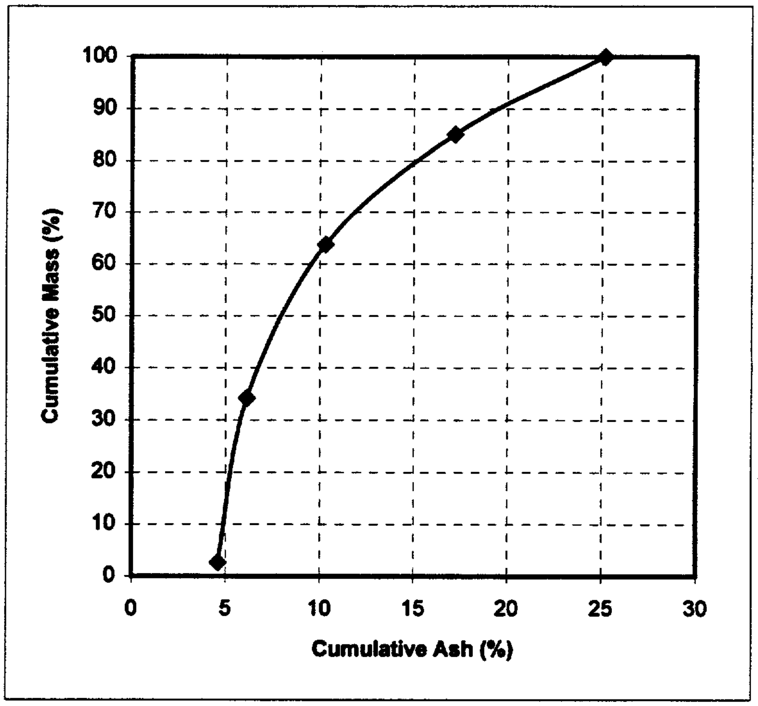



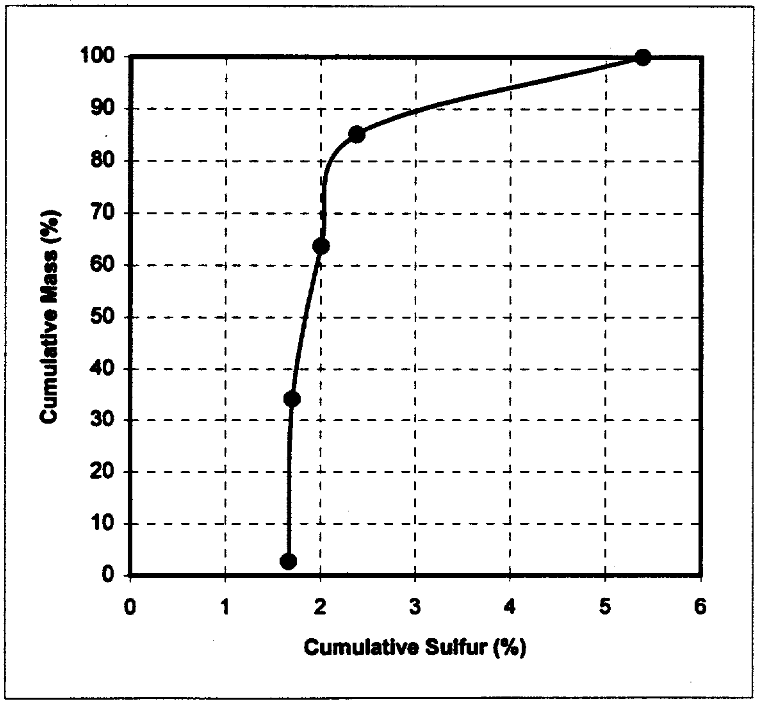
Seam: Pittsburgh No. 8
Sample: Crushed Middlings Only
Class: 28 x 100 M
Mass (%): 0.23



