INTERIM REPORT ON THE BULK SAMPLE WASHING OF TULAMEEN COAL AT ENERGY, MINES AND RESOURCES, EDMONTON

By:
N. E. Roberts, P. Eng.
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1.0 OBJECTIVES

The purpose of the first washing test on a ten ton sample of Tulameen Coal taken from a previously exposed trench across the outcrop was to determine:

(a) The relationship between the ash content of the clean coal and the yield when washed at the most economical cut point.

(b) The proximate analysis and heat content of the washed coal.

(c) The suitability of the coal for washing by water-only methods and the effect of the bentonite inclusions on the efficiency of separation.

(d) An identification of any fundamental problems likely to be encountered in the washing of this coal, particularly in the recovery and recycling of the process water.

From the results of this initial test, the conceptual feasibility of the project would be refined in conjunction with other input data from the current exploration programme.

2.0 ACQUISITION OF BULK SAMPLE

In order to obtain the above washability data at the earliest opportunity, it was decided to take the bulk sample from one of the existing trenches rather than wait for a new trench to be opened under the 1977 exploration programme. A survey of the open trenches was made by Mr. T. Adamson, who selected a site approximately 2,000 feet northeast of the old mine workings

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as being the most suitable location for the sample. This trench was then deepened over the entire length in an attempt to reach unoxidized and unweathered coal. An inspection of the exposed seam indicated that the coal was in reasonable condition, although not completely unaffected by weathering, but appeared to be representative of the coal likely to be mined under actual mining conditions near the surface of the deposit.

To simulate the degradation of the coal by mining methods with the consequent production of fines, a bulldozer was used to rip the coal down the middle of the trench before digging, and loading the coal by a backhoe commenced - REFER TO FIGURE 1. The exposed length of the trench was approximately 35 metres, which was marked out in five metre increments. Six 45-gallon capacity drums were filled with coal from each increment, five of which were sent to the pilot washing plant, and the sixth, which was specially filled with representative coal from the whole of the five metre increment, was sent to the laboratory of Cyclone Engineering Ltd. in Edmonton for preliminary raw coal analysis.

