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J. Visman and M.W. Mikhail
Western Research Laboratory

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BENEFICIATION OF POND SLUDGE FROM THE ROBENA MINE (US STEEL CORP.) BY MEANS OF THE E.M.R. PROCESS

by

J. Visman* and M.W. Mikhail**

SUMMARY

A sample of 1200 lb of pond sludge was received at the Western Research Laboratory in January 1975, dried, subsampled and stored for subsequent pilot plant tests.

Washability characteristics (float-sink test on 3 size fractions) were conducted on the subsample and results tabulated; see Table 1. Washability curves are plotted on Figure 1.

Based on pilot plant tests with an elongated 8-in. CW Cyclone, the expected results for a 2-stage 12-in. cleaning circuit were calculated and plotted on Figure 2. The data refer to the plus 200 mesh fraction (77%) of the sludge, containing 35% ash (density 1.63) with a mean particle size of 0.29 mm (48 mesh).

A data flowsheet was prepared showing the process (E.M.R.) recommended for this sludge; see Figure 6. The raw material (38% ash) is deslimed first, in order to remove high-ash silt and clay; then cleaned by CW Cyclones; with after-treatment of effluent solids by froth flotation. Remaining solids in plant water are removed by cyclonic flocculation. Clarified water returns to the raw feed entering the plant.

The proposed system would recover 47% clean coal at 13% ash, with the possibility of increasing the yield to 55% at 13% ash by installing additional flotation capacity for treating overflow product of the desliming cyclone (21 tph @ 50% ash) now discarded as reject.

* Head, Western Research Laboratory, Canada Centre for Mineral and Energy Technology, Dept. of Energy, Mines & Resources, Edmonton, Alberta.
** Coal Processing Engineer, WRL, CANMET.

INTRODUCTION

The recent increase in coal prices has encouraged operators to consider cleaning of accumulated sludge from old mines or existing wash plants to recover saleable coal as well as to reduce reclamation costs and eliminate the hazard of dump fires. Over the years many deposits of low-ash sludge have resulted from discarded untreated minus 28 mesh fines. This type of material is relatively easy to clean. Many deposits found near coal wash plants consist of reject containing fine coal lost in the cleaning of slimes, usually by froth flotation. These losses may have resulted from one or a combination of the following factors:

1) The presence of oxidized coal;
2) The presence of coal particles coarser than 28 mesh;
3) Overloading of the flotation cells due to excessive fines (friable coal) or to build-up of slimes in the system.

Reject slimes on the other hand, are generally more difficult to clean because of higher ash content, small average particle size and sometimes high clay content. Material dealt with in the present report belongs to this category.

A small sample of sludge from the Robena Mine - old No. 1 pond was received from the Stirling Processing Company of Pittsburgh, Pa., in October 1974, for washability studies and a larger sample (1200 lb) from the same source was received early in 1975 for pilot plant testing. Objective of the investigation was to develop a flowsheet capable of producing saleable coal from a study of washability characteristics of the sludge, and results of bench and pilot-scale washing tests.

WASHABILITY CHARACTERISTICS

The screen assay and float-sink analysis show this material to contain a relatively high percentage of slimes (23% by weight minus 200 mesh) and a fairly high and probably variable ash content - (average ~38%). Results of analysis are given in Table 1.

An example of a separation that can be theoretically obtained for this material is illustrated by the washability curves in Figure 1. The dashed lines represent a separation at ~1.9 specific gravity (Curve 4) whereby ~58% coal is theoretically recoverable (ordinate) at 8% ash (Curve 1) with reject containing 72% ash (Curve 3).

The performance evaluation (PE) shown as a network of curves in Figure 2 gives actual ash contents and yields that may be expected when cleaning this sludge at cutpoints ranging from 1.4 to 2.0 specific gravity and probable errors from 0.10 to 0.30. An example (dashed line, Figure 2) shows the expected result when cleaning this coal in 12-in. diameter Compound Water Cyclones (CWC) (Probable error, r= 0.20) at a cutpoint of 1.9 after removal of the minus 200 mesh fraction by desliming. The difference between the actual ash content of the clean coal and the theoretical ash content (Ash error) is 3% while the difference in yield (Yield error) is ~5%.

