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IMPROVEMENT OF STORAGE, HANDLING, AND TRANSPORTABILITY OF FINE COAL

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PROJECT SUMMARY

Background and Objectives

Fine coal production is on the rise in the U.S., and it will continue to increase as underground mining companies invest in more productive equipment. Fine coal cleaning technologies have been developed that can efficiently and economically separate coal from clay and other mineral matter in the fine size fractions, but they have not gained universal acceptance in the coal industry because they produce a product that is too wet for acceptance in the marketplace.

Historically coal producers take one of two approaches in dealing with fine coal production. On the one hand, they may wash it and recover it as a wet cake, which must be thermally dried prior to shipment. On the other hand, many operators make no attempt to recover fine coal, and dispose of it as a wet cake or slurry in refuse piles, slurry impounments and abandoned deep mines. There are environmental problems related to both of these practices.

The Mulled Coal Process was developed as a means of overcoming the adverse handling characteristics of wet fine coal without thermal drying. The process involves the addition of a low cost, harmless reagent to wet fine coal using off-the-shelf mixing equipment. Based on laboratory- and bench-scale testing, Mulled Coal can be stored, shipped and burned without causing any of the plugging, pasting, carryback and freezing problems normally associated with wet coal. On the other hand, Mulled Coal does not cause the fugitive and airborne dust problems normally associated with thermally dried coal.

The objectives of this project are to demonstrate that:

- The Mulled Coal Process, which has been proven to work on a wide range of wet fine coals at bench scale, will work equally well on a continuous basis, producing consistent quality, and at a convincing rate of production at a commercial coal preparation plant.

- The wet product from a fine coal cleaning circuit can be converted to a solid fuel form for ease of handling and cost savings in storage and rail car transportation.

- A wet fine coal product thus converted to a solid fuel form, can be stored, shipped, and burned with conventional fuel handling, transportation, and combustion systems.

Project Overview

It is useful to describe the project in groups of activities in order to fully understand the interactions between activities and to better understand the information flow and decisions of the project. The project is organized around two major demonstrations: (1) the production of Mulled Coal in a commercial operating setting, and (2) the delivery of the Mulled Coal product through existing commercial storage, transport, and handling systems. An Information Flow Diagram is presented in Figure 1.

The initial project activities are performed largely at the EI facilities and will produce the formulations, test procedures, and design packages required to procure and install the Mulled Coal circuit at the Drummond Company, Inc., Chetopa Preparation Plant in Graysville, Alabama. The installed circuit will be used for the demonstration of Mulled Coal production. The second set of demonstrations will be the shipment and handling of Mulled Coal in existing coal transportation systems available to Drummond and ER&L, a subsidiary of CSX Transportation. Data collected from all phases of production and delivery will then be analyzed, evaluated and reported.

The Mulled Coal circuit will be installed in the operating preparation plant located at the Chetopa Mine site. The Chetopa Plant processes 360 to 450 tonnes/hr (400 to 500 tons/hr) of raw coal to produce 250 to 320 tonnes/hr (275 to 350 tons/hr) of coal for shipment to the steam coal market. Approximately 45 to 55 tonnes/hr (50 to 60 tons/hr) of fine coal is cleaned in froth cells to produce 40 to 45 tonnes/hr (45 to 50 tons/hr) of a fine clean coal that is 10-14 percent ash. Froth concentrate reports to a vacuum filter where a 24-27 percent moisture filter cake is discharged to a collecting belt. In current operations, the wet filter cake is combined with the coarser size fractions of clean coal for storage and delivery to market. The wet filter cake comprise about 15 to 18 percent of the total clean coal product from the plant.

The proof-of-concept (or POC) circuit will process a 2.7 tonnes/hr (3 tons/hr) slipstream of froth concentrate from the existing froth cells in the Chetopa Plant as feed to the Mulled Coal circuit. The froth concentrate will be dewatered in a centrifuge to prepare a wet fine coal feed material for conversion into a free-flowing granular material. The Mulled Coal product will be directed to a 450 tonne (500 ton) open storage pile. The POC unit will be of a design that can be scaled up to 135 tonnes/hr (150 tons/hr). Figure 2 shows the key components of the Chetopa Plant cleaning circuit and the Mulled Coal circuit that will be installed.

The Mulled Coal circuit will be installed in an empty bay at the Chetopa Plant. This area is convenient to the discharge location from the froth cells and at a lower elevation. The use of gravity feeds will minimize field fabrication. Equipment will be installed to divert a 2.7 tonnes/hr (3 tons/hr) slipstream of the froth concentrate to a dewatering centrifuge. The concentrated wet coal fines from the centrifuge will be dropped directly into a surge hopper and feed system for the Mulled Coal circuit. The Mulled Coal product will discharge by gravity from the circuit to a truck or product discharge area from which it will be hauled to a stockpile located at the edge of the active clean coal stockpile area.

