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"Coal – Sand Attrition System and Its' Importance in Fine Coal Cleaning"
2 years: September 1, 1991 – August 31, 1993

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FIRST QUARTERLY REPORT: 9/1/91 – 11/30/91

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DISCLAIMER

"COAL – SAND ATTRITION SYSTEM AND ITS' IMPORTANCE 'N FINE COAL CLEANING"

Quarterly Report:

09/01/91 - 11/30/91

PROJECT OBJECTIVES

The primary objective of this project is geared toward the substitution of steel media by fracturing silica sand as a grinding media for ultrafine coal grinding.

The project has been divided into five sub–groups for bookkeeping purposes and possible ease of execution. Some of the tasks would be executed simultaneously as overlaping is inevitiable. The grouping is as follows:

1) Design and fabrication of attrition cell.
2) Sample procurement, preparation , and characterization.
3) Batch grinding tests.
4) Continuous grinding tests.
5) Fracture mechanics.

A general work scheme is given in Table 1.

MAJOR ACCOMPLISHMENTS

Task 1 Cell Design

The grinding cell to be used for the batch test has been designed, by using the principle of geometric similarity to scale down large stirred mills. The cell and stirring mechanism are made from stainless steel and lined with polyurethane. A schematic representation is shown in Figure 1.

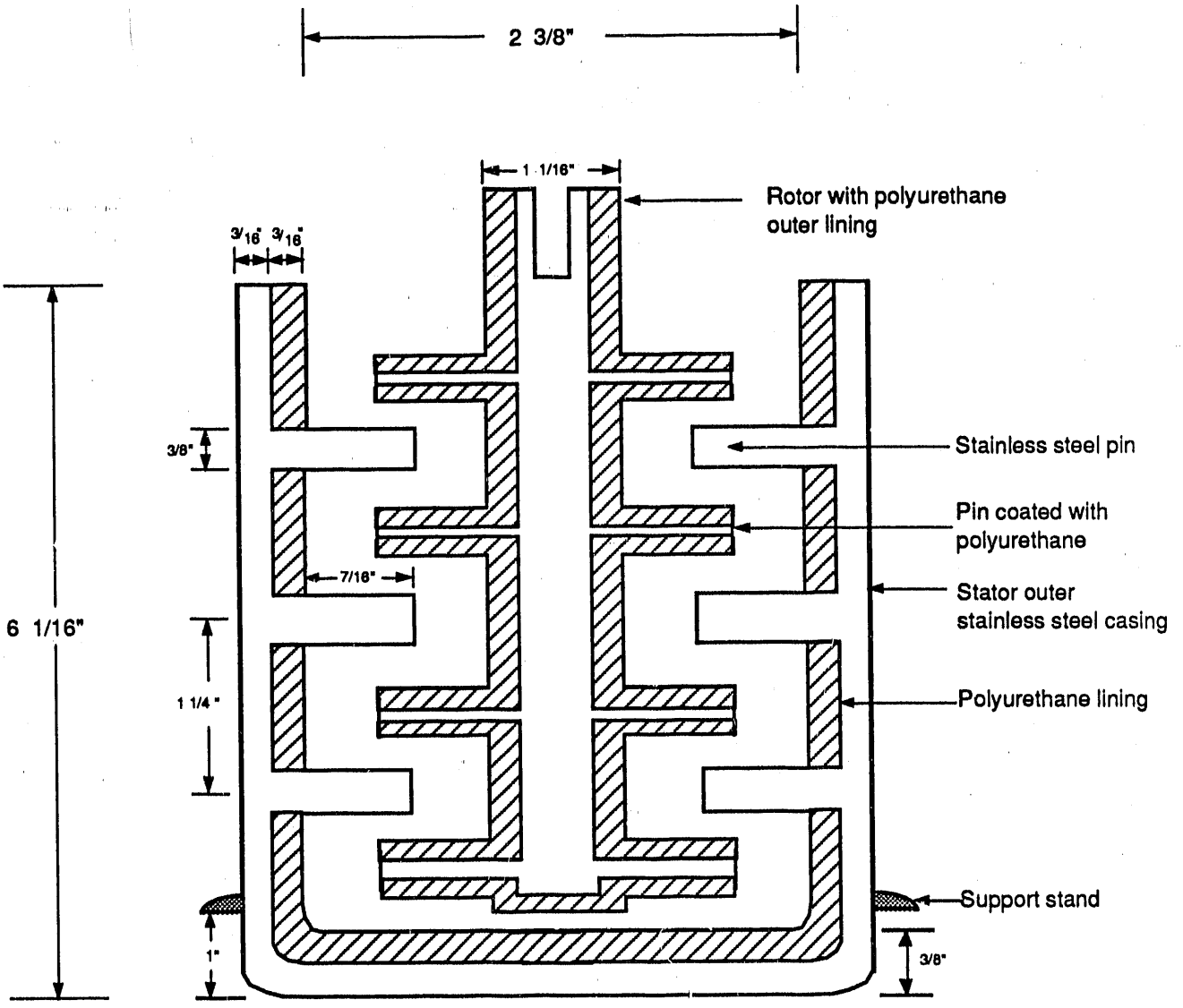

Figure 1. Schematic Diagram of the MRI Batch Attrition Scrubber with Polyurethane Lining for Conducting Coal - Sand Attrition Tests. All Dimensions Shown Are in Inches.

Task 2 Sample Procurement, Preparation, and Characterization

Sample procurement: Three coal types have been obtained so far. A drum of each: Pittsburgh #8 and Illinois #6 coal seam samples were obtained from the Southern Electric International Center of Alabama Power Company at Wilsonville. While a

drum of the Black Creek coal sample was obtained from the Drummond Coal Company at Jasper, Alabama. The fourth coal sample (Pochahontas #3) has been ordered but, it is yet to arrive. These coal samples/types, after consultation with the technical project officer, Mr. Otis Mills, were chosen to cover a rather broad range of properties such as hardness, sulfur content, mineral matter distribution, etc.

Sample Preparation: About 30kg of each of the coal types were taken from the bulk samples and dried at 40°C for about 3 days. The partially dried material was then reduced in stages down to the required size. The Black Creek and Pittsburgh coal samples being very coarse were first subjected to crushing in a jaw crusher.

