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PRELIMINARY INVESTIGATION ON THE RECOVERY OF THERMAL COAL FROM A SLUDGE DEPOSIT IN THE MINTO AREA, NEW BRUNSWICK

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PRELIMINARY INVESTIGATION ON THE RECOVERY OF THERMAL COAL FROM A SLUDGE DEPOSIT IN THE MINTO AREA, NEW BRUNSWICK

by

O.E. Humeniuk*

ABSTRACT

Results are given for a preliminary investigation on the recovery and dewatering of coal for thermal use (maximum 17.8% ash, 4% moisture) from a 24%-ash pond sludge from the Minto, New Brunswick area.

Washability data and performance evaluation calculations indicated that desliming at 200 mesh would be sufficient to produce the desired ash content at a yield of approx 77%. Calculations also indicated that a clean coal product containing $\leq$ 8% ash could be obtained by using a Compound Water Cyclone with elongated feed chamber which, as reported recently, is particularly well-suited to the washing of slimes. Further study is required on the oil-dewatering aspect.

A flowsheet is presented for a 2-stage elongated Compound Water Cyclone system based on the EMR Process with closed-circuit water recovery.

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INTRODUCTION

Finely divided waste from coal mining operations accumulated over a period of many years near Minto, New Brunswick, has been considered for reclamation at various times. One report (1) dealing with the recovery of coal from effluent discharged by the Avon beneficiation plant was prepared at this laboratory as early as 1961.

In the ensuing years when fine-coal cleaning using water cyclones was developed, and the increasing price of coal made reclamation of dumps more attractive, attention was drawn more and more to the value of deposits such as those in the Minto area and Stellarton, Nova Scotia, where three dumps are now being reworked.

There are reportedly 200,000 tons of coal sludge located near Minto which, with minimum upgrading, could serve as a fuel source for a local power plant. Preliminary bench tests carried out at the EMR-DEVCO Lingan laboratory in Nova Scotia during 1973 indicated that oil-treatment aimed at preferential wetting of the coaly material by the oil and subsequent dewatering was a possible means of attaining the power plant specifications of 17.8% ash and 4% moisture.

Two drums of the Minto sludge weighing approx 100 lb each were received at the Western Research Laboratory (WRL) for analysis and testing in January 1974. Results of float-sink analysis and ash - and sulphur - washability data are presented as well as results of preliminary desliming and oil dewatering tests. Performance evaluation calculations form the basis for recommendations offered for recovery of coal from this deposit using a modular installation which incorporates the EMR Process (2,3) and an improved Compound Water Cyclone (CWC) reported recently (4) designed for washing of slimes.

ANALYSIS AND TESTING

The samples contained 20.2% moisture as received. Discoloration of the sieves was noted during wet-screening and subsequent leaching of 20 grams of the material in approx 225 ml of water yielded a filtrate

with pH 2.8 when diluted to 1 liter, and containing 1.2% sulphur calculated on the dry-coal basis. In view of this, sulphur analysis was performed on the coal although no specifications had been set. However since the float-sink analysis was done on washed screen fractions obtained by wet-sieving, the sulphur values reported do not include this water-soluble portion which, in any event, would be removed when using wet-cleaning methods.

The size-consist of the sludge with corresponding ash and sulphur contents for the fractions are given in Table 1. Float-sink data are given in Table 2 and washability data of the plus 200 mesh fraction for ash and sulphur in Tables 3 and 4 with related curves in Figs. 1 and 2. Screenability data and FSI values are shown in Tables 5 and 6, and results of 2-in cyclone desliming tests at low and high feed concentrations in Table 7. Ash and sulphur washability data and curves for the individual size fractions are attached in Appendix A.

DISCUSSION OF RESULTS

It is evident from the data in Tables 1 to 5 that the sludge contains a high percentage of low-ash coal which could be recovered using size and/or specific gravity separation processes.

As indicated in Table 5, removal of the minus 200 mesh slimes would give a clean product containing 15.9% ash at approx 78% yield, ideally. On the other hand, because of its even distribution among the size and sp gr fractions, little or no improvement in sulphur content would be anticipated. Calculations in fact indicated that for a classifier cyclone operating at a cutpoint d_{50}= 74μ (200 mesh) and probable error, r=75μ, a deslimed product containing 17.1% ash and 2.3% sulphur could be expected at a yield of approx 77% with corresponding ash and sulphur contents of reject slimes of approx 46% and 2.3% respectively. From the data in Table 6, it is estimated that the clean coal would be moderately swelling with a Free-Swelling Index (FSI) of 5-5½ and should cause no combustion problems (5).

It is noted that much lower ash contents than the power plant specification of 17.8% could be obtained by gravity cleaning using a CWC with elongated chamber. Recent tests (4) showed that this modified cyclone gave considerably lower cutpoints and improved cleaning efficiency compared to the standard model for material finer than 28 mesh. Since the elongated model was not available at the time of testing, a performance

evaluation was calculated for the plus 200 mesh fraction of the sludge (see Fig. 3). It is apparent from the expected results shown for a range of probable errors (r) and sp gr cutpoints (d_p) that sorting by itself, or combined with a desliming operation would offer not only versatility and the capability for producing a range of products, but more importantly, good control of product given the expected variability of the feed. An elongated 12-in. dia cyclone (CWC-12L) would be capable of separating the sludge with a probable error of 0.10.

Classifier (Desliming) Tests

Results of desliming tests in a 2-in. diameter cyclone demonstrated that, at both low and high feed concentrations, ash content could be reduced by 25% i.e. the rate of reduction needed to produce an 18%-ash thermal coal from a 24%-ash feed (Table 7). Moisture contents of the deslimed products in the two tests were 36% and 47% respectively in contrast to the desired 4%-moisture level.

Oil Dewatering Tests

In view of the successful application of oil-conditioning for moisture reduction in many other coals, preliminary bench tests were carried out on slurries containing 50% solids of the raw sludge and of a deslimed cyclone product. Results for additions of 2 and 5% oil by weight with a conditioning time of 5 minutes were inconclusive: slight indications of agglomeration were observed for the deslimed product but not for the raw sludge. More thorough testing was not possible at the time of the investigation, but the fineness of the material itself suggests that the use of emulsified oils should be studied, with or without pH adjustments.

CONCLUSIONS AND RECOMMENDATIONS

From results of this preliminary investigation and based on the sample received, it is concluded that:

1) Minto sludge contains a high proporation of low-ash coal which can be readily recovered to produce a thermal coal of 17.5% ash.
2) Due to the likelihood of a great deal of variability in the feed, better control of ash content in clean coal could be obtained by means of 2-stage gravity separation using the Compound Water Cyclone with elongated chamber.
3) Because of even distribution, sulphur content of the sludge can not be reduced below 2.3%.

It is recommended that the oil-dewatering aspect of the study be resumed and extended to cover a variety of oils in emulsion form and other factors, such as pH which may have an important effect on the coal's amenability to oiling.

It is further recommended that the preliminary flowsheet of a 2-stage CWC system (EMR) process using elongated 12-in. dia cyclones (CWC-12L) as shown in Fig. 4 be considered a possible means of treating the sludge: given a feed ash of 23.9%, a three-product separation will produce a clean coal of 9.6% ash at a yield of 49%, a middlings containing 29.7% ash at approx 29% yield, and a reject of 49% ash. Combining the two former products would give a clean coal product of 17% ash with an overall yield of 78%.

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2. Visman, J., "Coal Washery Design - I. The EMR Process", Dept. of Energy, Mines and Resources, Metals Reduction and Energy Centre, Technical Bulletin TB 141, Sept. 1971.

