Energy, Mines and Resources Canada
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CANADA CENTRE FOR MINERAL AND ENERGY TECHNOLOGY
(Former Mines Branch)

IMPROVED COMPOUND WATER CYCLONE FOR CLEANING COAL SLIMES

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WESTERN RESEARCH LABORATORY

NOVEMBER 1975

ENERGY RESEARCH PROGRAM

ENERGY RESEARCH LABORATORIES
REPORT ERP/ERL 75-143(IR)

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by

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SUMMARY

The ash reduction of coal slimes by wet-mechanical means is adversely affected by size classification as the particle size decreases resulting in relatively high cutpoints and large probable errors.

A marked lowering of the specific gravity cutpoint and of the corresponding probable error can be achieved with standard CW Cyclones by lengthening the cylindrical section.

Error curve data obtained from tests with pond sludge from the Pittsburgh seam and a high-ash raw coal from Western Canada demonstrate the difference between the standard 8-in. CW Cyclone and an 8-in. CW Cyclone with its cylindrical length increased by 50%.

It is concluded that the elongated Compound Water Cyclone is particularly well suited for the purpose of recovering metallurgical-grade coal from minus 28 mesh pond sludge and similar fine coal products.

The only change required for the modification when cleaning coal slimes is to fit the standard model with a cylindrical spacer whose length equals one-half of the CW Cyclone chamber diameter. The limitation of the elongated model is that particles larger than 1 millimeter are being cleaned at unnecessarily low cutpoints.

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INTRODUCTION

Washing tests on minus 1/8-in. crushed subbituminous coal in a single-stage 8-in. diameter Compound Water Cyclone (CWC-8) showed that, with the vortex finder set at its maximum clearance (3 in.), the minimum obtainable cutpoint (d_p) was much higher than that needed (1.30-1.35) to obtain the desired ash content. In an effort to lower the cutpoint to fall within the required range, a standard CWC-8 was fitted with an insert to lengthen the cylindrical section by 4 in. (1/2 times the cyclone's diameter) to allow a maximum setting of 7-in. vortex finder clearance.

Two series of tests were run to compare performance in the elongated cyclone (CWC-8L) and standard cyclone (CWC-8) at the maximum vortex finder clearance using a 1/8-in. x 0 Pittsburgh Seam pond sludge containing approx 28% minus 150 mesh and a 1/8-in. x 0 high ash raw coal from the foothills region of Western Canada containing a comparable quantity of fines. Error curves were determined for individual size fractions down to 150 mesh.

PROCEDURE AND TEST RESULTS

The circuit used in the tests consisted of a CWC-8 which was operated in closed circuit with a sump and a centrifugal pump. Test conditions are presented in Table 1. For each test, a 60-lb split of the feed material was introduced into the feed tank and allowed to recirculate for a few minutes to attain equilibrium. Simultaneous samples were taken initially to determine flowrates and solids contents of the products. Incremental samples of the overflow and underflow were then collected for float-sink analysis. Six size fractions of the Pittsburgh Seam samples and three of the Foothills' samples were prepared for analysis by wet-screening.

The data in Table 2 represent best results for three tests in the standard cyclone and for four tests in the elongated cyclone. Cutpoint and probable error are plotted against mean particle size in Figs. 1 and 2 respectively.

Partition numbers for the averaged error curves of the individual size fractions are given in Table 3 for each cyclone and the corresponding curves are shown in Figs. 3 and 4. Cutpoints and probable errors of the average curves are listed in Table 4.

DISCUSSION OF RESULTS AND CONCLUSIONS

The results showed that lengthening the feed chamber not only caused the desired lowering of minimum cutpoint, but also caused a marked improvement in probable error of separation for a given size fraction.