PILOT PLANT TESTS

A. Froth Flotation Test

Testing was carried out in a standard 1000-g Denver laboratory flotation machine. Results for the 28 x 0 fraction are summarized in Table 2. Reagent consisted of one part MIBC to two parts kerosene and was used at the rate of 0.3 lb/ton. Conditioning time was 3 minutes. The relatively high ash of the froth is due to the interference of fine clay in the froth.

B. Compound Water Cyclone Test - Two-stage CWC-4 in.

A split sample of the sludge was treated in a two-stage 4-in. diameter Compound Water Cyclone circuit. The primary cyclone (I) has an extended body allowing for a vortex finder clearance of 3 inches and was fitted with an L-type cone and a wide vortex finder. The secondary cyclone (II) had an M-type cone, extended body and a wide vortex finder. Removal of clay from the overproduct of the primary cyclone was effected using a 4-in. diameter classifier cyclone. Results of the test are shown in flowsheet, Figure 3.

C. Compound Water Cyclone - Single-stage CWC-8 in.

The sludge was first deslimed to remove most of the minus 200 mesh fraction (50.3% ash) consisting primarily of clay. The deslimed sample was then treated in a single CWC-8L* (L-cone, wide vortex finder) having an extended body and a vortex finder clearance of 7 inches.

Float-sink analysis of the overproduct and underproduct of the cyclone was used to calculate error curves for the 6-28 m, 28-65 m and 65-150 m, as shown in Figure 4.

D. Compound Water Cyclone (CWC-4 in.) + Froth Flotation (Figure 5)

A 4-in. classifier cyclone was used to remove a portion of the slimes. The coarse underproduct of the classifier cyclone was treated in a standard CWC-4, (extended body, L-cone, wide vortex finder). As shown in Figure 5, the underproduct of the CWC-4 in. was combined with the overproduct of the classifier cyclone and processed in a 100-lb/hr capacity Denver flotation machine. The froth, combined with the cyclone overproduct gave a clean coal of 13.9% ash at 55% yield. The flotation refuse contained 53.5% ash.

Note: *) The L stands for "Long (extended) cylindrical section".

DISCUSSION OF FLOWSHEET

The sludge contains a high amount of slimes (22.8% by weight at 50.3% ash) which interferes with effective cleaning. In froth flotation high amounts of clay interfere in the froth resulting in high-ash clean coal. Excessive amounts of slimes may also interfere with the performance of the CW Cyclone by increasing viscosity and forming a kind of heavy-medium which raises the cutpoint of the fines (minus 48 mesh), causing part of the reject material to report with the clean coal. The cleaning of deslimed sludge in a single CWC-8L gave a lower ash content in the clean coal (14%) than sludge cleaned in the two-stage CWC-4 in. (16.7%).

On the basis of the washability characteristics and of bench and pilot plant test results, the following flowsheet for a 100 stph plant is recommended (see Figure 6).

1. Cleaning Section

Pulped sludge is deslimed in nine 12-in. classifier cyclones. The underflow is treated in a 2-stage CWC-12L circuit and the overflow goes directly to water recovery. The number of cyclones required is sixteen (6 + 6 + 4) as specified in Figure 6.

2. Drying Section

Clean products from the CWC-12L in. circuit and froth flotation are conditioned for dewatering with about 1% by weight dieseline oil and dried in a high speed centrifuge.

3. Water Recovery Section

Slimes from the desliming cyclone and the flotation tails are blended with flocculant in a flocculator unit and fed to a classifier cyclone. The cyclone overflow goes to a bottom-fed thickener whose underproduct together with the classifier cyclone underflow are dried in a high-speed centrifuge. Clarified water is recirculated for pulping the feed sludge.

CONCLUSIONS

1. The sample received contained a high percentage of slimes (23% by weight minus 200 mesh) and was high in ash content (38%). Washability results indicated that the sludge could be easily cleaned at cutpoints ranging from $d_p = 1.4$ to 2.0.

2. Pilot plant tests showed that desliming before cleaning improved the quality of clean coal (lower the ash content). Deslimed sample cleaned in a compound water cyclone plus froth flotation gave a clean coal of 55% yield with 13.9% ash.

3. A flowsheet for a 100 stph plant based on the sample received is recommended. The plant includes cleaning, drying and water recovery sections. The plant would be capable of producing clean coal at 47% yield with 13% ash. This yield could be increased to 55% at the same ash content by installing additional flotation capacity for (21 tph) treating the slimes that on Figure 6 are shown to be discarded as reject.