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Table 1 - Minto Sludge: Wet Screen Analysis

Size (Mesh)	Wt %	Ash %	Sulphur %
+ 28	19.83	11.05	2.71
- 28+ 48	27.41	11.32	2.26
- 48+100	17.56	17.86	1.93
-100+200	12.86	30.39	1.77
-200	22.34	51.68	2.39
TOTAL	100.00	23.89	2.26

Table 2 - Minto Sludge: Float-sink Data

Sp Gr / Screen Size	(Refer to foot note for symbols) 1.275	1.30	1.35	1.40	1.45	1.60	TOTAL
+28 Mesh	5.42 (2.03) 2.16*	4.57 (3.60) 2.62*	3.58 (7.08) 3.11*	1.97 (11.97) 3.16*	1.04 (16.84) 3.14*	1.69 (24.67) 3.04*	1.56 (53.60) 2.75*	19.83 (11.05) 2.71*
- 28 +48 Mesh	8.42 (1.49) 2.01*	5.35 (3.38) 2.30*	3.32 (6.26) 2.55*	2.33 (9.16) 2.51*	1.88 (11.76) 2.40*	3.23 (20.66) 2.31*	2.88 (51.65) 2.24*	27.41 (11.32) 2.26*
- 48 +100 Mesh	3.35 (1.11) 1.85*	2.64 (2.25) 1.93*	2.30 (4.59) 2.12*	1.73 (7.25) 2.09*	1.97 (9.14) 2.15*	2.01 (20.89) 2.02*	3.56 (62.10) 1.65*	17.56 (17.86) 1.93*
-100 + 200 Mesh	2.32 (1.06) 1.90*	1.88 (2.40) 2.02*	1.54 (5.69) 2.07*	0.60 (7.45) 2.09*	0.63 (11.63) 2.08*	1.24 (20.89) 1.98*	4.65 (72.56) 1.36*	12.86 (30.39) 1.77*
TOTAL	19.51 (1.52) 2.01*	14.44 (3.12) 2.30*	10.74 (6.09) 2.58*	6.63 (9.34) 2.56*	5.52 (11.77) 2.41*	8.17 (21.58) 2.34*	12.65 (62.52) 1.81*	77.66 (15.89) 2.22*
- 200 Mesh	This fraction forms 22.34% of the total sample and has an Ash content of 51.68% and a Sulphur content of 2.39%. Therefore the Ash content in the total sample is 23.89% and the Sulphur content is 2.26%.							

NOTE: Ash content in brackets and Sulphur content marked *

Table 3 - Minto Sludge: Ash Washability Data

Size Fraction plus 200 mesh (Fig. 1)						
Sp Gravity Fraction	Wt %	Ash %	Cum. Floats		Cum. Sinks	
			Wt %	Ash %	Wt %	Ash %
< 1.275	25.12	1.52	25.12	1.52	100.00	15.89
1.275-1.30	18.59	3.12	43.71	2.20	74.88	20.72
1.30-1.35	13.83	6.09	57.54	3.14	56.29	26.53
1.35-1.40	8.54	9.34	66.08	3.94	42.46	33.18
1.40-1.45	7.11	11.77	73.19	4.70	33.92	39.19
1.45-1.60	10.52	21.58	83.71	6.82	26.81	46.46
> 1.60	16.29	62.52	100.00	15.89	16.29	62.52
TOTAL	100.00	15.89				

Table 4 - Minto Sludge: Sulphur Washability Data

Size Fraction + 200 mesh (Fig.2)						
Sp Gravity Fraction	Wt %	Sulfur %	Cum. Floats		Cum. Sinks	
			Wt %	Sulfur %	Wt %	Sulfur %
< 1.275	25.12	2.01	25.12	2.01	100.00	2.22
1.275-130	18.59	2.30	43.71	2.13	74.88	2.29
1.30-1.35	13.83	2.58	57.54	2.24	56.29	2.29
1.35-1.40	8.54	2.56	66.08	2,28	42.46	2.19
1.40-1.45	7.11	2.41	73.19	2.29	33.92	2.10
1.45-1.60	10.52	2.34	83.71	2.30	26.81	2.02
> 1.60	16.29	1.81	100.00	2.22	16.29	1.81
TOTAL	100.00	2.22				

Table 5 - Minto Sludge: Screenability Data

Size (Mesh)	Oversize			Undersize		
	Wt %	Ash %	Sulphur %	Wt %	Ash %	Sulphur %
+28	19.8	11.0	2.71	100.00	23.9	2.26
28-48	47.2	11.2	2.45	80.2	27.1	2.14
48-100	64.8	13.0	2.31	52.8	35.2	2.08
100-200	77.7	15.9	2.22	35.2	43.9	2.16
-200	100.0	23.9	2.26	22.3	51.7	2.39

Table 6 - Minto Sludge: FSI Values

Sp Gr Fraction	Size Fraction (Mesh)					Total FSI (est)
	+28	28-48	48-100	100-200	-200	
-1.275	9	9	9	9 1/2		9
1.275-1.30	8 1/2	9	8 1/2	8 1/2		8 1/2
1.30-1.35	8	8 1/2	8 1/2	6		8
1.35-1.40	4 1/2	4 1/2	7	n.d.	0	4 1/2
1.40-1.45	1 1/2	1 1/2	2	3		2
1.45-1.60	1	1	1	1		1
+ 1.60	0	0	0	0		0
Total	6 1/2	6	5	4	0	4

Table 7 - Minto Sludge: 2" Classifier Cyclone Tests

Feed Inlet Pressure: 20 psi
20° Classifying Cone
Narrow Vortex Finder

TEST #1 - (Low percent solids)

	Overflow	Underflow	Reconstituted Feed
Wt % Solids	1.24	64.22	3.40
Solids Distribution	35.25	64.75	100.00
% Ash	39.39	10.69	20.80

NOTE: A slugging rope discharge was created in the underflow by initial restriction of the discharge.

TEST #2 - (High percent solids)

	Overflow	Underflow	Reconstituted Feed
Wt % Solids	3.06	52.80	15.73
Solids Distribution	14.51	85.49	100.00
% Ash	48.52	15.00	19.86

NOTE: A uniform thick slurry discharge resulted with the higher % of solids in the feed. (No restriction of the discharge was introduced).

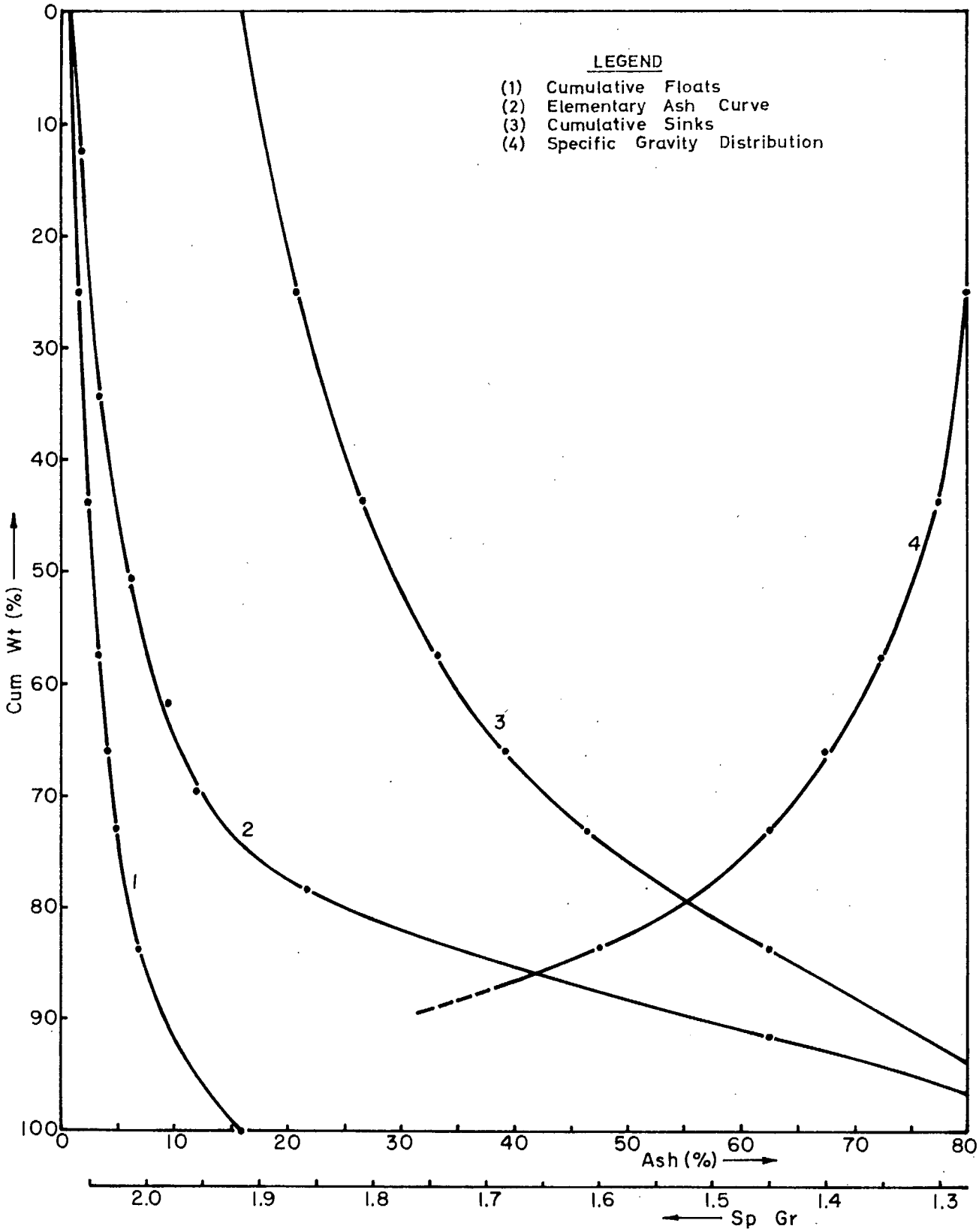


Fig. 1 - Minto Sludge: Ash Washability Curves for Plus 200 - mesh Fraction (77.66% of total)