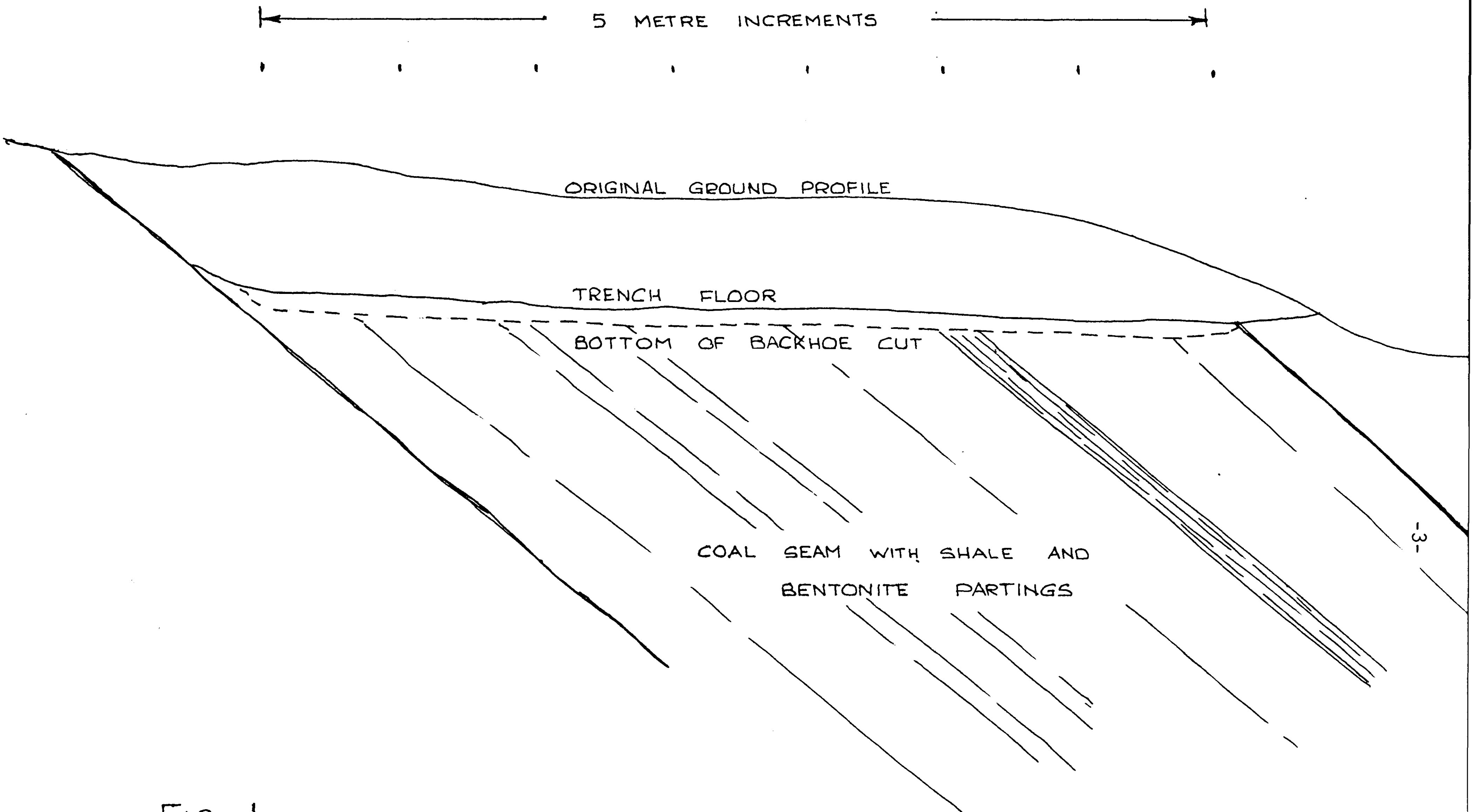


FIG. 1

SECTION OF TRENCH
SELECTED FOR BULK SAMPLE

3.0 RAW COAL ANALYSIS

In taking the sample, no attempt was made to high grade the coal to conform with any in-pit cleaning such as might be possible during actual mining operations. Consequently, the bulk sample obtained was a "worse case" situation and, as such, had an overall raw coal ash and dirt content of 35%. This compares unfavourably with the Mullins Open Pit lower section sample taken by Mr. R. W. Kenway for Imperial Metals and Power Ltd., which had a composite raw coal ash of 27.6%, but it parallels that of the upper pit sample, which averaged 34.9% ash.

The drums of coal sent to the Cyclone Laboratory were crushed to a maximum size of 1-1/2" and a sizing analysis conducted on the results.

TABLE 1

RAW COAL SIZE ANALYSIS BY DRY SCREENING

Size Fraction	Weight %
1-1/2" x 3/4"	34.70
3/4" x 1/4"	31.62
1/4" x 28 m	23.26
28 m x 100 m	6.62
100 m x 0	3.80
	100.00

The significant feature of this analysis is that only 10.42% of the raw feed is less than 28 mesh. This is contrary to the findings on Rocky Mountain coals generally, in which the same fraction contains approximately 40% of the total feed. The unexpected large percentage of fines resulting from the mining of these coals gave rise to serious difficulties when it was found that certain coal preparation plants had been under-designed in the fine coal section. Although the low fine coal percentage of the Tulameen coal is encouraging with prospects for a simplified washery design, the facts must be fully established by later investigations before any realistic conclusions can be made on the capital costs and performance of a suitable processing plant.

4.0 LABORATORY WASHING TESTS

The pilot washing plant itself is located in Edmonton and is operated by Energy, Mines and Resources. Close liaison exists between E. M. and R. and Cyclone Engineering in the use of this facility, which is designed around the use of water cyclones. Patents are held on this cyclone design which is used by other coal preparation plant builders in America, Australia, South Africa and Japan. To enable correct settings to be made on the cyclones, it was necessary to conduct preliminary laboratory float-sink tests on the coal in those size fractions enumerated in Table 1, these results of which are given in the following Tables 2 to 5 inclusive.