Thereafter, the materials were screened at 6 mesh and the oversize were further ground in a roll mill until all the particles could pass through the 6 mesh screen.

The minus 6 mesh materials were each throughly mixed and subsequently split down to about 10 kg using a riffle. The 10 kg lots were used in determining the bond work indices as will be described in preceeding paragraphs.

A 2 kg of 14 X 28 mesh material was prepared from the other fraction for the Hardgrove index determination, while the remaining materials were further reduced in steps down to minus 50 mesh size. The minus 50 mesh material was subsequently used to prepare the narrow sized fractions required for the batch optimization tests.

In order to preserve the properties of the coals, a sample preparation strategy has been adopted whereby the respective coal samples will be prepared in small batches to be used for specific tasks. The different size fractions prepared were placed in plastic bags which were further, stored in tightly sealed containers.

Sample Characterization: The minus 60 mesh material and the monodispersed feeds for the batch grinding tests prepared from the respective coal samples (Black Creek, Pittsburgh #8, and Illinois #6) were subjected to ultimate and proximate analyses, calorific value measurements, forms of sulfur, and chemical analyses for calcium, chromium, copper, iron, magnesium, manganese, and nickel. The results are given in Tables 2–4, appended to this report.

Bond Work Index:

The minus six mesh materials prepared as described above were used for the work index determinations. The work indices for the Black Creek coal, Pittsburgh #8, and Illinois #6, were determined using the method suggested by Hazen Company.

In this method, a certain amount of the minus 6 mesh size coal is slowly poured in a 2000 ml graduated cylinder while tapping to settle and compact the material, until the 700 ml mark is reached. This material is then weighed and used in the grinding test.

A grinding media charge of about 20 kg consisting of the following sizes, numbers, and weights, were employed:

Size (mm)	Number of Balls	Weight (kg)
39.9	37	9.82
31.8	44	5.82
24.1	32	2.24
18.3	25	0.86
12.7	59	1.40
		20.14

The target size was arbitrarily chosen as 65 mesh because of the ease with which the ground material could be seived at this size. It was assumed that at equilibrium operating conditions, a circulating load of 250% and a 100% minus 65 mesh product are desired.