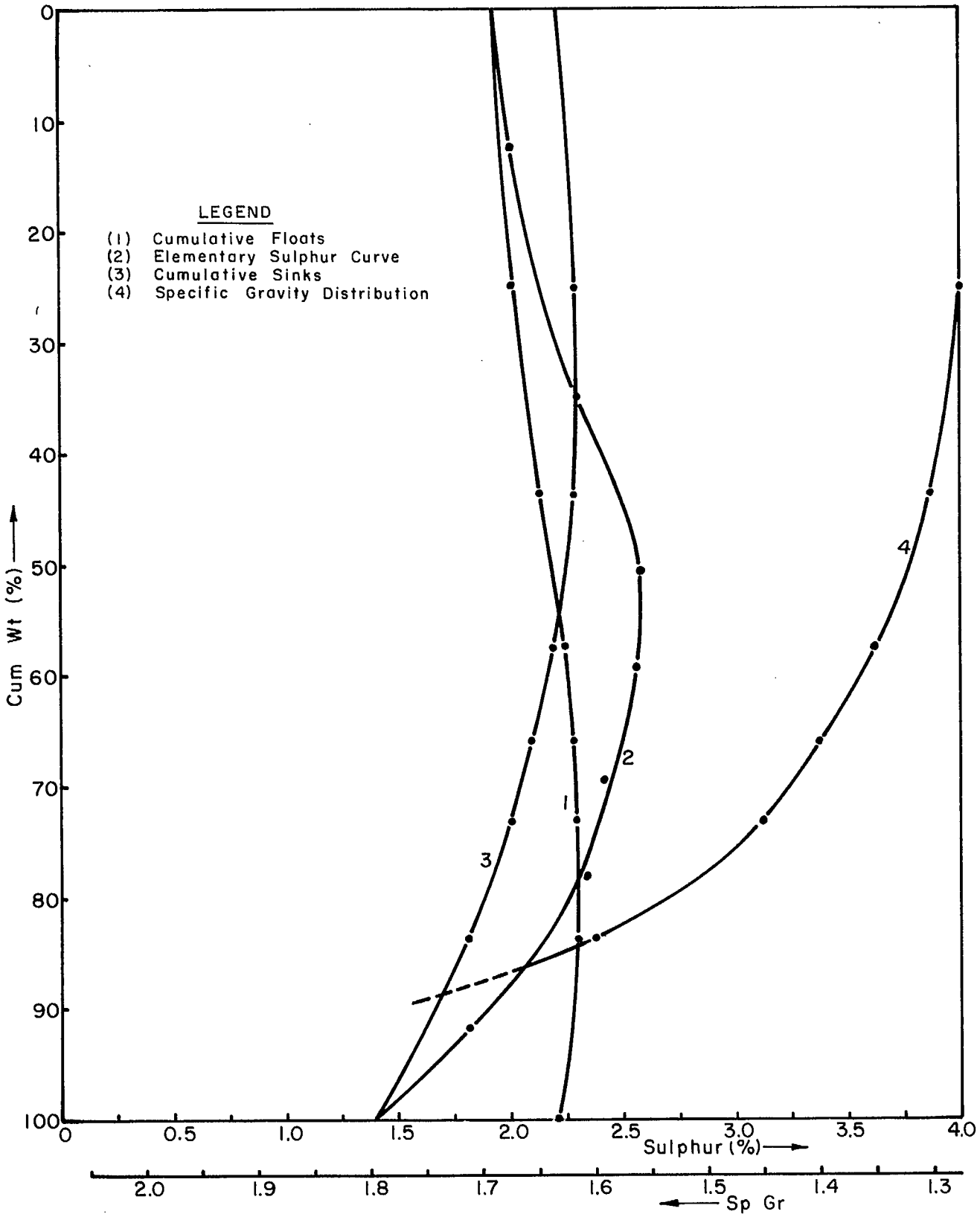


Fig. 2 - Minto Sludge: Sulphur Washability Curves for Plus 200 -mesh Fraction (77.66% of total)

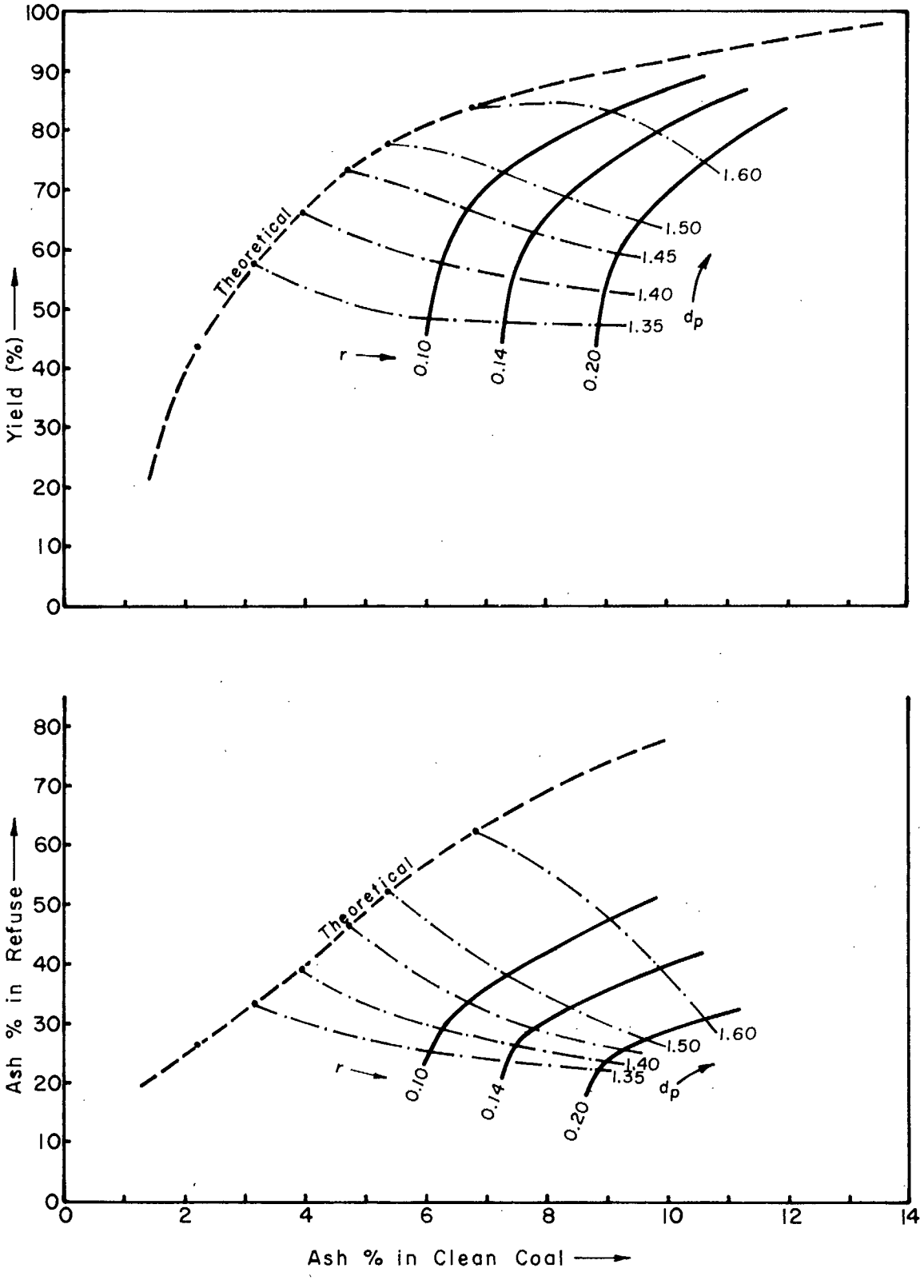


Fig. 3 - Minto Sludge: Performance Evaluation Curves (Plus 200 -mesh Fraction)

