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ULTRA-FINE COAL CHARACTERIZATION

10TH QUARTERLY REPORT

June 1, 1986 - August 31, 1986

F.J. Smit and L.K. Baltich

Prepared for

The United States Department of Energy
Pittsburgh Energy Technology Center
Pittsburgh, PA

Contract DE-AC22-84PC72007

March 12, 1987

AMAX Research and Development Center
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AMAX Minerals + Energy

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ABSTRACT

Research continued during the quarter to relate the beneficiation characteristics of ultra-fine coal to the mineral-matter liberation and the bulk properties of the coal. In particular, the application of kinetic model equations to time-recovery data from batch flotation was studied. The composition, washability and other bulk properties of three western coals were also determined. The three coals were Sunnyside bituminous coal from Utah, Anderson subbituminous coal from the Powder River Basin of Wyoming and Beulah-Zap lignite coal from North Dakota.

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INTRODUCTION

Research continued during the quarter to relate the beneficiation characteristics of ultra-fine coal to the mineral-matter liberation and the bulk properties of the coal. In particular, the application of kinetic model equations to time-recovery data from batch flotation was studied. The bulk properties of three western coals were also determined. The three coals were Sunnyside bituminous coal from Utah, Anderson subbituminous coal from the Powder River Basin of Wyoming and Beulah-Zap lignite coal from North Dakota. These coals complete the set of nine coals to be characterized.

MODEL OF FLOTATION KINETICS

An evaluation of flotation kinetics models was initiated. The goal of this evaluation is to select a satisfactory model for use in relating flotation rate constants to measurable coal characteristics. One could then use the kinetic model to predict flotation performance on the basis of these coal characteristics.

The first flotation kinetics model considered was the Gamma Function Distribution (GFD) model described by Woodburn and Loveday.[1] AMAX had previously found this model to be useful for understanding flotation performance in its molybdenite recovery plants. The model has the following form:

$$r = 1 - \frac{1}{[1 + (w + 1)k_o t]^a} \tag{1}$$

where r = recovery at time t (t = min),
a, k_o = parameters describing flotation rate behavior ($k_o = min^{-1}$)
w = weighting factor.

The basis of the GFD equation[1] model is the assumption that flotation feed material can be characterized by its chemical analysis, physical characteristics, and batch flotation behavior. This model assumes further that the flotability of the ground coal in a batch flotation cell can be described by the GFD equation. That is, the first-order flotability constants for individual increments of the feed vary from increment to increment but the overall distribution of these flotability constants follows a gamma function distribution. The gamma function is defined as follows:

$$u = \int_0^\infty x^{u-1} e^{-x} dx \tag{2}$$

where u = Integral argument
x = Integral variable $(\infty > x \geq 0)$

A further description of the GFD model for flotation kinetics is given in Appendix A.

The value of parameter a in Equation 1 represents the uniformity of flotation behavior for a given species (ie. coal or ash). Parameter k_0 can be considered a factor which reflects the influence of the operating conditions of the flotation process on kinetics. These parameters are invariant for a given set of flotation conditions.

The weighting factor, w, in the equation allows increased flexibility in modeling flotation behavior. The value of w can be varied to "weight" the portion of the time-recovery curve for which the most accuracy is required. This feature is particularly useful for species containing distinctive fast- and slow-floating fractions.

Initially, the GFD Model was studied to determine its ability to predict time-recovery relationships for the batch flotation tests performed to date. Actual and predicted time- recovery data for two tests carried out under different operating conditions with ultra-fine Illinois No. 6 coal are presented in Table 1. Comparison of these data indicate that the GFD model is capable of accurate prediction of time-recovery relationships.

Table 1. Actual and Predicted Time-Recovery Data for Two-Flotation Tests Using Illinois No. 6 Coal

Time	Actual Recovery, %			Predicted Recovery, %		
Minutes	Coal	Ash	Water	Coal	Ash	Water
				Test Opt 6		
3	27.7	17.2	10.3	32.6	19.7	11.9
6	49.9	30.2	18.6	50.6	29.8	18.1
12	71.5	43.1	26.5	69.2	41.1	25.2
24	83.3	51.2	31.9	83.8	52.0	32.5
				Test Opt 7		
3	19.1	12.0	7.6	24.5	14.8	9.4
6	35.9	22.0	14.7	36.2	21.6	14.6
12	53.7	32.4	23.0	48.5	29.0	20.8
24	57.7	34.7	26.5	59.9	36.4	27.5

Similar prediction accuracy was observed for all of the eleven batch flotation tests performed so far for this portion of the study. However, while the overall fit of a model to observed data is an important model requirement, each model parameter must also have a statistical significance narrow enough so that changes in the flotation system can be confidently assessed.[2] Therefore, the variation of the GFD model parameters a and k_0 for replicated batch flotation tests was investigated as well.

GFD rate constants a and k_o were calculated for two batch flotation tests performed under the same test conditions and which resulted in very similar time-recovery performance. The rate constants for these two tests, OPT 8 and 9, are shown in Table 2. The a and k_o values obtained are similar for coal, ash, and water recovery. The largest difference in values between the two tests was the 11.9 percent difference in the a value for water; the largest k_o value difference was 4.5 percent for ash.

Table 2. Gamma Function Distribution Rate Constants for Replicated Flotation Tests OPT 8 and 9

Para-	Coal			Ash			Water		
meter	OPT 8	OPT 9	Diff	OPT 8	OPT 9	Diff	OPT 8	OPT 9	Diff
a	1.33990	1.45010	7.6	0.32841	0.33826	2.9	0.12483	0.14164	11.9
k_o	0.0186	0.0188	0.8	0.2493	0.2610	4.5	0.3112	0.3196	2.6
w	10	10		1	1		1	1	

Table 3 presents GFD rate constants calculated for two additional tests performed at a different pulp level setting than OPT 8 and 9. These two tests, OPT 11 and 12, were also performed under the same conditions and the time-recovery results of the tests were very similar to each other. In this case though, the calculated values of a and k_o differed greatly between the two replicated tests. The values of a differed as much as 24.9 percent, and the values of k_o differed as much as 89.0 percent. These differences indicate that variations in the calculated flotation parameters for the GFD model probably would be too large for the model to be useful for describing the ultra-fine coal system.

Table 3. Gamma Function Distribution Rate Constants for Replicated Flotation Tests OPT 11 and 12 at a Lower Pulp Level

Para-	Coal			Ash			Water		
meter	OPT 11	OPT 12	Diff	OPT 11	OPT 12	Diff.	OPT 11	OPT 12	Diff
a	0.31316	0.23507	24.9	0.11602	0.10436	10.0	0.96425	0.05867	8.7
k_o	0.0977	0.1810	46.0	1.0591	0.1163	89.0	1.1308	1.3339	15.2
w	10	10		1	1		1	1	

Dr. Richard Klimpel of the Dow Chemical Company has reported that a 2-parameter, first-order flotation model with a rectangular distribution of flotabilities is useful when studying a variety of flotation systems.[2] Use of this model by Dr. Klimpel and his co-workers has resulted in accurate fits to observed data and an acceptable range of significance for the model parameters. A computer program for fitting this model to batch flotation test data will be developed and evaluated using the test data previously collected for this project.

PROPERTIES OF WESTERN COALS

Three coals were obtained from the western United States to complete the suite of nine coals to be characterized for the project. The coal seams and mine sources were as follows:

Upper and Lower Sunnyside :	Sunnyside Mine, Carbon Co, Utah
Anderson :	Belle Ayr Mine, Campbell Co, Wyoming
Beulah-Zap :	Beulah Mine, Mercer Co, North Dakota.

Each sample of about 1000 lb was typical whole-seam run-of-mine coal from the respective mines. The Sunnyside Mine is an underground operation of the Kaiser Coal Corporation producing bituminous coal in the Price, Utah area. The Belle Ayr Mine is a surface operation of the AMAX Coal Company producing subbituminous coal south of Gillette in the Powder River Basin. The Anderson coal bed merges with the Canyon bed further north to form the Wyodak coal bed and has at times been called the Smith-Roland bed. The Beulah Mine is a surface operation of the Knife River Coal Mining Company producing lignite from the Fort Union Formation northwest of Bismark, North Dakota.

The Anderson coal was a sampler reject and was received at minus 1/2 inch. The other two coals were crushed to passing 1/2 inch and representative samples were taken of all three lots of coal. The minus 1/2-inch Sunnyside coal was washed in the AMAX R&D pilot-plant dense-medium cone separator/shaking table circuit as described for the base-case coal.[3] The washing rejected coarse refuse and out-of-seam dilution. Table 4 provides the product analyses and yields for the pilot-plant washing.