TABLE 1

Washability Data for plus 200 - Mesh Fraction

Screen size, mesh	Wt % of 21 specific gravity fractions. Ash % in brackets							Total
	1.30	1.40	1.60	1.80	2.0	2.2		
+ 28 m	6.40 (3.77)	1.74 (9.42)	0.79 (19.08)	0.30 (38.14)	0.20 (44.09)	0.15 (57.28)	1.26 (75.16)	10.84 (16.54)
28 x 100 m	16.53 (3.04)	6.60 (8.82)	2.66 (20.03)	1.51 (34.47)	1.18 (43.90)	0.91 (53.61)	20.27 (73.11)	49.66 (36.18)
100 x 200 m	4.59 (2.43)	1.87 (8.20)	0.69 (17.59)	0.30 (32.00)	0.20 (41.55)	0.20 (50.94)	8.90 (74.99)	16.75 (43.84)
Total + 200 m	27.52 (3.11)	10.21 (8.81)	4.14 (19.44)	2.11 (34.64)	1.58 (43.63)	1.26 (53.62)	30.43 (73.74)	77.26 (35.08)

Note: Slimes minus 200 mesh constitute 22.75 wt % @ 50.28% ash. Total Ash = 38.5% (density 1.68).
Density of plus 200 mesh solids 1.63

Table 2 - Froth Flotation Test on Robena Sludge
28 Mesh x 0 Fraction

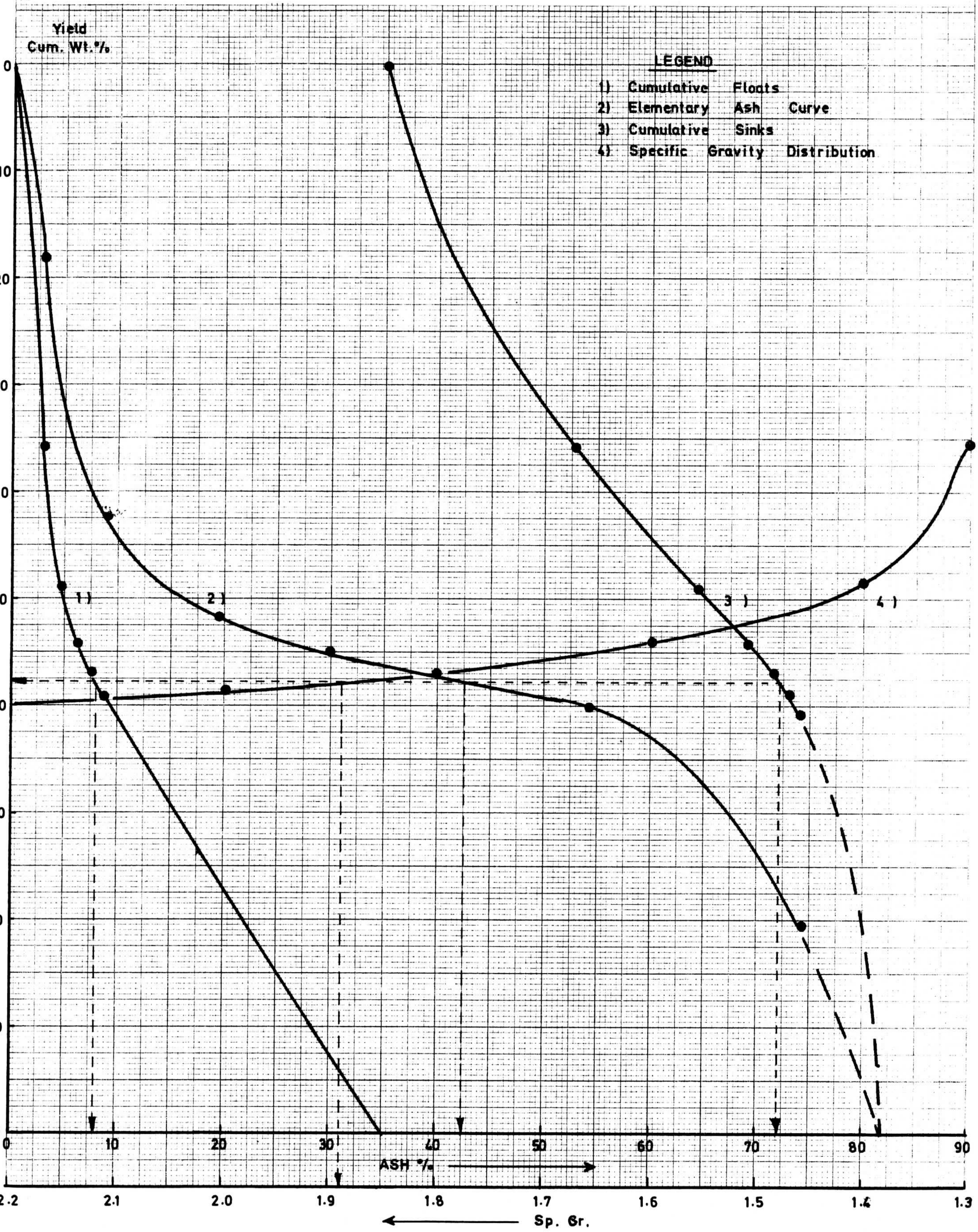
Time (Sec)	Wt %	Ash %	Cumulative Float Wt %	Cumulative Float Ash %
30	23.7	12.8	23.7	12.8
60	7.8	14.5	31.5	13.2
120	4.3	26.9	35.8	14.9
Tails	64.2	53.3	100.0	39.5

