TECHNICAL PROGRESS REPORT

DOE/PC/95154--T2

PRECOMBUSTION REMOVAL OF HAZARDOUS AIR POLLUTANT PRECURSORS

Contract No.: DE-AC22-95PC95154

Technical Project Report for the Second Quarter
January 1, 1996 - March 31, 1996

Prime Contractor:

Department of Mining and Minerals Engineering
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061-0239

Subcontractors:

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

Prepared for:

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U.S. Department of Energy
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Date Submitted: April 30, 1996

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, the project work plan and all associated technical/management reports were successfully approved by the COR (Subtask 1.1 - Work Plan Development). Test work is now actively moving forward on several different fronts. In Subtask 2.2 - Coal Procurement, arrangements have now been completed to procure/ship the three run-of-mine coals required to complete the project. All steps necessary to properly prepare and store these coals have been made under Subtask 2.3 - Preparation and Storage. For the Pittsburgh No. 8 coal, initial characterization studies have been initiated under Subtask 3.1 - Preliminary Analyses and Subtask 3.2 - Washability Analysis. Effort is also currently underway in Subtask 4.1 - Heavy Media to provide subcontractors (i.e., Clark-Atlanta) with samples of refuse material needed to begin the analysis of pond toxics. Since several of the project subtasks are slightly behind schedule due to unexpected delays, additional manpower has been allocated in an effort to bring all project activities back on schedule.

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 which do not meet this 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 1.1 - Work Plan Development

The preliminary draft of the Project Work Plan and all associated technical/management plans were submitted to the DOE COR on November 24, 1995. These preliminary documents were reviewed by the various project subcontractors and by the DOE COR. Since several modifications were requested, a revised draft Project Work Plan (Revision No. 1) was prepared and resubmitted to

DOE on January 14, 1996 for review. Several additional minor revisions were requested by the COR in correspondence dated February 1, 1996. These included the elimination of minor inconsistencies in project scheduling and the addition of clarifying statements related to project management and the technical programs. After incorporating these additional corrections, the final draft of the Project Work Plan (Revision No. 2) was resubmitted to the COR for final review and/or approval. This version of the Project Work Plan was approved by the COR in correspondence dated March 20, 1996.

Final copies of the completed Environmental Questionnaires (with original signatures) were provided to DOE for the prime contractor and for all project subcontractors. The COR has reviewed and approved these documents and has forwarded the questionnaires to appropriate parties within the Pittsburgh Energy Technology Center (PETC) for final review and approval. Notification of NEPA approval is expected shortly.

Subtask 1.2 - Project Reporting

Modified copies of the project reporting schedule have been prepared and forwarded to each of the project subcontractors. As a result of this planning, all project reports required to date have been submitted in a timely fashion to DOE. These include all status, management and technical reports. No delays are currently anticipated in meeting future reporting requirements.

Task 2 - Sample Acquisition

Subtask 2.1 - Coal Selection

As stated in the previous technical progress report, three different coal samples from major bituminous coal producing regions in the Northern Appalachia, Central Appalachia and the Illinois coal basins have been selected for the proposed test work. Table 1 provides a summary of the coals seams that have been chosen. The selections were largely based on input provided by the industrial participants, i.e., CONSOL Inc. and EPRI.

Table 1 - Coal samples selected for characterization and testing.

Sample	Coal Seam	Supplier	Request
1	Pittsburgh No. 8	Consol Inc.	4,500 kg
2	Illinois No. 6	EPRI (Illinois Power)	900 kg
3	Pocahontas No. 3	Consol Inc.	900 kg

Subtask 2.2 - Coal Procurement

As stated in the first technical progress report, approximately 4,500 kg (5 tons) of Pittsburgh No. 8 seam coal was shipped by CONSOL Inc. to Virginia Tech for testing and evaluation. At that time, arrangements were also underway to procure approximately 450 kg (1,000 lbs) of Illinois No. 6 and Pocahontas No. 3 coals. Table 1 shows that the amount of sample requested for the two additional coals has been nearly doubled from that reported in the first technical progress report, i.e., from 450 kg (1,000 lbs) to 900 kg (1 ton). This increase was deemed necessary in light of statistical calculations which indicated that the larger quantities of coal would be required to obtain representative samples in the characterization test work (see Subtask 3.2 - Washability Analyses). The suppliers of the Illinois No. 6 and Pocahontas No. 3 coals have been requested to withhold delivery until the characterization work is completed for the Pittsburgh No. 8 coal. This request was necessary i) to ensure that fresh, unoxidized samples would be supplied for the characterization test work and ii) to minimize the likelihood that the coal samples would be accidentally contaminated during long-term storage at the Virginia Tech test facility.

Subtask 2.3 - Preparation and Storage

At the request of CONSOL Inc., most of the initial project test work will be conducted using the Pittsburgh No. 8 coal. As outlined in the previous technical progress report, a representative split of this coal was set aside, allowed to air-dry and then transferred into 55 gallon drums for use in the characterization test work. The storage drums were lined with plastic inserts and mechanically sealed to prevent accidental contamination.

Preparation of the Pittsburgh No. 8 coal has proceeded as shown in Figure 1. As shown, the entire shipment of approximately 10.8 tons of coal was passed over a 50 mm (2 inch) grizzly screen. The oversize material was passed through a bench-scale jaw crusher to reduce the topsize to below 50 mm. The undersize material from the grizzly and the crushed oversize material were remixed and then rotary split into 30 drums as representative samples. One drum of the representative feed coal was set aside and subjected to particle size analysis and head grade analysis.

Five drums containing approximately 922 kg (2030 lbs) of the run-of-mine sample were passed across a hand-fed 10 mm (0.4 inch) vibratory screen deck. This procedure generated approximately 3 drums of 50 x 10 mm material weighing 517 kg (1139.5 lbs) and two drums of 10 x 0 mm material weighing 404 kg (890.8 lbs). The 10 x 0 mm undersize material was spread out on plastic sheets and again subjected to air-drying to ensure that all free surface moisture was removed from the fines fraction.

The air-dried 10 x 0 mm coal was hand-fed onto a 28 mesh (0.6 mm) Sweeco vibrating screen. The Sweeco screen was configured to operate with a forced circular motion to minimize particle breakage and to provide an adequate retention time to ensure that nearly perfect sizing would be achieved. This procedure generated approximately 323.6 kg (712.7 lbs) of 10 mm x

28 mesh oversize material and 80.9 kg (178.1 lbs) of 28 mesh x 0 undersize material. In order to ensure that no fine particles adhered to particles in the oversize, the 10 mm x 28 mesh fraction was passed across the Sweeco screen a second time while being rinsed with fresh water. The wet-screening reduced the weight of the oversize material from 323.6 kg (712.7 lbs) to 315.5 kg (695.0 lbs). An additional 8.1 kg (17.8 lbs) of 28 mesh x 0 coal fines was produced and added back to the 80.9 kg (178.1 lbs) of dry-sized 28 mesh x 0 coal. This resulted in a total weight of 89.0 kg (197 lbs) for the 28 mesh x 0 coal (i.e., 8.1 + 80.9 = 89.0 kg).

Approximately 275 liters (72.6 gallons) of rinse water were used during the wet-sizing of the 10 mm x 28 mesh coal. This water was reused to further subdivide the 28 mesh x 0 coal via wet-screening into 28 x 100 mesh, 100 x 270 mesh and 270 mesh x 0 size fractions. Each fraction of sized material was filtered and then placed in a low-temperature oven (<65°C) to obtain dry weights of 52.3 kg (115 lbs), 106 kg (23.3 lbs) and 17.9 kg (39.5 lbs), respectively. An additional 251 liters (66.2 gallons) of rinse water was required to thoroughly complete the wet-sizing. As a result, the total amount of water recovered by filtration was approximately 526 liters (i.e., 251+275 = 526 liters). A representative sample of the rinse water was collected for subsequent trace element analysis so that a complete trace element mass balance could be obtained for the sizing exercise. All solid samples have been placed in plastic storage containers, properly tagged and set aside for use in the characterization tests.

