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A Pilot Plant Investigation of

THE RECOVERY OF LEAD AND ZINC

from Cyprus Anvil samples

submitted by

CYPRUS ANVIL MINING CORPORATION

Progress Report No. 6 (Volume I)

Project No. L.R. 2202

NOTE:

This report refers to the samples as received.

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ABSTRACT

t plant testwork was conducted on two Cyprus Anvil samples o. 1 and No. 2) to evaluate the effect of fineness of primary te regrind on lead and zinc metallurgical results. The following ade:

increasing the fineness of the primary grind and using fine lead inc concentrate regrinds, the lead concentrate grade and recovery he zinc recovery increased significantly.

ead rougher concentrate grades and weight recoveries were similar l primary grinds. The zinc rougher concentrate grade and weight ery, however, varied from test to test regardless of the fineness imary grind. It was found that reproducibility of the weight ery in the zinc circuit was not affected by the fineness of primary , but was a function of the conditions applied in the zinc rougher $CuSO_4$, lime and collector additions).

SUMMARY

1. Sample Description

Two bulk ore samples from Cyprus Anvil were received during August 1979 and October 1979, for the pilot plant testwork. The samples were marked as follows:

Bulk Sample No. 1	160 tonnes
Bulk Sample No. 2	35 tonnes

During the crushing of these samples a representative sample was removed for head analyses and laboratory testwork.

Sample	Assays, %			
	Pb	Pb Ox.	Zn	Zn Ox.
Bulk Sample No. 1	2.35	0.40	3.85	0.25
Bulk Sample No. 2	2.40	0.35	4.34	0.22

Twenty-seven tests were conducted on bulk sample No. 1 and eight tests on bulk sample No. 2.

2. Pilot Plant Operation

A total of thirty-five flotation tests were conducted to evaluate the effects of primary grind and concentrate regrinds on the grades and recoveries of lead and zinc. In all tests the Cyprus Anvil flowsheet and reagent balance were used. The tests were run on a single-shift basis, averaging 7.5 hours duration per test. The circuit products were sampled during the last two hours of operation. Metallurgical balances were calculated using the three-product formula for the rougher concentrates.

The circuit products were assayed by a XRF spectrometer.

Summary - Continued

3. Grinding

One primary grinding and three regrinding mills were utilized in the flowsheet, and most of the flowsheet variations involved these three mills in some way, either through a change in the size of the cyclone, the steel load or the feed rate.

3.1. Primary Grind

Minus 12.7 mm crushed ore was fed to a 1219.2 mm diameter by 914.4 mm length Hendy, grate-discharge ball mill by a Gravimerrick feeder Model 930. The feed rate to the mill was varied from 565 to 365 kilograms per hour.

The mill discharge (Figure No. 1) was classified in a P50 Dorrclone and the cyclone underflow was returned to the mill feed. The cyclone overflow was passed over the tramp screen (Kason, 20 mesh) and pumped to the flotation circuit. Pertinent data for tests at different primary grinds are shown in Table No. 1. The relationship between power consumption and K_{80} of the product is illustrated in Figure No. 2.

Table No. 1

Primary Grinding Tests

Test No. Pilot Plant	Ore Sample	Cyclone O'Flow Product			Power Imput kWh/tonne	Work Index Metric
		% Pass. 200 m	% Pass. 400 m	K_{80} µm		
11,12	No. 1	96.95	84.1	30.9	22.30	16.81
9,10,24	No. 1	91.30	70.9	48.7	18.60	13.66
22,23	No. 1	77.90	50.9	76.6	12.10	12.04
16	No. 1	60.30	41.7	130.0	7.10	9.44
28,29	No. 2	59.70	36.0	137.2	6.62	9.00
31,35	No. 2	87.50	59.7	59.6	14.20	13.01

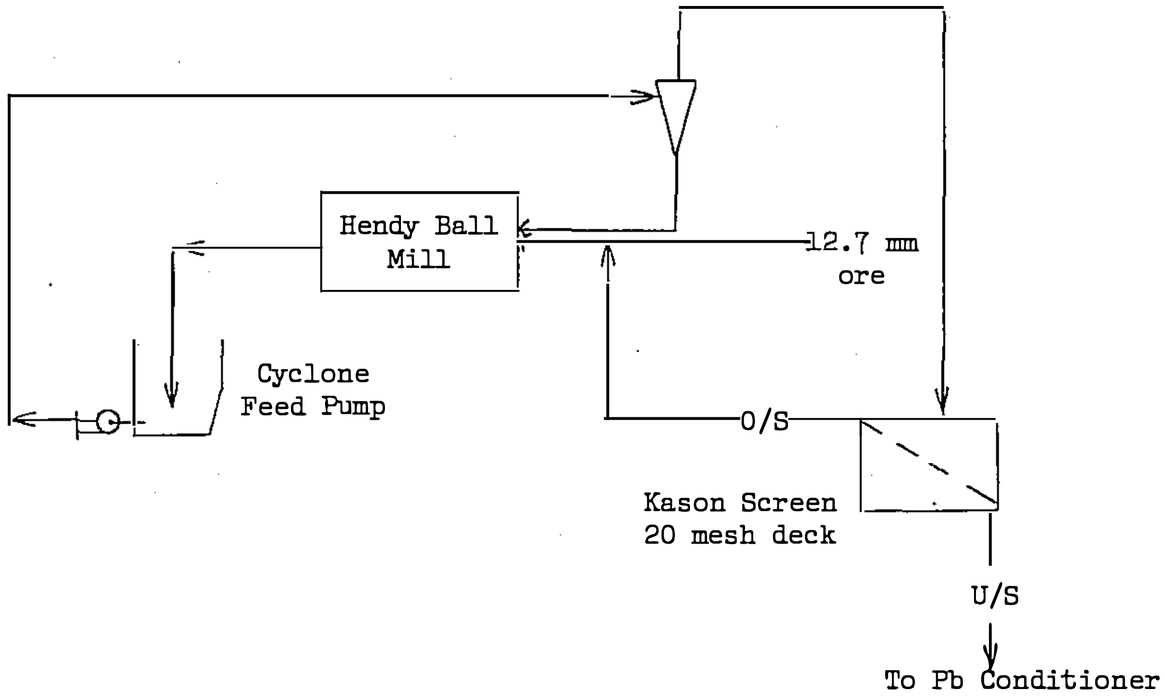
The required fineness of grind was adjusted by changing the composition of steel load, feed rate, pulp density and cyclone size.