Remarks: Feed solids content 7% by weight, Reagents: 1 part MIBC + 2 parts kerosene 0.3 lb/ton, conditioning time: 3 minutes

FIGURE 1

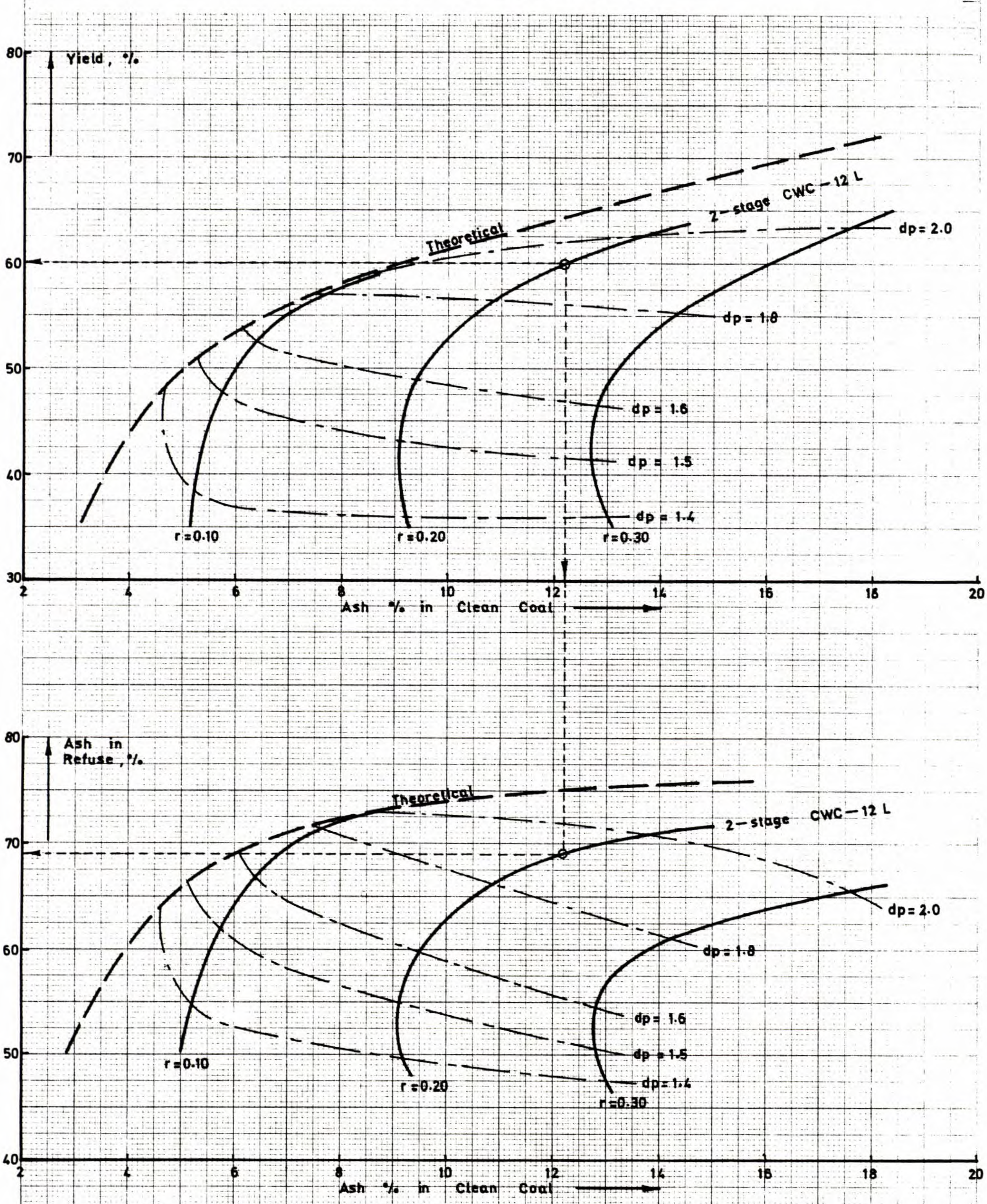
ROBENA MINE SLUDGE WASHABILITY CURVES

FOR PLUS 200 MESH FRACTION



MWM / GMS 22.8.75

FIGURE 2
PERFORMANCE EVALUATION CURVES FOR DESLIMED SLUDGE (+ 200 mesh)