Figure 1

INFORMATION FLOW DIAGRAM

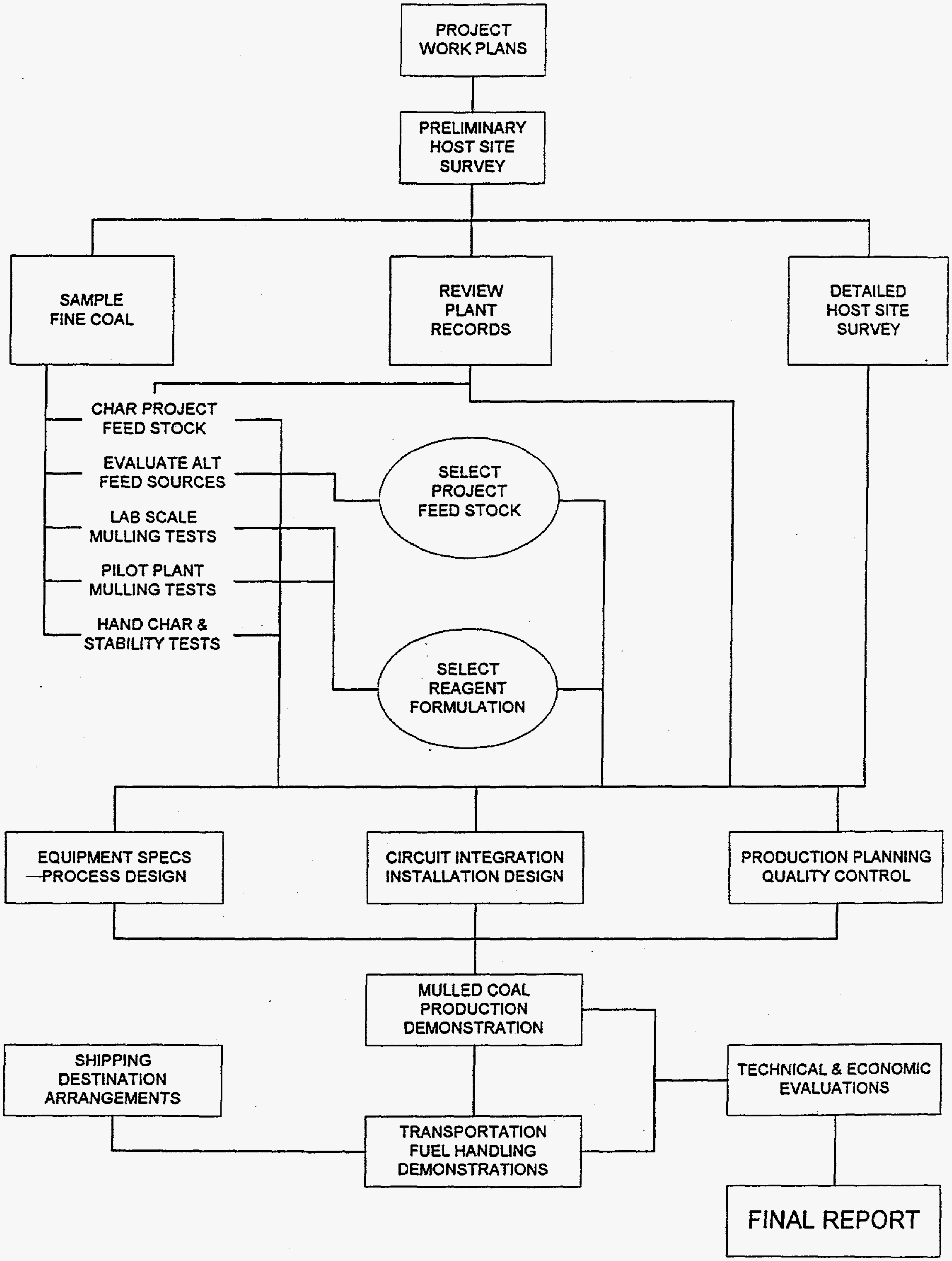
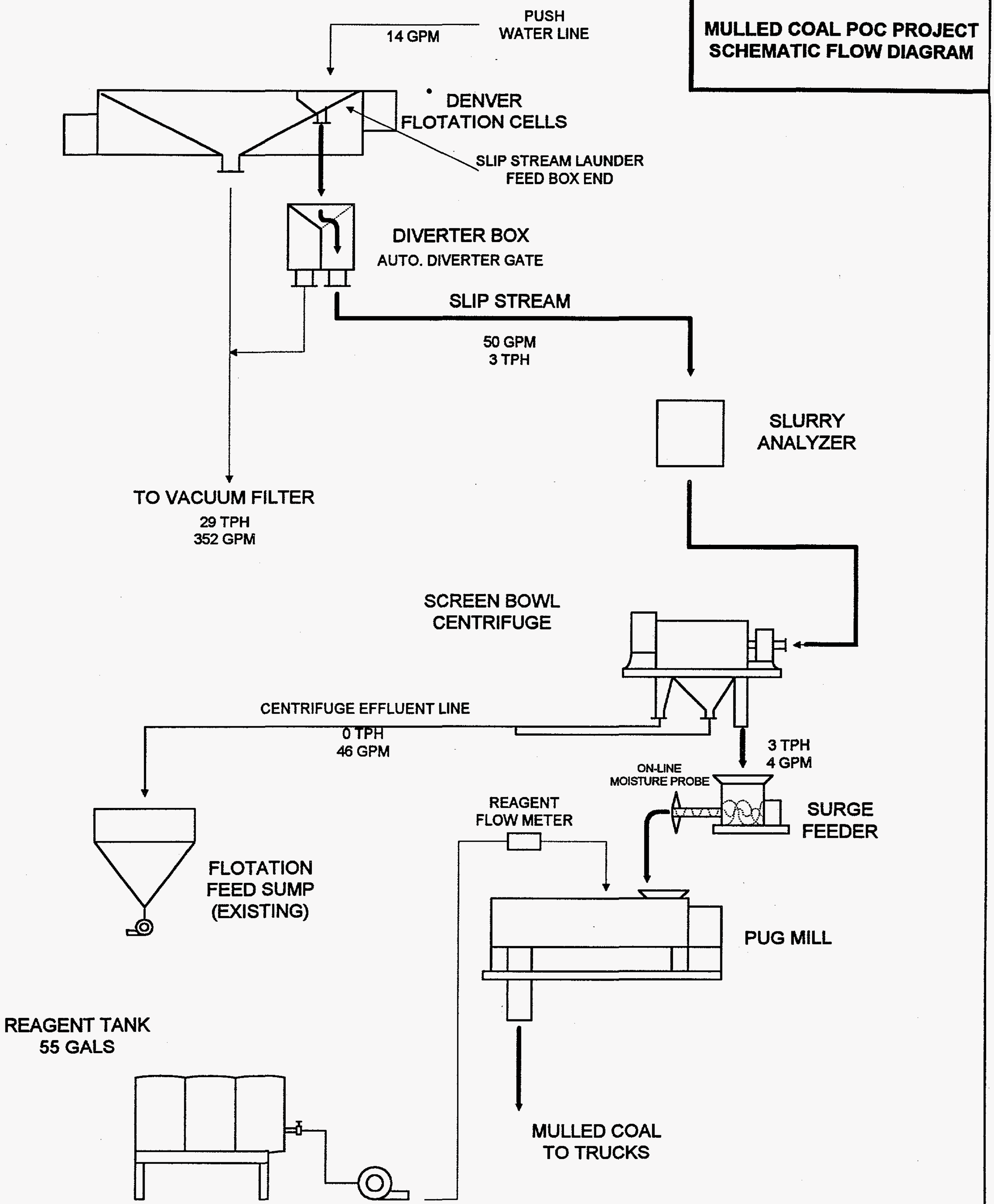