Table 4. Pilot-Plant Washing Results for 1/2-Inch x 0 Sunnyside Coal

	Dry Basis				
	Wt %	Ash %	S(T) %	S(Py) %	Btu/lb
Combined Clean Coal	80.8	5.19	0.61	0.05	14140
HMS Refuse	16.2	79.53	0.55	0.36	2554
Table Refuse	3.0	53.02	0.93	0.50	6498
Calculated Feed	100.0	18.67	0.61	0.11	12034

The Anderson and the Beulah-Zap coals were not washed. They were relatively free of coarse refuse and mine dilution when received, and previous experience at AMAX R&D when working with similar low-rank coals had shown that little upgrading could be expected washing at a 1/2-inch top-size.[4]

Tables 5 and 6 list the analytical and other determinations made on the whole-seam and washed Sunnyside coal and the whole- seam Anderson and Beulah-Zap coals, respectively. The Sunnyside coal is of high volatile A bituminous rank as indicated by the

Table 5. Analyses of Whole-Seam and Washed Sunnyside Coal

	Whole-Seam	Washed
Proximate Analysis, Dry %:		
Ash	20.14	5.19
Volatile Matter	32.95	38.54
Fixed Carbon	46.91	56.19
Fixed Carbon, Dmmf[a]	60.10	59.64
Forms of Sulfur, Dry %:		
Total	0.65	0.61
Pyrite	0.17	0.05
Sulfate	0.01	0.001
Organic	0.47	0.56
Calorific Value, Btu/lb:		
Dry	11,649	14,140
Maf[b]	14,587	14,914
Mmmf[c]	14,275	14,468
Ultimate Analyses, Dry %:		
Carbon	65.10	79.01
Hydrogen	4.43	5.41
Nitrogen	1.21	1.60
Sulfur	0.65	0.61
Chlorine	0.09	0.11
Ash	20.14	5.19
Oxygen (by difference)	8.38	8.07
Equilibrium Moisture, %	3.37	3.35
Carbonate CO_2, Dry %	0.46	0.26
Low-Temperature Ash, Dry %		6.14
Mean Vitrinite Maximum Reflectance (R_0max), %		0.79
Free Swelling Index	4.0	5.0
Hardgrove Grindability Index	53	50

[a] Dmmf = Dry, mineral-matter free, Parr Formula ASTM D-388

[b] Maf = Moisture and ash free

[c] Mmmf = Moist, mineral-matter free, Parr Formula ASTM D-388

Table 6. Analyses of Anderson and Beulah-Zap Whole-Seam Coals

	Anderson Whole-Seam	Beulah-Zap Whole-Seam
Proximate Analysis, Dry %:		
Ash	6.62	8.93
Volatile Matter	40.61	43.46
Fixed Carbon	52.77	44.61
Fixed Carbon, Dmmf[a]	56.96	49.52
Forms of Sulfur, Dry %:		
Total	0.71	1.07
Pyrite	0.01	tr
Sulfate	0.02	0.05
Organic	0.68	1.02
Calorific Value, Btu/lb:		
Dry	11,906	10,942
Maf[b]	12,750	12,015
Mmmf[c]	9,069	7,765
Ultimate Analyses, Dry %:		
Carbon	69.21	65.43
Hydrogen	4.59	4.32
Nitrogen	1.00	0.85
Sulfur	0.71	1.07
Chlorine	0.01	0.03
Ash	6.62	8.93
Oxygen (by difference)	17.87	19.37
Equilibrium Moisture, %	27.76	33.59
Carbonate CO_2, Dry %	0.04	0.20
Low-Temperature Ash, Dry %	8.75	13.54
Mean Vitrinite Maximum Reflectance ($R_o$max), %	0.33	0.3 (Huminite)
Free Swelling Index	0.0	0.0
Hardgrove Grindability Index	55	53

[a] Dmmf = Dry, mineral-matter free, Parr Formula ASTM D-388

[b] Maf = Moisture and ash free

[c] Mmmf = Moist, mineral-matter free, Parr Formula ASTM D-388

fixed carbon and calorific value determinations and confirmed by the vitrinite reflectance measurement. The Anderson and Beulah- Zap were of subbituminous C and lignite A ranks, respectively, from the calorific value and equilibrium moisture determinations. The vitrinite reflectance reports by WAL Inc (formerly Western Analytical Laboratory) are in Appendix B. The reflectance measurements reported for Beulah-Zap coal were actually on huminite macerals rather than vitrinite macerals. Huminite is the precursor of vitrinite during coalification. The low-temperature ash determinations reported in Tables 5 and 6 were done by BCR National Laboratory for this project.

The ash compositions and fusion temperatures for the three coals are reported in Tables 7 and 8. Microscopic examinations of the three coals and surface characterizations studies are in progress.

Table 9 is a comparison of the 1.30, 1.40 and 1.90 specific gravity float products from the washability testing. The Sunnyside coal contained a considerable fraction containing 2.27 percent ash or less which would float at 1.30 specific gravity. The 1/2-inch x 0 Anderson subbituminous coal also contained a component that would float in the 1.30 specific gravity liquid but that float contained 4.6 percent ash. The fraction floating at 1.30 specific gravity virtually disappeared when the Anderson coal was crushed to 14 mesh. What little coal that did float from the ground Anderson sample at specific gravity 1.30 was enriched in volatile matter and very likely was mostly resinous exinite. A similar effect was observed when midwestern coals were ground to micron sizes.[5] The separations on the Beulah-Zap lignite did not produce any appreciable quantity of 1.30 specific gravity float at any particle size.

There was very little liberated mineral-matter in either of the low-rank coals and crushing to 65 mesh failed to release very much more as shown be the very small amount of 1.90 specific gravity sink product recovered from the Anderson and Beulah-Zap samples.

Complete mass balances for the heavy-liquid washability tests are contained in Appendix C.

Table 7. Ash Compositions and Fusion Temperatures for Whole-Seam and Washed Sunnyside Coal

	Whole-Seam	Washed Coal
Total Ash in Sample, %	20.14	5.19
Composition, wt %:		
SiO_2	69.9	54.4
Al_2O_3	13.2	19.5
TiO_2	0.97	1.44
Fe_2O_3	3.23	7.19
CaO	2.01	4.74
MgO	0.70	0.61
SrO	0.04	0.13
K_2O	1.67	0.47
Na_2O	0.49	1.48
P_2O_5	0.46	1.55
SO_3	1.03	2.40
Ash Fusion Temperatures, ^{o}F:		
Reducing Atmosphere,		
Initial Deformation	2450	2250
Softening (Spherical)	2640	2335
Hemispherical	2700+	2450
Fluid	2700+	2587
Oxidizing Atmosphere,		
Initial Deformation	2490	2380
Softening (Spherical)	2665	2477
Hemispherical	2700+	2560
Fluid	2700+	2668

Table 8. Ash Compositions and Fusion Temperatures for Anderson and Beulah-Zap Whole-Seam Coals

	Anderson	Beulah-Zap
Total Ash in Sample, %	6.62	8.93
Composition, wt %:		
SiO_2	26.5	15.8
Al_2O_3	15.2	11.7
TiO_2	1.81	0.43
Fe_2O3	6.25	7.35
CaO	23.8	25.5
MgO	3.99	8.00
SrO	0.39	0.76
K_2O	0.42	0.32
Na_2O	1.84	7.19
P_2O_5	1.41	0.30
SO_3	13.5	24.2
Ash Fusion Temperatures, ^{o}F:		
Reducing Atmosphere,		
Initial Deformation	2125	2340
Softening (Spherical)	2200	2345
Hemispherical	2210	2354
Fluid	2216	2360
Oxidizing Atmosphere,		
Initial Deformation	2180	2380
Softening (Spherical)	2215	2390
Hemispherical	2225	2391
Fluid	2240	2410