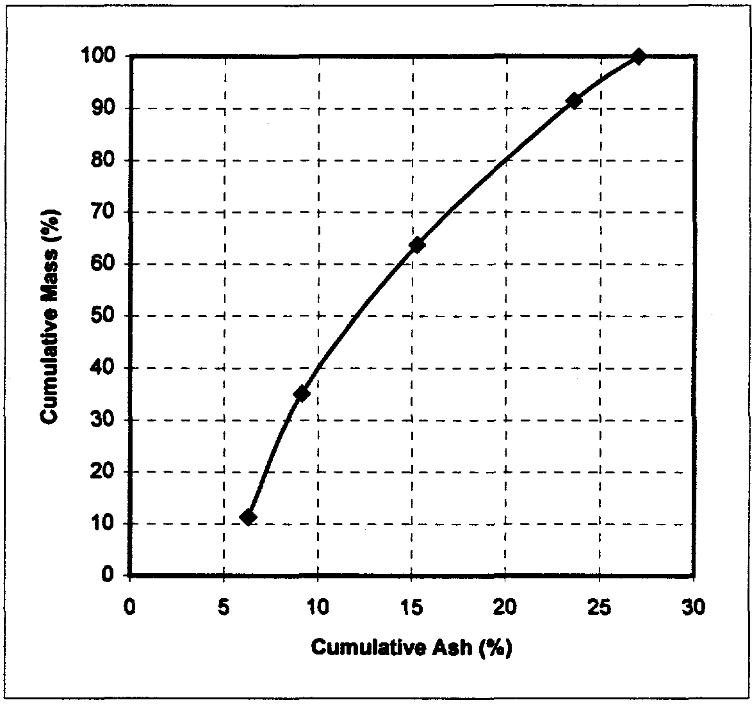



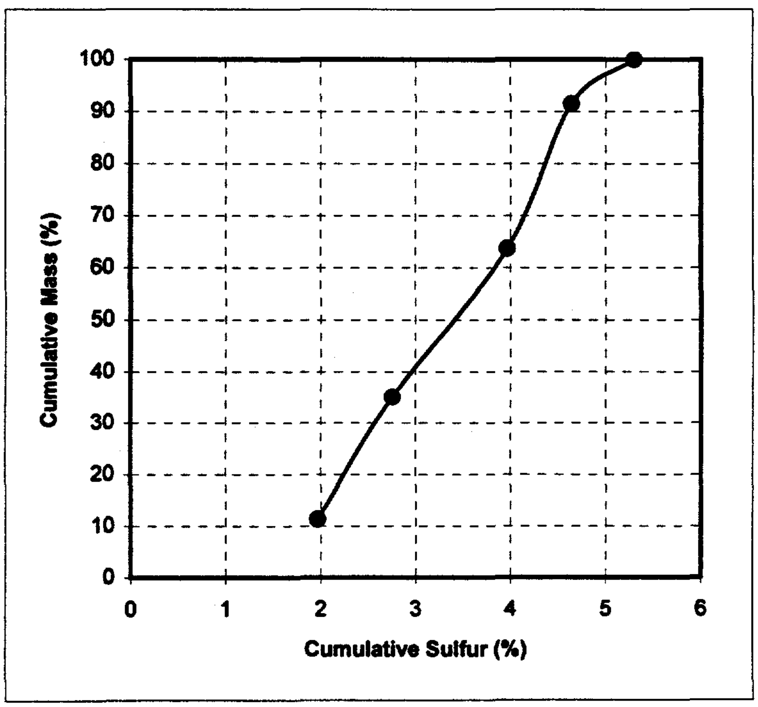
Seam: Pittsburgh No. 8
Sample: Crushed Middlings Only
Class: 100 x 270 M
Mass (%): 0.07