FIGURE 2

MULLED COAL POC PROJECT SCHEMATIC FLOW DIAGRAM



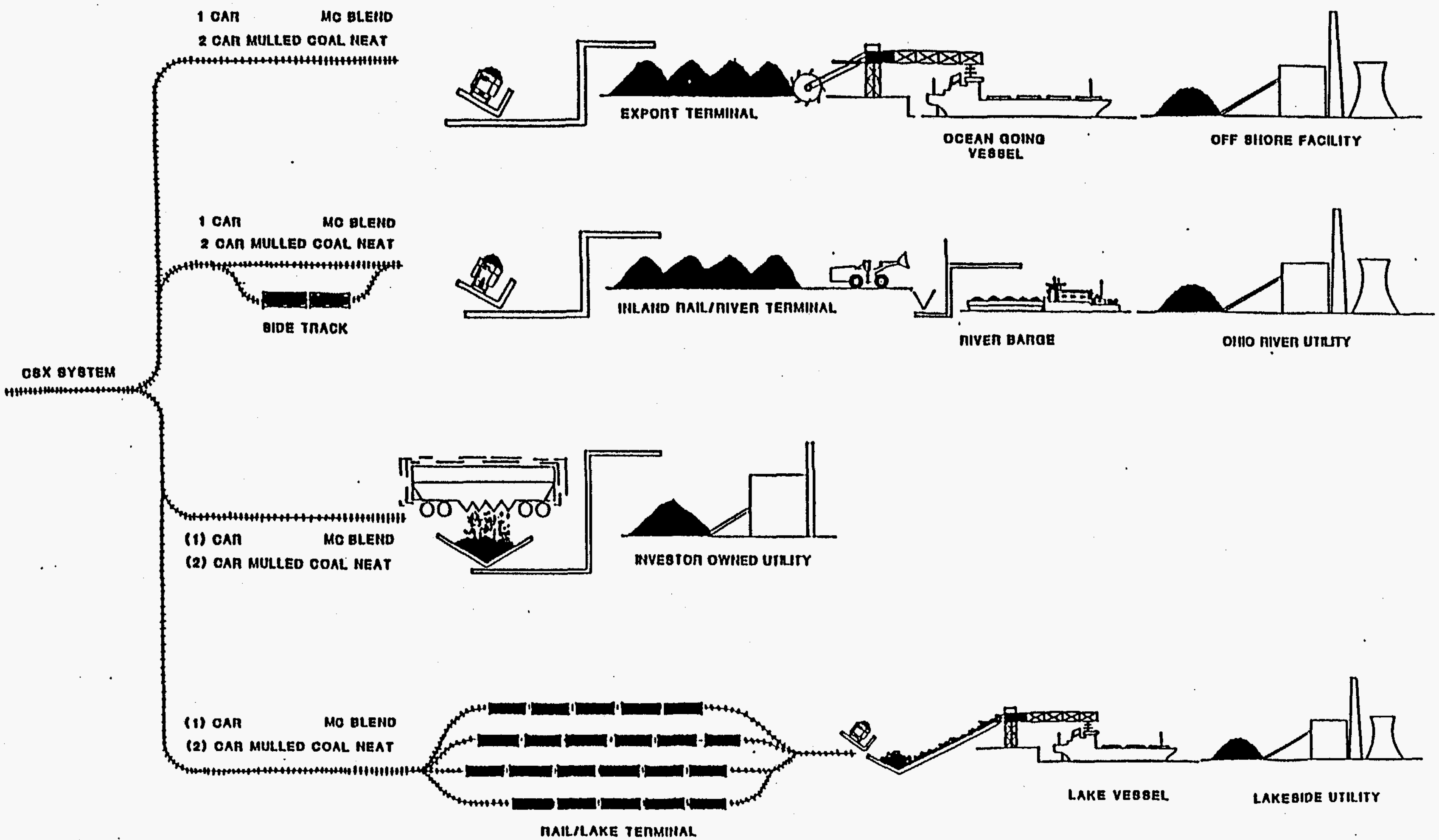
During the 3-month operating period, the facility should produce 910 tonnes (1000 tons) of the Mulled Coal for evaluation in various rail transport configurations. A representative variety of rail cars, trucks, terminal facilities, and users will be selected for demonstration of the delivery of Mulled Coal product in existing commercial equipment and facilities. The scope of the demonstration of deliveries is depicted in Figure 3. The Mulled Coal product will be shipped both as straight Mulled Coal and blends of Mulled Coal with washed Chetopa coarse coal. The loaded cars will be shipped to various locations representing:

Rail/river barge terminals
Trans-shipment terminals
Industrial users
Utility users

The cars will be monitored and sampled during transit and dumping. Videotapes will be made during unloading and transfer operations to observe any differences between the test shipments and other coals being handled at the same facility.

Figure 3

PROJECT FLOW DIAGRAM • OFF SITE FACILITIES



PROJECT TECHNICAL WORK PLAN

Technical Approach and Work Plan Overview

This project focuses on achieving two demonstrations of the Mulled Coal technology: (1) Production in a commercial operating environment, and (2) Delivery of product through a representative cross-section of existing storage transportation, and handling systems. To successfully complete these demonstrations, the project has been organized into a series of task activities that lead to the demonstrations, support the engineering and management needs of the project, and assess and report the activities and results. Further, the technical approach to structuring and accomplishing these work activities enables the key information and database to be generated and used in support of the overall project work plan. The development of the design basis and assessment of Mulled Coal technology application are direct parallels to activities that would be needed in any specific individual commercial application.