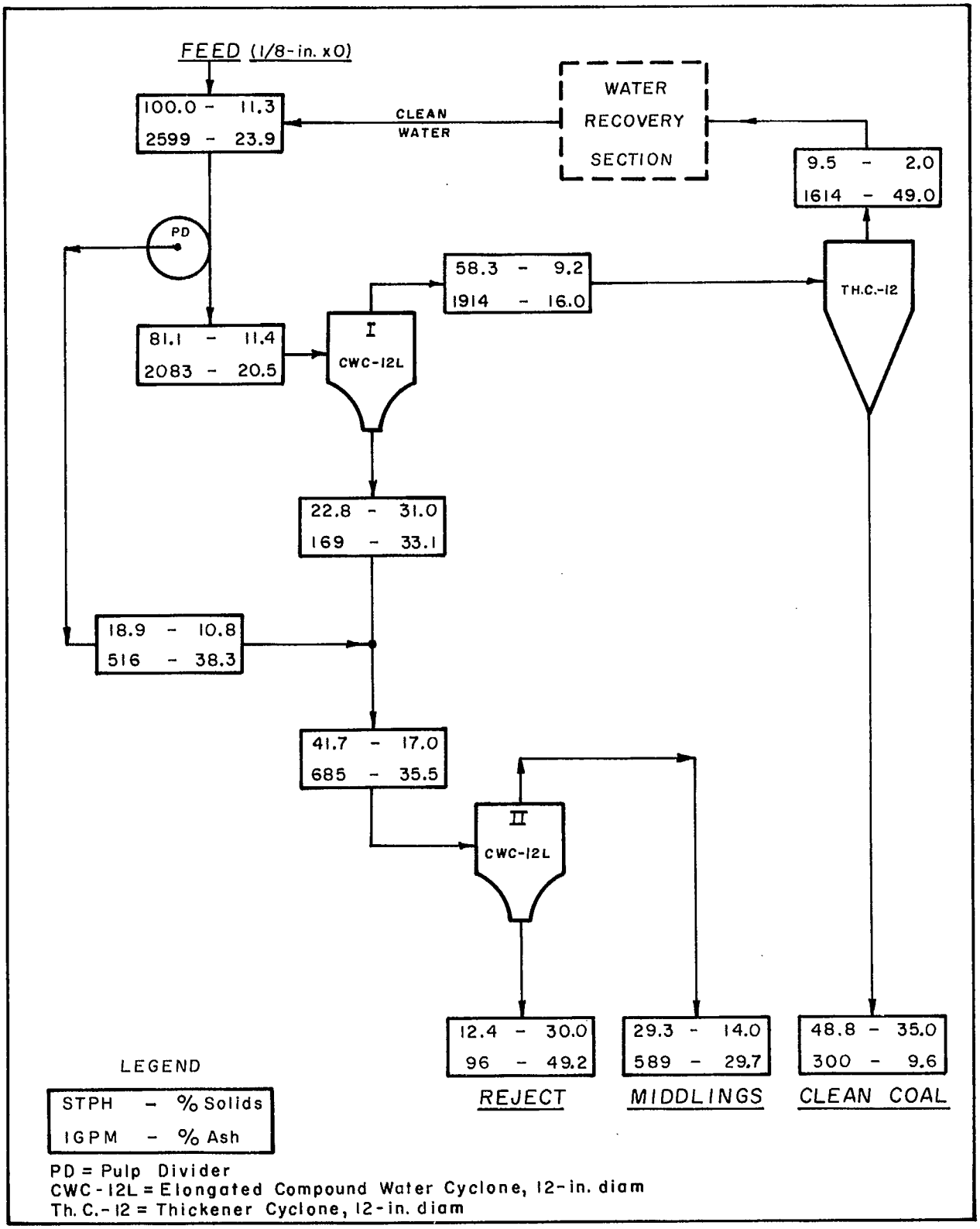


Fig. 4 - Minto Sludge: Flowsheet of Automatic 2-stage CWC-12L System with Pulp Divider

Appendix A

TABLE A - 1: Minto Sludge - Ash Washability Data

Size Fraction plus 28 mesh (Fig. A-1)						
Sp Gravity Fraction	Wt %	Ash %	Cum. Floats		Cum. Sinks	
			Wt %	Ash %	Wt %	Ash %
< 1.275	27.32	2.03	27.32	2.03	100.00	11.05
1.275-1.30	23.06	3.60	50.38	2.75	72.68	14.45
1.30-1.35	18.03	7.08	68.41	3.89	49.62	19.49
1.35-1.40	9.96	11.97	78.37	4.92	31.59	26.58
1.40-1.45	5.22	16.84	83.59	5.66	21.63	33.31
1.45-1.60	8.54	24.67	92.13	7.42	16.41	38.54
> 1.60	7.87	53.60	100.00	11.05	7.87	53.60
TOTAL	100.00	11.05				

TABLE A - 2: Minto Sludge - Ash Washability Data

Size Fraction -28 + 48 mesh (Fig. A-2)						
Sp Gravity Fraction	Wt %	Ash %	Cum. Floats		Cum. Sinks	
			Wt %	Ash %	Wt %	Ash %
< 1.275	30.73	1.49	30.73	1.49	100.00	11.32
1.275-1.30	19.50	3.38	50.23	2.22	69.27	15.68
1.30-1.35	12.12	6.26	62.35	3.01	49.77	20.50
1.35-1.40	8.49	9.16	70.84	3.75	37.65	25.09
1.40-1.45	6.87	11.76	77.71	4.45	29.16	29.72
1.45-1.60	11.79	20.66	89.50	6.59	22.29	35.26
> 1.60	10.50	51.65	100.00	11.32	10.50	51.65
TOTAL	100.00	11.32				

TABLE A - 3: Minto Sludge - Ash Washability Data

Size Fraction -48 + 100 mesh (Fig. A-3)						
Sp Gravity Fraction	Wt %	Ash %	Cum. Floats		Cum. Sinks	
			Wt %	Ash %	Wt %	Ash %
< 1.275	19.06	1.11	19.06	1.11	100.00	17.87
1.275-1.30	15.03	2.25	34.09	1.61	80.94	21.82
1.30-1.35	13.11	4.59	47.20	2.44	65.91	26.29
1.35-1.40	9.88	7.25	57.08	3.27	52.80	31.68
1.40-1.45	11.19	9.14	68.27	4.23	42.92	37.30
1.45-1.60	11.45	20.89	79.72	6.63	31.73	47.23
> 1.60	20.28	62.10	100.00	17.87	20.28	62.10
TOTAL	100.00	17.87				

TABLE A - 4: Minto Sludge - Ash Washability Data

Size Fraction -100 + 200 mesh (Fig. A-4)						
Sp Gravity Fraction	Wt %	Ash %	Cum. Floats		Cum. Sinks	
			Wt %	Ash %	Wt %	Ash %
< 1.275	18.06	1.06	18.06	1.06	100.00	30.39
1.275-1.30	14.59	2.40	32.65	1.66	81.94	36.84
1.30-1.35	11.96	5.69	44.61	2.74	67.35	44.30
1.35-1.40	4.67	7.45	49.28	3.19	55.39	52.64
1.40-1.45	4.90	11.63	54.18	3.95	50.72	56.80
1.45-1.60	9.69	20.89	63.87	6.52	45.82	61.63
> 1.60	36.13	72.56	100.00	30.39	36.13	72.56
TOTAL	100.00	30.39				

TABLE A - 5: Minto Sludge - Sulphur Washability Data

Size Fraction + 28 mesh (Fig. A-5)						
Sp Gravity Fraction	Wt %	Sulfur %	Cum. Floats		Cum. Sinks	
			Wt %	Sulfur %	Wt %	Sulfur %
< 1.275	27.32	2.16	27.32	2.16	100.00	2.71
1.275-1.30	23.06	2.62	50.38	2.37	72.68	2.92
1.30-1.35	18.03	3.11	68.41	2.57	49.62	3.05
1.35-1.40	9.96	3.16	78.37	2.64	31.59	3.02
1.40-1.45	5.22	3.14	83.59	2.67	21.63	2.96
1.45-1.60	8.54	3.04	92.13	2.71	16.41	2.90
> 1.60	7.87	2.75	100.00	2.71	7.87	2.75
TOTAL	100.00	2.71				

TABLE A - 6: Minto Sludge - Sulphur Washability Data

Size Fraction -28 + 48 mesh (Fig. A-6)						
Sp Gravity Fraction	Wt %	Sulfur %	Cum. Floats		Cum. Sinks	
			Wt %	Sulfur %	Wt %	Sulfur %
< 1.275	30.73	2.01	30.73	2.01	100.00	2.26
1.275-1.30	19.50	2.30	50.23	2.12	69.27	2.37
1.30-1.35	12.12	2.55	62.35	2.21	49.77	2.40
1.35-1.40	8.49	2.51	70.84	2.24	37.65	2.35
1.40-1.45	6.87	2.40	77.71	2.26	29.16	2.31
1.45-1.60	11.79	2.31	89.50	2.26	22.29	2.28
> 1.60	10.50	2.24	100.00	2.26	10.50	2.24
TOTAL	100.00	2.26				