Task 3 - Characterization

Subtask 3.1 - Preliminary Analyses

The preliminary analysis of the Pittsburgh No. 8 sample is presently underway. Figure 2 compares the size distribution of the sample shipped to Virginia Tech to that obtained at the host preparation plant site in late October 1995. As shown, the sample received at Virginia Tech has essentially the same size distribution at that tested at the plant site. The only discrepancy appears to be that the Virginia Tech sample contains a smaller proportion of weight in the >10 mm size range. However, this difference should be expected since the >50 mm material in the Virginia Tech sample was screened out and crushed to below 50 mm during the sample preparation step.

Complete proximate and ultimate analyses are presently underway for the Pittsburgh No. 8 coal. The results of these preliminary analyses will be reported after the data has been tabulated and reviewed by the contractor. Since this task is running slightly behind schedule, additional manpower has been allocated to bring this task back on track.

Subtask 3.2 - Washability Analyses

During the past quarter, the laboratory equipment necessary to determine the washabilities of the selected coal samples was set up at the coal testing facility at Virginia Tech. The required mass of sample for these tests have been determined using guidelines provided by ASTM and other

internationally accepted information sources. These guidelines are summarized in the charts provided in Appendix I.

Float-sink testing is presently underway with the Pittsburgh No. 8 coal. For comparison, washability analyses conducted by the participating coal company in late October 1995 have been provided in Appendix II. This data suggests that the Pittsburgh No. 8 coal contains a relatively small amount of middlings material. For example, the only 8.19% of the >25.4 mm (>1 inch) feed material is present in the 1.50 x 1.70 specific gravity class. This value varies from 5-15% for the other size fractions examined in this analysis. As a result, the recrushing of the middlings fraction to recover additional coal will have only a modest impact on this particular sample. It may be necessary to recrush a wider gravity fraction (e.g., 1.40 x 1.80 SG) in order to generate sufficient mass to properly evaluate the "mids" recrushing strategy outlined in the project work plan.

Although no numerical data was available at the time this report was generated, the float-sink testing has been initiated for the sample of Pittsburgh No. 8 coal shipped to Virginia Tech. The results of the washability analyses will be reported after all the data have tabulated and reviewed by the contractor. This subtask is presently running slightly behind schedule because of delays associated with sample shipping, preparation and analysis. However, it is anticipated that the allocation of additional manpower during the next two months will bring this effort back on schedule prior to the end of the next technical reporting period.

Task 4 - Bench-Scale Testing

Subtask 4.1 - Heavy Media

During the past quarter, a semi-continuous Wemco (deep cone) heavy media bath was refurbished and set up for the heavy media testing program at Virginia Tech. Shakedown tests have begun with this unit using coarse coal fractions of Pittsburgh No. 8 coal. Representative samples of the reject material from this process will be used to provide samples for testing by Clark Atlanta University. Operation of the heavy media bath for the detailed testing of the Pittsburgh No. 8 coal will not be initiated until after the completion of the characterization studies described in the previous section. It is anticipated that this effort will be initiated and completed for the Pittsburgh No. 8 coal by the end of the next technical reporting period.

Task 6 - Toxic Fate Studies

Subtask 6.1 - Analysis of Pond Toxics

As described above, samples of Pittsburgh No. 8 coal refuse are presently being prepared for analysis by personnel at Clark Atlanta University. These data will be reported as they become available.

Task 9 - Sample Analyses

Subtask 9.1 - Coal Analyses

All coal analyses have been completed by the contractor according to ASTM standards. To ensure the reliability of these data, a spreadsheet-based (Microsoft Excel) mass balance program has been developed for routine data evaluation. A copy of the spreadsheet program is provided in Appendix III. For demonstration purposes, example data has been entered for a combination coal spiral-froth flotation circuit. Copies of the program will be made available to all project participants involved in test data analysis.

Subtask 9.2 - Trace Element Analyses

An informal pay-per-sample agreement has been made with the Chemistry Department at Virginia Tech to utilize their ICP equipment for trace element determinations. The ability to conduct these analyses "in-house" with our own laboratory specialist will ensure that costs are held to a minimum and that quality control can be maintained. Since this task is presently running behind schedule, a request has been made to the COR to purchase a commercial microwave digestion system to speed the process of preparing samples for analysis. This unit has already been specified for bid-only by the Virginia Tech purchasing department and will be procured/shipped as soon as approval is obtained from DOE. Effort is also underway to expand the mass balance spreadsheet software to monitor the reliability of the trace element analyses. This effort should also be completed prior to the end of the next technical reporting period.

SUMMARY, STATUS AND PLANNED WORK

The project work plan and all associated technical/management reports were successfully approved by the COR during the past quarter (Subtask 1.1 - Work Plan Development). Test work is now actively moving forward in several areas including Subtask 2.2 - Coal Procurement, Subtask 2.3 - Preparation and Storage, Subtask 3.1 - Preliminary Analyses, Subtask 3.2 - Washability Analysis, Subtask 4.1 - Heavy Media and Task 9 - Sample Analyses. In addition, effort is currently underway to provide Clark-Atlanta with the necessary refuse material to begin test work under Subtask 6.1 - Analysis of Pond Toxics.

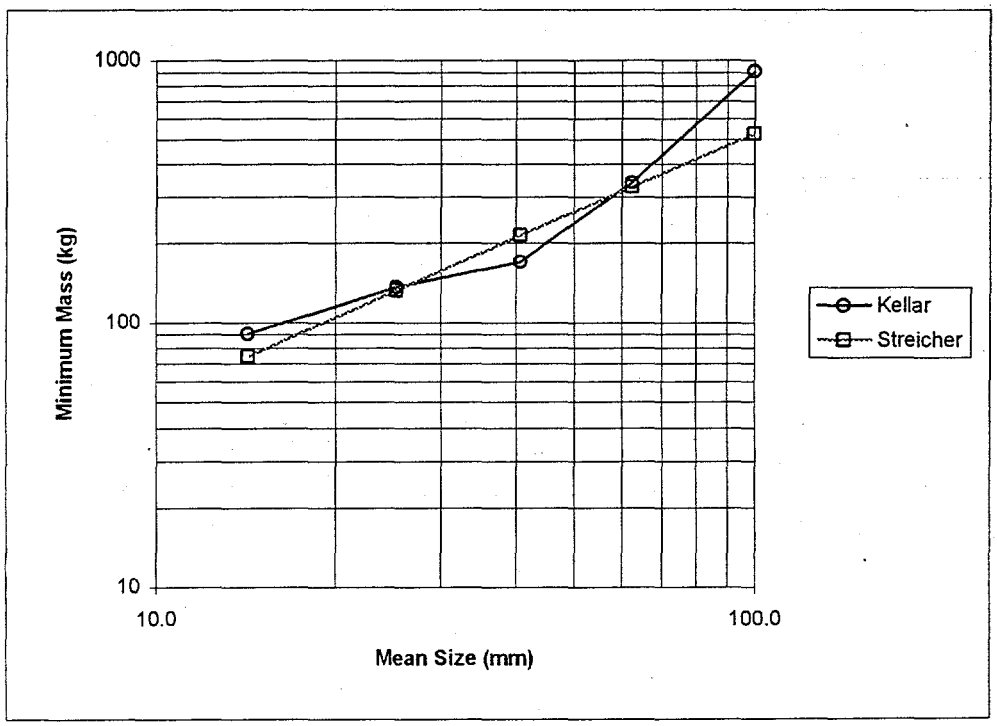
Unfortunately, several of the project subtasks are slightly behind schedule as a result of unexpected delays in acquiring the necessary coal samples and changes in project personnel and laboratory staffing. Additional manpower will continue to be allocated during the upcoming months to bring all project activities back on schedule. The project should be returned to its original schedule during the early summer months.