TABLE 2

WASHABILITY DATA FOR SIZE FRACTION 1-1/2" x 3/4"

Specific Gravity	FRACTIONAL		CUMULATIVE			
			Floats		Sinks	
	Wt. %	Ash %	Wt. %	Ash %	Wt. %	Ash %
-1.30	0.00	-	0.00	-	-	-
1.30 - 1.35	7.38	5.04	7.38	5.04	100.00	40.39
1.35 - 1.40	14.29	10.51	21.67	8.65	92.62	43.21
1.40 - 1.45	10.09	17.86	31.76	11.57	78.33	49.17
1.45 - 1.50	7.94	22.84	39.70	13.83	68.24	53.80
1.50 - 1.55	6.57	28.37	46.27	15.89	60.30	57.88
1.55 - 1.60	4.10	33.67	50.37	17.34	53.73	61.49
1.60 - 1.65	4.46	38.41	54.83	19.05	49.63	63.79
1.65 - 1.70	4.05	45.68	58.88	20.88	45.17	66.29
1.70 - 1.80	7.98	55.27	66.86	24.99	41.12	68.32
1.80 - 2.00	15.21	64.84	82.07	32.37	33.14	71.47
+2.00	17.93	77.09	100.00	40.39	17.93	77.09
TOTAL	100.00	40.39				

TABLE 3

WASHABILITY DATA FOR SIZE FRACTION 3/4" x 1/4"

Specific Gravity	FRACTIONAL		CUMULATIVE			
			Floats		Sinks	
	Wt. %	Ash %	Wt. %	Ash %	Wt. %	Ash %
-1.30	1.11	3.01	1.11	3.01	100.00	33.84
1.30 - 1.35	24.21	4.13	25.32	4.08	98.89	34.18
1.35 - 1.40	14.38	10.42	39.70	6.38	74.68	43.92
1.40 - 1.45	7.14	17.07	46.84	8.01	60.30	51.91
1.45 - 1.50	5.78	22.03	52.62	9.55	53.16	56.59
1.50 - 1.55	4.68	28.66	57.30	11.11	47.38	60.81
1.55 - 1.60	3.14	34.93	60.44	12.35	42.70	64.33
1.60 - 1.65	2.93	38.81	63.37	13.57	39.56	66.67
1.65 - 1.70	2.22	44.17	65.59	14.61	36.63	68.90
1.70 - 1.80	5.30	53.36	70.89	17.50	34.41	70.49
1.80 - 2.00	13.93	67.38	84.82	25.69	29.11	73.61
+2.00	15.18	79.33	100.00	33.84	15.18	79.33
TOTAL	100.00	33.84				

TABLE 4

WASHABILITY DATA FOR SIZE FRACTION 1/4" x 28 MESH

Specific Gravity	FRACTIONAL		CUMULATIVE			
			Floats		Sinks	
	Wt. %	Ash %	Wt. %	Ash %	Wt. %	Ash %
-1.30	26.63	2.25	26.63	2.25	100.00	29.30
1.30 - 1.35	17.32	4.34	43.95	3.07	73.37	39.12
1.35 - 1.40	5.98	10.59	49.93	3.97	56.05	49.87
1.40 - 1.45	5.78	16.10	55.71	5.23	50.07	54.56
1.45 - 1.50	3.93	23.15	59.64	6.41	44.29	59.58
1.50 - 1.55	1.05	25.43	60.69	6.74	40.36	63.13
1.55 - 1.60	2.22	30.34	62.91	7.57	39.31	64.14
1.60 - 1.65	2.01	33.50	64.92	8.38	37.09	66.16
1.65 - 1.70	1.40	38.07	66.32	9.00	35.08	68.03
1.70 - 1.80	5.27	46.27	71.59	11.75	33.68	69.28
1.80 - 2.00	7.50	61.43	79.09	16.46	28.41	73.54
+2.00	20.91	77.89	100.00	29.30	20.91	77.89
TOTAL	100.00	29.30				

TABLE 5

WASHABILITY DATA FOR SIZE FRACTION 28 MESH x 100 MESH

Specific Gravity	FRACTIONAL		CUMULATIVE			
			Floats		Sinks	
	Wt. %	Ash %	Wt. %	Ash %	Wt. %	Ash %
-1.30	22.79	1.37	22.79	1.37	100.00	31.24
1.30 - 1.35	17.64	3.47	40.43	2.29	77.21	40.06
1.35 - 1.40	4.62	8.36	45.05	2.91	59.57	50.90
1.40 - 1.45	6.85	13.19	51.90	4.27	54.95	54.47
1.45 - 1.50	3.38	17.82	55.28	5.09	48.10	60.35
1.50 - 1.55	2.16	20.74	57.44	5.68	44.72	63.56
1.55 - 1.60	2.07	25.90	59.51	6.39	42.56	65.74
1.60 - 1.65	1.74	29.85	61.25	7.05	40.49	67.78
1.65 - 1.70	1.61	33.74	62.86	7.74	38.75	69.48
1.70 - 1.80	4.17	41.99	67.03	9.87	37.14	71.03
1.80 - 2.00	4.17	51.70	71.20	12.32	32.97	74.70
+2.00	28.80	78.03	100.00	31.24	28.80	78.03
TOTAL	100.00	31.24				

A gratifying feature of these tests is that there is only a small percentage by weight of coal in those specific gravity ranges near the selected point of separation at 1.65 S.G. This indicates that the coal, apart from the bentonite problem, is a relatively straight forward washing proposition which could be handled by water-only processing designs. If the nature of the coal made it critical to hold the density of separation within fine limits, then dense media designs would be required.