TABLE A - 7: Minto Sludge - Sulphur Washability Data

Size Fraction -48 + 100 mesh (Fig. A-7)						
Sp Gravity Fraction	Wt %	Sulfur %	Cum. Floats		Cum. Sinks	
			Wt %	Sulfur %	Wt %	Sulfur %
< 1.275	19.06	1.85	19.06	1.85	100.00	1.93
1.275-1.30	15.03	1.93	34.09	1.89	80.94	1.95
1.30-1.35	13.11	2.12	47.20	1.95	65.91	1.96
1.35-1.40	9.88	2.09	57.08	1.97	52.80	1.92
1.40-1.45	11.19	2.15	68.27	2.00	42.92	1.88
1.45-1.60	11.45	2.02	79.72	2.01	31.73	1.78
> 1.60	20.28	1.65	100.00	1.93	20.28	1.65
TOTAL	100.00	1.93				

TABLE A - 8: Minto Sludge - Sulphur Washability Data

Size Fraction -100 + 200 mesh (Fig. A-8)						
Sp Gravity Fraction	Wt %	Sulfur %	Cum. Floats		Cum. Sinks	
			Wt %	Sulfur %	Wt %	Sulfur %
< 1.275	18.06	1.90	18.06	1.90	100.00	1.77
1.275-1.30	14.59	2.02	32.65	1.95	81.94	1.74
1.30-1.35	11.96	2.07	44.61	1.98	67.35	1.68
1.35-1.40	4.67	2.09	49.28	1.99	55.39	1.59
1.40-1.45	4.90	2.08	54.18	2.00	50.72	1.55
1.45-1.60	9.69	1.98	63.87	2.00	45.82	1.49
> 1.60	36.13	1.36	100.00	1.77	36.13	1.36
TOTAL	100.00	1.77				

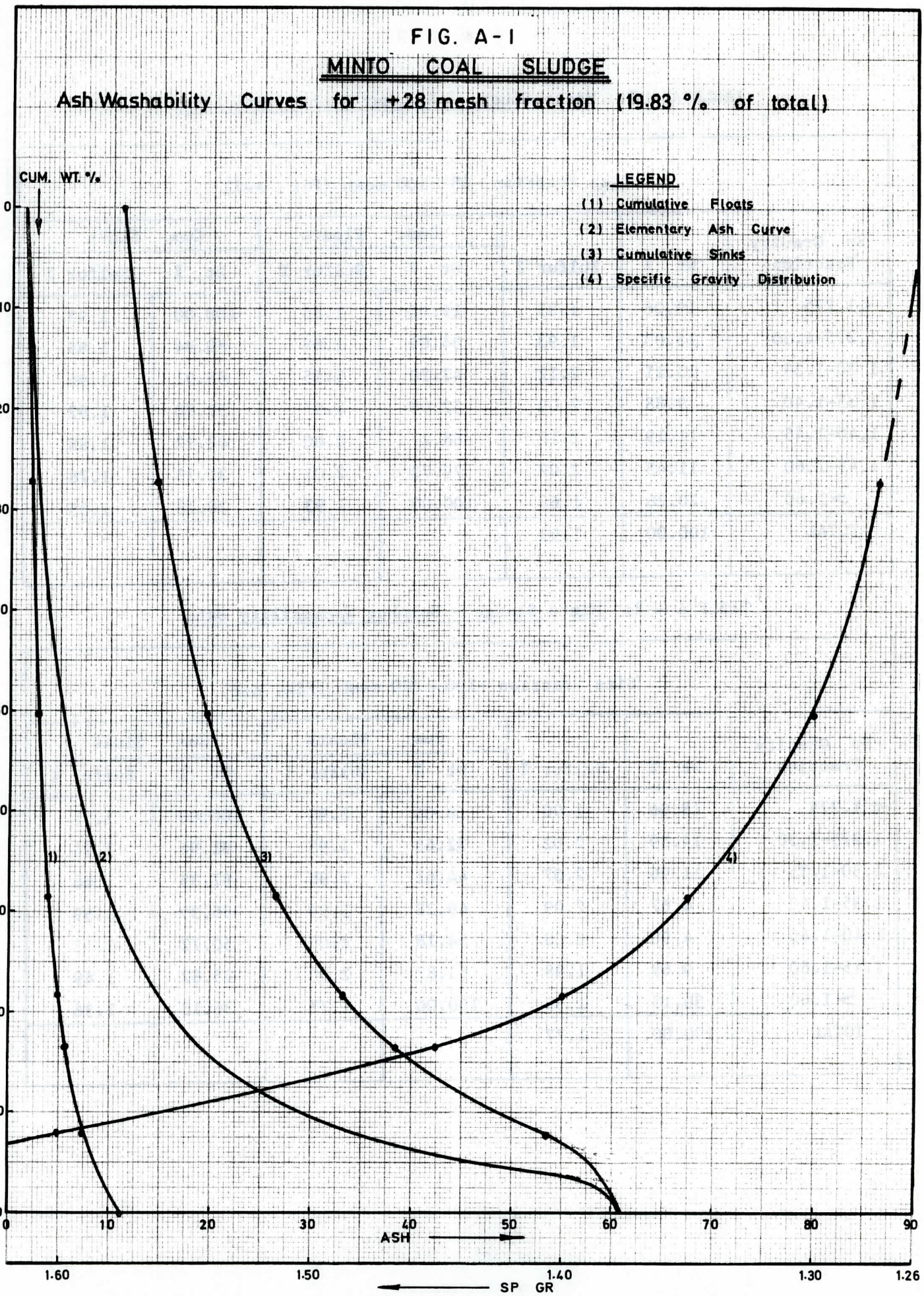


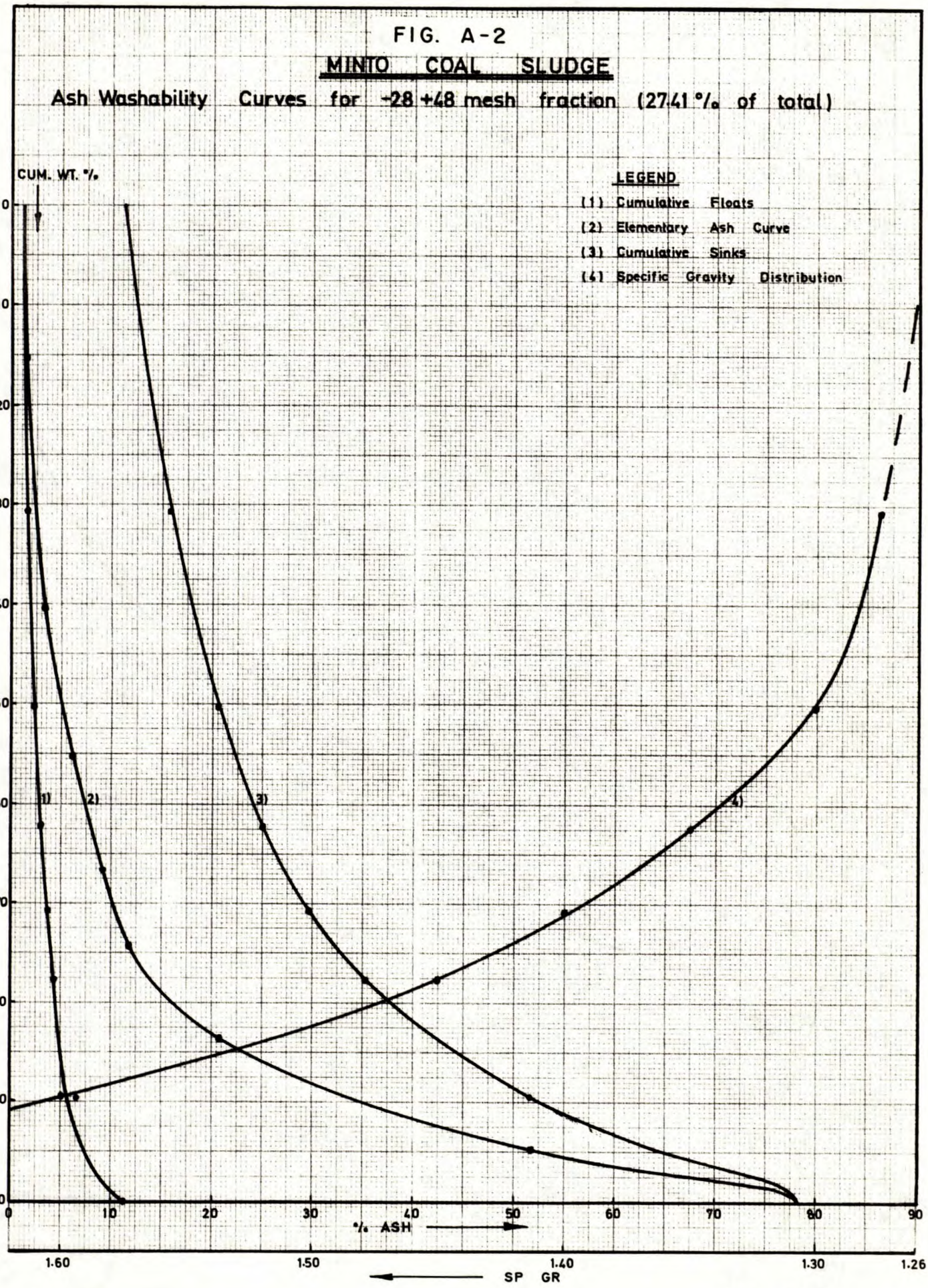
FIG. A-I
MINTO COAL SLUDGE
Ash Washability Curves for +28 mesh fraction (19.83 % of total)
CUM. WT. %
LEGEND
(1) Cumulative Floats
(2) Elementary Ash Curve
(3) Cumulative Sinks
(4) Specific Gravity Distribution
1)
2)
3)
4)
0
10
20
30
40
50
60
70
80
90
100
ASH
1.60
1.50
1.40
1.30
1.26
SP GR