Summary - Continued

3.1. Primary Grind - Cont'd

Figure No. 1

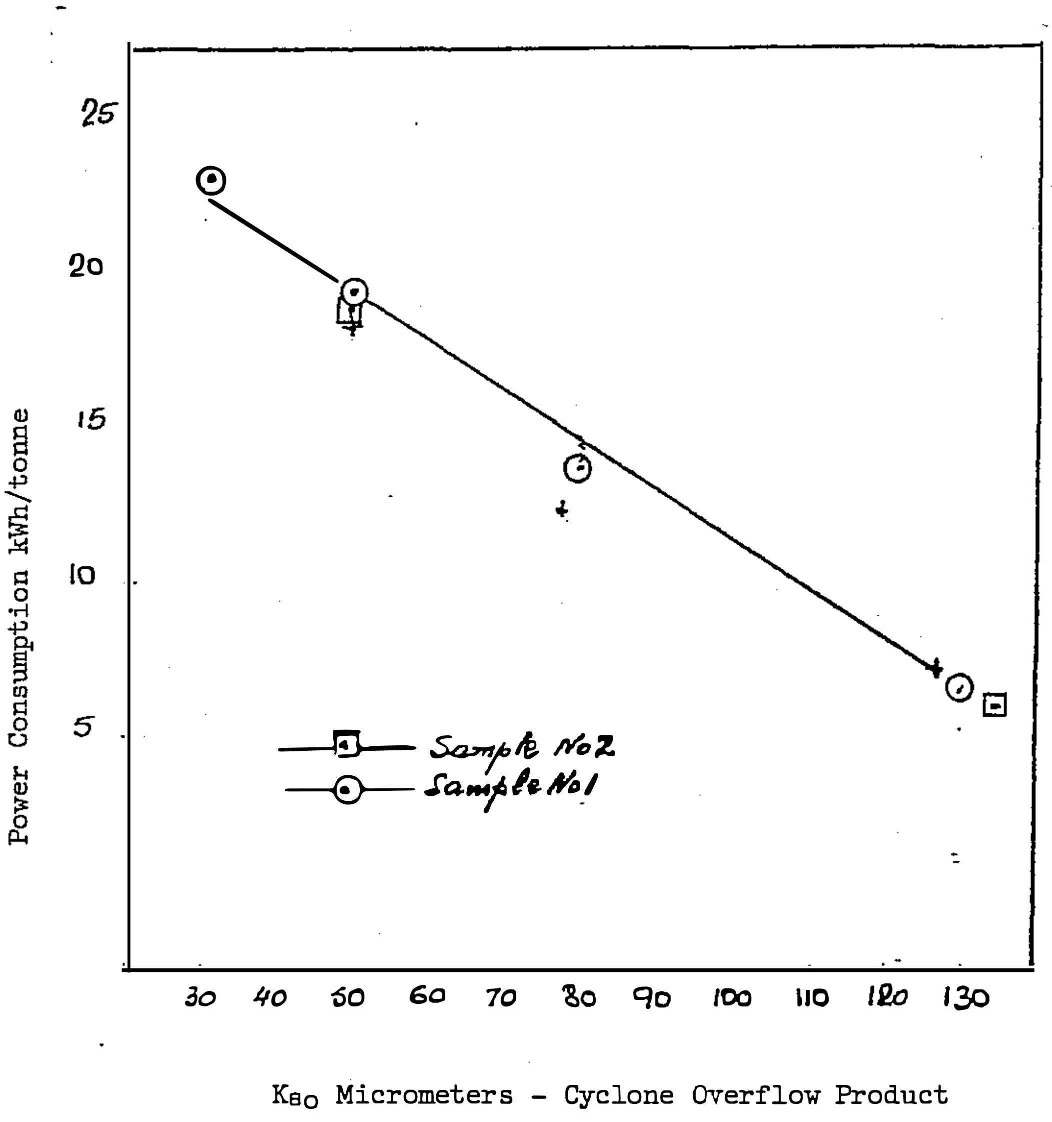
Flowsheet - Primary Grind



Summary - Continued

Figure No. 2

Power Consumption vs. K_{80} Micrometers of the Cyclone Overflow Product



Summary - Continued

3.2. Lead Concentrate Regrind

The combined lead rougher concentrate and lead scavenger cleaner concentrate were classified in either a 25.4 mm Krebs cyclone or a 38 mm Krebs cyclone. The cyclone underflow was reground in a Hardinge Conical mill and discharged to the cyclone feed pump. The cylcone overflow was pumped directly to the Pb cleaning circuit.

The fineness of the lead concentrate regrind was changed from 60 % passing 20 µm to 90 % passing 20 µm. The operation of the regrinding circuit was stable and the required size distribution in the regrind and classification stages was achieved without problems.

The lead regrinding test data for comparative tests are summarized in Table No. 2.

Table No. 2

Lead Rougher Concentrate Regrind Tests

Test No. Pilot Plant	Ore Sample	Pb Ro. Feed % Pass. 200 m	Pb Rougher Conc.		Pb Regrind Cyclone O'Flow		
			Rate kg/h	% Pass. 20 µm	% Pass. 10 µm	% Pass. 20 µm	K_{80} µm
9,10,24	No. 1	91.3	21.3	63.6	57.6	92.4	20.8
22,23	No. 1	77.9	23.1	52.0	65.5	88.5	18.3
16	No. 1	60.0	31.7	45.0	60.0	90.0	18.0
28,29	No. 2	57.6	26.1	42.5	43.0	77.0	23.0
31,35	No. 2	87.5	20.1	58.3	65.5	90.1	16.5

Summary - Continued

3.3. Zinc Concentrate Regrind

The combined zinc rougher concentrate, and zinc first cleaner scavenger concentrate were classified either in the P25 Dorr cyclone or the 38 mm Goodwin cyclone. The cyclone underflow was reground in a Denver mill which discharged to the cyclone feed pump; the cyclone overflow was pumped directly to the zinc cleaning circuit. The operation of the zinc regrind circuit was not stable during the testwork and the required fineness of regrind was difficult to achieve. The main problem was the variation in the weight recovery of the zinc rougher concentrate. This resulted in unstable circulating loads in the classification, and the variations in the fineness of regrind. The zinc regrind results from representative tests are shown in Table No. 3 below.

Table No. 3

Zinc Rougher Concentrate Regrind Tests

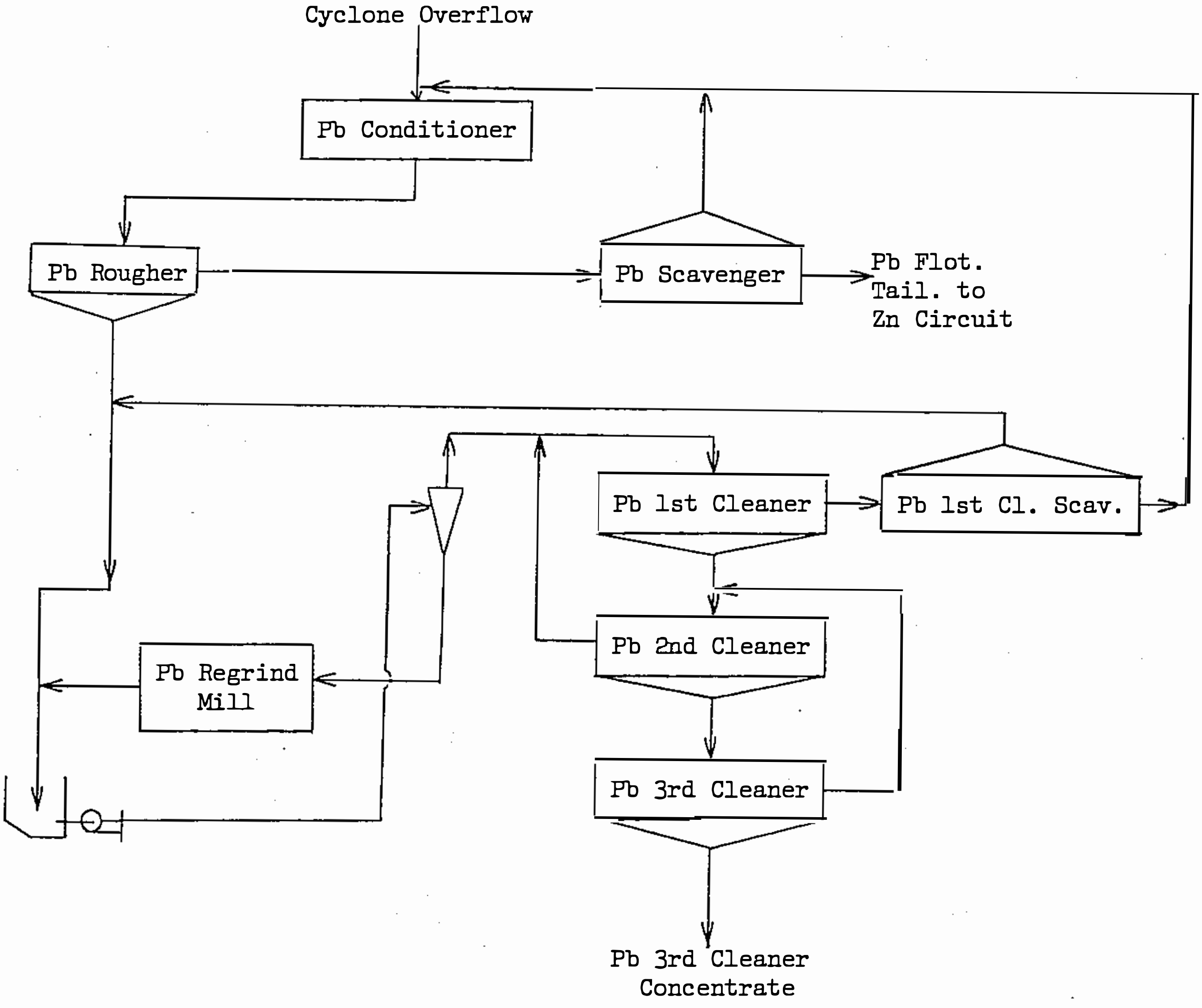
Test No. Pilot Plant	Ore Sample	Zn Ro. Feed % Pass. 200 m	Pb Rougher Conc.		Pb Regrind Cyclone O'Flow		
			Rate kg/h	% Pass. 20 µm	% Pass. 10 µm	% Pass. 20 µm	K_{80} µm
9,10,24	No. 1	91.30	33.6	53.4	47.3	87.60	19.0
22,23	No. 1	77.90	72.9	39.0	33.0	67.75	39.7
16	No. 1	60.00	71.2	26.0	20.2	45.00	44.0
28,29	No. 2	57.60	68.1	29.0	28.0	54.5	40.0
31,35	No. 2	87.50	49.1	46.0	40.0	77.5	28.0

Summary - Continued

4.1. Lead Flotation

Figure No. 3

Flowsheet - Pb Circuit



Summary - Continued

4. Flotation

4.1. Lead Flotation

4.1.1. Flowsheet

The flowsheet of the existing Cyprus Anvil mill was adopted for the pilot plant testwork. In the initial tests (Tests PP1 to PP6) the flowsheet configuration as well as the cleaning capacity were determined and were maintained unchanged for the remainder of the testwork.