===== APENDIX I =====

SAMPLE MASS REQUIREMENT GUIDELINES

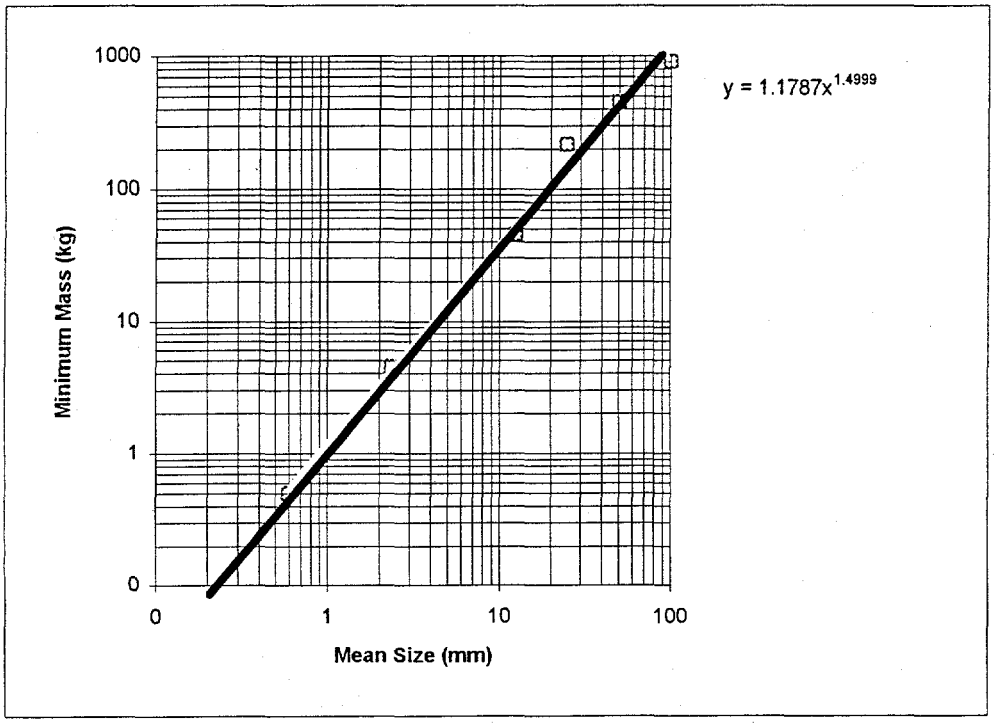
Required Sample Mass for Washability Analyses

Particle Size Upper (mm)	Particle Size Lower (mm)	Particle Size Mean (mm)	Kellar Upper Mass (kg)	Kellar Lower Mass (kg)	Kellar Mean Mass (kg)	Streicher Mean Mass (kg)
125	75	100.0	1134	680	907	524
75	50	62.5	454	227	341	328
50	32	40.8	227	113	170	214
32	19	25.3	181	91	136	132
19	9.5	14.3	113	68	91	75



Required Sample Mass for General Analysis (ASTM)

Particle Size Upper (mm)	ASTM Required Mass (kg)	Predicted Required Mass (kg)
100	900	1179
50	450	417
25	215	147
12.5	45	52
2.36	4.5	4.3
0.60	0.5	0.5



===== APENDIX II =====

WASHABILITY DATA
PITTSBURGH NO. 8 COAL

SIZE + 100M SIZE PCT: 95.19

SPEC GRAV		ELEMENTARY DATA				CUMULATIVE FLOAT				CUMULATIVE SINK			
SINK	FLOAT	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU
0.00	- 1.30	83.09	4.64	1.91	0	83.09	4.64	1.91	0	100.00	15.80	3.20	0
1.30	- 1.40	16.24	9.32	3.20	0	79.34	5.59	2.17	0	36.91	34.90	5.40	0
1.40	- 1.50	4.50	18.73	4.67	0	83.84	6.19	2.30	0	20.66	55.01	7.14	0
1.50	- 1.60	2.05	24.68	5.33	0	85.90	6.63	2.38	0	16.18	65.68	7.83	0
1.60	- 1.70	1.15	32.12	5.68	0	87.04	6.97	2.42	0	14.10	71.65	8.19	0
1.70	- 1.80	0.66	38.25	5.96	0	87.70	7.20	2.45	0	12.96	75.15	8.41	0
1.80	- 2.00	1.23	45.30	6.69	0	88.93	7.73	2.51	0	12.30	77.12	8.55	0
2.00	- OVER	11.07	80.67	8.75	0	100.00	15.80	3.20	0	11.07	80.67	8.75	0

SIZE - 100M SIZE PCT: 4.81

SPEC GRAV	ELEMENTARY DATA				CUMULATIVE FLOAT				CUMULATIVE SINK			
FROTH FLOAT	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU
1ST MINUTE	82.54	7.57	2.70	0	82.54	7.57	2.70	0	100.00	19.60	3.00	0
2ND MINUTE	0.00	0.00	0.00	0	82.54	7.57	2.70	0	17.46	78.45	4.42	0
TAILINGS	17.46	78.45	4.42	0	100.00	19.60	3.00	0	17.46	78.45	4.42	0

SIZE + 48M SIZE PCT: 93.22

SPEC GRAV		ELEMENTARY DATA				CUMULATIVE FLOAT				CUMULATIVE SINK			
SINK	FLOAT	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU
0.00 -	1.30	62.91	4.67	1.91	0	62.91	4.67	1.91	0	100.00	15.89	3.20	0
1.30 -	1.40	16.35	9.35	3.21	0	79.26	5.63	2.18	0	37.09	34.92	5.38	0
1.40 -	1.50	4.53	16.76	4.68	0	83.79	6.24	2.31	0	20.74	55.09	7.09	0
1.50 -	1.60	2.06	24.71	5.32	0	85.85	6.68	2.39	0	16.21	65.80	7.77	0
1.60 -	1.70	1.15	32.20	5.66	0	87.00	7.02	2.43	0	14.15	71.80	8.12	0
1.70 -	1.80	0.66	38.33	5.95	0	87.66	7.25	2.46	0	13.00	75.30	8.34	0
1.80 -	2.00	1.23	45.42	6.68	0	88.90	7.78	2.51	0	12.34	77.28	8.47	0
2.00 -	OVER	11.10	80.82	8.67	0	100.00	15.89	3.20	0	11.10	80.82	8.67	0

SIZE - 48M SIZE PCT: 6.78

SPEC GRAV		ELEMENTARY DATA				CUMULATIVE FLOAT				CUMULATIVE SINK			
SINK	FLOAT	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU
0.00 -	1.30	20.91	3.28	1.68	0	20.91	3.28	1.68	0	100.00	17.29	3.05	0
1.30 -	1.40	3.19	7.16	2.40	0	24.10	3.79	1.78	0	79.09	21.00	3.41	0
1.40 -	1.50	59.52	7.69	2.72	0	83.62	6.56	2.45	0	75.90	21.58	3.45	0
1.50 -	1.60	0.47	21.74	5.78	0	84.09	6.65	2.47	0	16.38	72.08	6.09	0
1.60 -	1.70	0.30	28.27	6.48	0	84.39	6.72	2.48	0	15.91	73.58	6.10	0
1.70 -	1.80	0.15	33.19	6.77	0	84.54	6.77	2.49	0	15.61	74.44	6.10	0
1.80 -	2.00	0.38	39.40	7.10	0	84.91	6.91	2.51	0	15.46	74.84	6.09	0
2.00 -	OVER	15.09	75.69	6.07	0	100.00	17.29	3.05	0	15.09	75.69	6.07	0

*
NOTE: FROTH IS INCLUDED IN THE FOLLOWING FRACTIONS.