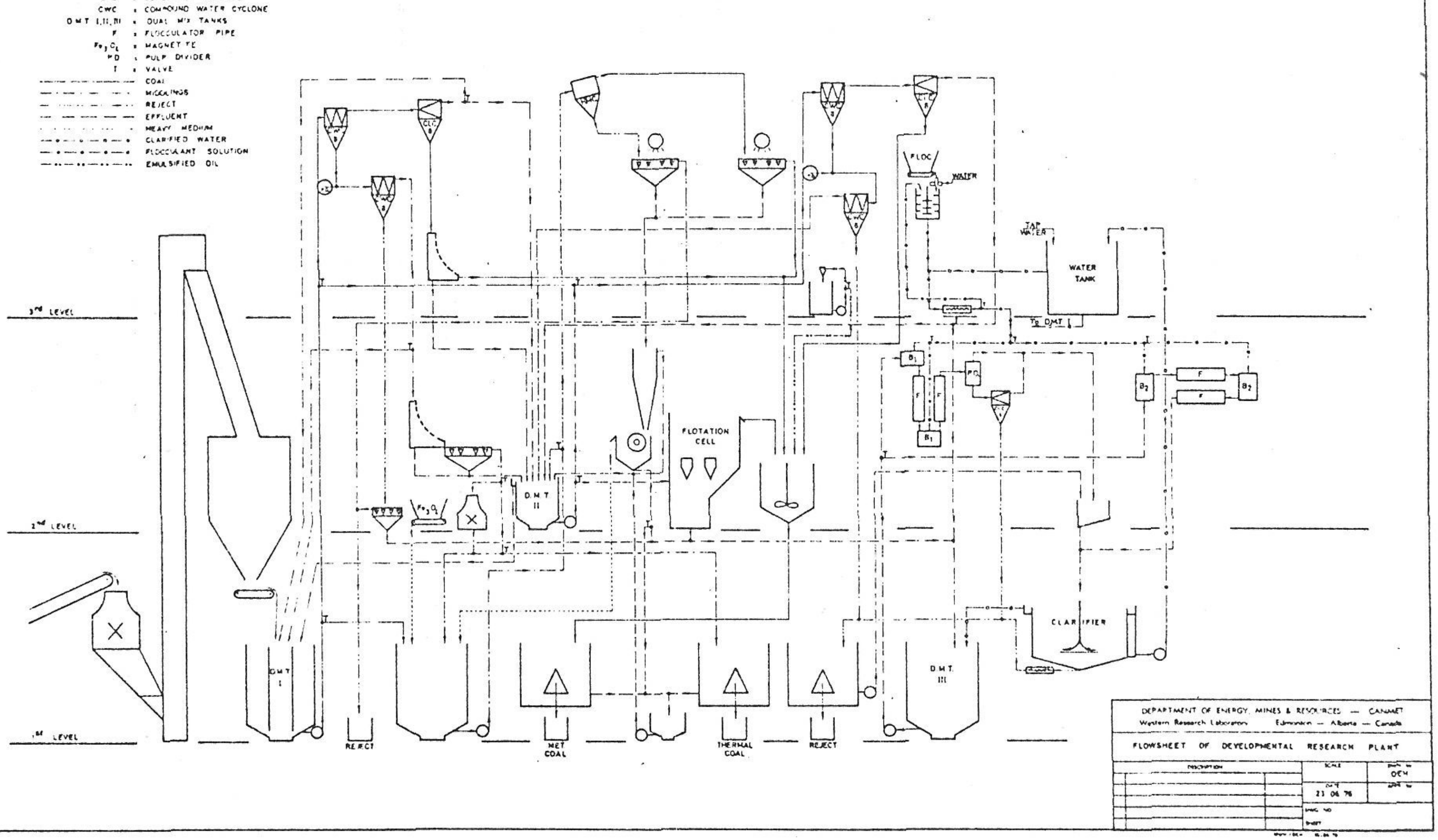
The reconstituted washability curves drawn from the above tables indicated that a theoretical yield of 60% could be obtained with a resultant coal having 13% ash. In practice, especially with a total ash/dirt content of 35% in the feed, the results are likely to be below this figure in the order of 58% yield at 15% ash.