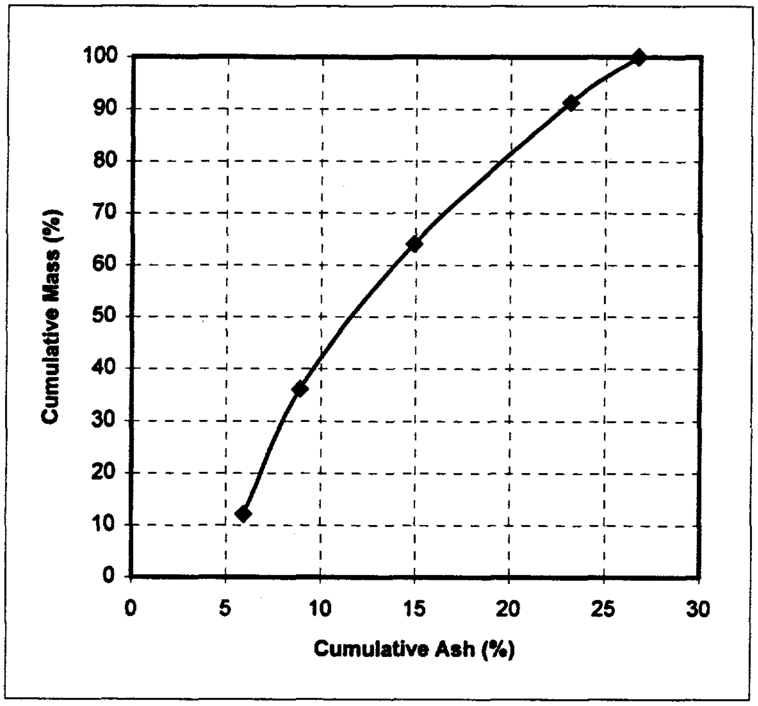



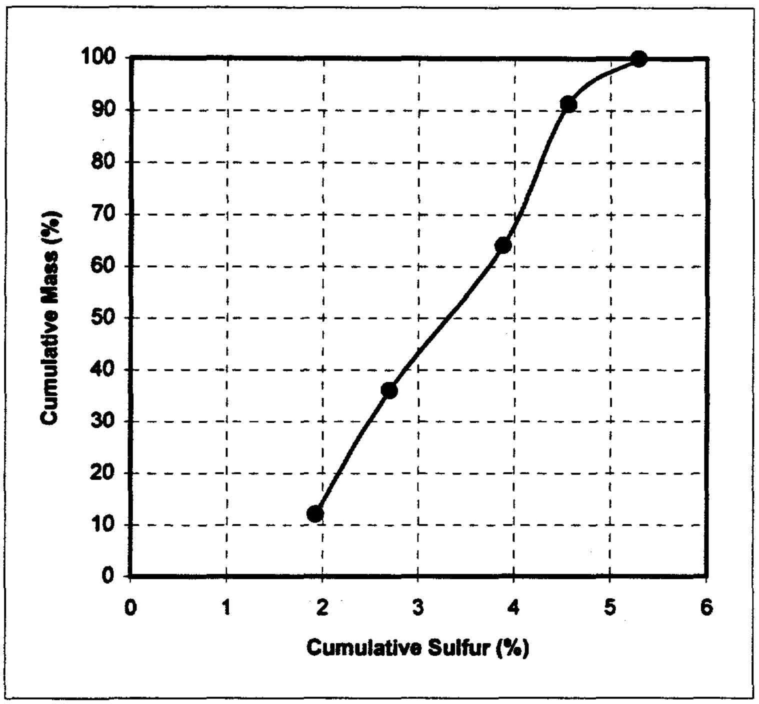
Seam: Pittsburgh No. 8
Sample: Crushed Middlings Only
Class: +28 M
Mass (%): 4.73