The flowsheet (Figure No. 3) consisted of the lead rougher and scavenger flotation and the regrinding of the rougher concentrate prior to three stages of cleaning. The lead scavenger concentrate was recirculated to the head of the rougher flotation. The lead first cleaner tailing was scavenged. The scavenger cleaner concentrate was recirculated to the lead regrind feed and the scavenger cleaner tailing was returned to the lead rougher conditioner.

4.1.2. Reagent Additions

The Cyprus Anvil plant reagent balance was utilized in this testwork and is shown in Table No. 4.

Table No. 4

Reagent Balance - Lead Circuit

Stage	Reagents Added, grams per tonne				pH
	Na_2CO_3	NaCN	Z-11	MIBC	
Primary Grind	2500- 13400	100- 150	10.0	-	9.7- 9.9
Pb Ro. and Scav.	-	-	120.0	100- 200	9.7- 9.9
Pb Regr. and Cl.	800- 1500	50- 110	12- 57	5- 10	10.0- 10.3
Total	3300- 14900	150- 260	142- 199	105- 210	-

Summary - Continued

4.1.2. Reagent Additions - Cont'd

The reagent additions were varied throughout the testwork, mainly to maintain similar froth conditions in all tests (See Summary of Tests data). It should be pointed out that when treating bulk sample No. 1, the soda ash and cyanide consumptions were high due to heavy oxidation of the sample. These two reagent additions were critical and small variations in either cyanide or soda ash addition resulted in pyrite flotation.

4.2. Zinc Flotation

4.2.1. Flowsheet

The zinc flowsheet (Figure No. 4) was similar to that of the lead circuit with the exception that the rougher concentrate was cleaned 4 times and the zinc first cleaner scavenger tailing was discarded to the final tailing.

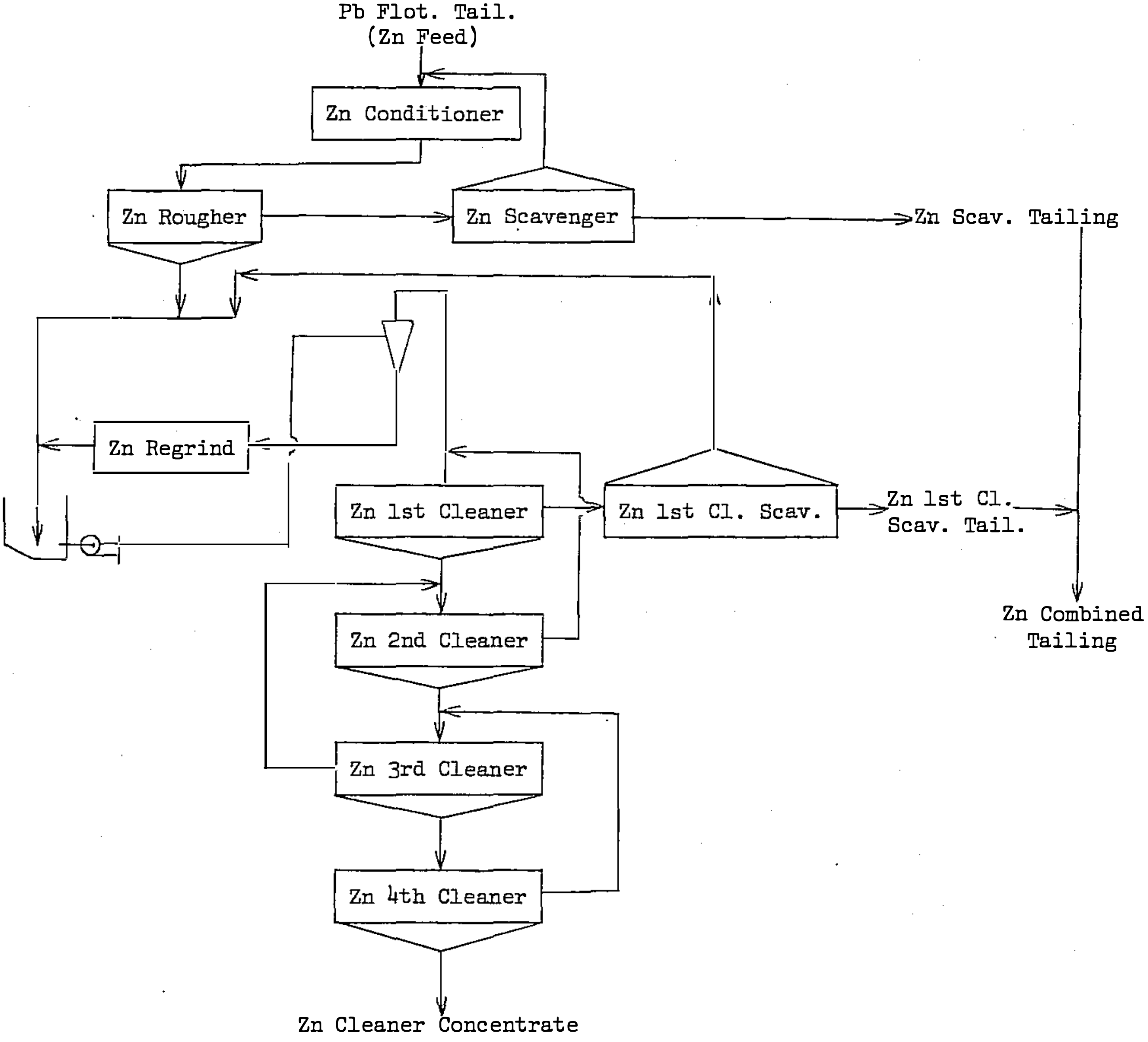
The variations in the zinc flowsheet were examined in tests PP1 to PP8 mainly to determine the point of middling recirculation and the cleaning capacity. From test PP9 to PP35 no changes in the zinc flowsheet were made.

Summary - Continued

4.2.1. Flowsheet - Cont'd

Figure No. 4

Zinc Circuit



Summary - Continued

4.2.2. Reagent Balance

The zinc reagent balance (Table No. 5) was slightly different from the Cyprus Anvil plant procedure. In the pilot plant operation the lime additions to the zinc second, third and fourth cleaner stages were omitted. Depressant D1902 (starch-base) was added to the zinc 3rd and 4th cleaners. Collectors R-208 and Z-200 were used in the zinc rougher and cleaning stages.

Table No. 5

Zinc Circuit Reagent Balance

Stage	Reagents Added, grams per tonne						pH
	Lime	$CuSO_4$	Z-11	Z-200	R-208	D-1902	
Zn Ro. and Scav. Zn Regr. and Cl.	3000 2200	800 150	100 25	- 36	120 -	- 66	10.4 9.9-12.2
Total	5200	950	125	36	120	66	-

5. Flotation Testwork

5.1. Objectives of the Testwork

The main objectives of the testwork were as follows:

1. To determine the effect of the fineness of primary grind on the lead and zinc metallurgical results.
2. To evaluate the effect of the fineness of lead and zinc concentrate regrinds using different fineness of primary grind.