5.0 PILOT WASHING PLANT

Essentially, the plant consists of one coarse and one fine hydro cyclone section with additional capability in dense media cyclone section using magnetite as the media and a froth flotation cell. In the treatment of the bulk sample submitted, only the hydro section cyclones were used. Each of these sections consists of two compound water cyclones with a classifier cyclone to de-water the product. REFER FIG. 2.

FIG. 2

EMR – COAL PROCESSING PLANT
(10 STPH CAPACITY)



The raw feed is all crushed to minus 3/8" and is fed into the coarse cyclone section via a pulp divider. The primary clean coal cyclone takes the first cut and passes the overflow to the classifier cyclone, the underflow of which is de-watered over a 28 mesh sieve bend which also takes out the fine coal. The oversize from the sieve bend reports directly to the centrifuge clean coal dryer. The overflow from the classifier cyclone, being clean water and fines, is directed into the secondary mixing tanks.

The underflow of the primary cyclone is further treated in the secondary or middlings cyclone, the overflow of which is passed to the primary mixing tank for re-processing. The underflow is refuse which, after de-watering, is stored in bins for analysis as to the efficiency of separation and yield.

Water and fine coal from the sieve bend is also fed into the secondary mixing tank, the pulp from which is fed into the fine coal cyclones. A similar process to the primary circuit takes out clean fine coal via a classifier cyclone. Similarly, a fine coal middlings cyclone recycles the overflow, while the underflow is, after de-watering, the fine refuse.

6.0 OPERATING OBSERVATIONS

On Friday, 24th June, the bulk sample was fed into the plant. The raw coal feed was crushed to minus 3/8", this being the top size the primary cyclone was designed for. It appeared that this crusher reduced the bulk of the coal to less than 1/4" top size but no sizing analysis has been conducted in detail on the crushed feed.

A disappointing problem arose shortly after start up of the plant, in that the clean coal centrifuge continually blocked up due to caking of the fine coal. Efforts by the operators to overcome this problem were unsuccessful and the plant was shut down after processing only one quarter of the sample.

It was claimed by Energy, Mines and Resources that they had experienced similar problems with other low rank coals and that the solution was to reduce the speed of the centrifuge. This, of course, would reduce the efficiency of the centrifuge, which is a self-defeating solution. An interesting insight into the operation of government-controlled installations was the tedious procedure for the acquisition of a slower 50 H.P. motor. This would take approximately another four weeks; meanwhile the plant is shut down.

Although from actual observations during the short period of operation there appeared to be no problems in the water cyclone circuits, the actual results obtained demonstrated that the efficiency of separation was not good. This was attributed to the high percentage of reject material in the feed which may have interferred with the separation process. Visual examination of the coarse reject indicated that there was a percentage of coal present so a float-sink analysis of this reject was requested to determine the loss.

During the run, no early problems were evident due to the bentonite inclusions, but it is premature to base any conclusions on this observation, as the effects of a fines build-up in the re-cycled water would not be apparent at this stage. Virtually all the bentonite material broke down in the process and reported to the fine reject bin, the contents of which had the constituency of clay.

7.0 RESULTS AND COMMENTS

7.1 Moisture Content

In the clean coal, the surface moisture was 14.3% and the residual moisture 5.3%, giving a total moisture of 19.6%. Obviously this is far too high in the saleable product. The fact that all this sample was crushed to minus 3/8 inch with a resultant increase in the minus 28 mesh fraction from 10.4% to 39.2% and further subsequent degradation in the washing process to 46.1%, would undoubtedly contribute greatly to the retention of this moisture. In actual practice where the coal would only be crushed to 1-1/2 inch size and the output passed through an efficient centrifuge, it could be expected that a total moisture content of 12% to 13% would be attainable without thermal drying. Depending on sales specifications and the extent of freezing problems in winter, it may be mandatory to provide a thermal dryer in the plant.