OEH 4.3.74

FIG. A-2

MINTO COAL SLUDGE

Ash Washability Curves for -28 +48 mesh fraction (27.41 % of total)

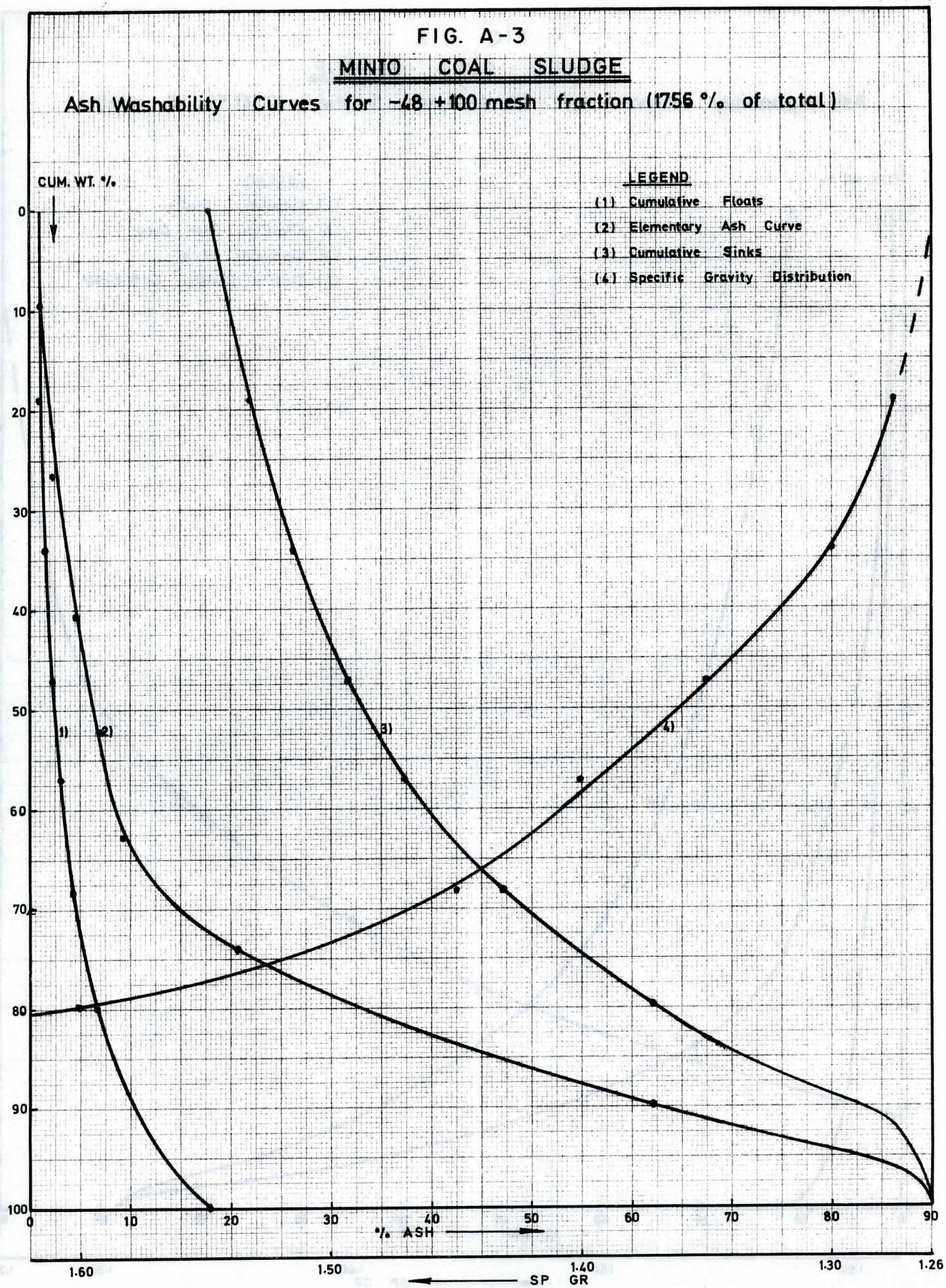


OEH 4.3.74

FIG. A-3

MINTO COAL SLUDGE

Ash Washability Curves for -48 +100 mesh fraction (17.56 % of total)

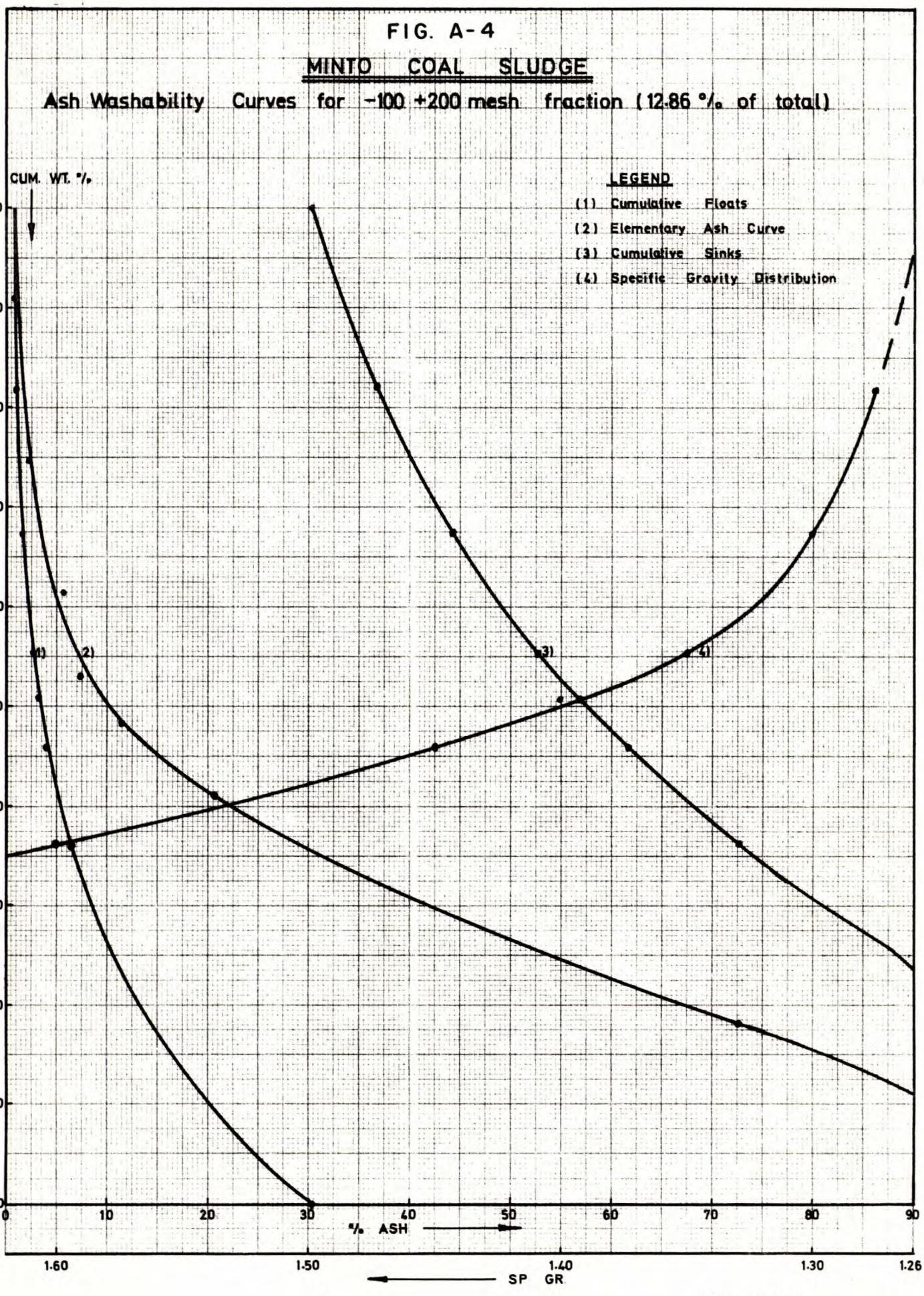


OEH 5.3.74

FIG. A-4

MINTO COAL SLUDGE

Ash Washability Curves for -100 +200 mesh fraction (12.86 % of total)