FROTH	SPEC GRAV	
	SINK	FLOAT
1ST MINUTE	1.40 -	1.50
2ND MINUTE	**********	
TAILINGS	2.00 -	OVER

SIZE + 1/4" SIZE PCT: 87.29

SPEC GRAV		ELEMENTARY DATA				CUMULATIVE FLOAT				CUMULATIVE SINK			
SINK	FLOAT	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU
0.00 -	1.30	59.04	5.07	1.98	0	59.04	5.07	1.98	0	100.00	17.72	3.37	0
1.30 -	1.40	17.66	9.38	3.25	0	76.69	6.06	2.28	0	40.96	35.95	5.37	0
1.40 -	1.50	4.91	16.99	4.57	0	81.61	6.72	2.41	0	23.31	56.09	6.98	0
1.50 -	1.60	2.33	24.88	5.10	0	83.94	7.22	2.49	0	18.39	66.53	7.62	0
1.60 -	1.70	1.24	32.75	5.31	0	85.18	7.60	2.53	0	16.06	72.58	7.98	0
1.70 -	1.80	0.72	39.18	5.76	0	85.90	7.86	2.56	0	14.82	75.91	8.21	0
1.80 -	2.00	1.35	48.42	6.58	0	87.25	8.48	2.62	0	14.10	77.80	8.33	0
2.00 -	OVER	12.75	81.11	8.52	0	100.00	17.72	3.37	0	12.75	81.11	8.52	0

SIZE - 1/4" SIZE PCT: 32.71

SPEC GRAV		ELEMENTARY DATA				CUMULATIVE FLOAT				CUMULATIVE SINK			
SINK	FLOAT	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU
0.00 -	1.30	62.16	3.79	1.75	0	62.16	3.79	1.75	0	100.00	12.42	2.81	0
1.30 -	1.40	23.08	8.29	2.84	0	85.24	5.01	2.05	0	37.84	28.60	4.54	0
1.40 -	1.50	3.00	15.86	5.02	0	88.24	5.38	2.15	0	14.76	55.23	7.20	0
1.50 -	1.60	1.18	23.79	6.26	0	89.43	5.62	2.20	0	11.76	65.26	7.76	0
1.60 -	1.70	0.78	30.09	6.86	0	90.21	5.83	2.24	0	10.57	69.91	7.92	0
1.70 -	1.80	0.43	35.00	6.68	0	90.64	5.97	2.27	0	9.79	73.09	8.01	0
1.80 -	2.00	0.82	41.49	7.06	0	91.46	6.29	2.31	0	9.36	74.83	8.07	0
2.00 -	OVER	8.54	78.04	8.17	0	100.00	12.42	2.81	0	8.54	78.04	8.17	0

*
NOTE: FROTH IS INCLUDED IN THE FOLLOWING FRACTIONS.

FROTH	SPEC GRAV	
	SINK	FLOAT
1ST MINUTE	1.30 -	1.40
2ND MINUTE	**********	
TAILINGS	2.00 -	OVER

SIZE + 3/8" SIZE PCT: 56.71

SPEC GRAV		ELEMENTARY DATA				CUMULATIVE FLOAT				CUMULATIVE SINK			
SINK	FLOAT	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU
0.00 -	1.30	60.48	5.16	2.02	0	60.48	5.16	2.02	0	100.00	18.56	3.46	0
1.30 -	1.40	14.96	9.99	3.48	0	75.44	6.12	2.31	0	39.52	39.05	5.65	0
1.40 -	1.50	5.08	17.13	4.51	0	80.52	6.81	2.45	0	24.56	58.75	6.98	0
1.50 -	1.60	2.38	25.40	4.99	0	82.90	7.35	2.52	0	19.48	67.08	7.62	0
1.60 -	1.70	1.29	32.82	5.12	0	84.19	7.74	2.56	0	17.10	72.88	7.98	0
1.70 -	1.80	0.75	39.19	5.67	0	84.94	8.02	2.59	0	15.81	76.15	8.22	0
1.80 -	2.00	1.40	46.64	6.57	0	86.34	8.64	2.66	0	15.06	77.99	8.34	0
2.00 -	OVER	13.66	81.21	8.53	0	100.00	18.56	3.46	0	13.66	81.21	8.53	0

SIZE - 3/8" SIZE PCT: 43.29

SPEC GRAV		ELEMENTARY DATA				CUMULATIVE FLOAT				CUMULATIVE SINK			
SINK	FLOAT	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU
0.00 -	1.30	59.51	3.93	1.75	0	59.51	3.93	1.75	0	100.00	12.62	2.83	0
1.30 -	1.40	25.29	8.16	2.80	0	84.80	5.19	2.08	0	40.49	25.39	4.43	0
1.40 -	1.50	3.25	15.92	5.00	0	88.05	5.59	2.17	0	15.20	54.04	7.14	0
1.50 -	1.60	1.40	23.01	6.07	0	89.45	5.86	2.23	0	11.95	64.43	7.72	0
1.60 -	1.70	0.83	30.69	6.82	0	90.28	6.09	2.27	0	10.55	69.92	7.94	0
1.70 -	1.80	0.46	36.26	6.57	0	90.74	6.25	2.30	0	9.72	73.26	8.04	0
1.80 -	2.00	0.87	42.47	6.94	0	91.62	6.59	2.34	0	9.26	75.12	8.11	0
2.00 -	OVER	8.38	78.53	8.23	0	100.00	12.62	2.83	0	8.38	78.53	8.23	0

*
NOTE: FROTH IS INCLUDED IN THE FOLLOWING FRACTIONS.

FROTH	SPEC GRAV	
	SINK	FLOAT
1ST MINUTE	1.30 -	1.40
2ND MINUTE	**********	
TAILINGS	2.00 -	OVER

SIZE + 1/2" SIZE PCT: 48.27

SPEC GRAV		ELEMENTARY DATA				CUMULATIVE FLOAT				CUMULATIVE SINK			
SINK	FLOAT	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU
0.00 -	1.30	61.45	5.24	2.08	0	61.45	5.24	2.08	0	100.00	19.37	3.54	0
1.30 -	1.40	12.30	10.44	3.69	0	73.74	6.11	2.33	0	38.55	41.89	5.91	0
1.40 -	1.50	5.69	17.08	4.48	0	79.43	6.89	2.49	0	26.26	56.62	6.95	0
1.50 -	1.60	2.50	25.54	4.91	0	81.94	7.46	2.56	0	20.57	67.56	7.64	0
1.60 -	1.70	1.27	33.46	4.94	0	83.21	7.86	2.60	0	18.06	73.38	8.01	0
1.70 -	1.80	0.76	39.12	5.56	0	83.97	8.14	2.62	0	16.79	76.42	8.25	0
1.80 -	2.00	1.45	47.05	6.63	0	85.43	8.81	2.69	0	16.03	78.19	8.38	0
2.00 -	OVER	14.57	81.29	8.55	0	100.00	19.37	3.54	0	14.57	81.29	8.55	0

SIZE - 1/2" SIZE PCT: 51.73

SPEC GRAV		ELEMENTARY DATA				CUMULATIVE FLOAT				CUMULATIVE SINK			
SINK	FLOAT	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU
0.00 -	1.30	58.76	4.05	1.76	0	58.76	4.05	1.76	0	100.00	12.83	2.85	0
1.30 -	1.40	26.09	8.31	2.83	0	84.85	5.36	2.09	0	41.24	25.35	4.42	0
1.40 -	1.50	2.98	16.15	5.01	0	87.83	5.72	2.19	0	15.15	54.70	7.15	0
1.50 -	1.60	1.45	23.24	6.00	0	89.28	6.01	2.25	0	12.17	64.14	7.67	0
1.60 -	1.70	0.92	30.39	6.63	0	90.20	6.25	2.29	0	10.72	69.65	7.90	0
1.70 -	1.80	0.50	37.00	6.53	0	90.70	6.42	2.32	0	9.80	73.33	8.02	0
1.80 -	2.00	0.91	42.69	6.77	0	91.61	6.79	2.38	0	9.30	75.28	8.10	0
2.00 -	OVER	8.39	78.84	8.24	0	100.00	12.83	2.85	0	8.39	78.84	8.24	0

*
NOTE: FROTH IS INCLUDED IN THE FOLLOWING FRACTIONS.

FROTH	SPEC GRAV	
	SINK	FLOAT
1ST MINUTE	1.30 -	1.40
2ND MINUTE	**********	
TAILINGS	2.00 -	OVER

SIZE TOTAL SAMPLE SIZE PCT: 100.00

SPEC GRAV		ELEMENTARY DATA				CUMULATIVE FLOAT				CUMULATIVE SINK			
SINK	FLOAT	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU
0.00 -	1.30	60.06	4.64	1.91	0	60.06	4.64	1.91	0	100.00	15.99	3.19	0
1.30 -	1.40	19.43	8.96	3.09	0	79.49	5.69	2.20	0	39.94	33.05	5.11	0
1.40 -	1.50	4.29	16.73	4.67	0	83.78	6.26	2.32	0	20.51	55.88	7.03	0
1.50 -	1.60	1.96	24.66	5.33	0	85.73	6.68	2.39	0	16.22	66.23	7.65	0
1.60 -	1.70	1.09	32.12	5.68	0	86.83	7.00	2.43	0	14.27	71.93	7.97	0
1.70 -	1.80	0.63	38.25	5.96	0	87.45	7.22	2.46	0	13.17	75.23	8.16	0
1.80 -	2.00	1.17	45.30	6.69	0	88.63	7.73	2.51	0	12.55	77.07	8.27	0
2.00 -	OVER	11.37	80.36	8.43	0	100.00	15.99	3.19	0	11.37	80.36	8.43	0

*
NOTE: FROTH IS INCLUDED IN THE FOLLOWING FRACTIONS.