Summary - Continued

5.2. Flotation Characteristics of the Ore Samples Tested

5.2.1. Bulk Sample No. 1

The metallurgical processing characteristics of the Cyprus Anvil bulk sample No. 1 could be summarized as follows:

1. The ore contained 0.4 % oxide lead and 0.25 % oxide zinc. The sample was heavily oxidized and the finer fraction of sample, (minus 150 µm fraction) was yellow in colour. About 10 to 13 kilograms of Na_2CO_3 per tonne of ore were required to obtain a pH of 9.6 to 9.8.
2. The finely reground pyrite was active in the lead first and second cleaning stages.
3. The lead losses in the lead first cleaner scavenger tailing were high; in most of the tests this tailing assayed 7 % to 12 % Pb.
4. In the lead cleaning a low pulp density of 10 % to 15 % solids was required to maintain a high lead concentrate grade.
5. High lime additions were also required in the zinc rougher and first cleaner stages to keep pyrite depressed. Small pH variations during roughing and 1st stage cleaning promoted pyrite flotation and resulted in unselective cleaning conditions. Very efficient cleaning conditions were achieved in the zinc first cleaner stage after regrinding; the concentrate grade was virtually doubled. However, cleaning in the subsequent stages was poor. It was observed that omitting the lime from the 2nd, 3rd and 4th cleaner stages improved cleaning efficiency slightly.

Summary - Continued

5.2.2. Bulk Sample No. 2

This sample contained a large portion of fine material (approximately 40 % minus 6 mesh) and assayed 0.3 % oxide lead and 0.2 % oxide zinc.

The flotation response of this sample was significantly better than that of bulk sample No. 1.

The reagent consumption was low and high-grade lead and zinc concentrates were readily produced.

6. Overall Metallurgical Results Using Different Fineness of Primary Grind

The results using different fineness of grind are compared in Table No. 6.

Table No. 6

Metallurgical Results Using Different Fineness of Grind

Test No.	Primary Grind				Pb Regrind		Zn Regrind	
Pilot Plant	Cyclone O/F % Pass.		K_{80} µm Product	Power kWh/tonne	Cyclone O/F % Passing 20 µm	K_{80} µm Product	Cyclone O/F % Passing 20 µm	K_{80} µm Produc
	400 mesh	200 mesh						
9,10,24	70.9	91.3	48.7	16.6	86.7	20.8	76.6	19.0
22,23	50.9	77.9	76.6	12.10	89.2	18.3	66.0	39.7
16	41.7	60.0	130.0	7.20	89.9	18.0	50.0	44.0
28,29	36.4	57.6	137.2	8.99	72.2	23.5	48.0	40.0
31,35	59.7	87.5	59.6	14.20	85.5	16.5	66.0	28.0

Summary - Continued

6. Overall Metallurgical Results Using Different Fineness of Primary Grind - Cont'd

Table No. 6 - Cont'd

Metallurgical Results Using Different Fineness of Grind

Test No. Pilot Plant	Ore Sample	Product	Weight %	Assays, %		% Distribution	
				Pb	Zn	Pb	Zn
9,10,24	No. 1	Pb Cl. Conc.	2.58	68.4	2.91	76.0	1.9
		Zn Cl. Conc.	6.35	0.46	52.10	1.2	86.0
		Zn Comb. Tail.	91.07	0.58	0.51	22.8	12.1
		Head (Calc.)	100.00	2.32	3.85	100.0	100.0
22,23	No. 1	Pb Cl. Conc.	2.69	64.65	3.49	75.0	2.5
		Zn Cl. Conc.	6.48	0.94	49.76	2.6	87.4
		Zn Comb. Tail.	90.83	0.57	0.41	22.4	10.1
		Head (Calc.)	100.00	2.32	3.71	100.0	100.0
16	No. 1	Pb Cl. Conc.	2.84	63.60	2.40	73.5	1.7
		Zn Cl. Conc.	6.55	1.10	51.40	2.9	85.4
		Zn Comb. Tail.	90.61	0.64	0.56	23.6	12.9
		Head (Calc.)	100.00	2.47	3.94	100.0	100.0
28,29	No. 2	Pb Cl. Conc.	2.70	71.6	3.55	77.5	2.2
		Zn Cl. Conc.	6.65	0.69	54.15	1.8	83.7
		Zn Comb. Tail.	90.65	0.57	0.67	20.7	14.1
		Head (Calc.)	100.00	2.50	4.30	100.0	100.0
31,35	No. 2	Pb Cl. Conc.	2.60	76.15	1.99	82.1	1.2
		Zn Cl. Conc.	6.96	0.49	55.00	1.4	88.0
		Zn Comb. Tail.	90.44	0.43	0.52	16.5	10.8
		Head (Calc.)	100.00	2.41	4.35	100.0	100.0

Summary - Continued

6. Overall Metallurgical Results Using Different Fineness of Primary Grind - Cont'd

In these tests the fineness of primary grind was varied from 57.6 % minus 200 mesh to 91 % minus 200 mesh (i.e. K_{80} = 50 μm to K_{80} = 130 μm). The tests were divided into three main groups and the metallurgical results obtained with a coarse primary grind (K_{80} = 130 μm), a medium primary grind (K_{80} = 76 μm) and fine primary grind (K_{80} = 50 μm) were compared. The results obtained indicated the following:

1. A significant increase in the lead concentrate grade and recovery as the fineness of primary grind increased.
2. The zinc recovery increased with increase in the fineness of primary grind.
3. The selectivity between lead and zinc minerals increased with increase in the fineness of grind.

It was not possible to demonstrate the effect of Pb and zinc concentrate regrinding, using either the coarse primary grind or medium primary grind for the following reasons:

1. Deterioration of the selectivity between pyrite and lead during cleaning, caused by the advanced oxidation of the ore.
2. Problem of adjusting the fineness of regrind in the zinc regrinding stage.

Summary - Continued

7. Settling and Filtration Tests

7.1. Settling Tests

Settling tests were carried out on the final lead and zinc concentrates from pilot plant test PP33. The results obtained are summarized in Tables No. 7 and 8.

Table No. 7

Lead Concentrate Thickening Tests

Test No.	pH	Feed Flocc.* Added g/tonne	Percent Solids Feed	Percent Solids Final	Settling Rate m/h Feed Zone	Settling Rate m/h Compr. Zone	Thickener Area m^2/tonne/day Feed Zone	Thickener Area m^2/tonne/day Compr. Zone
T-1	10.0	-	31.7	74.7	1.49	0.70	0.051	0.065
T-2	11.5	-	29.7	74.1	1.69	0.58	0.056	0.073
T-3	11.0	-	30.2	74.0	1.75	0.58	0.047	0.071
T-4	10.0	20	30.7	72.5	7.28	0.59	0.011	0.041
T-5	10.0	10	31.6	73.2	5.51	0.59	0.014	0.041

*Hercules 824 non-ionic

Table No. 8

Zinc Concentrate Thickening Tests

Test No.	pH	Feed Flocc.* Added g/tonne	Percent Solids Feed	Percent Solids Final	Settling Rate m/h Feed Zone	Settling Rate m/h Compr. Zone	Thickener Area m^2/tonne/day Feed Zone	Thickener Area m^2/tonne/day Compr. Zone
T-6	9.0	-	36.2	73.0	0.35	0.130	0.17	0.22
T-7	11.3	-	36.2	72.6	0.34	0.096	0.17	0.24
T-8	11.9	-	35.6	72.7	0.28	0.084	0.21	0.26
T-9	11.9	20	34.4	67.5	0.93	0.140	0.065	0.18

Summary - Continued

7.2. Filtration Tests

Three series of tests were conducted on each concentrate to investigate the effects of pulp temperature, slurry density, and filter aids. The results are summarized in Tables No. 9 and 10.