In comparing the results shown in Table 2 and Figs. 1 and 2, it is apparent that the difference in "base" operation for each cyclone i.e. at maximum vortex finder clearance, becomes more noticeable as particle size decreases. Below approx 0.3 mm (48 mesh), the differences in cutpoint (d_p) and probable error (r) increase noticeably with decreasing size of particle. This is further emphasized in Fig. 5 where clean coal ash content is shown in relation to particle size for each of the cyclones. Ash contents were calculated by applying the error curves of Figs. 3 and 4 to the specific gravity distribution of a high-ash pond sludge, using standarized ash contents for each size fraction.

It is concluded that a standard CW Cyclone with elongated feed chamber could be used to great advantage in the cleaning of coal fines especially below approx 28 mesh. Evidently, the capability exists for recovery of metallurgical-grade coal from material such as pond slimes and as such should be considered for the present, at least, as an accompaniment to flotation. Studies are continuing.

Table 1 - Cyclone Settings for Closed-circuit Single-stage CWC Test Runs

	Standard (CWC-8)	Elongated (CWC-8L)
Diameter	8 in.	8 in.
Inlet	2 in.	2 in.
Overflow	4 in.	4 in.
Underflow	2 in.	2 in.
V.F. Clearance	3 in.	7 in.
Cone	L	L
Feed Pressure	9 psi	9 psi

Table 2 - Separation Results Obtained for Single-stage Standard and Elongated CWC-8 Cleaning 1/8 in. x 0 Fines

Source: Pittsburgh Seam Rank: HVAB Feed Ash: 25.3% Mean Sp Gr: 1.441 g/cc [1)] Feed % Solids: 4.4 ± 1.7 Median size, μ: 330			Source: Pittsburgh Seam Rank: HVAB Feed Ash: 25.3% Mean Sp Gr: 1.441 g/cc [1)] Feed % Solids: 7.6 ± 3.6 Median size, μ: 330		Inner Foothills Alberta, Canada MVB 21.1% 1.453 g/cc [1)] 5.2 ± 2.0 290
STANDARD CYCLONE, CWC-8			ELONGATED CYCLONE, CWC-8(L)		
Mean Particle Size, mm	Cutpoint, d_p	Probable Error, r	Mean Particle Size, mm	Cutpoint, d_p	Probable Error, r
1.43	1.330	0.054	1.80	1.241	0.012
1.20	1.258	0.033	0.91*	1.220	0.010
0.74	1.435	0.076	0.80	1.230	0.020
0.72	1.405	0.075	0.78*	1.252	0.025
0.70	1.330	0.058	0.74	1.280	0.023
0.42	1.582	0.182	0.42	1.330	0.051
0.40	1.452	0.122	0.37	1.338	0.096
0.36	1.610	0.210	0.36*	1.316	0.075
0.25	1.696	0.265	0.31*	1.335	0.088
0.25	1.620	0.202	0.25	1.442	0.124
0.18	1.758	0.279	0.18	1.532	0.176
0.18	2.015	0.638	0.16	1.648	0.228
0.16	1.852	0.495	0.15*	1.646	0.305
0.13	1.910	0.468	0.13*	1.557	0.304
0.12	2.575	1.716	0.12	1.620	0.246

* MV Bituminous coal, Inner Foothills Belt, Alberta, Canada.

1) Value refers to plus 150 mesh fraction only.

Table 3 - Partition Numbers for Average Error Curves

Single-stage Cleaning Tests on 1/8-in. x 0 Fines

	Standard (CWC-8)					
Sp Gr	1/8-14	14-28	28-48	48-65	65-100	100-150
-1.3	33.0	13.5	6.5	3.5	2.3	1.5
1.3-1.35	57.0	27.0	12.2	6.6	4.0	2.5
1.35-1.4	76.6	44.0	20.0	10.5	6.9	4.0
1.4-1.5	93.0	68.0	34.2	18.9	12.2	7.9
1.5-1.6	98.7	87.5	53.5	32.5	21.9	14.8
1.6-2.0	100.0	98.7	81.8	61.0	47.0	34.8
+2.0	100.0	100.0	96.8	86.0	77.0	65.0