The technical approach as depicted in the Information Flow Diagram (Figure 1) is comprised of the following:

1. Prepare a work plan at the beginning of the project with mechanisms for adding detail and updating the plan as new information is generated.

2. Collect and evaluate information specific to the coal and plant operations at the host site that is needed to complete the circuit design, equipment selections, installation, and production plans and scheduling.

3. Procure, install, and startup the Mulled Coal circuit at the host site.

4. Conduct the demonstration of production operations.

5. Select delivery destinations and develop specific plans for monitoring dumping, fuel handling, etc. at each unique destination. Final decisions and detailed plans will be made when coal deliveries are ready to be scheduled, which in commercial practice can be several months from the expected availability of product for shipment.

6. Conduct the demonstration of Mulled Coal distribution in existing storage, transportation, and handling operations.

7. Prepare technical and economic assessment of the technology based on the data generated in the demonstration operations.

The key features to this approach include defined work plans, generation of information that enables specific decisions and contingencies to be addressed, and the utilization of experience to adjust the operations and data collection processes.

The work plan developed for this project contains the detail needed to direct and monitor all activities. This includes tasks in which the information that is specific to the coal and operations of the Drummond Chetopa facility will be used to update the work elements, and make key decisions or revisions as appropriate. For example, the evaluations and tests conducted in the early bench scale engineering activities will provide information needed to make some key decisions regarding feed material. If we find that results fall outside the expected range, then the plans and the capabilities of the facilities and personnel are sufficiently versatile to revise the work plans.

Work Plan Assumptions

Developing the work plans has required making key assumptions, namely:

1. The fine wet clean coal produced at the Chetopa Plant can be mulled within the range of our experience with reagent formulations and dosage rates.

2. The dilute froth concentrate will be a suitable alternative feedstock should the vacuum filter cake not be suitable.

3. The slipstream from the froth cell discharge can be taken without disruption of the existing plant operations.

4. The storage, transportation, handling, and stability characteristics of Mulled Coal will be similar to those properties as evaluated in the bench-scale engineering evaluations and testing.

TECHNICAL PROGRESS

1. Technical Approach

No major change has been made to the technical approach. An adjustment has been made in acknowledgement of the need to accelerate the schedule to enable a delivery of Mulled Coal during the winter freezing period in early 1995. To do so has required moving ahead with the Task 2.2 - Bench Scale Engineering to enable earlier design and procurement decisions.

2. Technical Progress in the Task Activities

Summary: During this second quarter of the contract period, activities were underway under Tasks 1, 2, and 3. Sufficient characterization of the feedstock coal options at the Chetopa Plant was conducted and mulling characteristics determined to enable a decision to be made regarding the feedstock selection. It was decided that the froth concentrate will be the feedstock wet fine coal used for the project. On that basis, activities in the areas of design and procurement were initiated.

Overview: During this reporting period, technical progress was made in three general activity areas. Those activity areas are: project planning, bench-scale and pugmill test evaluations, and preliminary process design and equipment selection. A major work effort contributed to the development of the technical work and test plans that were submitted to the DOE as part of the project plans, a separate document. Work in the other two activity areas will be described in the following sections.

The technical approach used during this period of technical activities was to collect sufficient information in bench-scale mulling tests and pugmill tests to enable the selection of the project feedstock coal and to permit the development of the preliminary Mulled Coal circuit schematic flow diagram. Samples of wet filter cake and froth concentrate were collected from the Drummond preparation plant. These coals were characterized and tested to determine the mulling characteristics.

Based on these evaluations, it was determined that the filter cake, which contains flocculent, would not be a suitable feedstock material for the project circuit demonstration. The froth concentrate is diverted from the plant circuit after the discharge from the froth cells and prior to the addition of the flocculent and vacuum filtration. This froth concentrate is well suited as a project feedstock. The technical decision was then made to design the circuit with the froth concentrate as the project feedstock.

A project schematic flow diagram for the Mulled Coal circuit as it is to be installed at Drummond was developed and is shown in Figure 2. The initial concept as shown in this figure allows for the diversion of a slipstream of the froth concentrate from the discharge stream from the flotation cells. It will most likely be taken from the feed end of the flotation cell launder, which will enable a high and consistent quality of the project feed and will have a minimal disruption to the plant process flow stream. The detailed design and locations of the slipstream take-off will be reviewed with Drummond for approval.

With the selection of froth concentrate as the project feedstock, it will be necessary to include a screen bowl centrifuge to concentrate the solids content and produce a wet cake of acceptable moisture content for the mulling circuit. This centrifuge will be supplied to the project by Decanter Machine at no cost to the project for the demonstration activities. The discharge from the centrifuge will then be fed through a surge feeder with a moisture probe to the pugmill for mulling.

The development of the preliminary project schematic flow diagram and conceptual design basis then provided sufficient information to begin selection and design of major equipment. Long lead time procurement actions are to be initiated as quickly as specifications and bid packages can be prepared. Along with that, additional testing in the bench-scale and pugmill tests will provide the more detailed database needed for the project operations.

3. Characterization of Project Feedstock

Samples of the wet filter cake from the vacuum filter operations at Chetopa were taken and characterized by wet screen analysis. The sizing analysis is summarized in Table 1. Samples were also taken from the launder of the froth cells. After decanting and filtering to dewater the samples, the froth concentrate samples were also characterized by wet screen analysis. This particle size analysis is summarized in Table 2.

As expected, the sizing of these two types of samples can be seen to be very similar by comparing the data in Table 1 and Table 2. The sizing analysis reported in these two tables also shows that there is not a significant difference between the different drum samples taken from the plant while operating. Neither is there any significant difference noted between the average calculated for the several drums as shown on Table 1 and the average as determined by a collected mixed sample from the several drums.