Table No. 9

Pb Concentrate Filtration Tests

Test No.	°C	Slurry pH	% Solids	Filter Cloth	Filter Aid* g/tonne	Filter Time Seconds Form	Dry	Cycle	Cake Rate kg/h/m^2	% Moist.	Filtrate Rate l/h/m^2	Clar g/
F-1	RT	10.8	50	POPR901F	-	30	90	180	467	12.1	473	2.5
F-2	RT	10.8	50	POPR901F	-	30	180	315	259	12.8	258	2.5
F-4	RT	10.8	50	POPR901F	-	60	360	630	181	11.6	187	2.5
F-5	RT	10.8	71	POPR901F	-	15	90	158	630	13.2	159	1.2
F-10	RT	10.8	62	POPR825F	10	30	180	315	295	11.4	160	0.32
F-11	RT	10.8	62	POPR825F	10	30	360	585	161	12.9	90	0.32
F-12	50.0	10.9	62	POPR825F	10	30	180	315	528	11.1	307	0.27
F-13	50.0	10.9	62	POPR825F	10	30	360	585	280	11.1	152	0.27
F-14	70.0	10.9	62	POPR825F	10	30	180	315	713	7.5	356	0.27
F-15	70.0	10.9	62	POPR825F	10	30	360	585	376	9.8	185	0.27

Table No. 10

Zn Concentrate Filtration Tests

F-16	RT	11.0	50	POPR901F	-	30	90	180	331	14.9	333	3.2
F-17	RT	11.0	50	POPR901F	-	30	180	315	247	14.8	197	3.2
F-18	RT	11.0	50	POPR901F	-	30	90	180	421	14.8	312	3.2
F-19	RT	11.0	66	POPR925F	-	15	90	158	522	15.1	172	1.7
F-20	RT	11.0	66	POPR925F	-	15	180	293	304	13.9	110	1.7
F-21	RT	11.0	66	POPR925F	-	15	360	563	146	14.1	62	1.7
F-22	RT	11.0	62	POPR925F	-	15	180	293	269	14.6	128	0.97
F-23	RT	11.0	62	POPR925F	-	15	360	563	126	14.6	59	0.97
F-24	RT	11.0	62	POPR925F	10	15	180	293	243	12.4	111	0.97
F-25	RT	11.0	62	POPR925F	10	15	360	563	109	11.2	50	0.55
F-26	50	11.0	62	POPR925F	10	15	180	293	295	11.5	162	0.55
F-27	50	11.0	62	POPR925F	10	15	360	563	167	11.3	87	0.55
F-28	70	11.0	62	POPR925F	10	15	180	293	387	11.7	176	0.55
F-29	70	11.0	62	POPR925F	10	15	360	563	198	12.1	88	0.55

* Drimax 1234

It was observed that higher pulp temperature improved filtration rate.

Summary - Continued

8. Summary of Results

8.1. Variables Investigated

Test No.	Variables
PP1	Preliminary test to fill the circuit and to test the mechanical operation of the equipment.
PP2	To produce coarser flotation feed in the grinding and to adjust the reagent additions to the lead and zinc flotation. 1) Replaced 50 mesh Sweco screen with 35 mesh screen. 2) Added collector Z-11 to the Pb regrind and 1st cleaner scavenger feed.
PP3	Repeated conditions of test PP2 with finer primary grind. (1) Added about 540 kg steel balls to the Hendy mill. The reagent additions to the lead and zinc circuit were adjusted as follows: a) Increased Na_2CO_3 and NaCN additions to the Hendy mill feed. b) Increased Z-11 additions to the lead regrind mill feed and lead 1st cleaner scavenger feed. c) Introduced Z-200 to the zinc rougher feed.
PP4	Decreased feed rate to the primary grinding and pulp density to the cyclone overflow. The lead and zinc flotation was carried out as for test PP3.
PP5	Repeated conditions of test PP4 for the primary grind. In the lead flotation circuit the lead 1st cleaner scavenger stage was omitted and the lead 1st cleaner tailing was recycled to the lead rougher feed. The Na_2CO_3 was increased. Collector additions to the lead scavenger feed increased slightly and the collector R-242 was added to the lead regrind. In the zinc circuit, lime and $CuSO_4$ additions were decreased.
PP6	Returned the Pb 1st cleaner scavenger stage to the circuit and the lead 1st cleaner scavenger tailing was recycled to the rougher feed. Decreased collector addition to the lead regrind feed. Added small quantities of frother D-1012 to zinc rougher.
PP7	1. Repeated primary grind fineness of test PP6. 2. Increased cyanide additions regrind mill feed. 3. Decreased pulp density in the lead 2nd cleaner feed. 4. Increased zinc 2nd and 3rd cleaning time and replaced collector Z-200 in the zinc rougher and scavenger feed with collector R-208.
PP8	1. Increased lead 1st, 2nd and 3rd cleaning capacity by 50 percent and increased lead 1st cleaner scavenger time from 14 minutes to 32 minutes. 2. Added frother D-1012 to the zinc rougher and scavenger feed.

Summary - Continued

8.1. Variables Investigated - Cont'd

Test No.	Variables
PP9	Increased fineness of primary grind. Omitted MIBC from the zinc scavenger feed. Omitted R-242 from the lead rougher and scavenger feed
PP10	1. Repeated conditions of test PP9 for grinding. 2. Added collector A-343 to the lead scavenger cleaner feed. 3. Added depressant D1902 to the zinc 2nd, 3rd and 4th cleaner feed.
PP11	Repeated conditions of test PP9 and PP10 at very fine primary grind 96 % % passing 200 mesh. In the primary grind 2 classification stages were introduced.
PP12	Repeated conditions of test PP11.
PP13	Repeated conditions of test PP11 and PP12 using coarse primary grind classification product. Decreased mill steel load and increased mill feed rate. In the regrind the small cyclones were replaced with bigger size.
PP14	Repeated conditions of test PP13 at slightly increased feed rate. The reagent additions to the lead and zinc circuit were adjusted.
PP15	Similar to test PP14 at higher mill feed rate.
PP16	Repeated conditions of test PP15 at finer lead and zinc concentrate regrind. The cyclones in the Pb an Zn regrind were changed.
PP17	Repeated conditions of test PP16.
PP18	Repeated conditions of test PP17.
PP19	Repeated conditions of test PP18.
PP20	Repeated conditions of test PP17 and PP18 using finer primary grind. The primary grind fineness increased from 60 % minus 200 mesh to 77 % minus 200 mesh by adjusting steel ball load, feed rate and pulp density.
PP21	Repeated conditions of test PP20.
PP22	Repeated conditions of test PP21 at finer Pb and Zn rougher concentrate regrinds. The fineness of Pb and Zn concentrate regrind increased by adjusting cyclone size.
PP23	Repeated conditions of test PP22 at finer Zn concentrate regrind. The zinc rougher regrinding capacity increased.

Summary - Continued

8.1. Variables Investigated - Cont'd

Test No.	Variables
PP24	Investigated the effect of finer primary grind (i.e. K_{80} = 55-60) and fine lead and zinc regrind. The Hendy mill load was adjusted.
PP25	Repeated conditions of test PP24.
PP26	Repeated conditions of test PP15 but the Pb-Zn bulk concentrate was produced by removing the zinc 4th cleaner tailing and lead 3rd cleaner tailing from the recirculation. The two cleaner tailings were combined to form Pb-Zn bulk concentrate.
PP27	Repeated conditions of test PP26 without removing bulk concentrate. In the second part of the test run the recycle water was added to the circuit.
PP28	Repeat conditions of test PP19 using newly prepared sample. The reagents in the Pb and zinc flotation circuit were slightly adjusted.
PP29	Repeated conditions of test PP28.
PP30	Similar to test PP29 with slightly finer primary grind and removal of bulk concentrate.
PP31	Repeated conditions of test PP28 and PP29 at fine primary grind and finer rougher concentrate regrinds.
PP32	Repeated conditions of test PP31 at slightly increased collector additions to the lead and zinc flotation.
PP33	Investigated the effect of higher collector additions to the lead and zinc cleaning.
PP34	Repeated conditions of test PP33.
PP35	Repeated conditions of test PP31 for Pb circuit and test PP34 for Zn circuit.