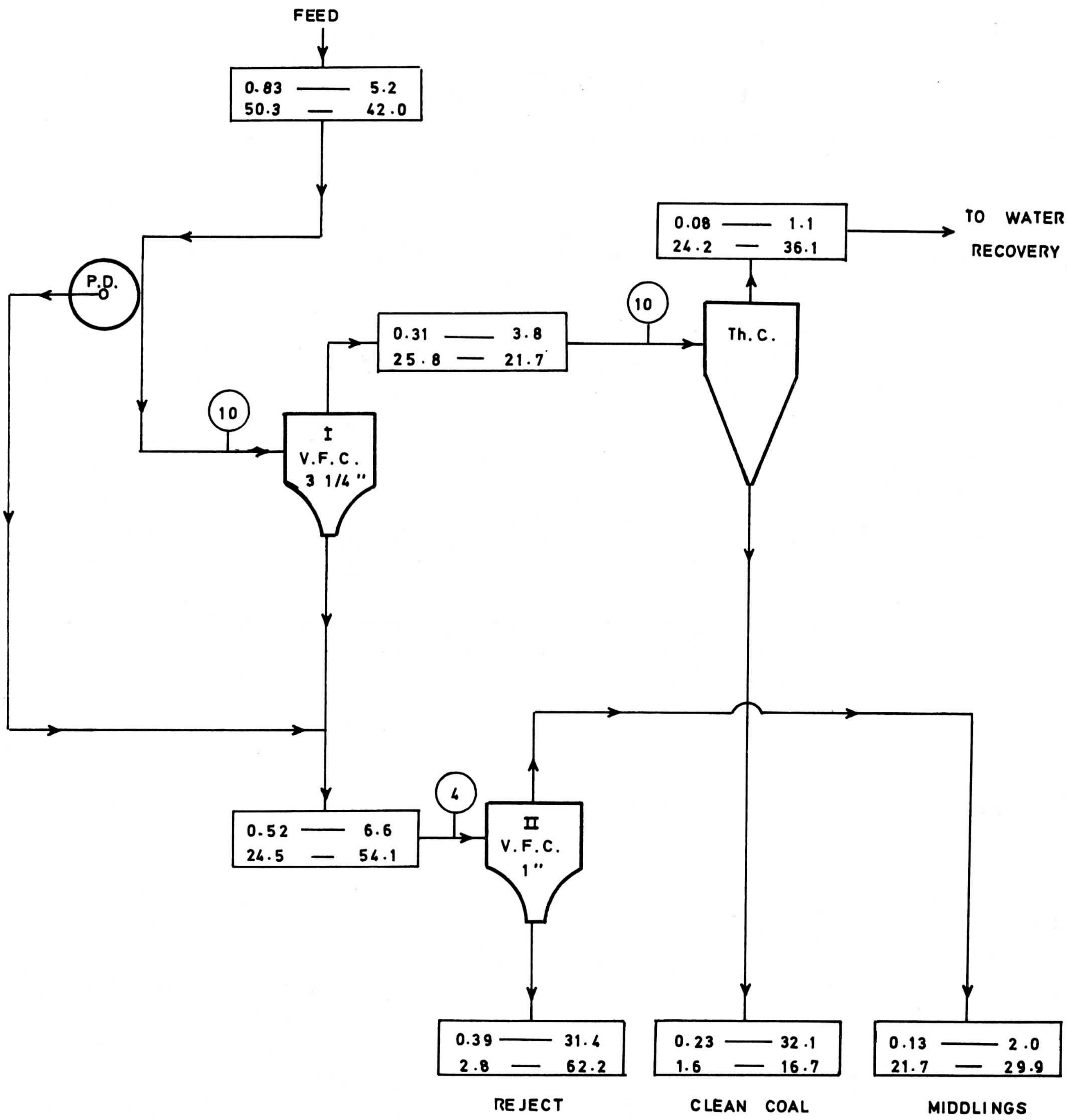


MM/OEH 15.07.75

FIG 3: FLOWSHEET OF AUTOMATIC 2-STAGE CWC-4" WITH PULP DIVIDER

Material ROBENA MINE SLUDGE

Test No. 2



Legend

STPH	— % SOLIDS
IGPM	— % ASH

I, II = PRIMARY AND SECONDARY CWC - 4"