The number of revolutions the mill must be operated to achieve the 250% circulating load was then determined by trial and error. After grinding, the material was sieved in three batches, each for a duration of 10 minutes in order to ensure an almost complete removal of the fine particles. In this method, a part of the initial starting material is used (until the desired circulating load is obtained) and the starting weight mass is maintained by the addition of an equivalent amount of fresh feed to replace the fines produced.

This cycle is repeated until a constant circulating load is obtained. In this way, the amount of material produced per revolution required in the work index equation was determined from the average value of repeated runs. The feed and product size distributions were obtained by sieving both materials for a duration of 15 minutes and the 80% passing sizes were determined from subsequent plots of the data. The calculated Bond Work indices for the coal seams are tabulated below:

Coal Seam	feed ,d80 (μm)	product, d80	Bond work Index (kWh/ton)
Black Creek	2400	166.5	17.46
Ilinois #6	2500	162	13.51
Pittsburgh #8	2184	168	13.37

Electron Microscopy and FTIR Spectroscopy:

Some samples have been prepared for use in either scanning electron microscope or electron microprobe for mineralogical studies which are scheduled for commencement during the next quarter. FTIR Spectroscopy works will also begin during the next quarter.

Hardgrove Index

Although some samples (14 X 28 mesh size materials) have been prepared, the Hardgrove indices for the coal seams will be made, as soon as the last coal type is received. This measurement will be performed at the R & D Center of Drummond Coal Company because the Institute does not have the grindability tester.

Task 3 Batch Grinding Optimization Tests

This task is scheduled for commencement during the next quarter. the work will begin possibly with the Black Creek coal which is the hardest among the four coal types

chosen in this project.

The parameters which will be studied are as follows:

i, Coal types.

ii, Grinding media types.

iii, Stirring speed.

iv, Coal concentration.

v, Feed size.

vi, Grinding or Residence time.

While the results will be evaluated in terms of most of the following:

a, Energy input or specific energy input (kWh/ton of 5 μm)

b, Particle size distribution (median size and distribution modulus)

c, Proximate analysis (i.e. moisture content, ash volatile matter, and fixed carbon)

d, Calorific value (BTU/lb)

e, Chemical analyses of coal and water for Fe, Mn, Cr, Ni and Cu

f, Media wear (lb/ton of coal)

g, Mineral distribution and

h, Oxidation (for samples ground for extended periods).

i. Slurry rheology

The tests will be made using the following composite factorial design.

Factors	Levels				
	-2	-1	0	1	2
Rotor speed (rpm) *X1*	900	1400	1900	2400	2900
Coal concentration (wt %) *X2*	10	20	30	40	50
Feed size (mesh) *X3*	270	200	150	100	60

Grinding time 2, 4, 8 mins.
Media types Steel Cyclopebs (1.1 mm) and Sand 12 X 20 mesh ~ 1.2 mm

Test Matrix

Exp. no.	*X1*	*X2*	*X3*
1	-1	-1	-1
2	1	-1	-1
3	-1	1	-1
4	1	1	-1
5	-1	-1	1
6	1	-1	1
7	-1	1	1
8	1	1	1
9	0	0	0
10	0	0	0
11	-2	0	0
12	2	0	0
13	0	0	-2
14	0	0	2
15	0	-2	0
16	0	2	0

The above matrix will be used with the two media types and the sampling schedule indicated previously. The total number of test runs per coal type may be 96 depending on how the sampling procedure is implemented.

Tasks 4 and 5

These are scheduled for commencement during the early part of the second year of the project.