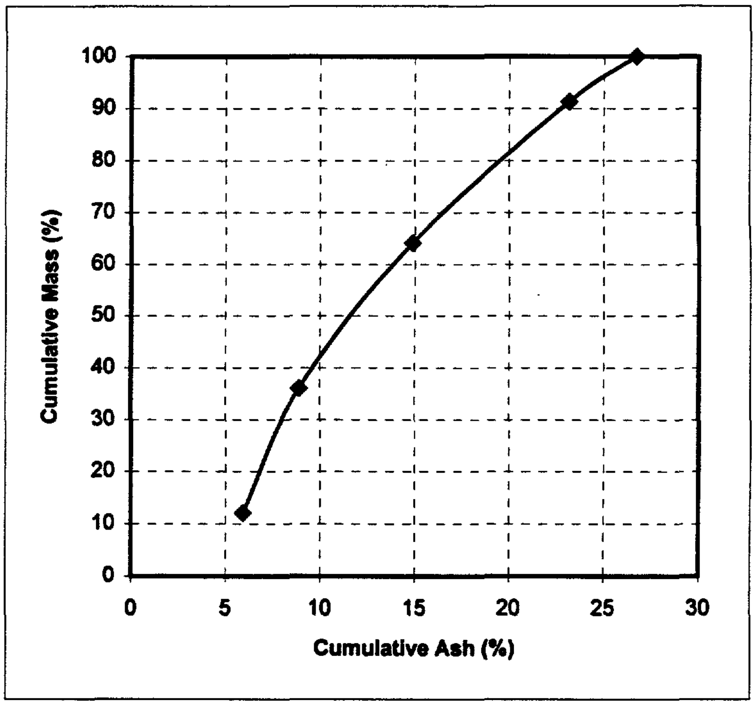



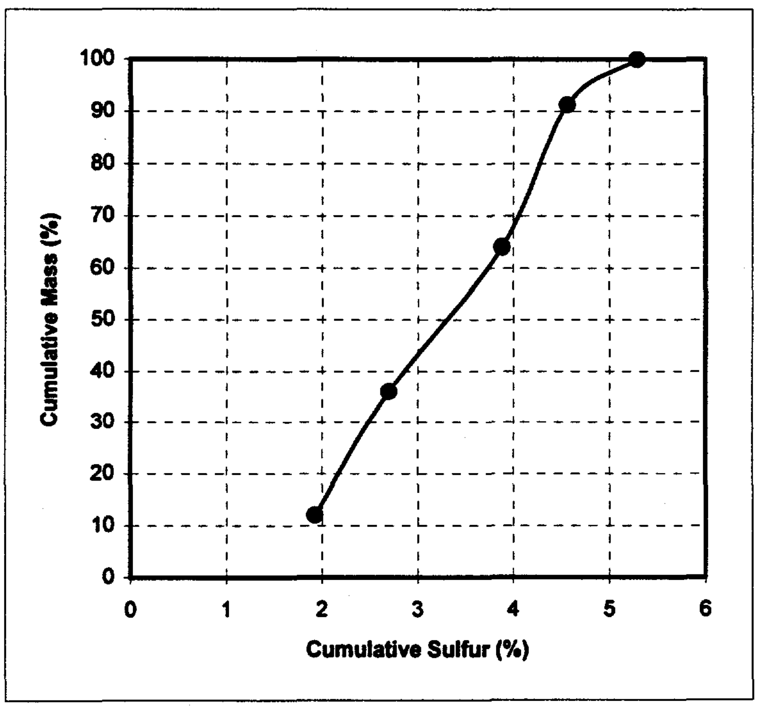
Seam: Pittsburgh No. 8
Sample: Crushed Middlings Only
Class: +100 M
Mass (%): 4.97



Seam: Pittsburgh No. 8
Sample: Crushed Middlings Only
Class: +270 M
Mass (%): 5.04



## APPENDIX II

**Flotation Release Analysis Characterization Data**
Pittsburgh No. 8 Seam

Table I. Ash and Sulfur release values for Pittsburg # 8 Coal

| Size Fraction | Ash (%) | Sulfur (%) | Ash Rejection(%) | Sulfur Rejection (%) | Combustible Recovery (%) |
|---|---|---|---|---|---|
| 28 x 100 | 3.53 | 1.83 | 97.1 | 99.53 | 14.57 |
| | 4.32 | 2.17 | 87.57 | 74.05 | 50.63 |
| | 5.19 | 2.66 | 80.46 | 58.24 | 65.73 |
| | 5.6 | 2.85 | 78.27 | 53.87 | 67.49 |
| | 15.55 | 3.73 | 0 | 0 | 100 |
| 100 x 270 | 3.96 | 2.19 | 95.26 | 98.8 | 33.57 |
| | 5.36 | 2.5 | 83.4 | 68.04 | 85.52 |
| | 6.33 | 2.95 | 78 | 57.74 | 94.99 |
| | 7.01 | 3.27 | 75.1 | 52.13 | 96.3 |
| | 22.58 | 5.48 | 0 | 0 | 100 |
| - 270 mesh | 3.42 | 1.37 | 99.79 | 99.91 | 6.12 |
| | 3.35 | 1.4 | 98.78 | 87.21 | 35.66 |
| | 4.5 | 1.73 | 95.99 | 61.37 | 86.49 |
| | 5.38 | 1.97 | 94.92 | 53.51 | 90.63 |
| | 50.36 | 2.01 | 0 | 0 | 100 |