Additional characterization was done by Microtrac analysis of the minus 30 mesh portion of these samples. This enabled us to review and compare the size profiles of the particles to give a better understanding of the nature of the small particles in the feedstock samples. It is the small particles that provide relatively large surface area per unit weight and generally the problems associated with retention of moisture and difficult handling characteristics. The mulling process works largely on collection of these very small particles and therefore, the characterization of the small particle distribution is very important. These samples were initially screened at 30 mesh and then the undersized fraction of the samples were analyzed in the Microtrac laser beam particle size instrument. The graphical results for the particle size distribution of the filter cake sample is shown in Figure 4 and the froth concentrate sample is shown in Figure 5. Figure 6 shows a comparison of the minus 30 mesh particle size distributions for the filter cake and froth concentrate coal samples. Very little difference is noted for the particle size distributions of the filter cake and froth concentrate samples.

Table 1

PROJECT FEED STOCK

WET SCREEN ANALYSIS

WET FILTER CAKE

SIZE FRACTION	+ 16 MESH		16M x 28M		28M x 100M		100M x 200M		200M x 325M		325M x 0	
	% WT	% ASH	% WT	% ASH	% WT	% ASH	% WT	% ASH	5 WT	% ASH	% WT	% ASH
DRUM 1	.11	*	10.59	7.6	46.77	11.0	13.97	12.5	8.06	12.3	20.51	14.8
DRUM 2	.20	*	11.61	7.7	46.54	11.4	13.68	12.4	7.76	10.9	20.20	15.3
DRUM 3	.15	*	10.38	7.4	46.78	11.0	13.97	12.7	8.25	12.0	20.46	15.1
DRUM 4	.19	*	9.98	7.6	44.99	11.1	13.97	13.2	7.93	11.5	22.94	15.6
DRUM 5	.13	*	9.12	7.2	46.25	10.3	14.20	11.6	8.22	10.5	22.08	15.3
AVE.	**.16**		**10.36**	**7.5**	**46.27**	**10.96**	**13.96**	**12.5**	**8.04**	**11.4**	**21.24**	**15.2**
COMPOSITE	.20	*	11.06	7.9	46.51	11.4	13.75	12.9	7.95	13.2	20.52	15.4

*** not enough sample to analize**

Table 2

PROJECT FEEDSTOCK WET SCREEN ANALYSIS FROTH CONCENTRATE

	DRUM 1		DRUM 2		DRUM 3		DRUM 4	
Screen Size	Wt. %	% Ash	Wt. %	% Ash	Wt. %	% Ash	Wt. %	% Ash
+ 16	0.51	*	0.41	*	0.34	*	0.65	*
16 x 28	11.30	7.98	8.37	7.40	8.20	7.37	10.16	7.67
28 x 100	48.02	11.71	45.26	9.97	45.24	9.69	48.42	9.95
100 x 200	14.83	12.75	16.56	13.09	17.09	9.88	14.45	11.48
200 x 325	7.12	13.75	8.36	11.88	8.06	11.27	7.51	10.68
- 325	18.21	20.56	21.04	18.85	21.07	17.12	18.81	17.11