OEH 5.3.74

FIG. A-5

MINTO COAL SLUDGE

Sulphur Washability Curves for +28 mesh fraction (19.83 % of total)

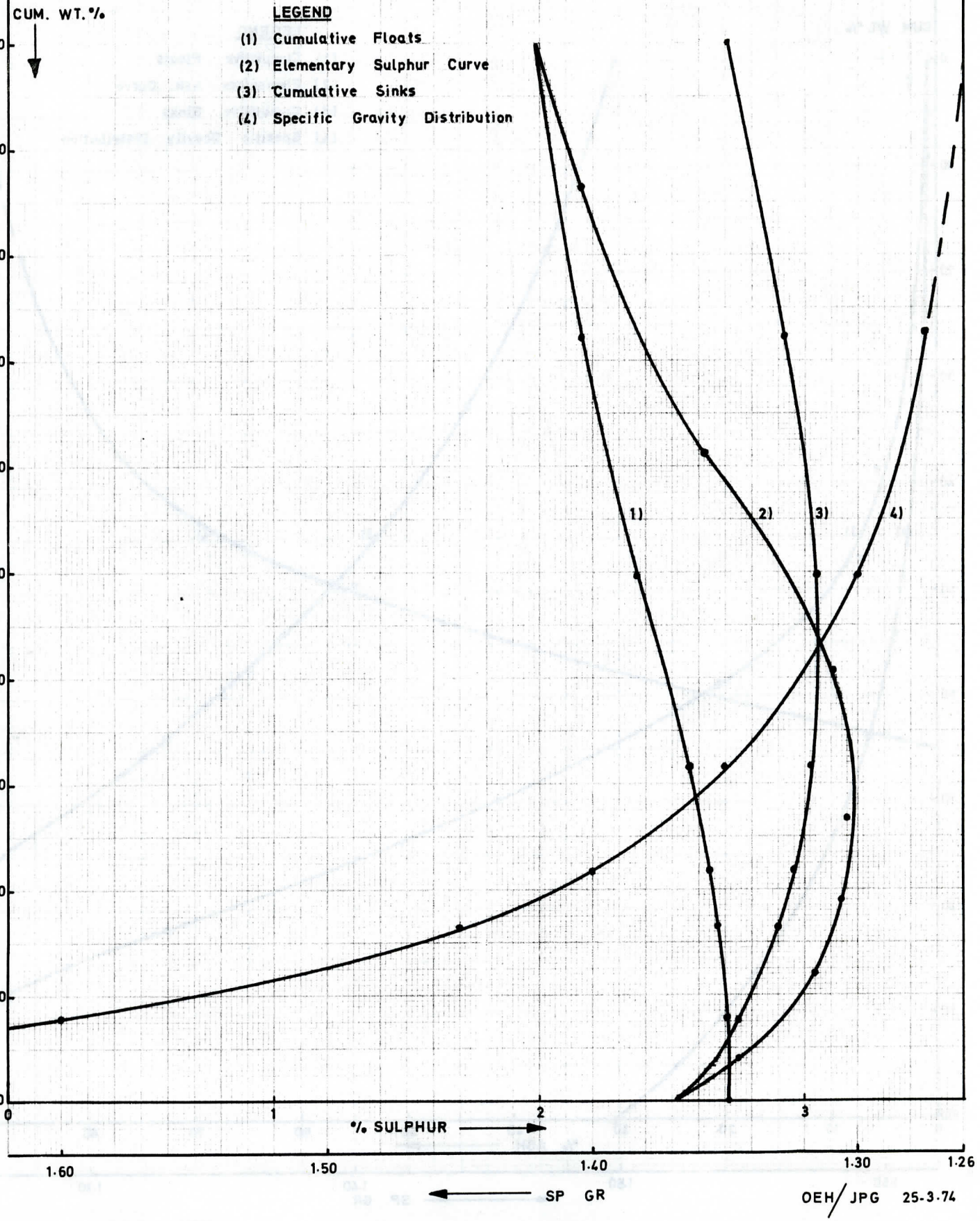


FIG. A-6

MINTO COAL SLUDGE

Sulphur Washability Curves for -28+48 mesh fraction (27.41 % of total)