7.2 Ash Content

This was analysed at 16.5%. However, an examination of the requested float-sink analysis on the 3/8 inch by 28 mesh products, which represents 53.57% of the total feed, reveals a significant amount of misplaced material. For example, there is 1.75% of plus 1.6 S.G. material in the clean coal and 3.6% of minus 1.6 S.G. coal material in the reject. Similarly, in the 28 mesh by 150 mesh fraction, there is 3.33% of plus 1.6 S.G. material in the clean product and 4.12% of clean coal in the rejects. This theoretically could reduce the ash content of the clean coal by 5% if the efficiency of separation was 100%.

7.3 Yield

The actual measured yield was only 45.63% but, as shown above, the efficiency of separation on the present test was poor. As described previously, the theoretical yield of this sample is 60% at 13% ash from the washability curves, with a practical expectation of 58% yield at 15% ash. The viability of the project depends on the attainment of a yield approaching these figures. It is also axiomatic that as much in pit cleaning or selective mining as is practical should be practised to reduce the amount of reject material delivered to the wash plant, thereby substantially increasing the yield at the plant.

7.4 Proximate Analysis

Ash	16.47
R.M.	5.25
V.M.	32.53
F.C.	45.75
S	0

7.5 Heat Value

On an air dried basis, this was 10,260 BTU's* per pound for the 16.5% ash coal.

8.0 SUMMARY

The test to date is unsatisfactory as a basis for any fundamental assumptions on quality and yield. When the test is resumed, with modifications to the plant, a better appreciation will be obtained of the overall performance that can be expected from a water-only process.

* Equals approximately 11,000 BTU's on a dry basis.

It is already apparent, however, that at least one bulk sample should be treated in a dense media pilot plant to derive a direct comparison in efficiences of separation. A 3% increase in efficiency on a million ton a year operation would result in an extra $900,000 revenue from sales of coal at $30 F.O.B. per ton.

N. E. ROBERTS, P. Eng.

NER/cb

July 15, 1977

CYCLONE ENGINEERING SALES LTD.

SEPARATION OF BULK MATERIALS

Manufacturing, Engineering, Testing Services

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Edmonton, Alberta T6E 4Z5
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Cable Address:
Cyclone, Edmonton
Telex: 037-3793

Ref: S1-232

July 5, 1977

Mr. Eric Roberts
1230 Sutton Place
West Vancouver, B. C.

Dear Sir:

Re: Status Report on the washing of Tulameen Bulk Sample at EMR, Edmonton

This report summarizes all the data on coal products and the efficiency of compound water cyclones, obtained or derived at this stage of the project, from the washing of Tulameen Bulk Sample at the pilot plant of EMR in Edmonton. The washing was performed on June 24, 1977, with the witness of Mr. E. Roberts, mining consultant for Cyprus Anvil Mining Corporation.

Due to the break down of the clean coal centrifuge during the run, the washing was discontinued and only about 2 1/2 tons of raw material were processed. The products collected from this run were analyzed for this report. Since the pilot plant was operated on and off during the washing caused by mechanical problem mentioned above, the effect of continuous interruption is difficult to measure. The performance of the compound water cyclone therefore shall not be considered standard under these operating conditions.

The results of the washing are briefly discussed as follows:

1. Recoveries of Products

The surface moisture contents and the recoveries of all products are listed in Table 1. These figures are combined results from the run and a test run conducted on June 23, 1977. A recovery of 45.63 % was obtained for the clean coal product.

Continued.

Table 1. Surface Moisture Content and Recoveries of Products (On air-dry basis).

	% Surface Moisture	% Recovery
Clean Coal	14.30	45.63
Coarse Reject	26.32	32.76
Fine Reject	29.32	21.61
Total		100.00

2. Size Consist of Products

The size consist of all products and the feed material were determined. Data for the reconstituted feed was also tabulated for comparison purpose and the results are presented in Table 2.

Table 2. Size Consist of Feed and Products

Size	Clean Coal	Coarse Reject	Fine Reject	Reconstituted Feed	Feed
+ 3/8"	0.00	0.36	0.00	0.36	0.64
3/8" x 28m	24.13	27.66	1.78	53.57	60.18
28m x 150m	19.08	4.17	7.92	31.17	31.26
150m x 0	2.42	0.57	11.91	14.90	7.92
Total	45.63	32.76	21.61	100.00	100.00

These data indicates that the recoveries of clean coal are about 45%, 61% and 16% in the size fractions of 3/8" x 28m, 28m x 150m, and 150m x 0 respectively.