Table 1. Work Plan

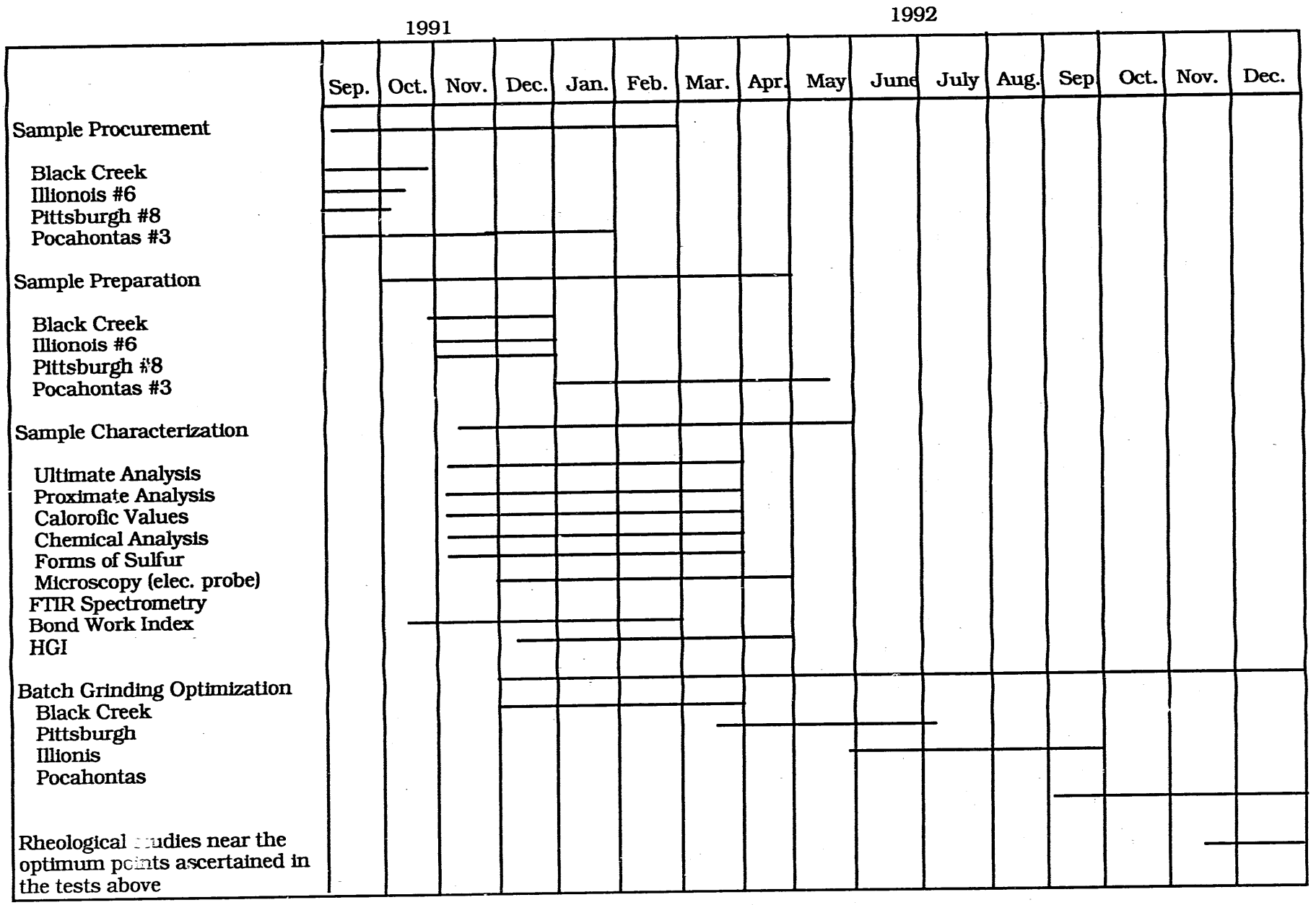

Table 1. Continuation

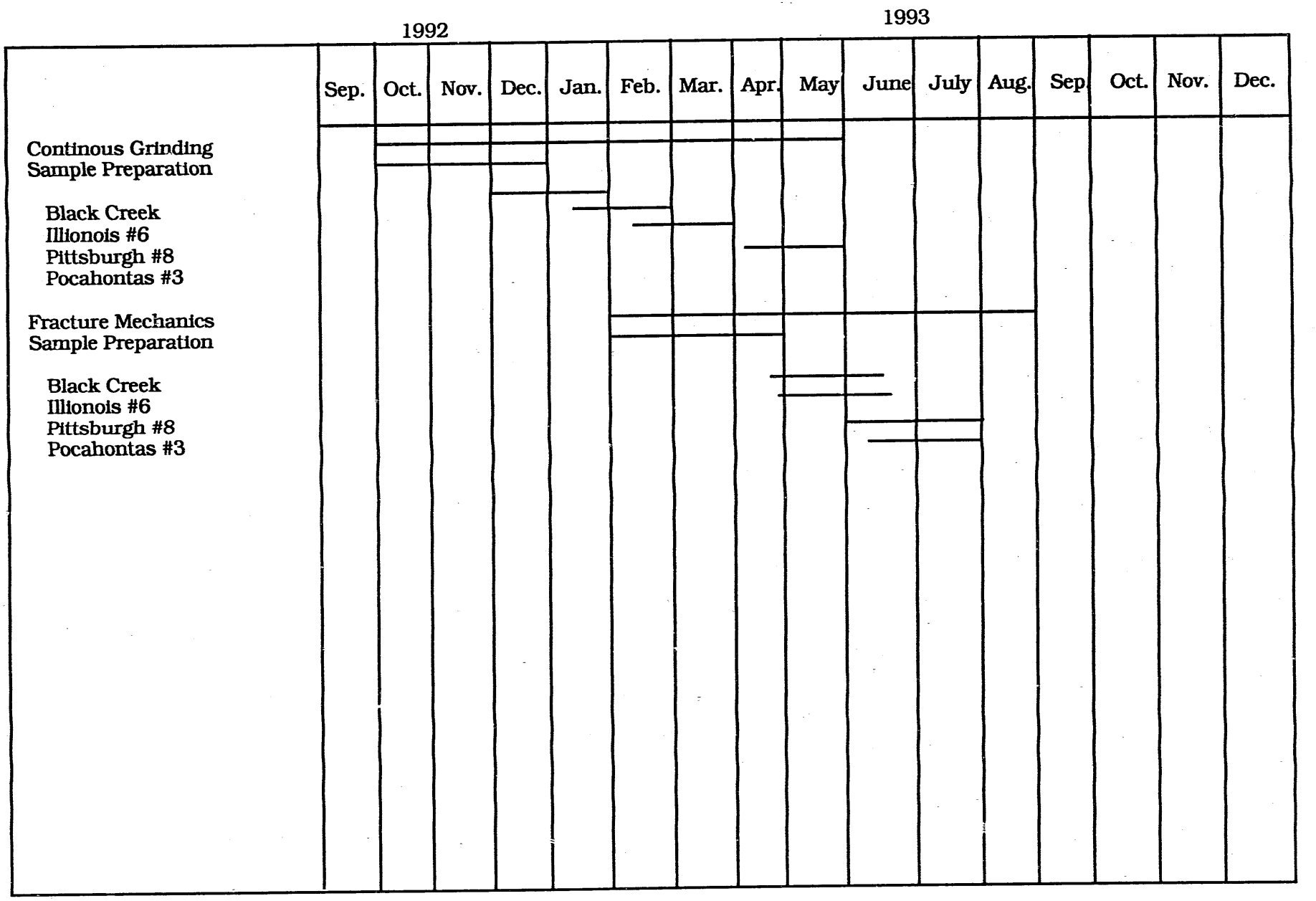

Table 2. Black Creek Coal Analysis

	Mesh Size					
	-60	50X60	60X100	100X150	150X200	200X270
Proximate Analysis (wt%)						
Moisture	2.55	2.21	2.38	2.39	2.48	2.39
Volatile Matter	30.42	32.94	32.32	31.60	30.44	29.05
Fixed Carbon	60.96	60.08	60.88	61.24	61.48	61.63
Ash	6.07	4.77	4.42	4.77	5.60	6.93
Ultimate Analysis (wt%)						
Carbon	77.61	79.46	79.65	79.11	78.04	76.93
Oxygen (by diff)	14.74	12.61	12.44	13.09	14.3	15.71
Hydrogen	5.22	5.54	5.45	5.39	5.27	5.10
Nitrogen	1.68	1.67	1.74	1.70	1.68	1.52
Total Sulphur	0.75	0.72	0.72	0.71	0.71	0.74
Calorific value (Btu/lb)	13,649	14,258	14,469	14,088	14,024	13,656
Forms of Sulphur (wt%)						
Pyritic	0.10	0.07	0.06	0.07	0.10	0.14
Organic	0.52	0.57	0.58	0.56	0.51	0.46
Sulphate	0.13	0.08	0.08	0.08	0.10	0.14
Analysis of Coal Ash (wt%)						
Calcium	0.002	0.002	0.003	0.002	0.002	0.002
Chromium	0.001	0.001	0.001	0.001	0.001	0.001
Copper	0.002	0.002	0.002	0.002	0.002	0.003
Iron	0.265	0.183	0.192	0.220	0.345	0.306
Magnesium	0.030	0.025	0.030	0.032	0.038	0.033
Maganese	0.001	0.001	0.000	0.001	0.001	0.001
Nickel	0.003	0.003	0.002	0.002	0.003	0.003