	Elongated (CWC-8L)					
Sp Gr	1/8-14	14-28	28-48	48-65	65-100	100-150
-1.3	95.4	76.0	38.0	15.5	9.0	4.0
1.3-1.35	98.4	89.5	57.0	26.2	15.0	7.3
1.35-1.4	99.3	94.8	71.1	38.0	23.0	12.0
1.4-1.5	99.7	97.5	84.0	54.5	36.3	21.0
1.5-1.6	99.8	98.8	91.2	69.5	52.5	35.0
1.6-2.0	100.0	99.7	96.9	86.4	76.0	60.5
+2.0	100.0	100.0	99.5	97.0	93.8	86.0

Table 4 - Cutpoints (d_p) and Probable Errors (r) for Average Error Curves (Table 3)

Size Fraction	CWC-8		CWC-8L	
	d_p	r	d_p	r
1/8 in.-14 mesh	1.310	0.057	1.195*	0.015*
14-28 mesh	1.390	0.080	1.230*	0.032*
28-48 mesh	1.530	0.156	1.306	0.076
48-65 mesh	1.687	0.279	1.430	0.141
65-100 mesh	1.839	0.466	1.534	0.196
100-150 mesh	2.058	0.784*	1.672	0.300

* estimated value

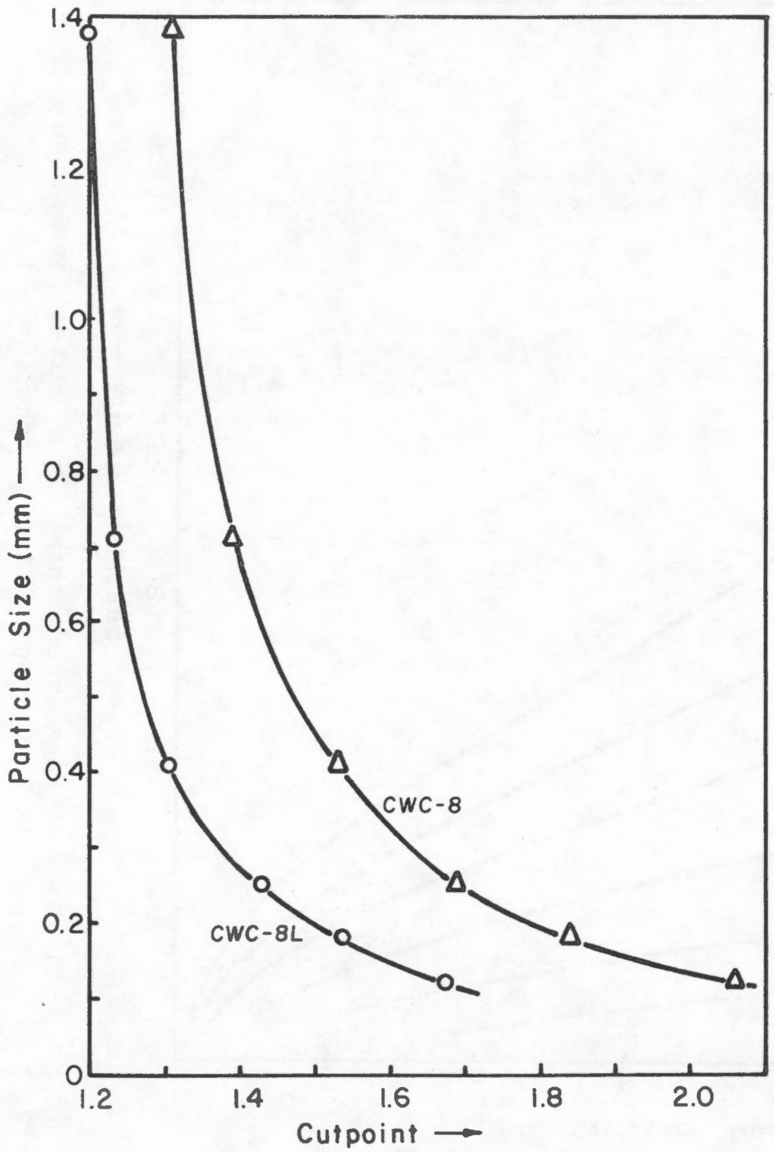

Fig. 1 - Cutpoint - Particle Size Relationship

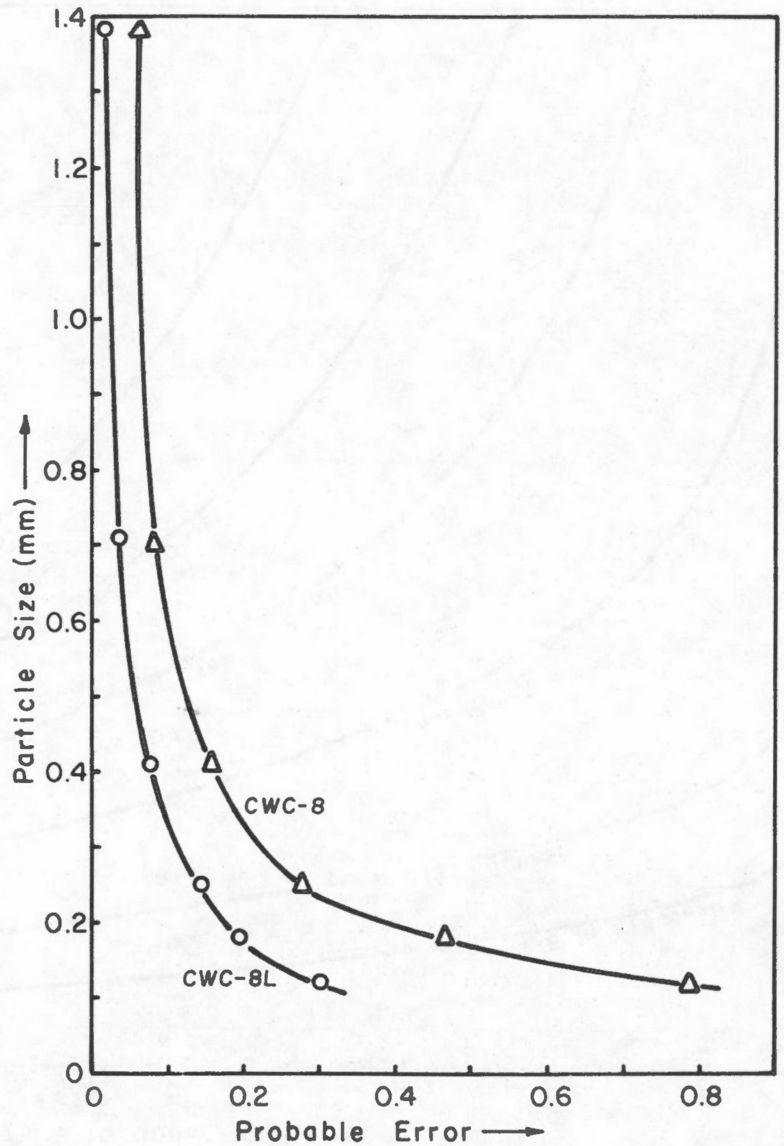

Fig. 2 - Probable Error - Particle Size Relationship

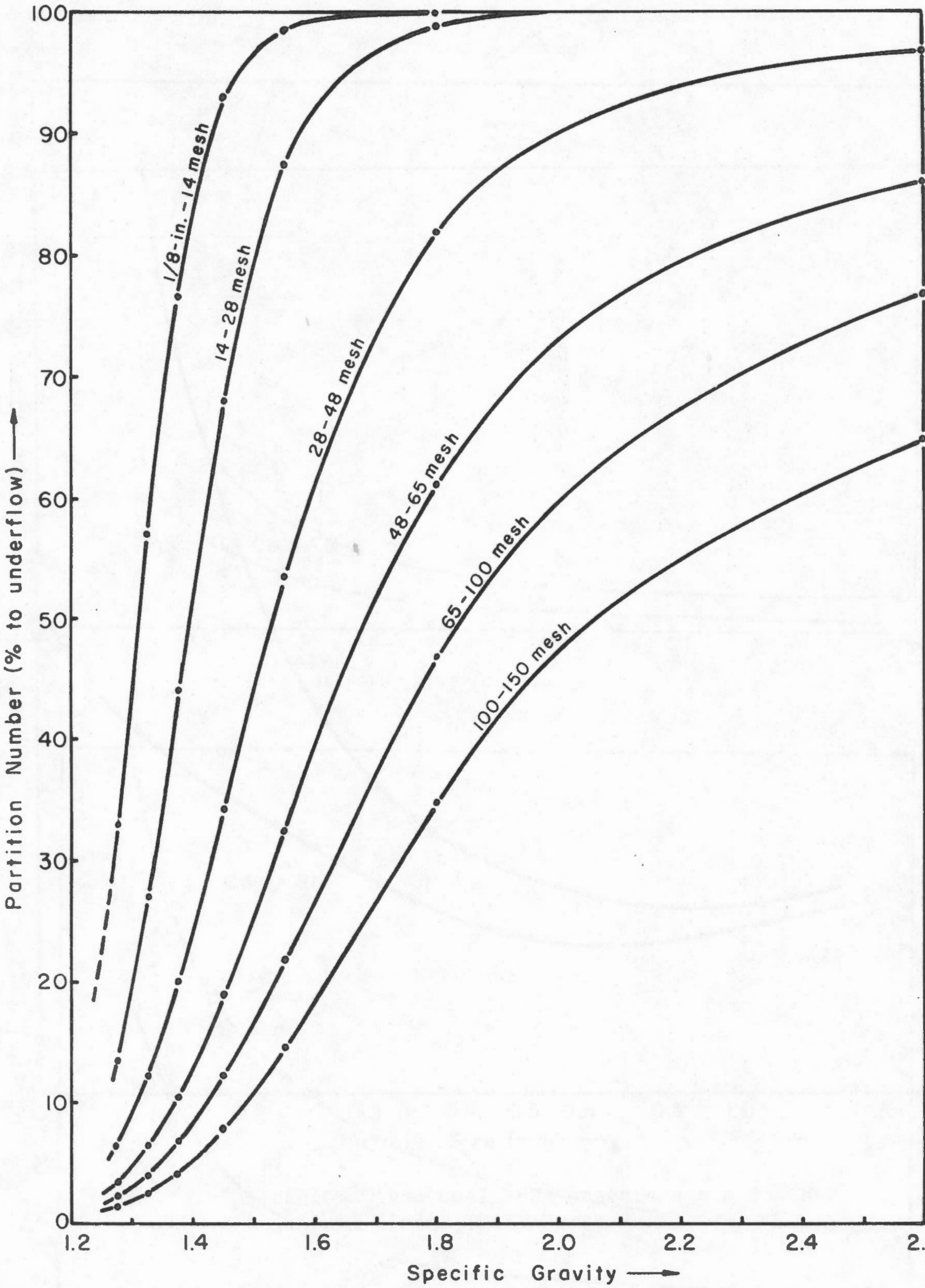

Fig. 3 - Average Experimental Error Curves for Standard Compound Water Cyclone (CWC-8)