Table II. Ash and Sulfur release values for Pittsburg # 8 Coal
( + 10 mm Crushed )

| Size Fraction | Ash (%) | Sulfur (%) | Ash Rejection(%) | Sulfur Rejection (%) | Combustible Recovery (%) |
|---|---|---|---|---|---|
| 28 x 100 | 8.14 | 3.19 | 93.72 | 98.93 | 19.7 |
| | 10.68 | 3.61 | 71.45 | 57.21 | 66.39 |
| | 12.56 | 3.87 | 57.82 | 42.35 | 81.69 |
| | 13.71 | 4 | 50.16 | 35.48 | 87.21 |
| | 21.76 | 4.91 | 0 | 0 | 100 |
| 100 x 270 | 8.86 | 2.73 | 94.41 | 99.05 | 21.47 |
| | 10.12 | 3.04 | 78.99 | 66.76 | 69.62 |
| | 11.57 | 3.25 | 69.48 | 54.83 | 87.06 |
| | 13.43 | 3.68 | 61.19 | 44.11 | 93.32 |
| | 27.17 | 5.16 | 0 | 0 | 100 |
| - 270 mesh | 8.83 | 2.29 | 97.91 | 99.56 | 15.1 |
| | 11.03 | 2.65 | 89.8 | 73.66 | 57.62 |
| | 12.22 | 2.8 | 85.58 | 64.4 | 72.55 |
| | 13.69 | 2.98 | 81.28 | 56.12 | 82.68 |
| | 41.19 | 3.83 | 0 | 0 | 100 |

## APPENDIX III

**Bench-Scale Heavy Media Test Data**
Pittsburgh No. 8 Seam

## *TECHBAL - MATERIAL BALANCE SPREADSHEET*

**CIRCUIT:** Node #1: Primary Sizing @ 10mm — **TABLE 1**

| | Measured Values | | | | | | Estimated Values | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream | Mass | Ash % | Sulfur % | | | | Mass | Ash % | Sulfur % | | | |
| Screen Feed | 7703.73 | 23.75 | 3.11 | | | | 7703.22 | 23.68 | 2.97 | | | |
| Oversize | 3907.54 | 27.61 | 2.90 | | | | 3913.02 | 27.66 | 3.01 | | | |
| Undersize | 3796.19 | 19.55 | 2.83 | | | | 3790.20 | 19.57 | 2.93 | | | |
| | | | | | | | | | | | | |

| | Relative Standard Deviations (%) | | | | | | Standard Deviations | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream | Mass | Ash % | Sulfur % | | | | Mass | Ash % | Sulfur % | | | |
| Screen Feed | 1.00 | 0.50 | 1.50 | | | | 77.04 | 0.12 | 0.05 | | | |
| Oversize | 1.10 | 0.50 | 2.00 | | | | 42.98 | 0.14 | 0.06 | | | |
| Undersize | 1.20 | 0.50 | 2.00 | | | | 45.55 | 0.10 | 0.06 | | | |
| | | | | | | | | | | | | |

| | Weighted Square Differences | | | | | | Relative Change in Measured Value (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream | Mass | Ash % | Sulfur % | | | | Mass | Ash % | Sulfur % | | | |
| Screen Feed | 0.00 | 0.35 | 8.91 | | | | -0.01 | -0.29 | -4.48 | | | |
| Oversize | 0.02 | 0.12 | 3.55 | | | | 0.14 | 0.17 | 3.77 | | | |
| Undersize | 0.02 | 0.06 | 3.18 | | | | -0.16 | 0.12 | 3.56 | | | |
| | | | | | | | | | | | | |
| WSSQ: | 0.03 | 0.52 | 15.64 | | | | | | | | | |
| Total WSSQ: | 16.20 | | | | | | | | | | | |

# *TECHBAL - MATERIAL BALANCE SPREADSHEET*

**CIRCUIT:** Node #2: Primary Dense Media Bath @ 1.35 & 2.0 SG's **Table 2**

| | Measured Values | | | | | | Estimated Values | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream | Mass | Ash % | | | | | Mass | Ash % | | | | |
| Bath Feed | 3022.36 | 27.61 | | | | | 3297.23 | 27.01 | | | | |
| Low SG Float | 2100.84 | 5.73 | | | | | 2077.17 | 5.80 | | | | |
| High SG Float | 450.74 | 25.60 | | | | | 450.64 | 26.23 | | | | |
| High SG Sink | 470.78 | 83.46 | | | | | 769.41 | 84.74 | | | | |