Summary - Continued

8.2. Primary Grinding Data

Test	Feed	Steel	Cyclone Overflow			K_{80} Micrometers		Power	Work
	Rate	Load	%	% minus	% minus				
No.	kg/h	kg	Solids	200 m	400 m	Feed	Product	kWh/t	Index
PP-1	435.6	544.2	37	64.6	44.2	5608	107.6	8.66	10.45
PP-2	433.6	544.2	38	66.9	45.0	8217	104.0	8.93	10.26
PP-3	433.8	818.9	37	86.8	60.2	8217	64.3	19.6	17.24
PP-4	405.8	818.9	27	91.6	71.7	8502	45.4	20.2	14.67
PP-5	412.0	818.9	31	68.4	45.7	6914	100.4	19.5	22.26
PP-6	418.8	818.9	31	87.9	68.0	5808	52.0	18.9	15.04
PP-7	412.1	818.9	27	91.4	70.8	6450	50.3	19.3	15.04
PP-8	406.2	818.9	27	88.3	64.5	6680	55.8	19.8	16.30
PP-9	368.6	909.6	26	92.9	75.6	5414	45.4	23.8	17.64
PP-10	365.6	909.6	27	91.7	69.4	8217	50.3	23.2	17.93
PP-11	366.0	909.6	19	96.7	84.0	7410	31.4	23.0	16.79
PP-12	369.0	909.6	38	97.2	84.2	6680	30.4	21.7	16.84
PP-13	473.8	675.7	33	71.3	49.0	5608	93.9	11.0	12.20
PP-14	508.5	675.7	38	69.5	46.4	7158	97.2	9.05	10.09
PP-15	646.0	675.7	39	56.9	37.6	6014	132.5	6.58	8.90
PP-16	615.1	675.7	39	60.3	41.7	6450	128.0	7.1	9.44
PP-17	623.0	675.7	40	59.4	37.0	4699	119.4	7.76	10.10
PP-18	627.3	675.7	37	60.4	40.8	7410	115.4	7.33	9.00
PP-19	627.0	675.7	38	55.3	35.7	7671	132.5	7.15	9.48
PP-20	426.0	802.6	28	77.2	49.9	6450	79.2	12.21	12.22
PP-21	405.4	802.6	28	79.9	53.2	7158	74.0	13.39	12.84
PP-22	406.4	802.6	27	77.4	49.4	8217	79.2	12.20	11.93
PP-23	404.5	802.6	26	78.4	52.5	8502	76.6	12.56	12.15
PP-24	394.9	950.0	26	89.5	67.7	7410	50.3	15.27	11.80
PP-25	424.1	950.0	27	85.9	62.5	6228	59.9	14.22	12.21
PP-26	640.4	675.7	38	54.1	33.8	6450	147.0	7.00	10.00
PP-27	645.9	675.7	38	53.5	33.2	4699	152.0	6.39	9.62
				NEW ORE SAMPLE					
PP-28	562.5	550.1	36	56.1	33.1	6914	137.2	6.70	8.96
PP-29	560.5	550.1	34	59.1	39.8	5808	137.2	6.51	9.02
PP-30	560.8	617.2	34	57.8	41.1	4095	132.5	6.85	9.62
PP-31	407.4	825.8	27	82.7	52.7	5414	69.0	12.17	11.43
PP-32	405.4	961.9	26	88.6	62.8	6450	52.0	14.58	11.54
PP-33	414.1	1098.0	32	92.7	67.6	7671	48.6	18.28	13.84
PP-34	408.3	1098.0	34	91.2	68.4	5414	48.6	18.25	14.05
PP-35	409.5	1098.0	34	92.1	66.7	6228	50.3	18.48	14.40

Summary - Continued

8.3. Regrinding Data

Test	Lead Regrind					Zinc Regrind				
No.	Feed kg/h	Steel Load kg	Cyclone Type	% minus 20 µm Feed	% minus 20 µm Cyc.O/f	Feed kg/h	Steel Load kg/h	Cyclone Type	% minus 20 µm Feed	% minus 20 µm Cyc.O/F
PP-1	-	181.4	Krebs	-	-	-	113.4	Dorr	-	-
PP-2	19.9	181.4	Krebs	45.0	82.1	29.0	113.4	Dorr	39	71
PP-3	26.2	181.4	Krebs	58.8	78.0	35.1	113.4	Dorr	48	91
PP-4	23.1	181.4	Krebs	60.0	83.0	28.2	113.4	Dorr	57	89
PP-5	25.0	181.4	Krebs	50.5	95.3	30.2	113.4	Dorr	42	81
PP-6	22.0	181.4	Krebs	64.1	95.5	36.6	113.4	Dorr	58	93
PP-7	27.3	181.4	Krebs	65.1	94.5	26.2	113.4	Dorr	54	78
PP-8	21.2	181.4	Krebs	56.6	85.0	37.8	113.4	Dorr	46	81
PP-9	22.4	181.4	Krebs	68.5	91.0	37.2	113.4	Dorr	50	83
PP-10	18.6	181.4	Krebs	56.7	84.5	30.7	113.4	Dorr	52	83
PP-11	24.1	181.4	Krebs	64.0	85.0	32.9	113.4	Dorr	54	68
PF-12	22.0	181.4	Krebs	66.0	95.0	34.0	113.4	Goodwin	57	78
PP-13	37.4	181.4	Krebs	50.0	51.5	181.6	113.4	Goodwin	30	32
PP-14	26.7	181.4	Krebs	49.0	58.0	42.5	113.4	Goodwin	31	43
PP-15	32.8	181.4	Krebs	43.5	66.5	110.0	113.4	Goodwin	9	27
PP-16	31.7	181.4	Krebs	41.5	89.9	71.2	113.4	Dorr	24	37
PP-17	33.0	181.4	Krebs	48.5	79.0	73.3	113.4	Dorr	28	45
PP-18	35.6	181.4	Krebs	40.5	52.5	125.1	113.4	Goodwin	19	32
PP-19	37.2	181.4	Krebs	43.0	53.5	74.9	113.4	Goodwin	32	42
PP-20	23.9	181.4	Krebs	52.5	52.2	47.4	113.4	Goodwin	38	42
PP-21	19.5	181.4	Krebs	54.0	56.0	61.8	113.4	Goodwin	34	45
PP-22	20.8	181.4	Krebs	50.0	85.0	73.5	113.4	Dorr	34	54
PP-23	25.4	181.4	Krebs	52.5	93.5	72.3	204.1	Dorr	36	67
PP-24	23.0	181.4	Krebs	61.5	84.2	51.5	204.1	Dorr	46	79
PP-25	25.7	181.4	Krebs	55.6	87.5	74.0	204.1	Dorr	47	75
PP-26	49.1	181.4	Krebs	45.5	58.0	126.0	204.1	Dorr	29	42
PP-27	40.6	181.4	Krebs	40.0	57.5	107.7	204.1	Dorr	28	42
				NEW ORE SAMPLE						
PP-28	24.4	181.4	Krebs	35.0	76.5	79.8	204.1	Dorr	30	49
PP-29	27.8	181.4	Krebs	42.0	68.0	56.4	204.1	Dorr	32	47
PP-30	30.3	181.4	Krebs	35.6	67.5	43.9	204.1	Dorr	33	50
PP-31	20.0	181.4	Krebs	43.0	87.5	46.7	204.1	Dorr	45	66
PP-32	17.2	181.4	Krebs	53.5	74.0	46.6	204.1	Dorr	43	58
PP-33	17.8	181.4	Krebs	59.6	83.5	53.0	204.1	Dorr	49	79
PP-34	18.8	181.4	Krebs	58.6	80.5	48.6	204.1	Dorr	54	79
PP-35	20.2	181.4	Krebs	54.0	83.5	51.5	204.1	Dorr	52	74