VFC = VORTEX FINDER CLEARANCE

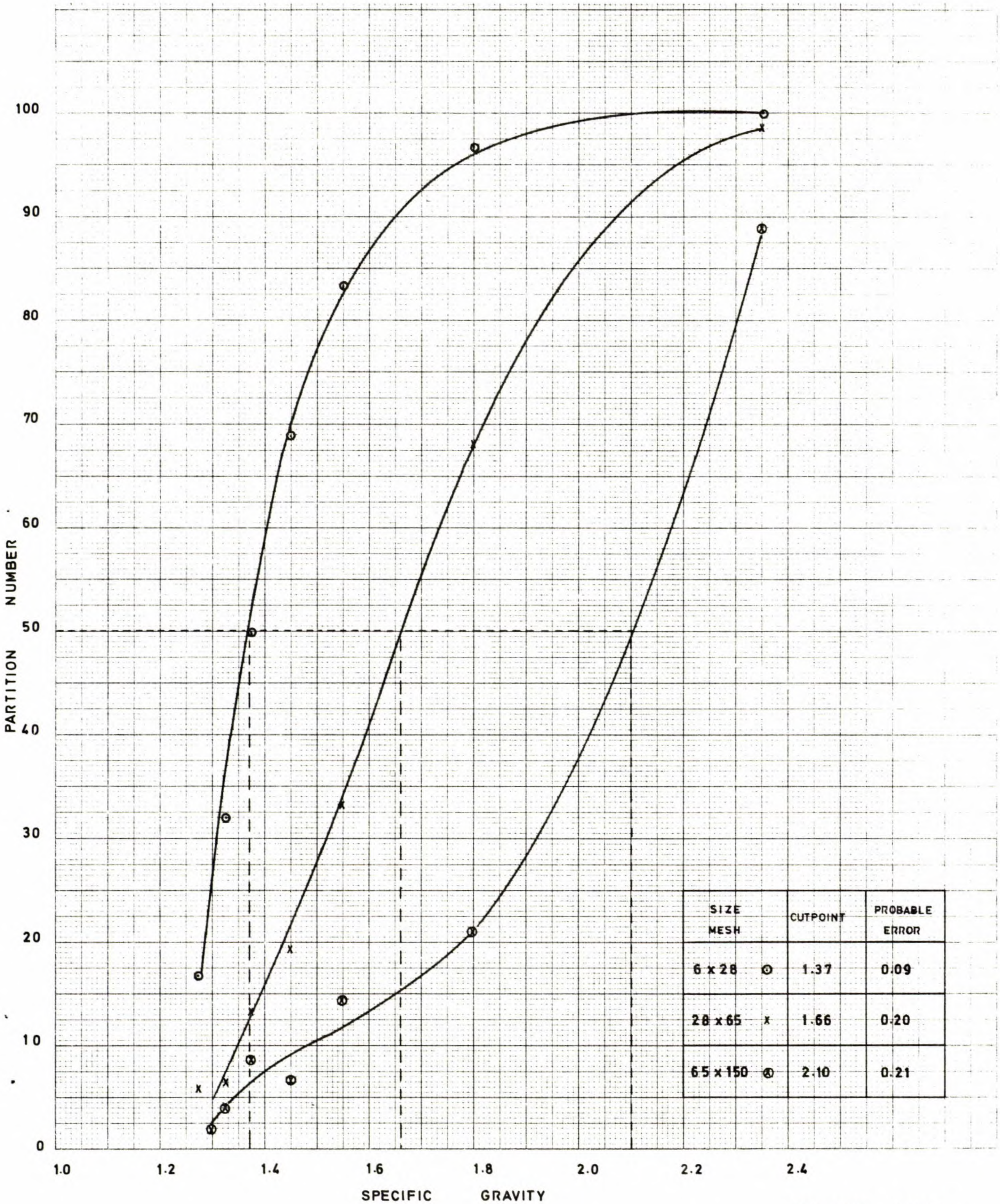
Th. C = THICKENER CYCLONE

PD = PULP DIVIDER

FIGURE 4

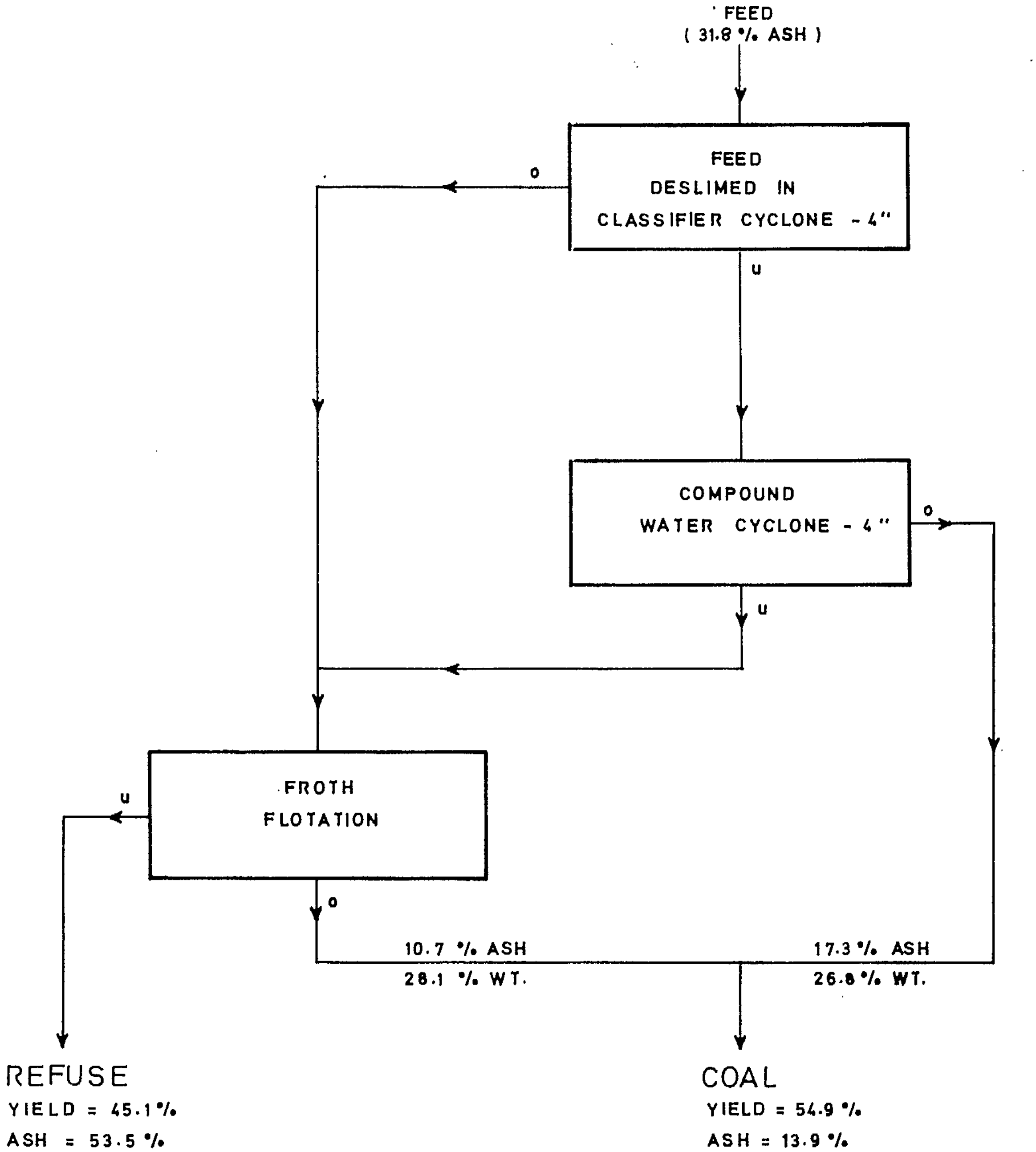
ERROR CURVES — DESLIMED SLUDGE

CWC-8L, L cone, V.F.C. = 7 in., 12 % solids, density = 1.63



MWM/GMS 2/6/75

FIGURE 5: PRELIMINARY PILOT PLANT TEST
(CWC - 4" + F. FLOTATION)