| | Relative Standard Deviations (%) | | | | | | Standard Deviations | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream | Mass | Ash % | | | | | Mass | Ash % | | | | |
| Bath Feed | 1.00 | 0.10 | | | | | 30.22 | 0.03 | | | | |
| Low SG Float | 0.10 | 0.20 | | | | | 2.10 | 0.01 | | | | |
| High SG Float | 0.10 | 0.30 | | | | | 0.45 | 0.08 | | | | |
| High SG Sink | 1.00 | 0.10 | | | | | 4.71 | 0.08 | | | | |

| | Weighted Square Differences | | | | | | Relative Change in Measured Value (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream | Mass | Ash % | | | | | Mass | Ash % | | | | |
| Bath Feed | 82.71 | 471.89 | | | | | 9.09 | -2.17 | | | | |
| Low SG Float | 126.95 | 32.26 | | | | | -1.13 | 1.14 | | | | |
| High SG Float | 0.05 | 68.20 | | | | | -0.02 | 2.48 | | | | |
| High SG Sink | 4023.88 | 234.79 | | | | | 63.43 | 1.53 | | | | |
| WSSQ: | 4233.59 | 807.15 | | | | | | | | | | |
| Total WSSQ: | 5040.74 | | | | | | | | | | | |

## TECHBAL - MATERIAL BALANCE SPREADSHEET

**CIRCUIT:** Node #3: Secondary Sizing @ 28M (including crushed 2" x 10mm mids) **Table 3**

| | Measured Values | | | | | | Estimated Values | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream | Mass | Ash % | | | | | Mass | Ash % | | | | |
| Sreen Feed | 3869.98 | 20.19 | | | | | 3872.44 | 20.18 | | | | |
| Oversize | 3051.71 | 19.02 | | | | | 3051.69 | 19.02 | | | | |
| Undersize | 820.75 | 24.49 | | | | | 820.74 | 24.49 | | | | |
| | | | | | | | | | | | | |

| | Relative Standard Deviations (%) | | | | | | Standard Deviations | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream | Mass | Ash % | | | | | Mass | Ash % | | | | |
| Sreen Feed | 1.00 | 1.00 | | | | | 38.70 | 0.20 | | | | |
| Oversize | 0.10 | 0.20 | | | | | 3.05 | 0.04 | | | | |
| Undersize | 0.10 | 1.00 | | | | | 0.82 | 0.24 | | | | |
| | | | | | | | | | | | | |

| | Weighted Square Differences | | | | | | Relative Change in Measured Value (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream | Mass | Ash % | | | | | Mass | Ash % | | | | |
| Sreen Feed | 0.00 | 0.00 | | | | | 0.06 | -0.05 | | | | |
| Oversize | 0.00 | 0.00 | | | | | 0.00 | 0.00 | | | | |
| Undersize | 0.00 | 0.00 | | | | | 0.00 | 0.01 | | | | |
| | | | | | | | | | | | | |
| WSSQ: | 0.00 | 0.00 | | | | | | | | | | |
| Total WSSQ: | 0.01 | | | | | | | | | | | |

## *TECHBAL - MATERIAL BALANCE SPREADSHEET*

**CIRCUIT:** Node #4: Secondary Dense Media Bath @ 1.65 — **Table 4**

| | Measured Values | | | | | | Estimated Values | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream | Mass | Ash % | | | | | Mass | Ash % | | | | |
| Bath Feed | 3049.24 | 19.02 | | | | | 2964.33 | 18.21 | | | | |
| Clean | 2639.69 | 11.49 | | | | | 2669.49 | 11.75 | | | | |
| Reject | 290.37 | 75.43 | | | | | 294.85 | 76.69 | | | | |
| | | | | | | | | | | | | |

| | Relative Standard Deviations (%) | | | | | | Standard Deviations | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream | Mass | Ash % | | | | | Mass | Ash % | | | | |
| Bath Feed | 1.00 | 1.00 | | | | | 30.49 | 0.19 | | | | |
| Clean | 1.00 | 1.00 | | | | | 26.40 | 0.11 | | | | |
| Reject | 1.00 | 1.00 | | | | | 2.90 | 0.75 | | | | |
| | | | | | | | | | | | | |