Summary - Continued

8.4. Reagent Additions Pb Circuit - Grams Per Tonne

Test	Primary Grind		Pb Rougher + Scavenger				Pb Regrind and Cleaning					
No.	Na_2CO_3	NaCN	Z-11	R-242	MIBC	pH	Na_2CO_3	NaCN	Z-11	R-242	MIBC	pH
PP-1	1350	132	30.3	24.4	56.9	9.6	756	54.4	-	9.8	-	10.8- 9.7
PP-2	5347	185	30.0	26.1	58.9	9.0	803	52.9	13.2	7.1	-	10.3- 9.3
PP-3	8963	247	34.7	22.1	58.4	9.6	726	56.0	22.4	13.6	-	10.1- 9.7
PP-4	9670	263	29.9	23.8	62.4	9.9	1145	59.1	47.6	4.3	-	10.4-10.7
PP-5	14520	264	58.7	31.1	60.1	10.1	1144	78.3	11.9	4.4	-	10.4-10.0
PP-6	8668	258	85.4	19.5	59.6	9.7	1276	21.8	14.5	4.5	-	10.4-10.5
PP-7	8668	260	87.4	19.0	60.9	9.7	1098	106.8	11.0	-	-	10.3-10.5
PP-8	8798	271	88.8	21.0	60.9	9.8	1024	105.8	11.5	-	-	10.2-10.2
PP-9	9660	290	125.3	-	60.9	9.8	1407	104.3	13.0	-	-	10.3-10.3
PP-10	9671	309	123.8	-	67.9	9.7	1339	117.8	29.4	-	4.5	10.0-10.1
PP-11	9740	292	149.3	-	94.8	9.7	1436	120.3	29.0	-	2.5	10.1-10.1
PP-12	9863	280	174.9	-	125.1	9.8	1366	121.1	29.0	-	4.3	10.4-10.4
PP-13	7653	234	97.5	-	95.1	9.7	1063	94.0	22.6	-	1.3	10.4-10.5
PP-14	7009	223	91.6	-	90.3	9.4	1014	88.5	21.3	-	3.1	10.1-10.3
PP-15	8652	205	72.2	-	69.7	9.8	796	69.7	16.6	-	2.5	10.1-10.3
PP-16	8823	217	75.6	-	53.4	9.7	854	73.3	17.4	-	2.6	10.1-10.3
PP-17	8628	220	72.4	-	53.9	9.9	813	68.4	17.0	-	-	10.1-10.2
PP-18	8636	220	73.0	-	72.2	9.9	808	71.2	17.0	-	2.5	10.2-10.2
PP-19	8674	217	74.2	-	72.0	9.8	831	70.9	17.2	-	2.5	10.1-10.2
PP-20	12898	324	108.2	-	107.8	10.0	1229	106.9	24.8	-	3.7	10.2-10.3
PP-21	13353	331	115.1	-	115.3	10.1	1264	113.6	26.3	-	3.9	10.3-10.4
PP-22	13288	334	114.9	-	111.6	10.0	1265	110.4	26.7	-	-	10.1-10.2
PP-23	13450	334	112.6	-	112.1	9.9	1237	110.9	26.6	-	-	10.1-10.1
PP-24	13703	340	118.0	-	113.8	9.9	1209	109.4	27.7	-	-	10.0-10.1
PP-25	12758	318	110.2	-	106.8	10.1	1167	102.8	25.3	-	-	10.1-10.1
PP-26	8327	209	76.0	-	70.8	9.7	783	68.6	16.6	-	-	10.1-10.2
PP-27	8377	211	72.8	-	70.4	9.6	780	68.3	16.7	-	-	10.0-10.1
					NEW ORE SAMPLE							
PP-28	2400	160	82.4	-	96.5	9.8	877	79.7	27.4	-	-	10.2-10.2
PP-29	2408	107	82.6	-	135.2	9.9	872	79.9	27.5	-	2.8	10.2-10.2
PP-30	3113	169	82.0	-	141.0	9.7	875	77.1	27.8	-	8.2	10.0-10.0
PP-31	3270	147	113.0	-	246.0	9.7	1227	109.0	38.6	-	-	10.0-10.0
PP-32	3397	192	115.0	-	301.9	9.8	1208	109.5	38.2	-	-	10.1-10.0
PP-33	3390	246	139.0	-	187.9	9.9	1194	109.4	58.3	-	11.5	10.4-10.2
PP-34	3373	257	170.0	-	212.4	9.7	1220	107.9	57.8	-	10.7	10.1-10.1
PP-35	3429	148	128.6	-	197.3	9.7	1176	149.7	41.2	-	9.7	10.1-10.1

Summary - Continued

8.5. Reagent Additions Zinc Circuit - Grams Per Tonne

Test	Zn Rougher + Scavenger						Zn Regrind + Cleaning						
No.	Lime	$CuSO_4$	Z-11	Z-200	MIBC	pH	Lime	$CuSO_4$	Z-11	Z-200	MIBC	1902	pH
PP-1	1198	413	69.9	-	158.5	10.6	1719	-	8.95	18.3	53.2	-	12.1- 9.7
PP-2	1695	554	55.4	15.3	140.6	10.5	1674	110.7	8.37	9.2	130	-	11.9- 9.5
PP-3	1881	622	76.0	39.3	195.4	10.0	1701	111.3	21.2	19.4	112	-	11.8- 9.2
PP-4	4288	609	81.3	33.9	208.6	10.9	1789	118.3	7.5	19.8	129	-	12.0-10.6
PP-5	3604	466	94.6	56.6	148.0	10.5	1948	117.0	23.9	20.4	89	-	12.1-11.1
PP-6	4226	716	93.1	55.2	146.0	10.8	1508	115.0	14.0	21.5	114	-	11.8- 9.9
				R-208	MIBC+ 1012								
PP-7	3613	724	98.3	79.8	84.1	10.3	1627	114.8	2.50	-	74.9	-	11.5-11.3
PP-8	5293	1158	145.7	46.2	258.5	10.3	1920	219.6	35.9	23.0	25.0	-	11.8-11.3
PP-9	3683	968	121.3	53.9	244.5	10.3	2041	234.0	24.0	24.5	5.0	-	11.9- 8.8
PP-10	3124	978	122.3	139.2	229.0	10.1	1761	209.6	25.0	36.9	76.3	149.7	11.6- 8.8
PP-11	3248	973	154.2	129.2	236.6	10.4	2415	227.0	32.4	37.9	43.4	112.6	11.9- 8.8
PP-12	4732	1301	121.6	169.1	224.5	10.5	2829	240.6	32.5	34.2	42.9	51.1	12.1- 9.0
PP-13	4121	1013	94.7	133.7	146.3	10.4	1880	188.6	25.3	13.3	33.4	13.3	11.6- 8.7
PP-14	3522	708	88.3	99.1	165.8	10.4	1823	175.8	23.8	12.4	31.2	36.3	11.9- 9.4
PP-15	3009	557	69.5	78.0	131.2	10.4	1477	141.2	18.7	9.8	24.5	29.6	11.9- 9.0
PP-16	3243	585	73.2	93.7	137.8	10.4	1463	146.3	19.4	10.2	25.8	30.6	12.1- 9.3
PP-17	3293	570	71.9	79.3	127.2	10.4	2370	133.7	19.0	9.5	25.5	28.0	12.2- 9.8
PP-18	2841	574	71.7	80.3	135.1	10.5	2501	145.4	19.4	10.0	25.3	29.4	12.4- 9.1
PP-19	3015	574	71.7	80.4	135.2	10.3	2266	143.6	19.3	10.1	25.3	28.7	12.2- 9.4
PP-20	4479	845	105.4	118.8	199.0	10.6	3232	214.1	28.3	14.8	37.2	44.2	12.4- 9.0
PP-21	4373	888	111.0	124.3	201.2	10.5	2642	223.5	37.0	15.5	39.0	74.7	12.0- 8.8
PP-22	3787	886	110.2	124.0	208.5	10.4	1823	218.5	37.2	15.5	39.0	71.8	12.1- 9.0
PP-23	4049	890	110.7	124.6	137.1	10.4	1713	219.5	37.2	15.6	39.2	76.4	11.9- 9.2
PP-24	3988	912	113.7	127.6	140.4	10.4	1823	227.9	38.4	16.0	40.1	74.0	11.7- 9.0
PP-25	3926	849	106.4	118.8	134.1	10.3	1719	212.2	35.4	14.9	37.4	67.1	11.7- 8.9
PP-26	2136	562	70.3	78.7	88.1	10.2	2172	138.7	23.4	9.8	24.7	51.4	12.1- 9.2
PP-27	1951	557	69.6	78.0	87.5	10.0	1973	139.7	23.2	10.0	24.5	42.1	12.4-10.0
					NEW ORE SAMPLE								
PP-28	2304	640	72.3	89.6	142.5	11.1	1621	160.0	25.6	17.9	28.2	50.1	12.1- 8.7
PP-20	2205	642	64.2	89.9	56.5	11.1	1927	157.0	26.2	18.5	28.3	63.5	12.2- 9.3
PP-30	2237	642	64.2	89.9	56.5	11.0	1990	159.4	26.3	18.4	28.3	55.4	12.1- 9.0
PP-31	3446	1090	102.7	123.7	101.3	11.0	2629	222.4	36.5	33.9	38.9	75.9	12.0- 9.5
PP-32	3001	1147	142.6	126.1	143.0	10.6	2583	213.2	59.2	40.4	36.9	113.7	12.0- 9.2
PP-33	3106	1330	134.2	163.7	201.3	10.9	2452	220.8	58.0	36.1	38.9	112.7	12.1- 9.1
PP-34	2638	1176	132.0	170.6	132.9	10.7	2638	220.4	66.9	36.5	38.8	100.4	12.0- 9.0
PP-35	2908	1172	131.9	164.1	137.8	10.4	2923	219.8	66.7	36.4	38.7	43.8	12.1- 9.0