Table 9. Comparison 1.30-, 1.40- and 1.90-Specific Gravity Float Products

	Dry Basis				
	Wt %	Ash %	S(T) %	S(Py) %	Btu/lb
1.30 Specific Gravity Float:					
Sunnyside (Utah Bituminous):					
1/2 inch x 0 whole seam	53.9	2.27	0.56	0.02	14562
14 mesh x 0 whole seam	66.3	1.96	0.57	0.01	14478
14 mesh x 0 washed coal	76.6	1.56	0.53	0.01	14584
65 mesh x 0 washed coal	73.6	1.00	0.52	0.01	14579
Anderson (Powder River Subbituminous):					
1/2 inch x 0 whole seam	18.9	4.60	0.51	tr	12013
14 mesh x 0 whole seam	1.8	5.82	0.43	0.01	12607
65 mesh x 0 whole seam	0.8	4.25	0.27	tr	13029
Beulah-Zap (North Dakota Lignite):					
1/2 inch x 0 whole seam	2.2	3.87	0.57	0.01	11109
14 mesh x 0 whole seam	0.3	3.30	0.55		
65 mesh x 0 whole seam	1.2	3.22	0.75	0.01	11638
Cumulative 1.40 Specific Gravity Float:					
Sunnyside (Utah Bituminous):					
1/2 inch x 0 whole seam	78.4	4.26	0.56	0.04	14223
14 mesh x 0 whole seam	77.8	3.24	0.57	0.02	14258
14 mesh x 0 washed coal	91.9	2.89	0.53	0.02	14369
65 mesh x 0 washed coal	89.9	1.97	0.53	0.01	14425
Anderson (Powder River Subbituminous):					
1/2 inch x 0 whole seam	79.3	5.01	0.45	0.01	12013
14 mesh x 0 whole seam	65.3	4.47	0.36	0.01	11850
65 mesh x 0 whole seam	32.9	3.99	0.33	0.01	11929
Beulah-Zap (North Dakota Lignite):					
1/2 inch x 0 whole seam	52.0	5.78	0.62	0.01	11109
14 mesh x 0 whole seam	32.3	4.76	0.58	0.01	10950
65 mesh x 0 whole seam	14.6	3.81	0.62	0.01	10943
Cumulative 1.90 Specific Gravity Float:					
Sunnyside (Utah Bituminous):					
1/2 inch x 0 whole seam	84.4	6.96	0.57	0.06	13773
14 mesh x 0 whole seam	85.9	5.85	0.57	0.04	13821
14 mesh x 0 washed coal	98.9	4.64	0.54	0.03	14079
65 mesh x 0 washed coal	97.5	3.81	0.52	0.02	14118
Anderson (Powder River Subbituminous):					
1/2 inch x 0 whole seam	99.1	6.01	0.47	0.04	11588
14 mesh x 0 whole seam	99.2	5.77	0.37	0.04	11636
65 mesh x 0 whole seam	97.9	4.86	0.35	0.01	11525
Beulah-Zap (North Dakota Lignite):					
1/2 inch x 0 whole seam	98.5	7.43	0.63	0.06	10658
14 mesh x 0 whole seam	97.9	6.73	0.54	0.04	10588
65 mesh x 0 whole seam	98.6	5.91	0.49	0.02	10387

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APPENDIX A

GAMMA FUNCTION DISTRIBUTION MODEL FOR FLOTATION KINETICS

The Gamma Function Distribution (GFD) model has been described by Woodburn and Loveday (1) and has been shown to be a versatile method for describing the flotation behavior in continuous circuits. The model has the following form:

$$r = 1 - \frac{1}{[1 + (w + 1)k_o t]^a} \qquad \text{(A-1)}$$

where r = recovery at time t,
a, k_o, = parameter describing flotation rate behavior (ko, = min-1)
w = weighting factor.

The basis of the equation (A-1) model is the assumption that flotation feed material can be characterized by its chemical analysis, physical characteristics, and batch flotation behavior. This model relies on the assumption that the flotability of the feed material in a batch flotation cell can be described by the GFD equation. That is, the mass fraction of material in the feed having a first-order flotability constant, k, in the range from k to k + dk can be represented as a function of k such as f(k)dk. In the case of batch flotation, the gamma function equation describing this flotability constant distribution has the following form:

$$f(k) = \frac{1}{(w + 1)^a \Gamma(a)} \left[\frac{k}{k_o}\right]^{a-1} \exp - \left[\frac{k/k_o}{(u + 1)}\right] \qquad \text{(A-2)}$$

where:
f(k) = flotability constant distribution function.
k = First order flotability constant for a differential feed component.
a,k_o = Gamma function parameters describing feed k value distribution (k_o = min^{-1}).
w = Weighting factor.

Definition of gamma function, $\Gamma(u)$:

$$\Gamma(u) = \int_0^\infty x^{u-1} e^{-x} dx \qquad \text{(A-3)}$$

where:
u = Integral argument
x = Integral variable ($\infty > x \geq 0$).

The value of parameter a represents the uniformity of flotation behavior for a given species (ie. coal or ash). Parameter k_0 can be considered a factor which reflects the influence of the operating conditions of the flotation process on kinetics. These parameters are invariant for a given set of flotation conditions. The a and ko parameters can be determined for each component species in the system (valuable minerals, gangue minerals, water etc), therefore the equations for each species can be combined to predict performance of a continuous flotation system.

Equations (A-1) and (A-2) also contain a weighting factor, w, which allows for increased flexibility in modeling flotation behavior. The value of w can be varied to "weight" the portion of the time-recovery curve for which the most accuracy is required. This feature is particularly useful for species containing distinctive fast- and slow-floating fractions.

APPENDIX B

Vitrinite Reflectance Reports

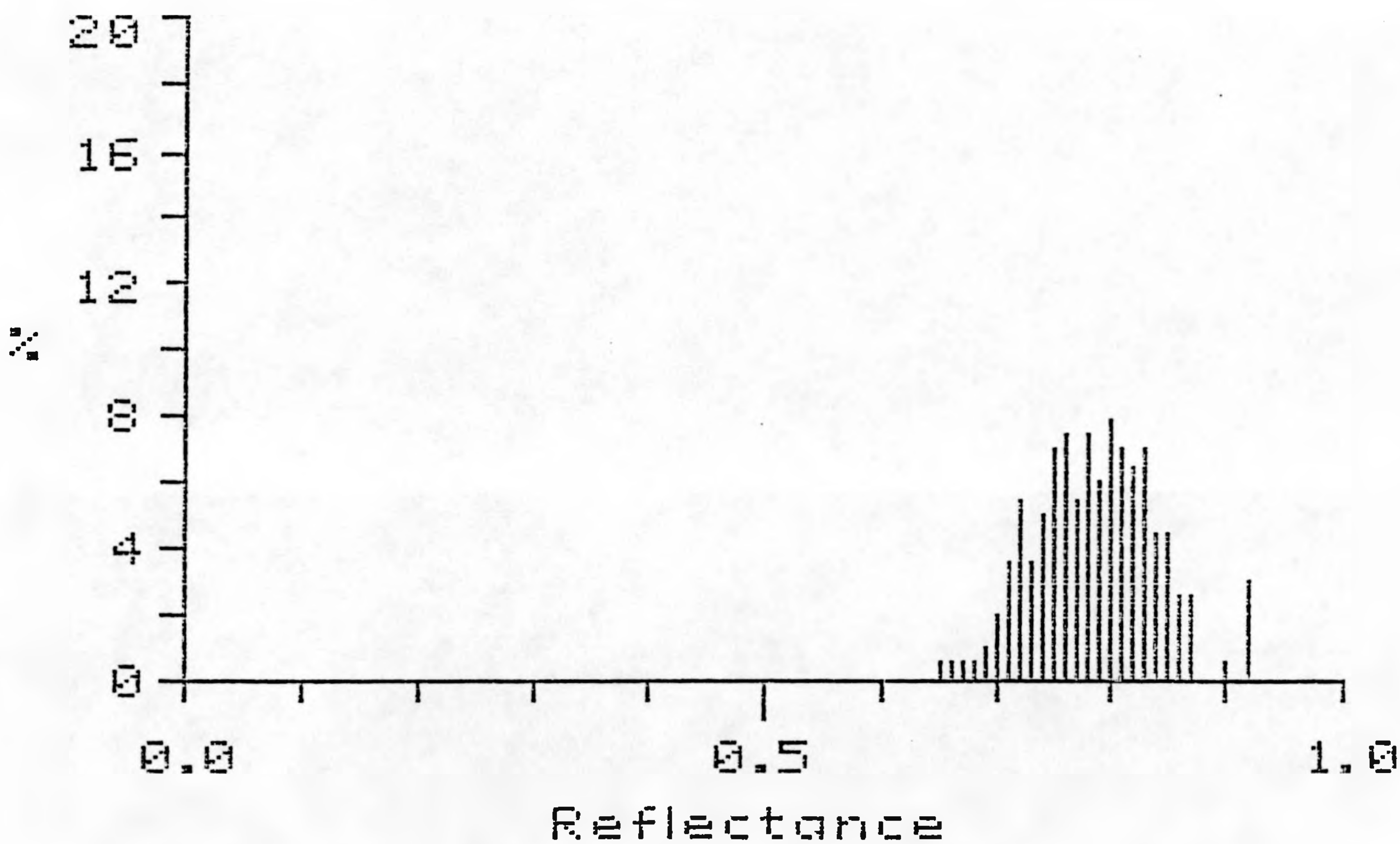
WAL, Inc

REFLECTANCE ANALYSIS

WAL BATCH #: 86249-1

REPORT OF ANALYSIS ON SAMPLE: 81666-1 SUNNY SIDE CLEAN COAL

DISTRIBUTION OF VITRINITE REFLECTANCE READINGS



MEAN-MAXIMUM VITRINITE Ro: .79 STD. DEVIATION: .05
NUMBER OF COUNTS: 204

V-TYPE TABLE FOR VITRINITES (=100%)