FROTH	SPEC GRAV	
	SINK	FLOAT
1ST MINUTE	1.30 -	1.40
2ND MINUTE	**********	
TAILINGS	2.00 -	OVER

SIZE + 1" SIZE PCT: 26.39

SPEC GRAV		ELEMENTARY DATA				CUMULATIVE FLOAT				CUMULATIVE SINK			
SINK	FLOAT	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU
0.00 -	1.30	56.80	5.38	2.12	0	56.80	5.38	2.12	0	100.00	22.28	3.96	0
1.30 -	1.40	14.70	10.87	3.87	0	71.50	6.49	2.48	0	43.20	44.54	6.37	0
1.40 -	1.50	4.44	19.36	4.41	0	75.94	7.25	2.59	0	28.50	61.90	7.66	0
1.50 -	1.60	2.67	26.87	4.57	0	78.61	7.91	2.68	0	24.06	69.75	8.26	0
1.60 -	1.70	1.08	34.90	4.47	0	79.69	8.28	2.68	0	21.39	75.10	8.72	0
1.70 -	1.80	0.67	40.02	5.49	0	80.36	8.54	2.71	0	20.31	77.24	8.94	0
1.80 -	2.00	1.74	47.57	7.10	0	82.10	9.37	2.80	0	19.64	78.51	9.06	0
2.00 -	OVER	17.90	81.52	9.25	0	100.00	22.28	3.96	0	17.90	81.52	9.25	0

SIZE - 1" SIZE PCT: 73.61

SPEC GRAV		ELEMENTARY DATA				CUMULATIVE FLOAT				CUMULATIVE SINK			
SINK	FLOAT	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU
0.00 -	1.30	61.23	4.40	1.84	0	61.23	4.40	1.84	0	100.00	13.73	2.91	0
1.30 -	1.40	21.13	8.48	2.90	0	82.36	5.44	2.11	0	38.77	28.47	4.61	0
1.40 -	1.50	4.23	15.74	4.77	0	86.59	5.95	2.24	0	17.64	52.40	6.66	0
1.50 -	1.60	1.70	23.42	5.75	0	88.29	6.28	2.31	0	13.41	63.97	7.26	0
1.60 -	1.70	1.09	31.14	6.10	0	89.38	6.59	2.35	0	11.71	69.88	7.48	0
1.70 -	1.80	0.61	37.55	6.15	0	89.99	6.80	2.38	0	10.62	73.85	7.62	0
1.80 -	2.00	0.97	43.84	6.42	0	90.97	7.19	2.42	0	10.01	76.06	7.71	0
2.00 -	OVER	9.03	79.53	7.85	0	100.00	13.73	2.91	0	9.03	79.53	7.85	0

*
NOTE: FROTH IS INCLUDED IN THE FOLLOWING FRACTIONS.

FROTH	SPEC GRAV	
	SINK	FLOAT
1ST MINUTE	1.30 -	1.40
2ND MINUTE	**********	
TAILINGS	2.00 -	OVER

SIZE 1/4" X 48M SIZE PCT: 25.93

SPEC GRAV		ELEMENTARY DATA				CUMULATIVE FLOAT				CUMULATIVE SINK			
SINK	FLOAT	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU
0.00 -	1.30	72.95	3.83	1.78	0	72.95	3.83	1.78	0	100.00	11.15	2.75	0
1.30 -	1.40	12.97	9.22	3.04	0	85.92	4.64	1.95	0	27.05	30.88	5.41	0
1.40 -	1.50	3.53	15.94	5.09	0	89.45	5.09	2.08	0	14.08	50.83	7.59	0
1.50 -	1.60	1.37	23.97	6.30	0	90.82	5.37	2.14	0	10.55	62.50	8.43	0
1.60 -	1.70	0.91	30.24	6.89	0	91.73	5.62	2.19	0	9.18	68.25	8.75	0
1.70 -	1.80	0.50	35.14	6.67	0	92.23	5.78	2.21	0	8.27	72.43	8.95	0
1.80 -	2.00	0.94	41.70	7.06	0	93.17	6.14	2.26	0	7.77	74.83	9.10	0
2.00 -	OVER	6.83	79.39	9.38	0	100.00	11.15	2.75	0	6.83	79.39	9.38	0

SIZE 48M X 100M SIZE PCT: 1.97

SPEC GRAV		ELEMENTARY DATA				CUMULATIVE FLOAT				CUMULATIVE SINK			
SINK	FLOAT	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU
0.00 -	1.30	71.98	3.28	1.68	0	71.98	3.28	1.68	0	100.00	11.67	3.16	0
1.30 -	1.40	10.97	7.16	2.40	0	82.95	3.79	1.78	0	28.02	33.23	6.95	0
1.40 -	1.50	3.31	14.69	4.00	0	86.26	4.21	1.88	0	17.05	50.00	9.87	0
1.50 -	1.60	1.63	21.74	5.76	0	87.89	4.54	1.93	0	13.74	58.51	11.29	0
1.60 -	1.70	1.02	28.27	6.46	0	88.91	4.81	1.98	0	12.11	63.45	12.03	0
1.70 -	1.80	0.52	33.19	6.77	0	89.43	4.97	2.01	0	11.09	68.69	12.55	0
1.80 -	2.00	1.25	39.40	7.10	0	90.68	5.45	2.08	0	10.57	68.34	12.83	0
2.00 -	OVER	9.32	72.22	13.60	0	100.00	11.67	3.16	0	9.32	72.22	13.60	0

SIZE TOTAL W/O FROTH SIZE PCT: 95.19

SPEC GRAV		ELEMENTARY DATA				CUMULATIVE FLOAT				CUMULATIVE SINK			
SINK	FLOAT	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU
0.00 -	1.30	63.09	4.64	1.91	0	63.09	4.64	1.91	0	100.00	15.80	3.20	0
1.30 -	1.40	16.24	9.32	3.20	0	79.34	5.59	2.17	0	36.91	34.90	5.40	0
1.40 -	1.50	4.50	16.73	4.67	0	83.84	6.19	2.30	0	20.66	55.01	7.14	0
1.50 -	1.60	2.05	24.66	5.33	0	85.90	6.63	2.38	0	16.16	65.68	7.83	0
1.60 -	1.70	1.15	32.12	5.68	0	87.04	6.97	2.42	0	14.10	71.65	8.19	0
1.70 -	1.80	0.66	38.25	5.96	0	87.70	7.20	2.45	0	12.96	75.15	8.41	0
1.80 -	2.00	1.23	45.30	6.69	0	88.93	7.73	2.51	0	12.30	77.12	8.55	0
2.00 -	OVER	11.07	80.67	8.75	0	100.00	15.80	3.20	0	11.07	80.67	8.75	0

SIZE MINUS 100M SIZE PCT: 4.81

SPEC GRAV	ELEMENTARY DATA				CUMULATIVE FLOAT				CUMULATIVE SINK			
FROTH FLOAT	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU
1ST MINUTE	82.54	7.57	2.70	0	82.54	7.57	2.70	0	100.00	19.60	3.00	0
2ND MINUTE	0.00	0.00	0.00	0	82.54	7.57	2.70	0	17.46	76.45	4.42	0
TAILINGS	17.46	76.45	4.42	0	100.00	19.60	3.00	0	17.46	76.45	4.42	0