| | Weighted Square Differences | | | | | | Relative Change in Measured Value (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream | Mass | Ash % | | | | | Mass | Ash % | | | | |
| Bath Feed | 7.75 | 17.97 | | | | | -2.78 | -4.24 | | | | |
| Clean | 1.27 | 5.32 | | | | | 1.13 | 2.31 | | | | |
| Reject | 2.38 | 2.80 | | | | | 1.54 | 1.67 | | | | |
| | | | | | | | | | | | | |
| WSSQ: | 11.40 | 26.08 | | | | | | | | | | |
| Total WSSQ: | 37.48 | | | | | | | | | | | |

## *TECHBAL - MATERIAL BALANCE SPREADSHEET*

**CIRCUIT:** Node #5: Tertiary Screening @ 100 Mesh — **Table 5**

| | Measured Values | | | | | | Estimated Values | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream | Mass | Ash % | | | | | Mass | Ash % | | | | |
| Screen Feed | 820.75 | 24.49 | | | | | 809.64 | 24.73 | | | | |
| Oversize | 197.87 | 15.28 | | | | | 227.36 | 14.64 | | | | |
| Undersize | 354.09 | 39.91 | | | | | 582.28 | 28.66 | | | | |
| | | | | | | | | | | | | |

| | Relative Standard Deviations (%) | | | | | | Standard Deviations | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream | Mass | Ash % | | | | | Mass | Ash % | | | | |
| Screen Feed | 0.50 | 0.20 | | | | | 4.10 | 0.05 | | | | |
| Oversize | 2.00 | 1.00 | | | | | 3.96 | 0.15 | | | | |
| Undersize | 10.00 | 1.00 | | | | | 35.41 | 0.40 | | | | |
| | | | | | | | | | | | | |

| | Weighted Square Differences | | | | | | Relative Change in Measured Value (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream | Mass | Ash % | | | | | Mass | Ash % | | | | |
| Screen Feed | 7.33 | 23.12 | | | | | -1.35 | 0.96 | | | | |
| Oversize | 55.52 | 17.74 | | | | | 14.90 | -4.21 | | | | |
| Undersize | 41.53 | 793.90 | | | | | 64.44 | -28.18 | | | | |
| | | | | | | | | | | | | |
| WSSQ: | 104.38 | 834.76 | | | | | | | | | | |
| Total WSSQ: | 939.14 | | | | | | | | | | | |

## TECHBAL - MATERIAL BALANCE SPREADSHEET

**CIRCUIT:** Node #6: 10mm Undersize and Crushed Middlings Blend — **Table 6**

| | Measured Values | | | | | | Estimated Values | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream | Mass | Ash % | | | | | Mass | Ash % | | | | |
| Passing 10mm | 3423.06 | 19.55 | | | | | 3423.57 | 19.55 | | | | |
| Crushed Mids | 444.14 | 25.60 | | | | | 444.14 | 25.60 | | | | |
| Product | 3869.98 | 20.19 | | | | | 3867.72 | 20.24 | | | | |
| | | | | | | | | | | | | |

| | Relative Standard Deviations (%) | | | | | | Standard Deviations | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream | Mass | Ash % | | | | | Mass | Ash % | | | | |
| Passing 10mm | 1.00 | 0.10 | | | | | 34.23 | 0.02 | | | | |
| Crushed Mids | 0.10 | 0.10 | | | | | 0.44 | 0.03 | | | | |
| Product | 2.00 | 2.00 | | | | | 77.40 | 0.40 | | | | |
| | | | | | | | | | | | | |

| | Weighted Square Differences | | | | | | Relative Change in Measured Value (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream | Mass | Ash % | | | | | Mass | Ash % | | | | |
| Passing 10mm | 0.00 | 0.00 | | | | | 0.01 | 0.00 | | | | |
| Crushed Mids | 0.00 | 0.00 | | | | | 0.00 | 0.00 | | | | |
| Product | 0.00 | 0.02 | | | | | -0.06 | 0.27 | | | | |
| | | | | | | | | | | | | |
| WSSQ: | 0.00 | 0.02 | | | | | | | | | | |
| Total WSSQ: | 0.02 | | | | | | | | | | | |