Figure 4

MICROTRAC ANALYSIS OF MINUS 30 MESH

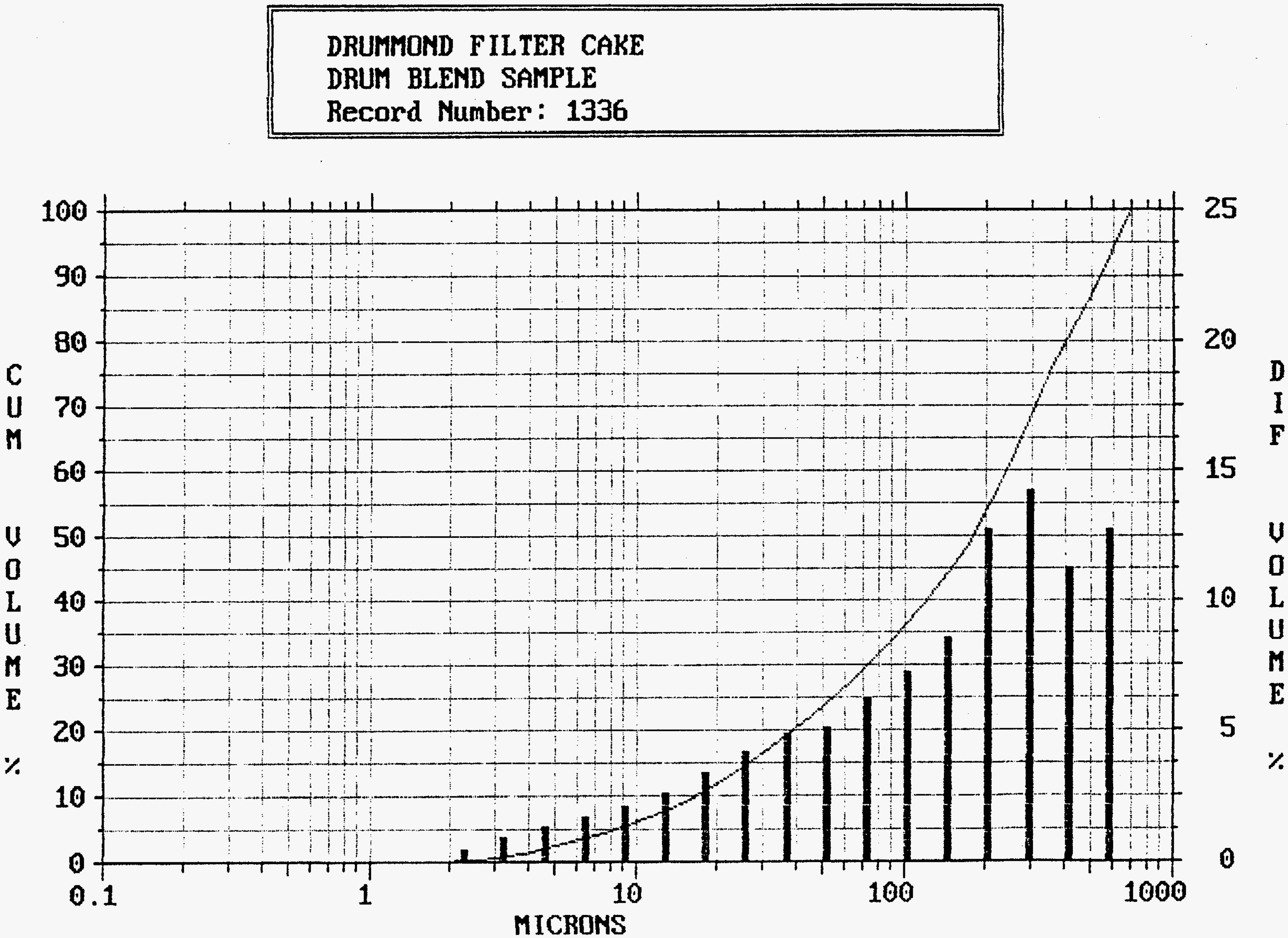


Figure 5

MICROTRAC ANALYSIS OF MINUS 30 MESH

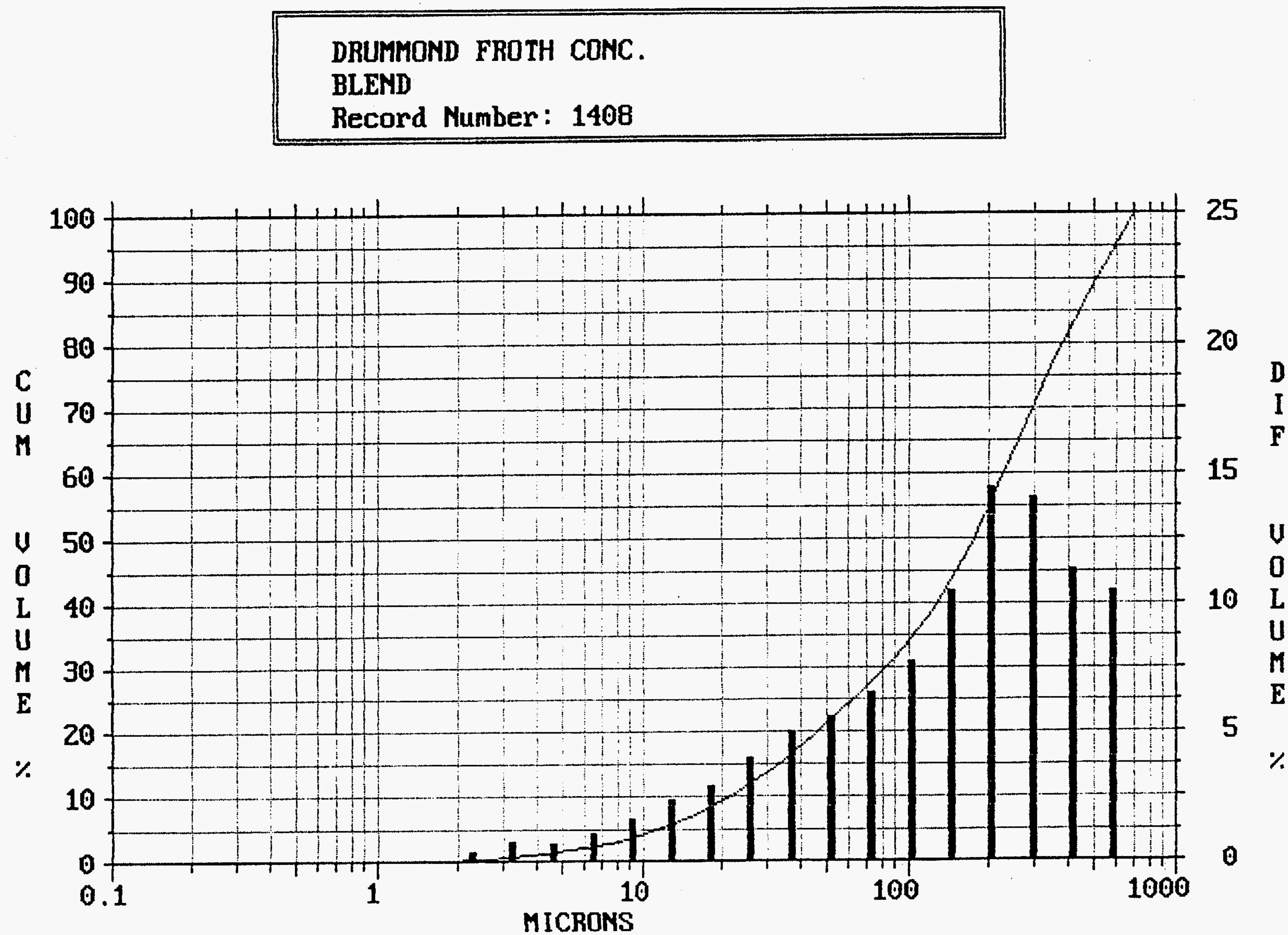
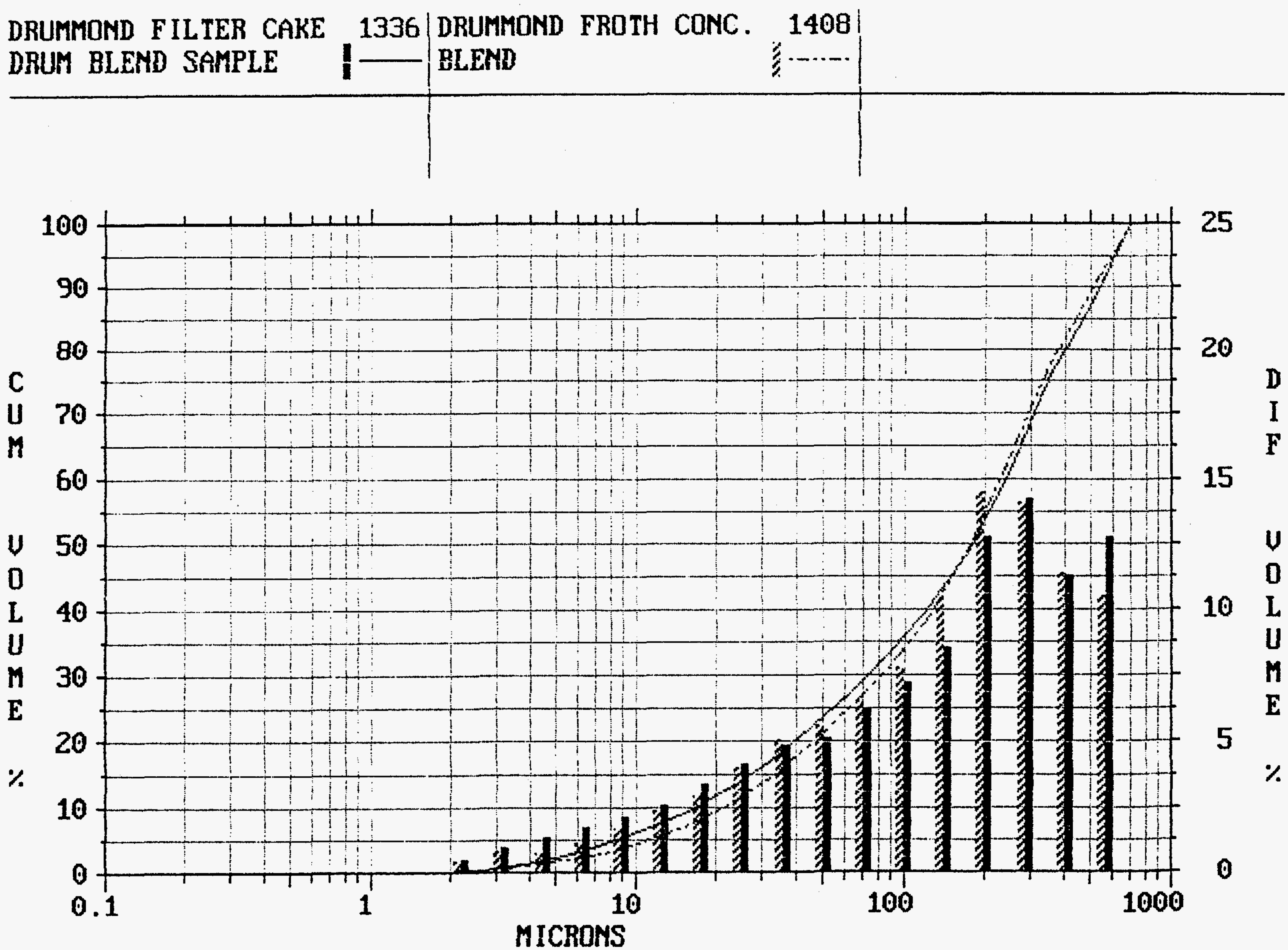