SIZE PLUS 1" SIZE PCT: 28.39

SPEC GRAV	ELEMENTARY DATA				CUMULATIVE FLOAT				CUMULATIVE SINK			
SINK FLOAT	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU
0.00 - 1.30	56.80	5.36	2.12	0	56.80	5.36	2.12	0	100.00	22.28	3.96	0
1.30 - 1.40	14.70	10.87	3.87	0	71.50	6.49	2.48	0	43.20	44.54	6.37	0
1.40 - 1.50	4.44	19.36	4.41	0	75.94	7.25	2.59	0	28.50	61.90	7.66	0
1.50 - 1.60	2.67	28.87	4.57	0	78.61	7.91	2.66	0	24.06	69.75	8.26	0
1.60 - 1.70	1.08	34.90	4.47	0	79.69	8.28	2.68	0	21.39	75.10	8.72	0
1.70 - 1.80	0.67	40.02	5.49	0	80.36	8.54	2.71	0	20.31	77.24	8.94	0
1.80 - 2.00	1.74	47.57	7.10	0	82.10	9.37	2.80	0	19.64	78.51	9.06	0
2.00 - OVER	17.90	81.52	9.25	0	100.00	22.28	3.96	0	17.90	81.52	9.25	0

SIZE 1" X 1/2" SIZE PCT: 21.88

SPEC GRAV	ELEMENTARY DATA				CUMULATIVE FLOAT				CUMULATIVE SINK			
SINK FLOAT	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU
0.00 - 1.30	67.05	5.12	2.00	0	67.05	5.12	2.00	0	100.00	15.85	3.05	0
1.30 - 1.40	9.40	9.62	3.34	0	76.45	5.67	2.18	0	32.95	37.70	5.19	0
1.40 - 1.50	7.20	15.35	4.53	0	83.65	6.51	2.37	0	23.55	48.90	5.92	0
1.50 - 1.60	2.30	23.68	5.38	0	85.95	6.97	2.45	0	16.35	63.68	6.54	0
1.60 - 1.70	1.51	32.22	5.34	0	87.46	7.40	2.50	0	14.05	70.23	6.73	0
1.70 - 1.80	0.87	38.29	5.63	0	88.33	7.71	2.53	0	12.54	74.80	6.89	0
1.80 - 2.00	1.11	46.08	5.74	0	89.44	8.18	2.57	0	11.67	77.52	6.99	0
2.00 - OVER	10.56	80.83	7.12	0	100.00	15.85	3.05	0	10.56	80.83	7.12	0

SIZE 1/2" X 3/8" SIZE PCT: 8.44

SPEC GRAV	ELEMENTARY DATA				CUMULATIVE FLOAT				CUMULATIVE SINK			
SINK FLOAT	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU
0.00 - 1.30	54.93	4.66	1.78	0	54.93	4.66	1.78	0	100.00	13.90	2.96	0
1.30 - 1.40	30.21	8.95	3.00	0	85.14	6.18	2.21	0	45.07	25.17	4.39	0
1.40 - 1.50	1.56	18.58	5.16	0	86.70	6.40	2.27	0	14.86	58.14	7.22	0
1.50 - 1.60	1.69	24.20	5.73	0	88.39	6.75	2.33	0	13.30	62.78	7.46	0
1.60 - 1.70	1.38	29.46	6.06	0	89.77	7.09	2.39	0	11.61	68.40	7.71	0
1.70 - 1.80	0.68	39.61	6.37	0	90.45	7.34	2.42	0	10.23	73.65	7.93	0
1.80 - 2.00	1.12	43.55	6.10	0	91.57	7.78	2.46	0	9.55	76.08	8.04	0
2.00 - OVER	8.43	80.40	8.30	0	100.00	13.90	2.96	0	8.43	80.40	8.30	0

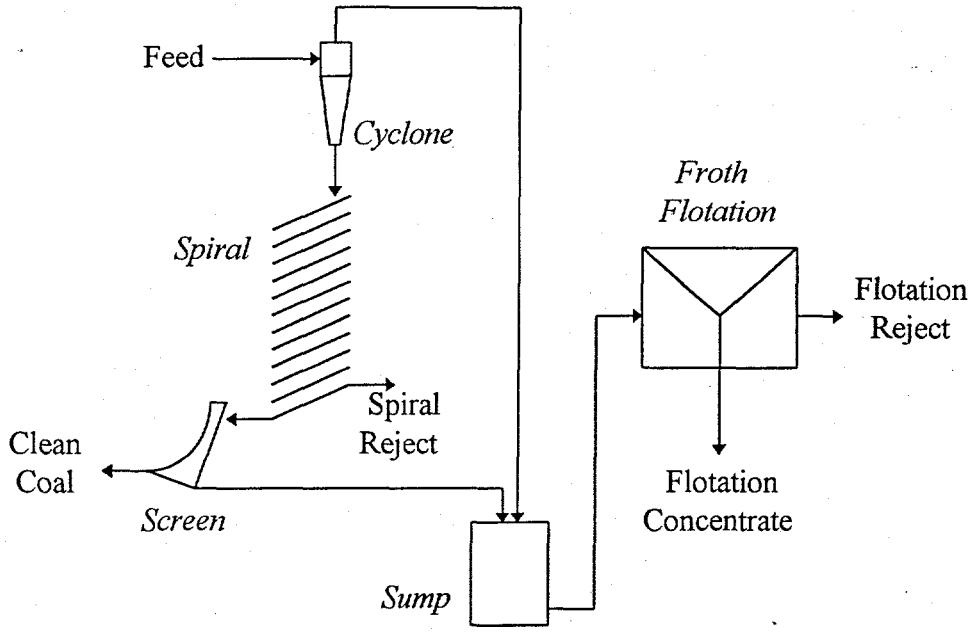
SIZE 3/8" X 1/4" SIZE PCT: 10.58

SPEC GRAV	ELEMENTARY DATA				CUMULATIVE FLOAT				CUMULATIVE SINK			
SINK FLOAT	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU	WT%	ASH	SUL	BTU
0.00 - 1.30	51.31	4.47	1.74	0	51.31	4.47	1.74	0	100.00	13.24	2.91	0
1.30 - 1.40	32.11	7.86	2.69	0	83.42	5.77	2.11	0	48.69	22.48	4.15	0
1.40 - 1.50	4.05	16.07	4.98	0	87.47	6.25	2.24	0	16.58	50.79	6.97	0
1.50 - 1.60	2.06	21.64	5.73	0	89.53	6.61	2.32	0	12.53	62.01	7.62	0
1.60 - 1.70	0.97	32.21	6.72	0	90.50	6.88	2.37	0	10.47	69.95	7.99	0
1.70 - 1.80	0.58	39.13	6.34	0	91.08	7.09	2.39	0	9.50	73.81	8.12	0
1.80 - 2.00	1.04	44.87	6.64	0	92.12	7.51	2.44	0	8.92	76.08	8.24	0
2.00 - OVER	7.88	80.18	8.45	0	100.00	13.24	2.91	0	7.88	80.18	8.45	0

===== APENDIX III =====

TECHBAL SPREADSHEET
EXCEL MASS BALANCE PROGRAM

TECHBAL - EXAMPLE MASS BALANCE



Experimental test data for the combined spiral-froth flotation circuit.

Stream	Rate (tph)	Ash (%)	Sulfur (%)
Circuit Feed	149.0	27.90	0.89
Cyclone Oversize	112.0	26.10	0.71
Cyclone Undersize	37.0	33.50	1.33
Spiral Concentrate	83.0	8.60	0.56
Spiral Reject	28.0	76.20	1.21
Screen Oversize	78.0	7.81	0.55
Screen Undersize	4.9	21.40	0.71
Flotation Feed	42.0	32.20	1.25
Flotation Concentrate	26.0	8.10	0.86
Flotation Reject	15.9	71.80	1.71

TECHBAL - MATERIAL BALANCE SPREADSHEET

CIRCUIT: *Example: Combination Spiral-Flotation Coal Processing Circuit*

(1=In,-1=Out,0=No Effect)

	Node											
Stream	*Cyclone*	*Spiral*	*Screen*	*Sump*	*Flotation*						Sum	Circuit
Circuit Feed	*1*	*0*	*0*	*0*	*0*						1	feed
Cyclone O/S	*-1*	*1*	*0*	*0*	*0*						0	internal
Cyclone U/S	*-1*	*0*	*0*	*1*	*0*						0	internal
Spiral Conc	*0*	*-1*	*1*	*0*	*0*						0	internal
Spiral Tail	*0*	*-1*	*0*	*0*	*0*						-1	product
Screen O/S	*0*	*0*	*-1*	*0*	*0*						-1	product
Screen U/S	*0*	*0*	*-1*	*1*	*0*						0	internal
Float Feed	*0*	*0*	*0*	*-1*	*1*						0	internal
Float Conc	*0*	*0*	*0*	*0*	*-1*						-1	product
Float Tail	*0*	*0*	*0*	*0*	*-1*						-1	product
Junction	0	0	0	1	0						1	
Separator	1	1	1	0	1						4	