V-6	2.9
V-7	52
V-8	41.7
V-9	3.4

RAW DATA FOR 81666-1 SUNNY SIDE CLEAN COAL

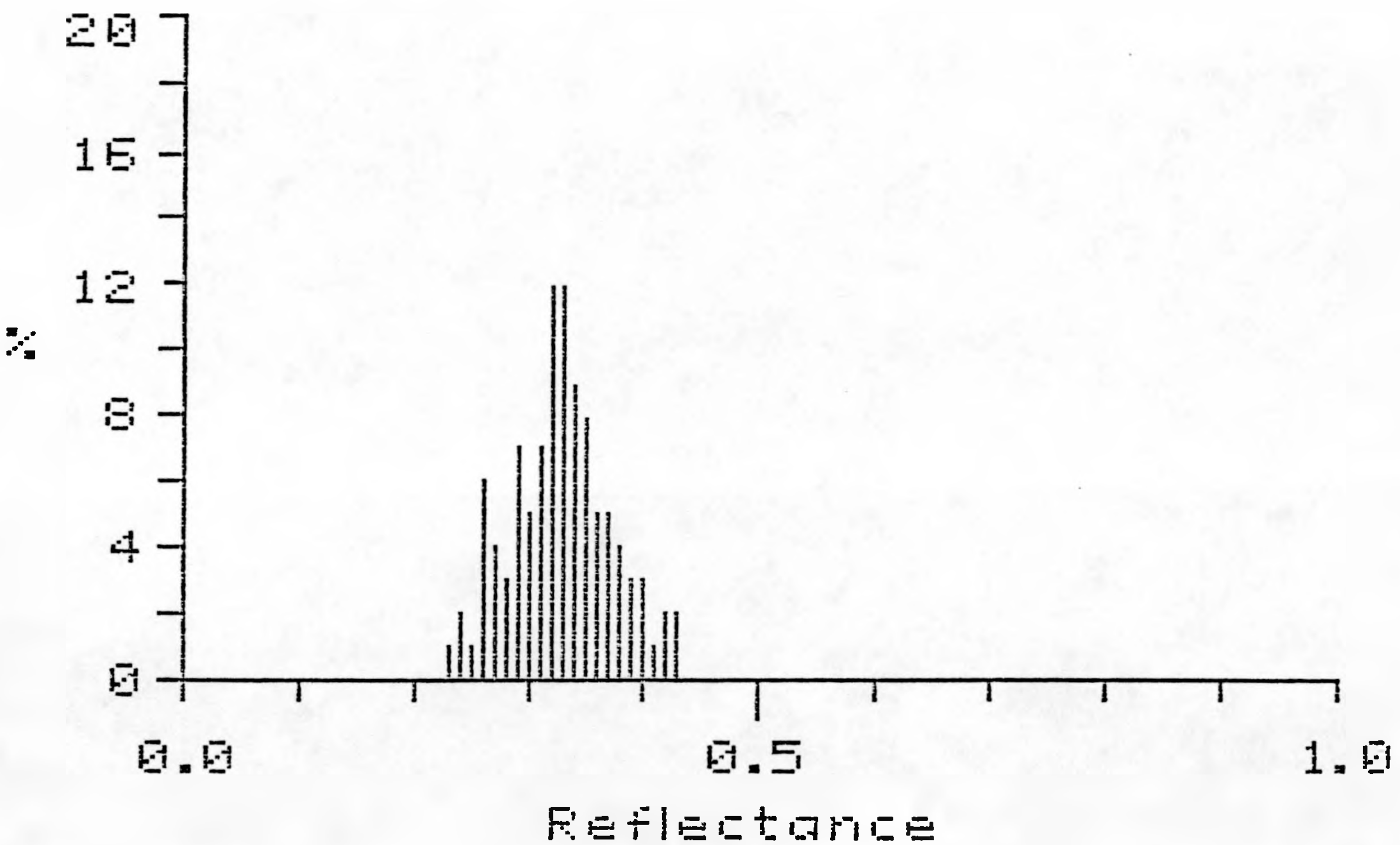
REFL.	#	;	REFL.	#
.01			.51	
.02			.52	
.03			.53	
.04			.54	
.05			.55	
.06			.56	
.07			.57	
.08			.58	
.09			.59	
.1			.6	
.11			.61	
.12			.62	
.13			.63	
.14			.64	
.15			.65	1
.16			.66	1
.17			.67	1
.18			.68	1
.19			.69	2
.2			.7	4
.21			.71	7
.22			.72	11
.23			.73	7
.24			.74	10
.25			.75	14
.26			.76	15
.27			.77	11
.28			.78	15
.29			.79	12
.3			.8	16
.31			.81	14
.32			.82	13
.33			.83	14
.34			.84	9
.35			.85	9
.36			.86	5
.37			.87	5
.38			.88	
.39			.89	
.4			.9	1
.41			.91	
.42			.92	6
.43			.93	
.44			.94	
.45			.95	
.46			.96	
.47			.97	
.48			.98	
.49			.99	
.5			1	

REFLECTANCE ANALYSIS

WAL BATCH #: 86248-2

REPORT OF ANALYSIS ON SAMPLE: 81666-2 BELLE AYRE WHOLE SEAM

DISTRIBUTION OF VITRINITE REFLECTANCE READINGS



MEAN-MAXIMUM VITRINITE Ro: .33 STD. DEVIATION: .04
NUMBER OF COUNTS: 102

V-TYPE TABLE FOR VITRINITES (=100%)