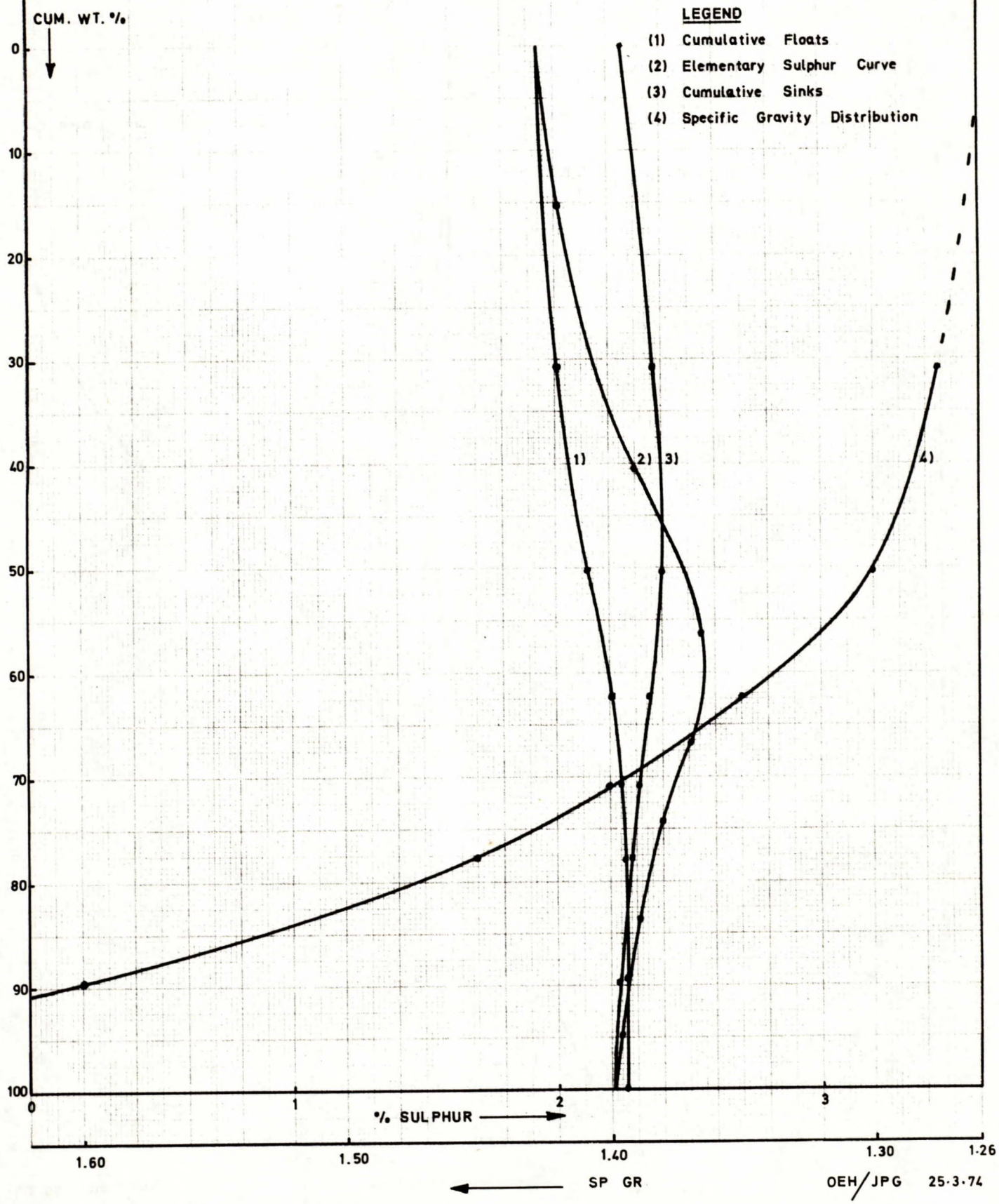
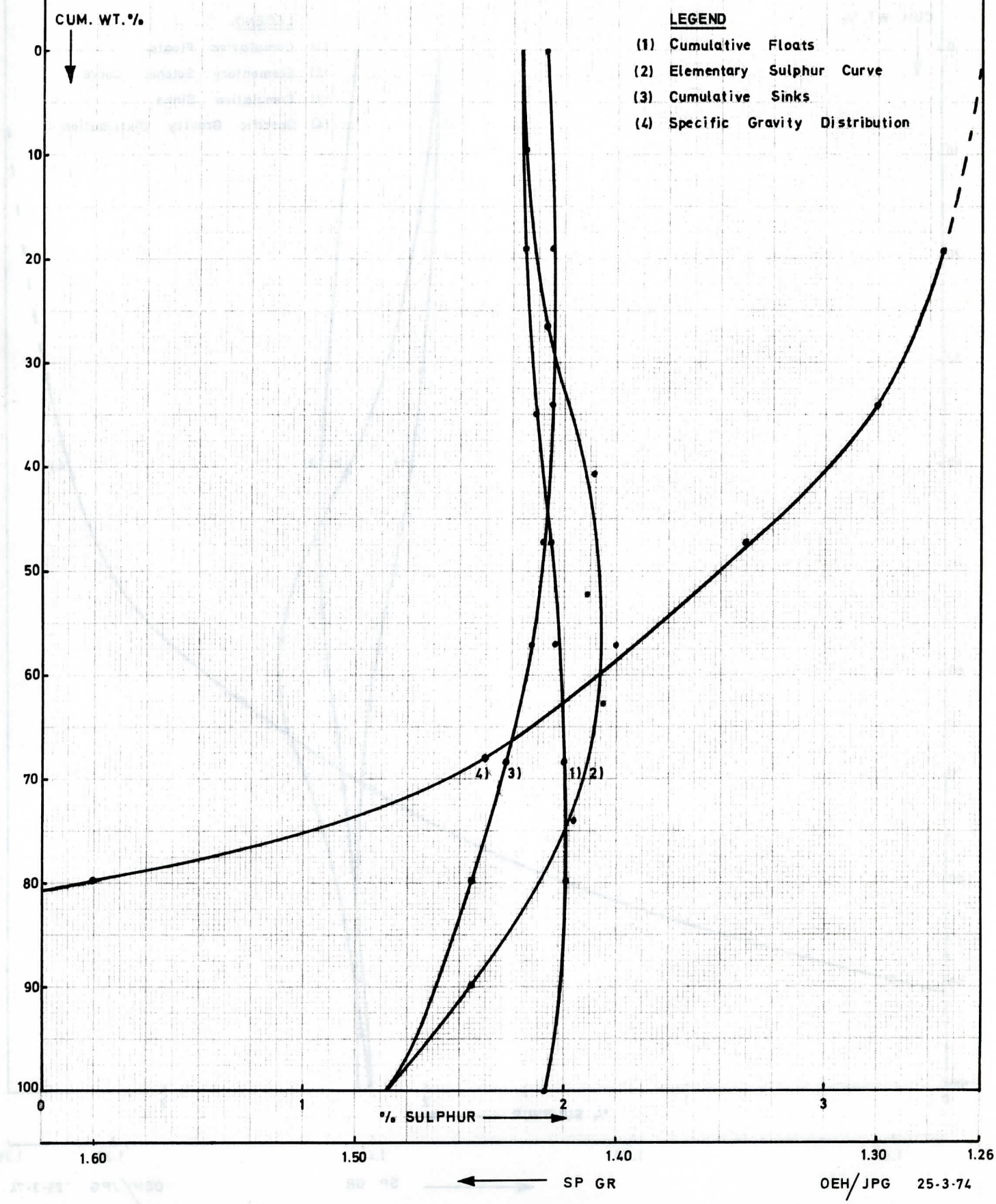


FIG. A-7

MINTO COAL SLUDGE

Sulphur Washability Curves for −48 + 100 mesh fraction (17·56 % of total)



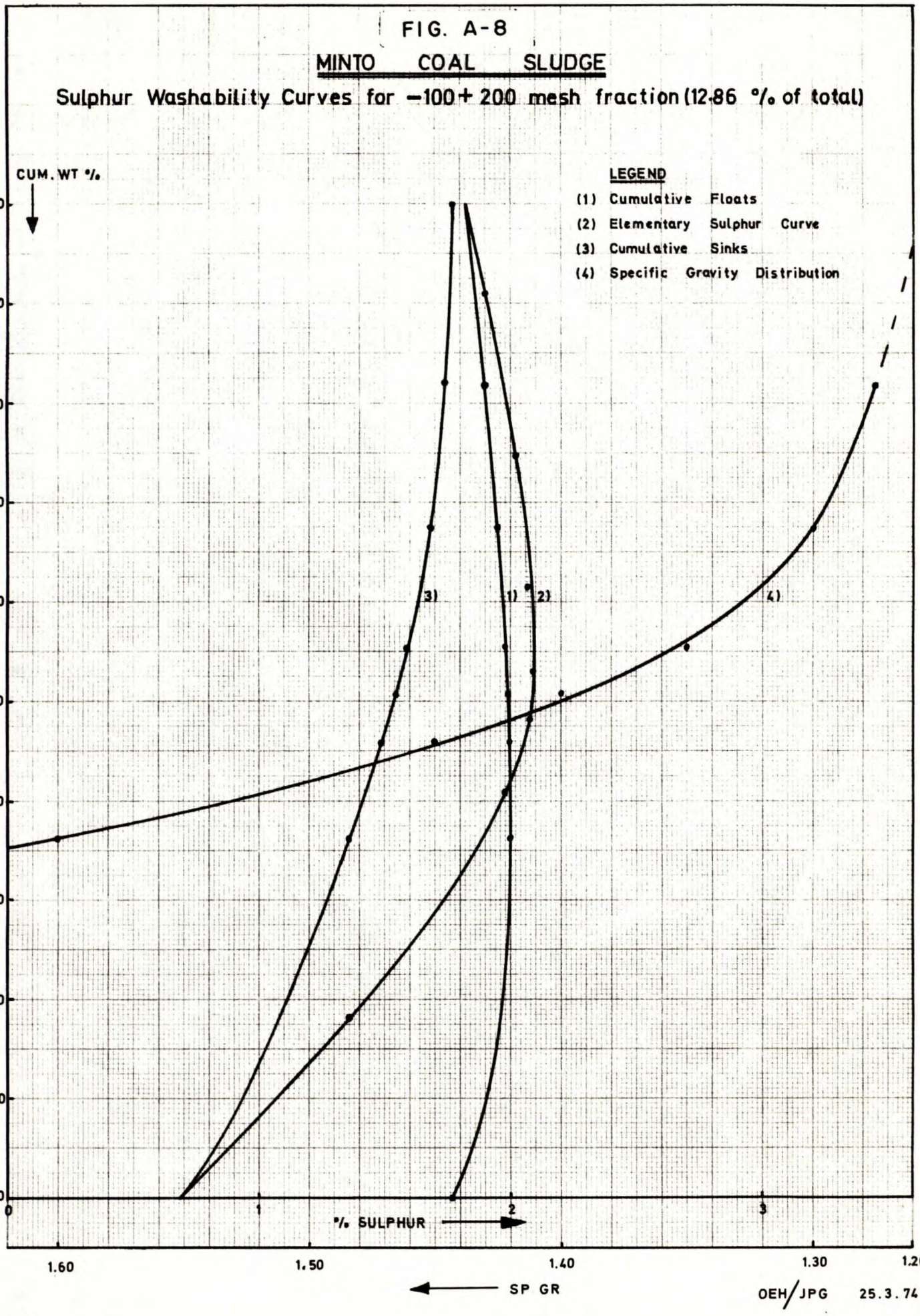


FIG. A-8
MINTO COAL SLUDGE
Sulphur Washability Curves for −100+200 mesh fraction (12.86 % of total)
CUM. WT %
LEGEND
(1) Cumulative Floats
(2) Elementary Sulphur Curve
(3) Cumulative Sinks
(4) Specific Gravity Distribution
0
10
20
30
40
50
60
70
80
90
100
3)
1)
2)
4)
0
1
2
3
% SULPHUR
1.60
1.50
1.40
1.30
1.26
SP GR
OEH/JPG 25.3.74