Number of feed streams: 1

Number of product streams: 4

Number of internal streams: 5

Minimum required samples: 9

TECHBAL - MATERIAL BALANCE SPREADSHEET

CIRCUIT: Example: Combination Spiral-Flotation Coal Processing Circuit

	Measured Values						Estimated Values					
Stream	Mass	*Ash %*	*Sulfur %*				Mass	Ash %	Sulfur %			
Circuit Feed	*149.00*	*27.90*	*0.89*				*145.11*	*28.01*	*0.87*			
Cyclone O/S	*112.00*	*26.10*	*0.71*				*107.28*	*25.94*	*0.72*			
Cyclone U/S	*37.00*	*33.50*	*1.33*				*37.83*	*33.89*	*1.29*			
Spiral Conc	*83.00*	*8.60*	*0.56*				*79.89*	*8.65*	*0.56*			
Spiral Tail	*28.00*	*76.20*	*1.21*				*27.38*	*76.38*	*1.21*			
Screen O/S	*78.00*	*7.81*	*0.55*				*74.75*	*7.77*	*0.55*			
Screen U/S	*4.90*	*21.40*	*0.71*				*5.14*	*21.41*	*0.71*			
Float Feed	*42.00*	*32.20*	*1.25*				*42.98*	*32.40*	*1.22*			
Float Conc	*26.00*	*8.10*	*0.86*				*26.24*	*8.07*	*0.88*			
Float Tail	*15.90*	*71.80*	*1.71*				*16.73*	*70.54*	*1.76*			

TECHBAL - MATERIAL BALANCE SPREADSHEET

CIRCUIT: Example: Combination Spiral-Flotation Coal Processing Circuit

	Relative Standard Deviations (%)						Standard Deviations					
Stream	Mass	Ash %	Sulfur %				Mass	Ash %	Sulfur %			
Circuit Feed	10.00	1.00	1.00				14.90	0.28	0.01			
Cyclone O/S	10.00	1.00	1.00				11.20	0.26	0.01			
Cyclone U/S	10.00	1.00	1.00				3.70	0.34	0.01			
Spiral Conc	10.00	1.00	1.00				8.30	0.09	0.01			
Spiral Tail	10.00	1.00	1.00				2.80	0.76	0.01			
Screen O/S	10.00	1.00	1.00				7.80	0.08	0.01			
Screen U/S	10.00	1.00	1.00				0.49	0.21	0.01			
Float Feed	10.00	1.00	1.00				4.20	0.32	0.01			
Float Conc	10.00	1.00	1.00				2.60	0.08	0.01			
Float Tail	10.00	1.00	1.00				1.59	0.72	0.02			

TECHBAL - MATERIAL BALANCE SPREADSHEET

CIRCUIT: Example: Combination Spiral-Flotation Coal Processing Circuit

	Weighted Square Differences						Relative Change in Measured Value (%)					
Stream	Mass	Ash %	Sulfur %				Mass	Ash %	Sulfur %			
Circuit Feed	0.07	0.17	3.80				-2.61	0.41	-1.95			
Cyclone O/S	0.18	0.37	3.87				-4.22	-0.61	1.97			
Cyclone U/S	0.05	1.36	7.23				2.25	1.17	-2.69			
Spiral Conc	0.14	0.37	0.04				-3.74	0.61	-0.20			
Spiral Tail	0.05	0.06	0.13				-2.20	0.24	-0.36			
Screen O/S	0.17	0.20	0.06				-4.16	-0.45	-0.25			
Screen U/S	0.24	0.00	0.07				4.94	0.03	-0.27			
Float Feed	0.05	0.38	4.29				2.32	0.61	-2.07			
Float Conc	0.01	0.10	5.84				0.93	-0.31	2.42			
Float Tail	0.28	3.10	9.40				5.25	-1.76	3.07			
WSSQ:	1.24	6.10	34.75									
Total WSSQ:	42.09											

TECHBAL - MATERIAL BALANCE SPREADSHEET

CIRCUIT: Example: Combination Spiral-Flotation Coal Processing Circuit

Unit Matrix: **Mass**

	Node										
Stream	Cyclone	Spiral	Screen	Sump	Flotation						Sum
Circuit Feed	145.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	145.1
Cyclone O/S	-107.3	107.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyclone U/S	-37.8	0.0	0.0	37.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spiral Conc	0.0	-79.9	79.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spiral Tail	0.0	-27.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-27.4
Screen O/S	0.0	0.0	-74.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-74.8
Screen U/S	0.0	0.0	-5.1	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Float Feed	0.0	0.0	0.0	-43.0	43.0	0.0	0.0	0.0	0.0	0.0	0.0
Float Conc	0.0	0.0	0.0	0.0	-26.2	0.0	0.0	0.0	0.0	0.0	-26.2
Float Tail	0.0	0.0	0.0	0.0	-16.7	0.0	0.0	0.0	0.0	0.0	-16.7
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TECHBAL - MATERIAL BALANCE SPREADSHEET

CIRCUIT: Example: Combination Spiral-Flotation Coal Processing Circuit

Unit Matrix: **Ash %**

	Node										
Stream	Cyclone	Spiral	Screen	Sump	Flotation						Sum
Circuit Feed	4065.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4065.1
Cyclone O/S	-2782.9	2782.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyclone U/S	-1282.2	0.0	0.0	1282.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spiral Conc	0.0	-691.3	691.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spiral Tail	0.0	-2091.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-2091.6
Screen O/S	0.0	0.0	-581.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-581.2
Screen U/S	0.0	0.0	-110.1	110.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Float Feed	0.0	0.0	0.0	-1392.3	1392.3	0.0	0.0	0.0	0.0	0.0	0.0
Float Conc	0.0	0.0	0.0	0.0	-211.9	0.0	0.0	0.0	0.0	0.0	-211.9
Float Tail	0.0	0.0	0.0	0.0	-1180.4	0.0	0.0	0.0	0.0	0.0	-1180.4
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TECHBAL - MATERIAL BALANCE SPREADSHEET

CIRCUIT: Example: Combination Spiral-Flotation Coal Processing Circuit

Unit Matrix: **Sulfur %**

	Node										
Stream	Cyclone	Spiral	Screen	Sump	Flotation						Sum
Circuit Feed	126.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	126.6
Cyclone O/S	-77.7	77.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyclone U/S	-49.0	0.0	0.0	49.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spiral Conc	0.0	-44.6	44.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spiral Tail	0.0	-33.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-33.0
Screen O/S	0.0	0.0	-41.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-41.0
Screen U/S	0.0	0.0	-3.6	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Float Feed	0.0	0.0	0.0	-52.6	52.6	0.0	0.0	0.0	0.0	0.0	0.0
Float Conc	0.0	0.0	0.0	0.0	-23.1	0.0	0.0	0.0	0.0	0.0	-23.1
Float Tail	0.0	0.0	0.0	0.0	-29.5	0.0	0.0	0.0	0.0	0.0	-29.5
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TECHBAL - MATERIAL BALANCE SPREADSHEET

CIRCUIT: Example: Combination Spiral-Flotation Coal Processing Circuit

Unit Matrix: **Not Used**

	Node										
Stream	Cyclone	Spiral	Screen	Sump	Flotation						Sum
Circuit Feed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyclone O/S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyclone U/S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spiral Conc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spiral Tail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Screen O/S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Screen U/S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Float Feed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Float Conc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Float Tail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TECHBAL - MATERIAL BALANCE SPREADSHEET

CIRCUIT: Example: Combination Spiral-Flotation Coal Processing Circuit

Unit Matrix: **Not Used**

	Node									
Stream	Cyclone	Spiral	Screen	Sump	Flotation					Sum
Circuit Feed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyclone O/S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyclone U/S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spiral Conc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spiral Tail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Screen O/S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Screen U/S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Float Feed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Float Conc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Float Tail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TECHBAL - MATERIAL BALANCE SPREADSHEET

CIRCUIT: Example: Combination Spiral-Flotation Coal Processing Circuit

Unit Matrix: **Not Used**

	Node										
Stream	Cyclone	Spiral	Screen	Sump	Flotation						Sum
Circuit Feed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyclone O/S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyclone U/S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spiral Conc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spiral Tail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Screen O/S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Screen U/S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Float Feed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Float Conc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Float Tail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 1. Sample preparation diagram for the Pittsburgh No. 8 coal.