V-2	23.6
V-3	68.6
V-4	7.8

RAW DATA FOR 31666-2 BELLE AYRE WHOLE SEAM

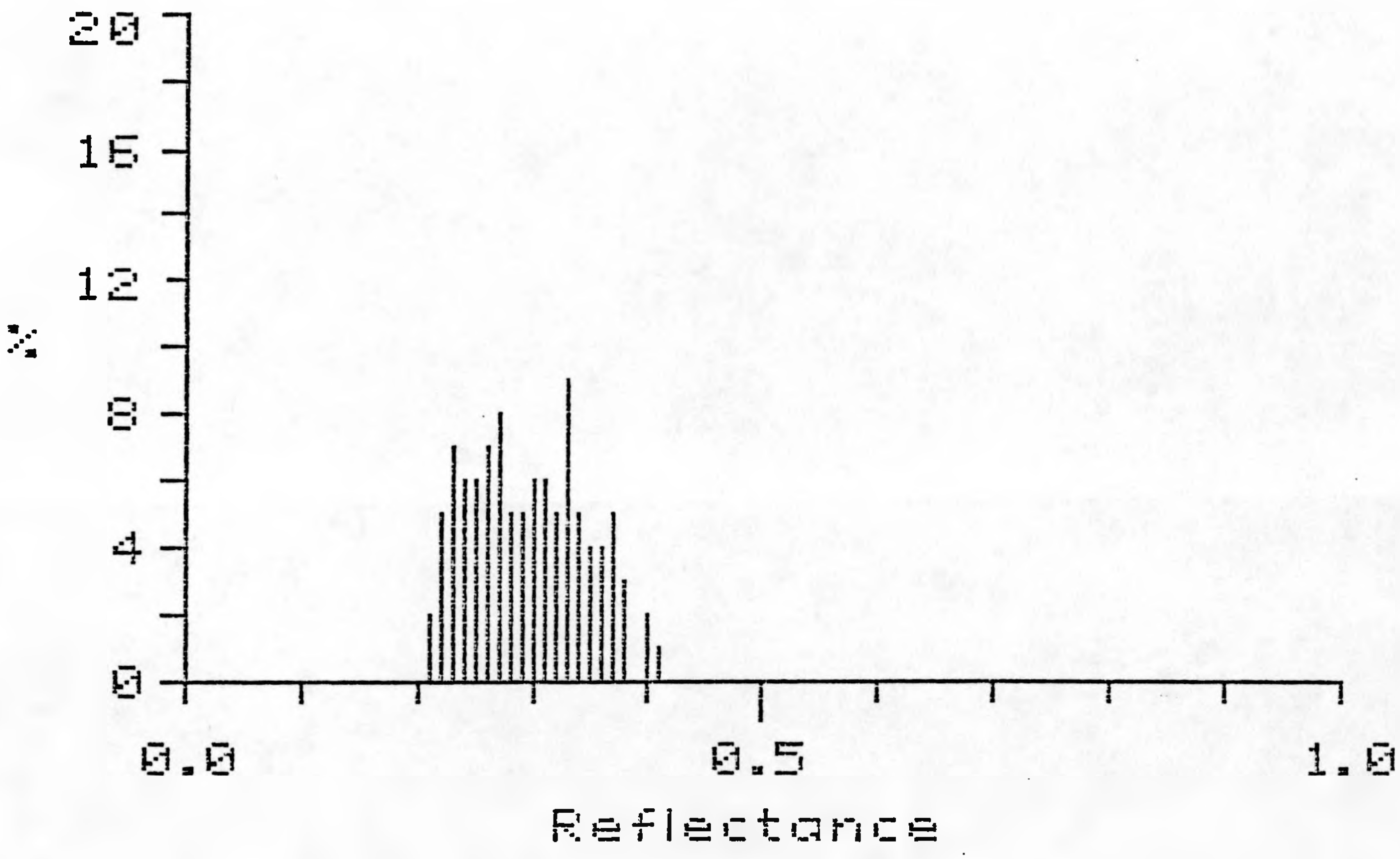
REFL.	#	:	REFL.	#
.01			.51	
.02			.52	
.03			.53	
.04			.54	
.05			.55	
.06			.56	
.07			.57	
.08			.58	
.09			.59	
.1			.6	
.11			.61	
.12			.62	
.13			.63	
.14			.64	
.15			.65	
.16			.66	
.17			.67	
.18			.68	
.19			.69	
.2			.7	
.21			.71	
.22			.72	
.23	1		.73	
.24	2		.74	
.25	1		.75	
.26	6		.76	
.27	4		.77	
.28	3		.78	
.29	7		.79	
.3	5		.8	
.31	7		.81	
.32	12		.82	
.33	12		.83	
.34	9		.84	
.35	8		.85	
.36	5		.86	
.37	5		.87	
.38	4		.88	
.39	3		.89	
.4	3		.9	
.41	1		.91	
.42	2		.92	
.43	2		.93	
.44			.94	
.45			.95	
.46			.96	
.47			.97	
.48			.98	
.49			.99	
.5			1	

REFLECTANCE ANALYSIS

WAL BATCH #: 86248-3

REPORT OF ANALYSIS ON SAMPLE: 81666-3 BEULAH ZAP WHOLE SEAM

DISTRIBUTION OF VITRINITE REFLECTANCE READINGS



MEAN-MAXIMUM VITRINITE Ro: .3 STD. DEVIATION: .05
NUMBER OF COUNTS: 101

V-TYPE TABLE FOR VITRINITES (=100%)

V-2	50.5
V-3	46.5
V-4	3

RAW DATA FOR S1666-3 BEULAH ZAP WHOLE SEAM

REFL.	#	:	REFL.	#
.01			.51	
.02			.52	
.03			.53	
.04			.54	
.05			.55	
.06			.56	
.07			.57	
.08			.58	
.09			.59	
.1			.6	
.11			.61	
.12			.62	
.13			.63	
.14			.64	
.15			.65	
.16			.66	
.17			.67	
.18			.68	
.19			.69	
.2			.7	
.21	2		.71	
.22	5		.72	
.23	7		.73	
.24	6		.74	
.25	6		.75	
.26	7		.76	
.27	8		.77	
.28	5		.78	
.29	5		.79	
.3	6		.8	
.31	6		.81	
.32	5		.82	
.33	9		.83	
.34	5		.84	
.35	4		.85	
.36	4		.86	
.37	5		.87	
.38	3		.88	
.39			.89	
.4	2		.9	
.41	1		.91	
.42			.92	
.43			.93	
.44			.94	
.45			.95	
.46			.96	
.47			.97	
.48			.98	
.49			.99	
.5			1	

APPENDIX C

Washability Test Mass Balances

Table C-1. Washability of Sunnyside 1/2-Inch x 0 Whole Seam Coal.

Specific Gravity		Direct (Dry Basis)							Cumulative Float (Dry Basis)						
Sink	Float	Wt %	Ash, %	Vol %	S(t), %	$S(SO_4)$, %	S(Py), %	Btu/lb	Wt %	Ash, %	Vol %	S(t), %	$S(SO_4)$, %	S(Py), %	Btu/lb
1/2 Inch x 14 Mesh, 77.8 Wt%:															
	1.30	54.7	2.35	37.51	0.58	0.012	0.02	14562	54.7	2.35	37.51	0.58	0.012	0.02	14562
1.30	1.40	22.8	9.32	35.97	0.56	0.012	0.08	13390	77.5	4.40	37.06	0.57	0.012	0.04	14218
1.40	1.50	3.3	23.68	32.18	0.69	0.016	0.21	10992	80.7	5.18	36.86	0.57	0.012	0.04	14088
1.50	1.60	1.7	34.04	29.25	0.58	0.016	0.22	9248	82.4	5.77	36.70	0.57	0.012	0.05	13988
1.60	1.90	2.8	49.13	24.54	0.54	0.021	0.28	6819	85.2	7.20	36.30	0.57	0.013	0.05	13752
1.90		14.8	83.08	9.70	0.66	0.047	0.62	1963	100.0	18.40	32.38	0.59	0.018	0.14	12012
14 Mesh x 100 Mesh, 17.3 Wt%:															
	1.30	52.8	1.84	38.28	0.53	0.018	0.02	14603	52.8	1.84	38.28	0.53	0.018	0.02	14603
1.30	1.40	30.8	6.99	35.86	0.58	0.020	0.07	13717	83.6	3.74	37.39	0.54	0.019	0.04	14277
1.40	1.50	3.4	20.65	31.89	0.71	0.027	0.25	11458	87.0	4.40	37.17	0.55	0.019	0.05	14166
1.50	1.60	1.7	29.65	28.62	0.78	0.033	0.38	9911	88.7	4.88	37.01	0.56	0.019	0.05	14085
1.60	1.90	2.8	44.47	23.77	0.66	0.043	0.39	7504	91.4	6.07	36.61	0.56	0.020	0.06	13887
1.90		8.6	78.76	12.53	0.79	0.077	0.71	2302	100.0	12.30	34.55	0.58	0.025	0.12	12894
100 Mesh x 0 , 4.9 Wt%:															
	1.30	45.7	2.46	38.62	0.53	0.017	0.01	14418	45.7	2.46	38.62	0.53	0.017	0.01	14418
1.30	1.40	29.3	6.84	37.34	0.57	0.030	0.05	13630	74.9	4.17	38.12	0.54	0.022	0.03	14110
1.40	1.50	6.7	15.35	31.74	0.56	0.044	0.12	12221	81.6	5.08	37.60	0.54	0.024	0.03	13956
1.50	1.60	2.5	23.18	26.96	0.63	0.053	0.23	10949	84.1	5.62	37.29	0.55	0.025	0.04	13868
1.60	1.90	2.9	38.97	23.83	0.70	0.067	0.39	8331	86.9	6.71	36.84	0.55	0.026	0.05	13685
1.90		13.1	83.12	12.39	0.80	0.091	0.71	1517	100.0	16.71	33.64	0.58	0.035	0.14	12093
1/2 Inch x 0 Composite, 100.0 Wt%:															
	1.30	53.9	2.27	37.85	0.56	0.013	0.02	14562	53.9	2.27	37.85	0.56	0.013	0.02	14562
1.30	1.40	24.5	8.64	36.04	0.56	0.015	0.07	13479	78.4	4.26	38.28	0.56	0.014	0.04	14223
1.40	1.50	3.5	22.24	32.08	0.68	0.021	0.21	11208	81.9	5.03	37.06	0.57	0.014	0.04	14095
1.50	1.60	1.7	32.40	28.95	0.62	0.022	0.25	9501	83.6	5.60	36.89	0.57	0.014	0.05	13999
1.60	1.90	2.8	47.72	24.36	0.57	0.028	0.30	7027	86.4	6.96	36.49	0.57	0.015	0.06	13773
1.90		13.6	82.60	10.16	0.68	0.053	0.63	1976	100.0	17.23	32.91	0.58	0.020	0.13	12172