Comparison of data between calculated feed and the raw feed also indicate the degradation of coarse fractions and the amount of fine material (150m x 0) almost double its original amount.

3. Qualities of Products

The ash content of all the products and their size fractions are determined to review the qualities of the products. From Table 3 listed below, it shows that the fine material (150m x 0) are high in ash content and partial beneficiation was also realized in this size fractions with the present system.

Continued

The total ash content on the clean coal product is 16.47% from the washing.

Table 3. Ash Contents of Products

Size	Clean Coal	Coarse Reject	Fine Reject	Feed
+ 28m	11.95	67.58	--	38.39
28m x 150m	17.22	67.20	38.87	35.96
150m x 0	45.57	71.71	61.94	49.58
Total	16.47	67.82	47.24	38.85

4. Performance of Compound Water Cyclone

Float-sink analysis was performed on the size fractions of all products with an aim to determine the probable error and the actual cut-point in the compound water cyclone. The data for both size fractions are presented in Tables 4a and 4b for reference. Fig. 1 is plotted using data from Tables 4a.

These data also indicate the amount of misplaced material and the theoretical yield of clean coals from both size fractions.

Probable error of 0.15 at a cut point of 1.61 is established for the size fraction 3/8" x 28 mesh. The data from the size fraction 28m x 150 mesh is rather scattering and therefore determination of both probably error and cut-point fails in this particular case.

Table 4. Float-sink analysis of Product.

a. 3/8" x 28 mesh

Sp. Gr.	Clean Coal	Coarse Reject	Fine Reject	Reconstituted Feed	Partition #
- 1.30	8.07	0.81	0.73	9.61	16.02
1.30 - 1.35	6.74	0.52	0.39	7.65	11.90
1.35 - 1.40	2.83	0.32	0.17	3.32	14.76
1.40 - 1.45	1.94	0.38	0.10	2.42	19.83
1.45 - 1.50	1.70	0.47	0.10	2.27	25.11
1.50 - 1.55	0.59	0.45	0.03	1.07	44.86
1.55 - 1.60	0.51	0.31	0.04	0.86	40.70
1.60 - 1.65	0.50	0.55	0.01	1.06	52.83
1.65 - 1.70	0.28	0.42	0.03	0.73	61.64
1.70 - 1.80	0.39	0.89	0.04	1.32	70.45
1.80 - 2.00	0.43	4.19	0.06	4.68	90.81
+ 2.00	0.15	18.35	0.08	18.58	99.19
	24.13	27.66	1.78	53.57	

Table 4. Float-sink analysis of Product continued

4b. 28m x 150

Sp. Gr.	Clean Coal	Coarse Reject	Fine Reject	Reconstituted Feed	Partition #
- 1.30	0.40	0.06	1.06	1.52	73.68
1.30 - 1.35	6.33	0.17	0.98	7.48	15.37
1.35 - 1.40	4.17	0.16	0.33	4.66	10.52
1.40 - 1.45	1.91	0.05	0.18	2.14	10.75
1.45 - 1.50	1.71	0.06	0.30	2.07	17.39
1.50 - 1.55	0.63	0.06	0.56	1.25	49.60
1.55 - 1.60	0.60	0.03	0.12	0.78	19.23
1.60 - 1.65	0.37	0.04	0.84	1.25	70.40
1.65 - 1.70	0.67	0.05	0.15	0.87	22.99
1.70 - 1.80	0.64	0.10	0.18	0.92	30.43
1.80 - 2.00	0.83	0.28	0.51	1.62	48.76
+ 2.00	0.82	3.11	2.71	6.64	87.65
	19.08	4.17	7.92	31.17	

We would advise the determination of ash content on the float-sink fractions in Table 4 for future reference and performance evaluation. Washing of the Tulameen Bulk Sample wil continue after installation of a new motor which has been on order since May for the clean coal centrifuge.

The function of this report is to review all the available data. We are of the opinion that it is too early to make comments on the result and this should be done only after a steady flow in the washing ..is established.

I trust this is satisfactory.

Yours very truly,

CYCLONE ENGINEERING SALES LTD.

Per: [signature]

B. Y. H. Wong

BYHW/ejr

cc Miss J. Picard
Western Regional Laboratory
Energy Mines and Resources
c/o Alberta Research Council
11315 - 87 Avenue
Edmonton, Alberta T6G 2C2

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