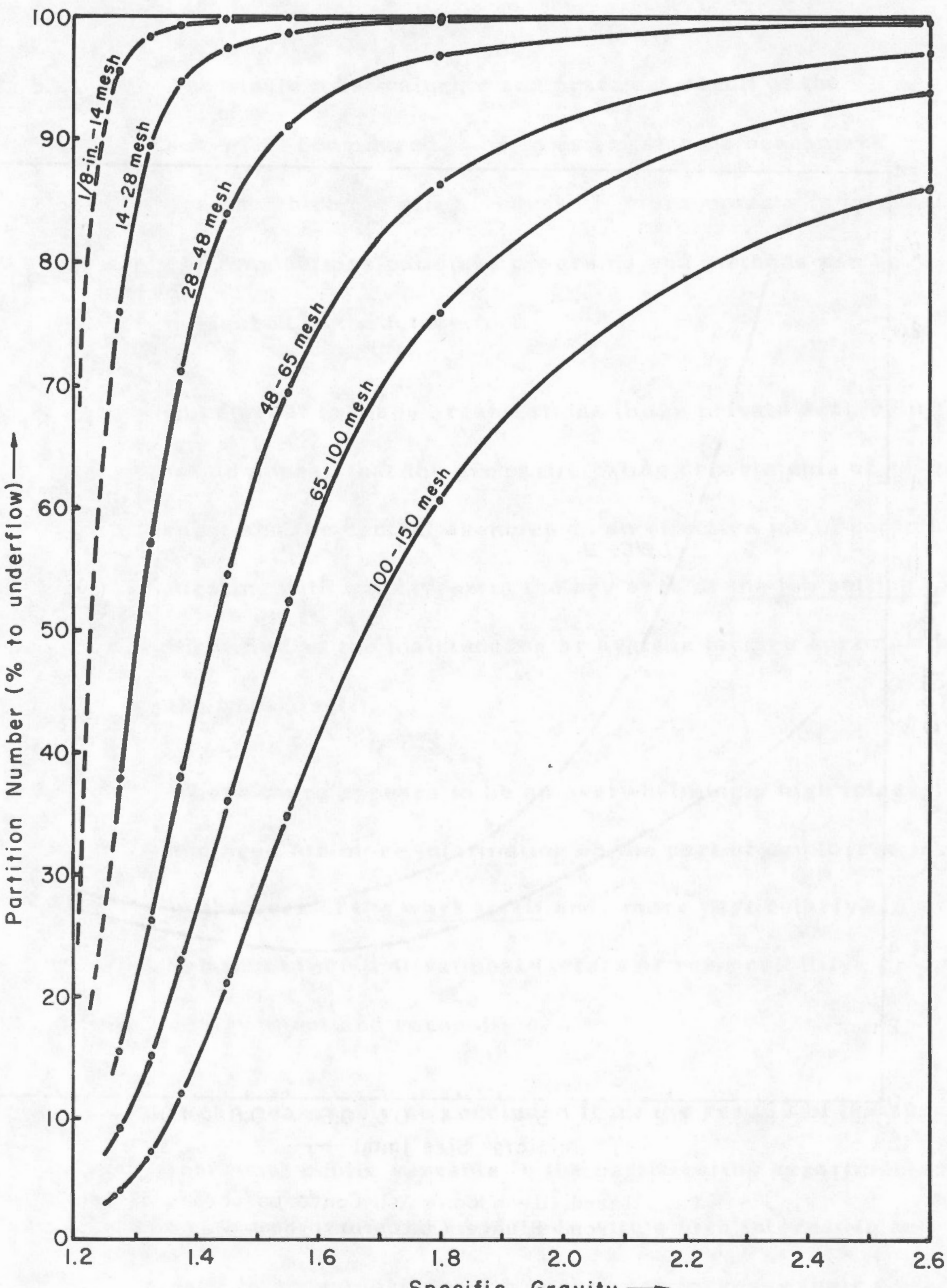

Fig. 4 - Average Experimental Error Curves for Elongated Compound Water Cyclone (CWC-8L)