Table C-2. Washability of Sunnyside 14 Mesh x 0 Whole Seam Coal

Specific Gravity		Direct (Dry Basis)							Cumulative Float (Dry Basis)						
Sink	Float	Wt %	Ash, %	Vol %	S(t), %	$S(SO_4)$, %	S(Py), %	Btu/lb	Wt %	Ash, %	Vol %	S(t), %	$S(SO_4)$, %	S(Py), %	Btu/lb
14 Mesh x 100 Mesh, 76.8 Wt%:															
	1.30	68.0	2.09	38.72	0.56	0.009	0.01	14472	68.0	2.09	38.72	0.56	0.009	0.01	14472
1.30	1.40	10.8	12.26	35.87	0.56	0.013	0.07	12774	78.8	3.48	38.33	0.56	0.010	0.02	14240
1.40	1.50	3.4	22.17	32.12	0.61	0.013	0.14	11078	82.2	4.26	38.07	0.57	0.010	0.02	14108
1.50	1.60	1.7	32.68	29.08	0.62	0.023	0.23	9343	83.9	4.85	37.89	0.57	0.010	0.03	14009
1.60	1.90	2.8	45.94	24.29	0.56	0.022	0.25	7182	86.7	6.15	37.46	0.57	0.010	0.04	13794
1.90		13.3	82.70	10.82	0.71	0.035	0.61	1803	100.0	16.36	33.90	0.59	0.014	0.11	12194
100 Mesh x 0, 23.2 Wt%:															
	1.30	60.7	1.46	39.76	0.61	0.008	0.01	14501	60.7	1.46	39.76	0.61	0.008	0.01	14501
1.30	1.40	13.8	6.49	36.22	0.61	0.019	0.04	13529	74.5	2.39	39.11	0.61	0.010	0.02	14321
1.40	1.50	4.4	15.39	31.71	0.58	0.029	0.09	12111	78.9	3.12	38.69	0.60	0.011	0.02	14197
1.50	1.60	2.0	24.28	30.95	0.60	0.045	0.16	10606	80.9	3.64	38.50	0.60	0.012	0.02	14110
1.60	1.90	2.7	40.44	25.04	0.64	0.055	0.37	7962	83.6	4.80	38.07	0.61	0.013	0.04	13915
1.90		16.4	84.58	11.58	0.73	0.061	0.64	1293	100.0	17.91	33.72	0.63	0.021	0.14	11841
14 Mesh x 0 Composite, 100.0 Wt%:															
	1.30	66.3	1.96	38.94	0.57	0.009	0.01	14478	66.3	1.96	38.94	0.57	0.009	0.01	14478
1.30	1.40	11.5	10.65	35.97	0.57	0.015	0.06	12984	77.8	3.24	38.50	0.57	0.010	0.02	14258
1.40	1.50	3.6	20.27	32.01	0.60	0.017	0.12	11367	81.4	4.01	38.21	0.57	0.010	0.02	14128
1.50	1.60	1.8	30.53	29.56	0.61	0.029	0.21	9666	83.2	4.58	38.02	0.57	0.011	0.03	14032
1.60	1.90	2.7	44.69	24.46	0.58	0.029	0.28	7359	85.9	5.85	37.60	0.57	0.011	0.04	13821
1.90		14.1	83.21	11.03	0.72	0.042	0.62	1665	100.0	16.72	33.86	0.59	0.016	0.12	12112

Table C-3. Washability of Sunnyside 14 Mesh x 0 Washed Coal

Specific Gravity		Direct (Dry Basis)							Cumulative Float (Dry Basis)						
Sink	Float	Wt %	Ash, %	Vol %	S(t), %	$S(SO_4)$, %	S(Py), %	Btu/lb	Wt %	Ash, %	Vol %	S(t), %	$S(SO_4)$, %	S(Py), %	Btu/lb
14 Mesh x 100 Mesh, 83.6 Wt%:															
	1.30	76.9	1.67	38.57	0.52	0.001	0.01	14577	76.9	1.67	38.57	0.52	0.001	0.01	14577
1.30	1.40	15.4	10.15	36.41	0.55	0.005	0.07	13219	92.3	3.09	38.21	0.53	0.002	0.02	14350
1.40	1.50	4.0	21.68	33.15	0.59	0.008	0.14	11256	96.3	3.86	38.00	0.53	0.002	0.03	14221
1.50	1.60	1.7	31.31	29.34	0.59	0.009	0.21	9739	98.0	4.33	37.85	0.53	0.002	0.03	14144
1.60	1.90	1.3	42.76	26.32	0.57	0.014	0.30	7719	99.3	4.84	37.70	0.53	0.002	0.04	14059
1.90		0.7	66.94	29.09	1.37	0.024	1.28	2998	100.0	5.27	33.64	0.54	0.002	0.04	13982
100 Mesh x 0, 16.4 Wt%:															
	1.30	75.3	0.99	39.62	0.55	0.003	0.01	14618	75.3	0.99	39.62	0.55	0.003	0.01	14618
1.30	1.40	14.9	6.37	36.15	0.52	0.008	0.04	13702	90.2	1.88	39.05	0.55	0.004	0.01	14467
1.40	1.50	3.4	18.18	31.32	0.51	0.012	0.09	11767	93.6	2.47	38.77	0.55	0.004	0.02	14369
1.50	1.60	1.4	26.85	29.69	0.51	0.020	0.18	10310	95.0	2.83	38.63	0.55	0.004	0.02	14309
1.60	1.90	1.9	41.83	24.96	0.50	0.026	0.29	7809	96.9	3.60	38.36	0.55	0.005	0.02	14181
1.90		3.1	78.92	18.77	0.48	0.034	0.45	1440	100.0	5.94	37.75	0.54	0.006	0.04	13785
14 Mesh x 0 Composite, 100.0 Wt%:															
	1.30	76.6	1.56	38.74	0.53	0.001	0.01	14584	76.6	1.56	38.74	0.53	0.001	0.01	14584
1.30	1.40	15.3	9.55	36.37	0.55	0.005	0.06	13296	91.9	2.89	38.35	0.53	0.002	0.02	14369
1.40	1.50	4.0	21.19	32.89	0.58	0.009	0.14	11328	95.9	3.64	38.12	0.54	0.002	0.03	14245
1.50	1.60	1.6	30.68	29.39	0.58	0.011	0.20	9820	97.5	4.09	37.98	0.54	0.002	0.03	14171
1.60	1.90	1.4	42.56	26.02	0.56	0.017	0.30	7739	98.9	4.64	37.81	0.54	0.002	0.03	14079
1.90		1.1	72.51	24.29	0.96	0.029	0.89	2274	100.0	5.38	37.66	0.54	0.003	0.04	13950

Table C-4. Washability of Sunnyside 65 Mesh x 0 Washed Coal

Specific Gravity		Direct (Dry Basis)							Cumulative Float (Dry Basis)						
Sink	Float	Wt %	Ash, %	Vol %	S(t), %	$S(SO_4)$, %	S(Py), %	Btu/lb	Wt %	Ash, %	Vol %	S(t), %	$S(SO_4)$, %	S(Py), %	Btu/lb
	1.30	73.6	1.00	40.04	0.52	0.003	0.01	14579	73.6	1.00	40.04	0.52	0.003	0.01	14579
1.30	1.40	16.3	6.35	36.26	0.54	0.007	0.03	13731	89.9	1.97	39.35	0.53	0.004	0.01	14425
1.40	1.50	4.1	18.61	32.57	0.48	0.009	0.05	11668	94.0	2.70	39.06	0.52	0.004	0.01	14305
1.50	1.60	1.8	27.32	29.80	0.49	0.012	0.09	10190	95.8	3.15	38.89	0.52	0.004	0.01	14229
1.60	1.90	1.7	40.55	24.44	0.39	0.016	0.14	7969	97.5	3.81	38.63	0.52	0.004	0.02	14118
1.90		2.5	78.30	19.13	0.77	0.031	0.74	1570	100.0	5.69	38.14	0.53	0.005	0.03	13802