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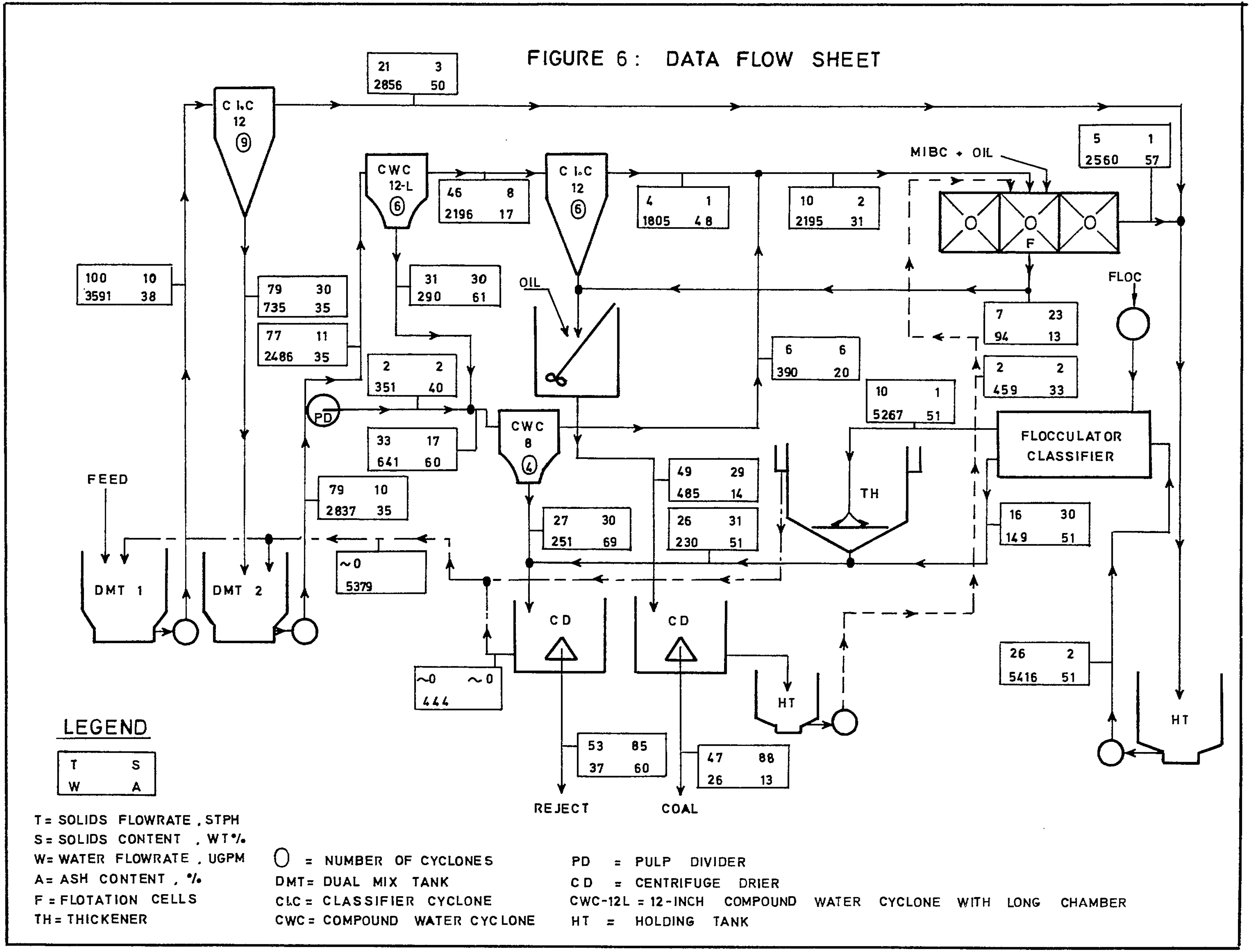

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