Figure 6

MICROTRAC ANALYSIS - COMPARISON



4. Evaluation of Alternate Feedstock Coals in Bench-Scale Mulling Tests

Initial screening of the mulling characteristics of the coal feedstock options was done using the KA laboratory mulling equipment and testing procedures as established in earlier investigations by EI. These practices were described in the proposal for this project and in the project plans. The purpose for the initial set of screening tests was to determine that a good quality mull could be made under a reasonable set of operating conditions. The initial parameters of concern included:

Particle sizing
Moisture content
Reagent dosage

The initial screening tests enable a variety of test parameters to be evaluated using small quantities of the feedstock samples. Past experience has indicated that there is a good correspondence between results obtained in the KA Muller at bench-scale and the larger scale pilot plant tests conducted in the pugmill. The pugmill requires the use of much larger quantities of the samples. For example, a typical pugmill test with changes in several operating conditions during the test might use a full drum of sample. Therefore, the bench-scale screening tests provide a more effective use of the limited quantities of sample coals from the plant.

The initial screening tests and other bench-scale evaluations are not intended to either optimize the set of operating conditions or coal characteristics or to develop a complete set of data for all possible combinations of parameters. Rather, the intent is to guide the evaluation through a logic process to determine a suitable set of operating parameters and determine that an acceptable mull can be produced. This information was to be used for determining the choice of feedstock for the project circuit and provide input information for equipment and circuit design and selection.

In these tests, the wet feed coal sample at a given moisture content is put into the KA Muller mixing bowl and a predetermined weight percent of reagent is added and mixed into the wet coal sample. The results of the test are usually visually self-evident and can be categorized as not a good mull (unacceptable), marginal, or good mull. The experienced technician will notice the type of mull readily as the test is conducted. If the result is marginal or good, further tests will be able to be conducted for evaluation. If the result is unacceptable and a decent mull is not obtained, then the evaluation tests cannot be made. If the combination of reagent dosage, moisture, particle size, mixing conditions, and coal characteristics are not suited to producing a good mull, the coal sample being mixed in the KA Muller will not turn into a dry, free-flowing, granular like powder material. It will still be a sticky wet mass of coal fines and further bench-scale testing will not be meaningful, so the test is halted based on the visual results. If the resulting mull is visually observed to be of either good or marginal quality, the sample of mull product can then be evaluated using the uniformity or bulk density tests. In the uniformity test, the sample is placed in a set of shaker screens and the amounts retained on each screen size is recorded. The handleability index (HI) or uniformity is the percentage of the initial sample that is retained in the 14 mesh by 0 fractions. When the sample remains too wet and sticky, wet fines remain lumpy and will not pass through the larger screens at all. One indication that a high quality mull has been attained is that a large portion of the coal sample is distributed in the small size range so that they will pass through the 14 mesh screen and yet not be wet and sticky.

For the initial screening, a test matrix was set up. An initial test was conducted at baseline values of 23 and 25% moisture and 2% reagent. If the mull made at these baseline conditions was of at least marginally acceptable quality (index of 20% in the 14 mesh by 0 range or greater), the moisture was increased for the next test. If the index was 19% or less, then the moisture level was not changed and the reagent was increased. This procedure was used in the initial test screenings.