Table C-5. Washability of Anderson 1/2-Inch x 0 Whole Seam Coal

Specific Gravity		Direct (Dry Basis)							Cumulative Float (Dry Basis)						
Sink	Float	Wt %	Ash, %	Vol %	S(t), %	$S(SO_4)$, %	S(Py), %	Btu/lb	Wt %	Ash, %	Vol %	S(t), %	$S(SO_4)$, %	S(Py), %	Btu/lb
1/2 Inch x 14 Mesh, 81.0 Wt%:															
	1.30	22.9	4.55	46.98	0.51	0.013	tr	12011	22.9	4.55	46.98	0.51	0.013	tr	12011
1.30	1.40	64.0	5.23	48.33	0.44	0.014	0.01	11675	86.9	5.05	47.97	0.46	0.014	0.01	11764
1.40	1.50	9.3	7.84	46.93	0.50	0.022	0.15	11217	96.2	5.32	47.87	0.46	0.015	0.02	11711
1.50	1.60	1.6	17.04	40.57	0.75	0.027	0.33	9791	97.8	5.52	47.75	0.47	0.015	0.02	11678
1.60	1.90	1.5	36.75	33.16	0.78	0.032	0.36	7217	99.3	5.99	47.53	0.47	0.015	0.03	11611
1.90		0.7	62.42	19.46	2.28	0.056	2.14	4115	100.0	6.36	47.35	0.48	0.015	0.04	11562
14 Mesh x 100 Mesh, 15.7 Wt%:															
	1.30	1.9	7.59	58.71	0.48	0.016	tr	12096	1.9	7.59	58.71	0.48	0.016	tr	12096
1.30	1.40	48.8	4.66	50.20	0.41	0.020	0.01	11692	50.7	4.77	50.52	0.41	0.020	0.01	11707
1.40	1.50	41.8	5.83	46.93	0.42	0.024	0.08	11485	92.5	5.25	48.90	0.42	0.022	0.04	11607
1.50	1.60	3.6	13.98	41.93	0.88	0.046	0.48	10258	96.1	5.57	48.64	0.43	0.023	0.06	11557
1.60	1.90	2.1	33.60	32.90	2.00	0.140	1.58	7620	98.2	6.18	48.30	0.47	0.025	0.09	11472
1.90		1.8	58.93	27.79	16.19	0.481	14.05	4012	100.0	7.14	47.97	0.75	0.033	0.34	11337
100 Mesh x 0 , 3.3 Wt%:															
	1.30	0.4	3.52	59.53	0.30	0.018	tr	12995	0.4	3.52	59.53	0.30	0.018	tr	12995
1.30	1.40	28.2	4.01	49.57	0.35	0.028	tr	11919	28.6	4.00	49.71	0.35	0.028	tr	11934
1.40	1.50	59.7	5.12	43.77	0.36	0.045	0.01	11590	88.3	4.76	45.69	0.36	0.039	0.01	11701
1.50	1.60	6.8	8.62	36.79	0.39	0.055	0.10	11002	95.1	5.03	45.06	0.36	0.041	0.01	11652
1.60	1.90	2.3	30.13	36.58	0.93	0.134	0.57	8193	97.4	5.64	44.85	0.37	0.043	0.02	11568
1.90		2.6	68.76	21.76	11.51	0.351	10.28	2761	100.0	7.28	44.26	0.66	0.051	0.29	11340
1/2 Inch x 0 Composite, 100.0 Wt%:															
	1.30	18.9	4.60	47.18	0.51	0.013	tr	12013	18.9	4.60	47.18	0.51	0.013	tr	12013
1.30	1.40	60.4	5.14	48.59	0.43	0.015	0.01	11681	79.3	5.01	48.25	0.45	0.015	0.01	11760
1.40	1.50	16.1	6.68	46.54	0.45	0.026	0.10	11372	95.4	5.29	47.97	0.45	0.016	0.02	11694
1.50	1.60	2.1	15.34	40.53	0.75	0.035	0.35	10043	97.5	5.51	47.80	0.46	0.017	0.03	11659
1.60	1.90	1.6	35.78	33.27	1.04	0.059	0.62	7347	99.1	6.01	47.57	0.47	0.018	0.04	11588
1.90		0.9	61.92	22.94	7.56	0.218	6.68	3953	100.0	6.51	47.34	0.53	0.019	0.10	11519

Table C-6. Washability of Anderson 14 Mesh x 0 Whole Seam Coal

Specific Gravity		Direct (Dry Basis)							Cumulative Float (Dry Basis)						
Sink	Float	Wt %	Ash, %	Vol %	S(t), %	$S(SO_4)$, %	S(Py), %	Btu/lb	Wt %	Ash, %	Vol %	S(t), %	$S(SO_4)$, %	S(Py), %	Btu/lb
14 Mesh x 100 Mesh, 85.6 Wt%:															
	1.30	1.9	5.95	54.92	0.44	0.011	0.01	12590	1.9	5.95	54.92	0.44	0.011	0.01	12590
1.30	1.40	68.5	4.47	48.99	0.36	0.012	0.01	11828	70.4	4.51	49.15	0.36	0.012	0.01	11849
1.40	1.50	25.5	6.75	45.98	0.37	0.016	0.07	11476	95.9	5.11	48.31	0.36	0.013	0.03	11750
1.50	1.60	1.9	16.88	40.27	0.71	0.035	0.37	10021	97.8	5.34	48.15	0.37	0.013	0.04	11716
1.60	1.90	1.6	34.52	33.74	0.77	0.067	0.60	7660	99.4	5.81	47.92	0.38	0.014	0.04	11650
1.90		0.6	61.19	21.81	7.51	0.280	7.20	4026	100.0	6.12	47.77	0.42	0.016	0.08	11607
100 Mesh x 0, 14.4 Wt%:															
	1.30	0.9	4.07	69.62	0.24	0.012	tr	12836	0.9	4.07	69.62	0.24	0.012	tr	12836
1.30	1.40	33.9	3.98	47.89	0.31	0.013	tr	11843	34.8	3.98	48.43	0.31	0.013	tr	11868
1.40	1.50	56.5	5.05	43.68	0.32	0.015	0.01	11563	91.3	4.64	45.49	0.32	0.014	tr	11679
1.50	1.60	5.1	11.70	37.51	0.43	0.042	0.13	10585	96.4	5.01	45.07	0.32	0.016	0.01	11622
1.60	1.90	1.6	35.11	36.34	0.62	0.073	0.52	7509	98.0	5.50	44.93	0.33	0.017	0.02	11556
1.90		2.0	75.80	20.86	4.55	0.226	4.29	2458	100.0	6.94	44.44	0.41	0.021	0.11	11369
14 Mesh x 0 Composite, 100.0 Wt%:															
	1.30	1.8	5.82	55.96	0.43	0.011	0.01	12607	1.8	5.82	55.96	0.43	0.011	0.01	12607
1.30	1.40	63.5	4.43	48.91	0.36	0.012	0.01	11829	65.3	4.47	49.10	0.36	0.012	0.01	11850
1.40	1.50	29.9	6.29	45.35	0.36	0.016	0.05	11500	95.2	5.04	47.92	0.36	0.013	0.02	11740
1.50	1.60	2.4	15.29	39.51	0.62	0.037	0.30	10195	97.6	5.29	47.71	0.37	0.014	0.03	11702
1.60	1.90	1.6	34.60	34.11	0.75	0.068	0.59	7639	99.2	5.77	47.49	0.37	0.015	0.04	11636
1.90		0.8	66.78	21.45	6.38	0.259	6.09	3426	100.0	6.24	47.29	0.42	0.017	0.09	11573

Table C-7. Washability of Anderson 65 Mesh x 0 Whole Seam Coal

Specific Gravity		Direct (Dry Basis)							Cumulative Float (Dry Basis)						
Sink	Float	Wt %	Ash, %	Vol %	S(t), %	$S(SO_4)$, %	S(Py), %	Btu/lb	Wt %	Ash, %	Vol %	S(t), %	$S(SO_4)$, %	S(Py), %	Btu/lb
	1.30	0.8	4.25	58.97	0.27	0.015	tr	13029	0.8	4.25	58.97	0.27	0.015	tr	13029
1.30	1.40	32.1	3.98	48.08	0.33	0.016	0.01	11902	32.9	3.99	48.35	0.33	0.016	0.01	11929
1.40	1.50	62.6	5.03	48.31	0.35	0.017	0.01	11544	95.5	4.67	48.32	0.34	0.017	0.01	11677
1.50	1.60	2.4	12.55	43.61	0.45	0.043	0.16	10453	97.9	4.86	48.21	0.35	0.017	0.01	11647
1.60	1.90	1.8	56.34	24.46	3.37	0.143	3.21	4683	99.7	5.76	47.79	0.40	0.019	0.07	11525
1.90		0.3	78.60	21.96	10.57	0.2(a)	10.5(a)	1817	100.0	6.00	47.71	0.43	0.020(a)	0.10(a)	11493

(a) Estimated values.