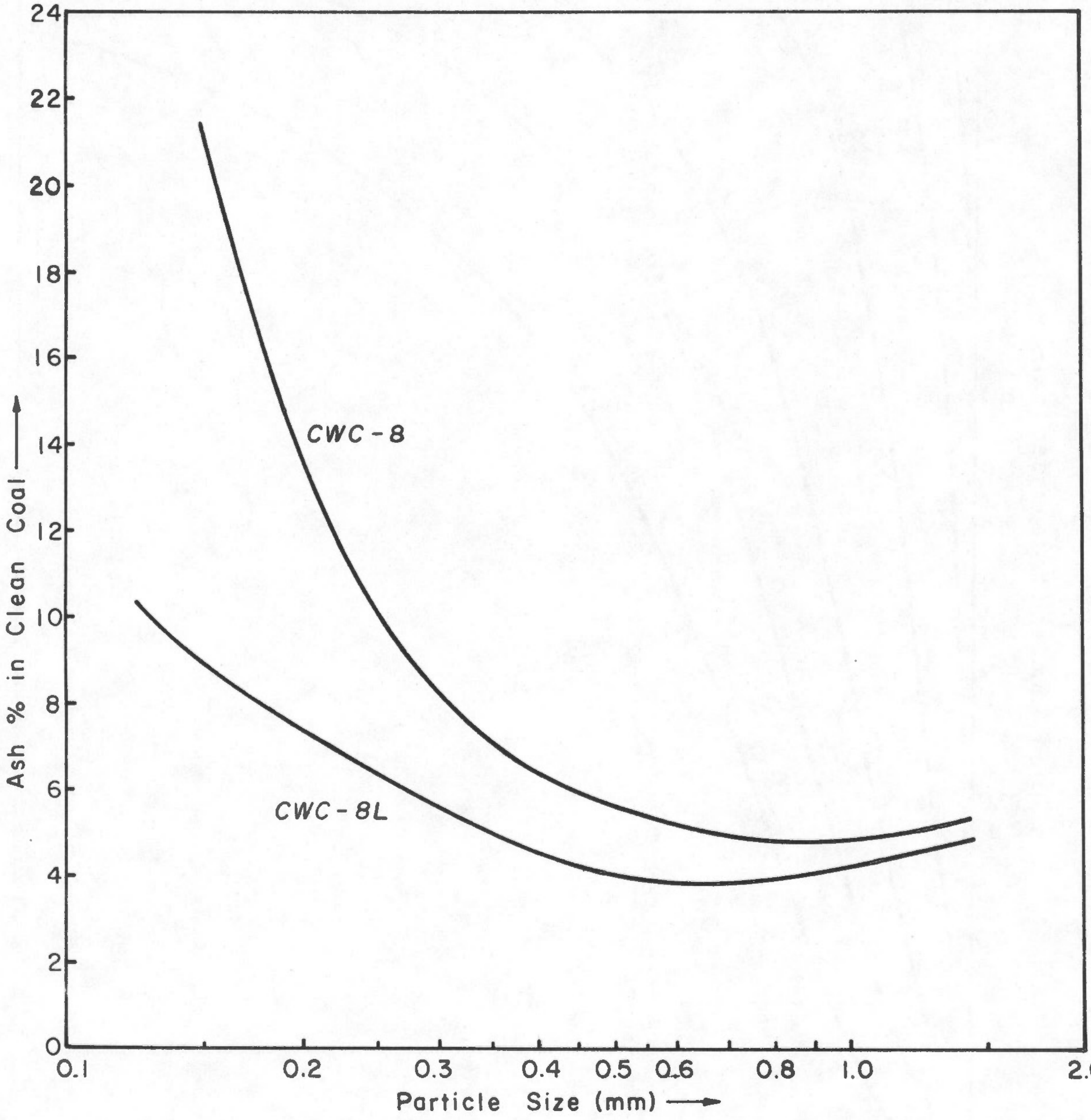

Fig. 5 - Calculated Clean Coal Ash Contents for a 35% Ash Pond Sludge (Pittsburgh Seam).