Table 3. Pittsburgh #8 Coal Analysis

	Mesh Size					
	-60	50X60	60X100	100X150	150X200	200X270
Proximate Analysis (wt%)						
Moisture	2.51	2.32	2.36	2.49	2.49	2.67
Volatile Matter	37.64	37.87	37.46	37.47	37.18	36.53
Fixed Carbon	50.78	50.47	50.92	50.87	51.36	51.61
Ash	9.07	9.34	9.26	9.17	8.97	9.19
Ultimate Analysis (wt%)						
Carbon	71.82	62.25	71.78	71.55	70.93	70.49
Oxygen (by diff)	17.34	17.23	17.38	18.01	18.05	18.76
Hydrogen	5.19	5.25	5.31	5.29	5.24	5.21
Nitrogen	1.32	1.35	1.36	1.28	1.39	1.31
Total Sulphur	4.33	3.92	4.17	3.87	4.39	4.23
Calorific value (Btu/lb)	13,145	13,133	12,995	12,398	13,136	13,036
Forms of Sulphur (wt%)						
Pyritic	1.63	1.50	1.58	1.71	1.79	1.51
Organic	1.99	1.78	1.89	1.43	1.78	1.53
Sulphate	0.71	0.64	0.70	0.73	0.82	1.19
Analysis of Coal Ash (wt%)						
Calcium	0.006	0.005	0.004	0.005	0.006	0.008
Chromium	0.002	0.002	0.002	0.002	0.002	0.002
Copper	0.001	0.001	0.001	0.001	0.001	0.001
Iron	2.061	1.876	1.999	2.175	2.226	1.975
Magnesium	0.035	0.041	0.035	0.033	0.035	0.040
Maganese	0.002	0.002	0.002	0.002	0.002	0.002
Nickel	0.002	0.003	0.002	0.003	0.003	0.003

Table 4. Illinois #6 Coal Analysis

	Mesh Size					
	-60	50X60	60X100	100X150	150X200	200X270
Proximate Analysis (wt%)						
Moisture	9.08	8.18	8.54	8.78	8.82	8.59
Volatile Matter	35.10	35.48	35.88	35.02	35.10	34.96
Fixed Carbon	46.74	45.36	46.12	46.99	46.78	46.48
Ash	9.08	10.98	9.46	9.21	9.30	9.99
Ultimate Analysis (wt%)						
Carbon	63.98	63.36	64.16	64.07	64.19	63.16
Oxygen (by diff)	26.19	26.79	26.10	26.15	26.08	27.25
Hydrogen	5.41	5.36	5.48	5.48	5.47	5.37
Nitrogen	1.31	1.28	1.24	1.28	1.29	1.26
Total Sulphur	3.11	3.21	3.02	3.02	2.97	2.96
Calorific value (Btu/lb)	11,682	11,587	11,628	11,703	11,491	11,699
Forms of Sulphur (wt%)						
Pyritic	0.76	0.94	0.81	0.81	0.82	0.78
Organic	2.01	1.69	1.73	1.78	1.71	1.69
Sulphate	0.34	0.58	0.48	0.43	0.44	0.49
Analysis of Coal Ash (wt%)						
Calcium	0.016	0.153	0.061	0.029	0.030	0.039
Chromium	0.002	0.002	0.002	0.002	0.002	0.002
Copper	0.001	0.002	0.002	0.001	0.001	0.002
Iron	1.190	1.350	1.325	1.275	1.252	1.230
Magnesium	0.063	0.070	0.065	0.060	0.067	0.073
Maganese	0.003	0.004	0.004	0.003	0.003	0.004
Nickel	0.008	0.004	0.002	0.004	0.002	0.005

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DATE FILMED

3/27/92