The results of several sets of initial screening tests wit filter cake and froth concentrate samples taken from the Chetopa Plant are shown in Table 3. These sets of screening tests are discussed in the following paragraphs.

In the initial set of KA Muller screening tests with the wet filter cake samples, the following results were obtained through this test matrix procedure:

1. Acceptable mull (Index = 25) at 23-25% moisture and 2% reagent
2. Better mull (Index = 57) at 26% moisture and 4% reagent
3. Acceptable mull (Index = 27) at 27% moisture and 4% reagent
4. Unacceptable at other values
5. Prefer the combination of lower moisture (23 to 25%) and 2% reagent for economic cost of reagent

Upon reviewing the initial set of screening tests, there was some concern that the marginal results obtained could be attributed to the amount of flocculent in the filter cake sample. A set of tests was conducted in which a second reagent additive (a dessicant type) was included with the mulling agent to counteract the effect of the flocculent. This second additive was included at about 0.5% along wit the mulling reagent at 2%. In these tests, an index value of 78 at 26% moisture and index of 67 at 27% moisture were obtained. This seems to indicate that a good mull could be obtained with the filter cake as feed if there is a willingness to use a more complex two component reagent for the process. At this time, this is not a preferred option.

Screening tests in the KA Muller were also made with the samples of froth concentrate. The sample coal taken from the launder of the flotation cells at the Chetopa plant were decanted, filtered to collect the coal solids, and moisture adjusted to evaluate the mulling characteristics and acceptability. The results of the froth concentrate screening tests follow:

1. Index = 96, moisture 23%, reagent 2%
2. Index = 84, moisture 26%, reagent 2%
3. Index = 68, moisture 27%, reagent 2%

TABLE 3

ALTERNATIVE FEED SOURCE EVALUATION

KA MULLING TESTS

FILTER CAKE HGO ONLY								UNIFORMITY TEST			
LAB NO	DATE	SIZE	MOIST	ASH	LAB METHOD	MIX TIME	HGO DOSE	+ 6M	6M x 14M	14M x 28M	28M x 0
016-42	4-8-94	A/R	24	12	KA	5	2	6.2	68.99	23.54	1.27
016-42A	4-8-94	A/R	26	12	KA	5	2	25.27	63.65	10.36	0.72
016-43	4-8-94	A/R	26	12	KA	5	4	6.06	36.58	44.50	12.86
016-43A	4-8-94	A/R	27	12	KA	5	4	5.81	67.15	23.04	3.99

FILTER CAKE HGO PLUS DESSICANT								UNIFORMITY TEST			
LAB NO	DATE	SIZE	MOIST	ASH	LAB METHOD	MIX TIME	REA DOSE	+ 6M	6M x 14M	14M x 28M	28M x 0
016-44	4-11-94	A/R	26	12	KA	5	HGO-2 DESS-0.5	0.72	21.70	65.83	11.75
016-44A	4-11-94	A/R	27	12	KA	5	HGO-2 DESS-0.5	0.38	32.63	60.27	6.71

FROTH CONCENTRATE HGO ONLY								UNIFORMITY TEST			
LAB NO	4-12-94	SIZE	MOIST	ASH	LAB METHOD	MIX TIME	HGO DOSE	+ 6M	6M x 14M	14M x 28M	28M x 0
016-45	4-12-94	A/R	23	12	KA	5	2	0.00	3.79	30.93	65.28
016-45A	4-12-94	A/R	26	12	KA	5	2	0.95	14.96	41.86	42.23
016-46	4-13-94	A/R	27	12	KA	5	2	3.91	27.58	49.28	19.21

4. Excellent mull with high index values over a wide range of moisture content
5. Decreasing quality and index value with increasing moisture

From the initial screening test, the moisture content of 23 to 25% and reagent dosage of 2% seemed to provide the best results and the froth concentrate (before the addition of the flocculent) appeared to produce a significantly better product.

5. Pilot Plant Mulling Tests

The first pilot plant mulling test was run using Drum #4 of the Chetopa filter cake sample with moisture at the 24/25% level as the feed coal for the test. In spite of increasing the reagent dose up to as high as 4%, an acceptable Mulled Coal was not able to be produced during this test. The presence of flocculent on the filter cake was considered to be the main contributing factor to the adverse mulling characteristics. This result was consistent with the marginal results attained in the bench-scale tests with the difference being that the pugmill product was not at all acceptable.

To confirm the results attained with the filter cake feed coal option, the remaining drums of filter cake samples were also tested in the pugmill. The results for all drums produced the same results as with the single Drum #4 test and unacceptable mulling characteristics were the results in all cases with the filter cake option.

Following the pugmill test with the filter cake feed, a test was run using the froth concentrate as the feed for the test. Two drums of froth concentrate were collected at the Chetopa plant and were available for pugmill testing at EI. One drum contained partially decanted froth concentrate. The second drum was dilute froth concentrate in the as produced condition. These two samples had been characterized as reported above. The two drums were filtered at the EI facilities producing a flocculent-free filter cake as feed for the pugmill testing. The filtered product at 24% moisture was then tested in the pugmill and produced an excellent mull with uniformity index in excess of 70. With this positive result combined with the positive results attained with the froth concentrate feed coal at the bench-scale level, a basis was established for selecting the froth concentrate as the feed for the project's demonstration circuit in the Chetopa plant.

In addition to determining the quality of the mull produced, this test provided answers to some operational questions needed to specify the pugmill for the demonstration circuit. During the pugmill test with froth concentrate, the pugmill speed was increased from 125 RPM to 140 RPM. This change appeared to result in a slightly better mull. The unit was operated at 140 RPM for the remainder of the test. When the discharge weir was used and regulated, Mulled Coal built up above the shaft level at the discharge end of the machine. The Mulled Coal began to roll around in the mixing chamber at the discharged end and form loosely agglomerated balls which will probably break up in the uniformity test. One bucket of Mulled Coal was collected by discharge through the bottom discharge port on the pugmill and this completely eliminated the problem of balling.