Figure 2. Particle size distribitions for the Pittsburgh No. 8 coal.

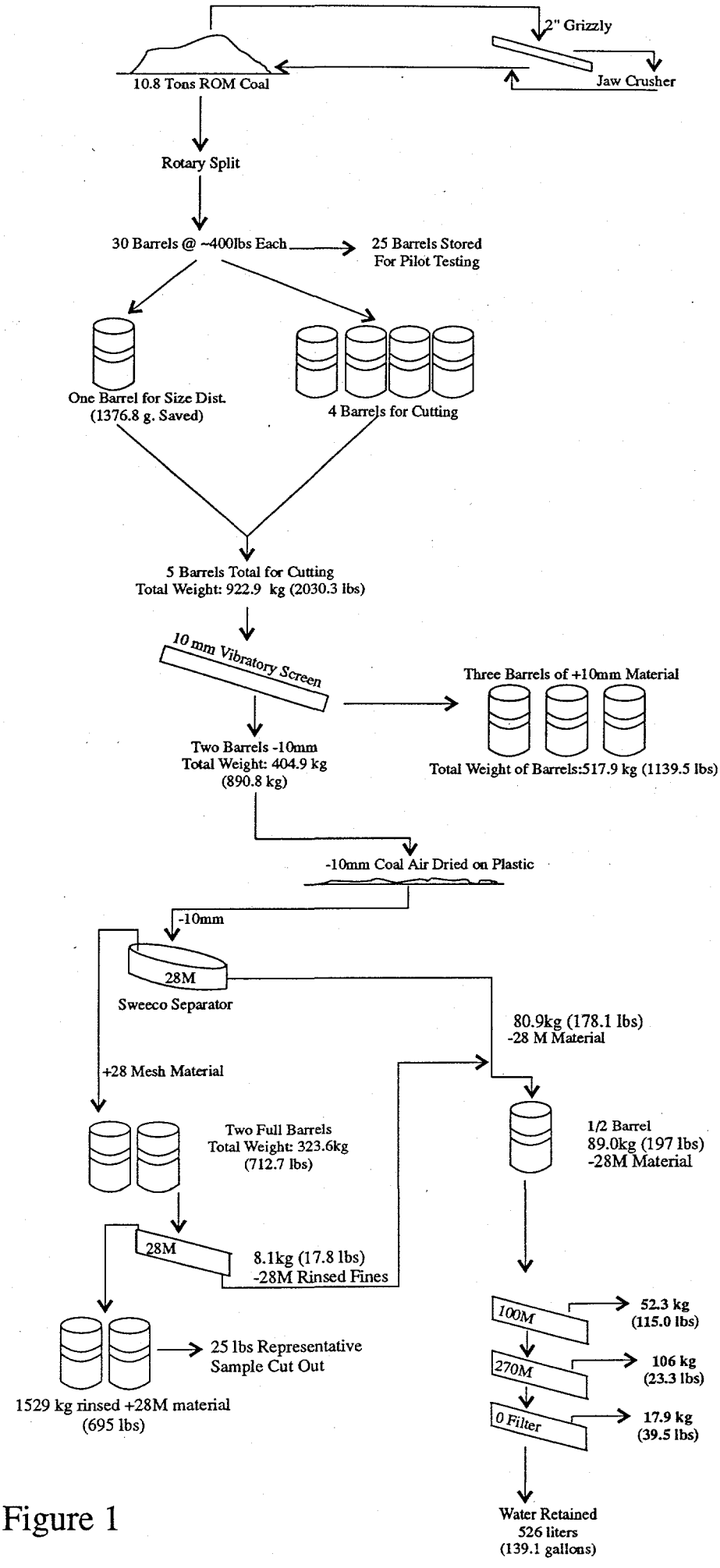

2" Grizzly
10.8 Tons ROM Coal
Jaw Crusher
Rotary Split
30 Barrels @ ~400lbs Each
25 Barrels Stored For Pilot Testing
One Barrel for Size Dist. (1376.8 g. Saved)
4 Barrels for Cutting
5 Barrels Total for Cutting
Total Weight: 922.9 kg (2030.3 lbs)
10 mm Vibratory Screen
Three Barrels of +10mm Material
Two Barrels -10mm
Total Weight: 404.9 kg
(890.8 kg)
Total Weight of Barrels:517.9 kg (1139.5 lbs)
-10mm Coal Air Dried on Plastic
-10mm
28M
Sweeco Separator
80.9kg (178.1 lbs)
-28 M Material
+28 Mesh Material
Two Full Barrels
Total Weight: 323.6kg
(712.7 lbs)
1/2 Barrel
89.0kg (197 lbs)
-28M Material
28M
8.1kg (17.8 lbs)
-28M Rinsed Fines
100M
52.3 kg
(115.0 lbs)
270M
106 kg
(23.3 lbs)
0 Filter
17.9 kg
(39.5 lbs)
25 lbs Representative Sample Cut Out
1529 kg rinsed +28M material
(695 lbs)
Water Retained
526 liters
(139.1 gallons)

Figure 1

Pittsburgh No. 8 Coal
Particle Size Distribution (Virginia Tech)

Size (mm)		Weight	Cumulative
Passing	Retained	(%)	(%)
	10.00	44.03	44.03
10.00	3.35	26.90	70.93
3.35	1.18	13.82	84.75
1.18	0.60	5.82	90.57
0.60	0.15	5.24	95.81
0.15		4.19	100.00
		100.00	

Pittsburgh No. 8 Coal
Particle Size Distribution (CONSOL)

Size (mm)		Weight	Cumulative
Passing	Retained	(%)	(%)
	9.50	56.70	56.70
9.50	2.36	20.80	77.50
2.36	1.18	7.80	85.30
1.18	0.60	4.80	90.10
0.60	0.15	5.10	95.20
0.15		4.80	100.00
		100.00	

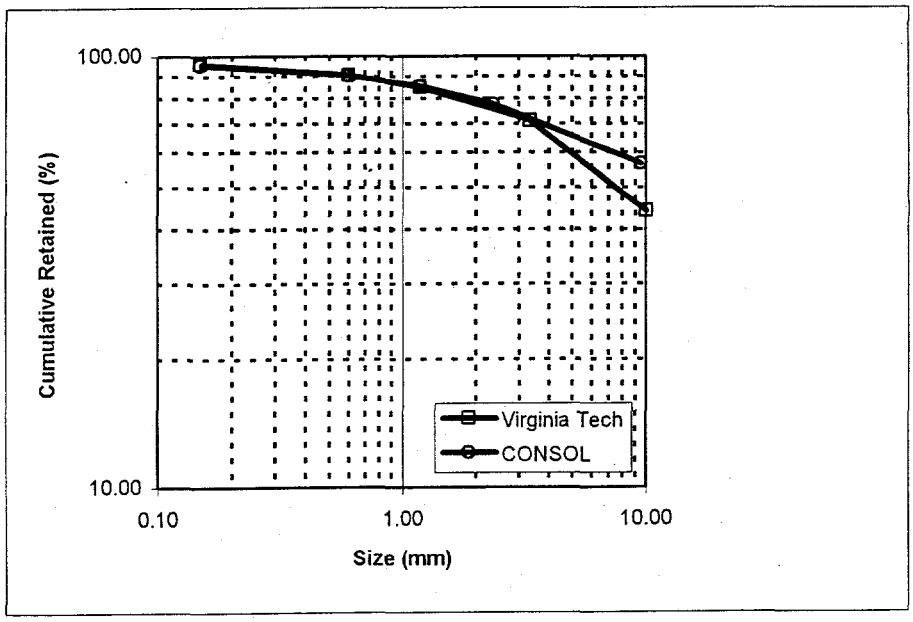


Figure 2