Table C-8. Washability of Beulah-Zap 1/2-Inch x 0 Whole-Seam Coal

Specific Gravity		Direct (Dry Basis)							Cumulative Float (Dry Basis)						
Sink	Float	Wt %	Ash, %	Vol %	S(t), %	$S(SO_4)$, %	S(Py), %	Btu/lb	Wt %	Ash, %	Vol %	S(t), %	$S(SO_4)$, %	S(Py), %	Btu/lb
1/2 Inch x 14 Mesh, 87.3 Wt%:															
	1.30	2.4	3.84	45.75	0.58	0.019	0.01	11392	2.4	3.84	45.75	0.58	0.019	0.01	11392
1.30	1.40	54.6	5.88	45.30	0.62	0.023	0.01	10960	57.0	5.79	45.32	0.62	0.023	0.01	10978
1.40	1.50	33.3	7.90	41.87	0.62	0.033	0.01	10513	90.3	6.57	44.05	0.62	0.027	0.01	10807
1.50	1.60	7.1	13.77	37.90	0.64	0.039	0.32	9557	97.5	7.10	43.60	0.62	0.027	0.03	10716
1.60	1.90	1.3	28.15	35.20	2.58	0.069	2.34	7848	98.8	7.38	43.49	0.65	0.028	0.06	10677
1.90		1.2	67.11	37.47	18.11	0.986	15.66	3407	100.0	8.10	43.41	0.86	0.040	0.25	10589
14 Mesh x 100 Mesh, 10.1 Wt%:															
	1.30	0.4	5.51	51.85					0.4	5.51	51.85				
1.30	1.40	20.3	5.49	47.20	0.60	0.027	0.01	11155	20.7	5.49	47.30	0.59	0.026	0.01	10922
1.40	1.50	58.6	6.58	43.45	0.53	0.040	0.01	10707	79.3	6.30	44.45	0.54	0.036	0.01	10763
1.50	1.60	13.8	11.22	39.59	0.45	0.052	0.17	9942	93.1	7.02	43.74	0.53	0.039	0.03	10642
1.60	1.90	3.8	25.11	36.10	1.20	0.114	0.97	7961	96.9	7.74	43.43	0.56	0.042	0.07	10535
1.90		3.1	69.41	30.50	12.76	1.317	10.91	2532	100.0	9.62	43.04	0.93	0.081	0.40	10291
100 Mesh x 0 , 2.6 Wt%:															
	1.30	0.4	2.63	56.02	0.50				0.4	2.63	56.02	0.50			
1.30	1.40	5.5	4.98	48.85	0.56	0.046	0.01	11256	5.9	4.83	49.32	0.56	0.043	0.01	10518
1.40	1.50	49.8	6.28	41.79	0.46	0.060	0.01	10797	55.7	6.13	42.59	0.47	0.058	0.01	10767
1.50	1.60	33.6	8.57	39.40	0.29	0.075	0.01	10267	89.2	7.04	41.39	0.40	0.065	0.01	10579
1.60	1.90	5.0	22.29	37.49	0.62	0.148	0.40	8154	94.2	7.85	41.19	0.41	0.069	0.03	10452
1.90		5.8	73.52	28.43	7.17	0.844	5.27	1477	100.0	11.67	40.44	0.81	0.114	0.34	9929
1/2 Inch x 0 Composite, 100.0 Wt%:															
	1.30	2.2	3.87	45.92	0.57	0.019	0.01	11109	2.2	3.87	45.92	0.57	0.019	0.01	11109
1.30	1.40	49.8	5.86	45.39	0.62	0.023	0.01	10969	52.0	5.78	45.41	0.62	0.023	0.01	10975
1.40	1.50	36.3	7.63	42.12	0.60	0.035	0.01	10555	88.3	6.54	44.06	0.61	0.028	0.01	10802
1.50	1.60	8.5	12.81	38.33	0.57	0.045	0.26	9694	96.8	7.09	43.56	0.61	0.029	0.03	10705
1.60	1.90	1.7	26.99	35.59	2.11	0.086	1.87	7898	98.5	7.43	43.42	0.63	0.030	0.06	10658
1.90		1.5	68.23	34.14	15.92	1.039	13.64	3034	100.0	8.35	43.30	0.86	0.046	0.27	10542

Table C-9. Washability of Beulah-Zap 14 Mesh x 0 Whole Seam Coal

Specific Gravity		Direct (Dry Basis)							Cumulative Float (Dry Basis)						
Sink	Float	Wt %	Ash, %	Vol %	S(t), %	$S(SO_4)$, %	S(Py), %	Btu/lb	Wt %	Ash, %	Vol %	S(t), %	$S(SO_4)$, %	S(Py), %	Btu/lb
14 Mesh x 100 Mesh, 84.2 Wt%:															
	1.30	0.2	3.90	48.86	0.55				0.2	3.90	48.86	0.55			
1.30	1.40	34.8	4.80	47.40	0.58	0.026	0.01	11044	35.0	4.79	47.41	0.58	0.026	0.01	10979
1.40	1.50	53.4	6.28	43.68	0.52	0.024	0.01	10609	88.4	5.69	45.16	0.54	0.025	0.01	10755
1.50	1.60	7.5	11.72	38.80	0.52	0.034	0.19	9785	95.9	6.16	44.66	0.54	0.025	0.02	10680
1.60	1.90	2.3	25.27	39.39	1.00	0.056	0.80	7978	98.2	6.62	44.53	0.55	0.026	0.04	10615
1.90		1.8	71.49	34.73	17.28	0.576	14.83	2789	100.0	7.79	44.36	0.86	0.036	0.31	10474
100 Mesh x 0, 15.8 Wt%:															
	1.30	1.0	2.63	45.83	0.54				1.0	2.63	45.83	0.54			
1.30	1.40	17.2	4.41	46.96	0.57	0.023	0.01	11252	18.2	4.32	46.90	0.57	0.022	0.01	10653
1.40	1.50	53.3	6.14	44.13	0.42	0.033	0.01	10759	71.5	5.68	44.83	0.46	0.030	0.01	10732
1.50	1.60	19.7	8.62	37.98	0.44	0.046	0.01	10052	91.2	6.31	43.35	0.45	0.034	0.01	10585
1.60	1.90	5.3	24.68	36.07	0.85	0.113	0.48	7922	96.5	7.32	42.95	0.48	0.038	0.04	10439
1.90		3.5	72.02	32.84	8.72	0.411	7.60	1751	100.0	9.57	42.60	0.76	0.051	0.30	10137
14 Mesh x 0 Composite, 100.0 Wt%:															
	1.30	0.3	3.30	47.44	0.55				0.3	3.30	47.44	0.55			
1.30	1.40	32.0	4.77	47.36	0.58	0.026	0.01	11062	32.3	4.76	47.36	0.58	0.026	0.01	10950
1.40	1.50	53.4	6.26	43.75	0.50	0.025	0.01	10633	85.7	5.69	45.11	0.53	0.025	0.02	10665
1.60	1.90	2.8	24.09	38.40	0.96	0.073	0.71	7961	97.9	6.73	44.29	0.54	0.028	0.04	10588
1.90		2.1	71.63	34.23	15.00	0.532	12.91	2413	100.0	8.07	44.08	0.84	0.038	0.31	10421

Table C-10. Washability of Beulah-Zap 65 Mesh x 0 Whole Seam Coal

Specific Gravity		Direct (Dry Basis)							Cumulative Float (Dry Basis)						
Sink	Float	Wt %	Ash, %	Vol %	S(t), %	$S(SO_4)$, %	S(Py), %	Btu/lb	Wt %	Ash, %	Vol %	S(t), %	$S(SO_4)$, %	S(Py), %	Btu/lb
	1.30	1.2	3.22	46.11	0.75	0.014	0.01	11638	1.2	3.22	46.11	0.75	0.014	0.01	11638
1.30	1.40	13.4	3.86	46.30	0.61	0.019	0.01	10880	14.6	3.81	46.28	0.62	0.019	0.01	10943
1.40	1.50	69.6	5.45	43.66	0.47	0.023	0.01	10582	84.2	5.17	44.11	0.50	0.022	0.01	10644
1.50	1.60	12.6	8.33	36.82	0.40	0.035	0.01	9894	96.8	5.58	43.16	0.48	0.024	0.01	10547
1.60	1.90	1.8	23.85	32.35	0.77	0.038	0.62	8003	98.6	5.91	42.97	0.49	0.024	0.02	10501
1.90		1.4	75.34	19.72	13.10	0.742	10.64	2247	100.0	6.87	42.65	0.66	0.034	0.19	10387