Summary - Continued

8.6. Metallurgical Results

Test No.	Product	Weight %	Assays %, g/tonne			% Distribution		
			Pb	Zn	Ag	Pb	Zn	Ag
PP-1	Pb Cl. Conc.	2.33	68.2	2.18	-	70.0	1.3	-
	Zn Cl. Conc.	5.43	0.67	53.6	-	1.6	73.9	-
	Zn Comb. Tail.	92.24	0.70	1.06	-	28.4	24.8	-
	Cyclone O'Flow	100.00	2.27	3.94	-	100.0	100.0	-
PP-2	Pb Cl. Conc.	2.97	60.8	4.25	-	73.9	3.3	-
	Zn Cl. Conc.	5.60	0.60	53.9	-	1.4	78.6	-
	Zn Comb. Tail.	91.43	0.66	0.76	-	24.7	18.1	-
	Cyclone O'Flow	100.00	2.44	3.84	-	100.0	100.0	-
PP-3	Pb Cl. Conc.	3.04	59.4	4.43	-	77.4	3.6	-
	Zn Cl. Conc.	5.87	0.43	53.5	-	1.1	84.2	-
	Zn Comb. Tail.	91.09	0.55	0.50	-	21.5	12.2	-
	Cyclone O'Flow	100.00	2.33	3.73	-	100.0	100.0	-
PP-4	Pb Cl. Conc.	3.09	57.4	4.95	-	77.1	4.1	-
	Zn Cl. Conc.	5.70	0.27	53.2	-	0.7	80.8	-
	Zn Comb. Tail.	91.21	0.56	0.62	-	22.2	15.1	-
	Cyclone O'Flow	100.00	2.30	3.75	-	100.0	100.0	-
PP-5	Pb Cl. Conc.	3.10	56.5	3.75	-	76.4	3.1	-
	Zn Cl. Conc.	5.58	0.53	50.0	-	1.3	75.4	-
	Zn Comb. Tail.	91.32	0.56	0.87	-	22.3	21.5	
	Cyclone O'Flow	100.00	2.29	3.70	-	100.0	100.0	-
PP-6	Pb Cl. Conc.	3.06	59.6	3.04	-	76.3	2.4	-
	Zn Cl. Conc.	5.96	0.37	54.1	-	0.9	83.3	-
	Zn Comb. Tail.	90.98	0.60	0.61	-	22.8	14.3	-
	Cyclone O'Flow	100.00	2.39	3.87	-	100.0	100.0	-
PP-7	Pb Cl. Conc.	2.74	66.2	3.8	-	76.6	2.7	-
	Zn Cl. Conc.	5.47	0.41	51.7	-	0.9	73.6	-
	Zn Comb. Tail.	91.79	0.58	0.99	-	22.5	23.7	-
	Cyclone O'Flow	100.00	2.37	3.84	-	100.0	100.0	-

Summary - Continued

8.6. Metallurgical Results - Cont'd

Test	Product	Weight	Assays %, g/tonne			% Distribution		
No.		%	Pb	Zn	Ag	Pb	Zn	Ag
PP-8	Pb Cl. Conc.	2.96	61.2	3.9	-	77.2	3.0	-
	Zn Cl. Conc.	6.50	0.64	51.30	-	1.7	87.1	-
	Zn Comb. Tail.	90.52	0.55	0.42	-	21.1	9.9	-
	Cyclone O'Flow	100.00	2.36	3.83	-	100.0	100.0	-
PP-9	Pb Cl. Conc.	2.58	69.1	2.4	501.13	75.8	1.6	60.3
	Zn Cl. Conc.	6.56	0.43	52.5	38.32	1.2	88.8	11.7
	Zn Comb. Tail.	90.86	0.59	0.41	6.62	23.0	9.6	28.0
	Cyclone O'Flow	100.00	2.35	3.88	21.46	100.0	100.0	100.0
PP-10	Pb Cl. Conc.	2.61	68.2	2.82	486.38	76.7	1.9	58.2
	Zn Cl. Conc.	6.24	0.34	52.0	34.86	0.9	85.6	10.0
	Zn Comb. Tail.	91.15	0.57	0.52	7.62	22.4	12.5	31.8
	Kason U'Size	100.00	2.32	3.79	21.82	100.0	100.0	100.0
PP-11	Pb Cl. Conc.	2.86	67.5	2.30	-	76.6	1.6	-
	Zn Cl. Conc.	6.33	0.44	52.1	-	1.1	83.8	-
	Zn Comb. Tail.	90.81	0.62	0.64	-	22.3	14.6	-
	Cyclone O'Flow	100.00	2.52	3.94	-	100.0	100.0	-
PP-12	Pb Cl. Conc.	2.88	65.1	2.68	-	75.9	1.9	-
	Zn Cl. Conc.	6.49	0.54	51.6	-	1.4	84.6	-
	Zn Comb. Tail.	90.63	0.62	0.59	-	22.7	13.5	-
	Cyclone O'Flow	100.00	2.47	3.96	-	100.0	100.0	-
PP-13	Pb Cl. Conc.	2.79	63.4	4.56	-	73.2	3.3	-
	Zn Cl. Conc.	6.56	0.78	50.6	-	2.1	85.7	-
	Zn Comb. Tail.	90.65	0.66	0.47	-	24.7	11.0	-
	Cyclone O'Flow	100.00	2.42	3.87	-	100.0	100.0	-
PP-14	Pb Cl. Conc.	4.04	45.8	7.89	-	77.0	8.2	-
	Zn Cl. Conc.	5.76	0.66	51.7	-	1.6	76.3	-
	Zn Comb. Tail.	90.20	0.57	0.67	-	21.4	15.5	
	Kason U'Size	100.00	2.40	3.90	-	100.0	100.0	-

Summary - Continued

8.6. Metallurgical Results - Cont'd

Test	Product	Weight	Assays, %, g/tonne			% Distribution		
No.		%	Pb	Zn	Ag	Pb	Zn	Ag
PP-15	Pb Cl. Conc.	2.74	63.0	4.01	454.48	73.2	2.9	59.1
	Zn Cl. Conc.	6.56	1.22	50.0	44.75	3.4	85.1	13.9
	Zn Comb. Tail.	90.70	0.61	0.51	6.29	23.4	12.0	27.0
	Kason U'Size	100.00	2.36	3.85	21.09	100.0	100.0	100.0
PP-16	Pb Cl. Conc.	2.84	63.6	2.40	-	73.5	1.7	-
	Zn Cl. Conc.	6.55	1.10	51.4	-	2.9	85.4	-
	Zn Comb. Tail.	90.61	0.64	0.56	-	23.6	12.9	-
	Kason U'Size	100.00	2.46	3.94	-	100.0	100.0	-
PP-17	Pb Cl. Conc.	2.57	67.6	3.17	-	72.2	2.1	-
	Zn Cl. Conc.	6.02	0.94	50.9	-	2.4	80.2	-
	Zn Comb. Tail.	91.41	0.67	0.74	-	25.4	17.7	-
	Kason U'Size	100.00	2.41	3.82	-	100.0	100.0	-
PP-18	Pb Cl. Conc.	2.85	61.6	5.06	-	72.3	3.7	-
	Zn Cl. Conc.	6.46	1.16	49.0	-	3.1	81.0	-
	Zn Comb. Tail.	90.69	0.66	0.66	-	24.6	15.3	-
	Kason U'Size	100.00	2.43	3.91	-	100.0	100.0	-
PP-19	Pb Cl. Conc.	2.66	64.3	4.08	-	72.1	2.8	-
	Zn Cl. Conc.	6.46	1.66	46.8	-	4.5	78.9	-
	Zn Comb. Tail.	90.88	0.61	0.77	-	23.4	18.3	-
	Kason U'Size	100.00	2.37	3.83	-	100.0	100.0	-
PP-20	Pb Cl. Conc.	2.50	66.2	3.88	-	71.9	2.6	-
	Zn Cl. Conc.	6.39	1.16	48.3	-	3.2	82.5	-
	Zn Comb. Tail.	91.11	0.63	0.61	-	24.9	14.9	-
	Kason U'Size	100.00	2.30	3.74	-	100.0	100.0	-
PP-21	Pb Cl. Conc.	2.63	67.3	3.68	-	74.3	2.6	-
	Zn Cl. Conc.	6.56	1.18	48.8	-	3.2	84.5	-
	Zn Comb. Tail.	90.81	0.59	0.54	-	22.5	12.9	-
	Kason U'Size	100.00	2.38	3.79	-	100.0	100.0	-

Summary - Continued

8.6. Metallurgical Results - Cont'd

Test No.	Product	Weight %	Assays, %, g/tonne			% Distribution		
			Pb	Zn	Ag	Pb	Zn	Ag
PP-22	Pb Cl. Conc.	2.46	66.7	2.79	-	73.3	2.0	-
	Zn Cl. Conc.	6.29	1.07	49.0	-	2.9	88.6	-
	Zn Comb. Tail.	91.25	0.58	0.36	-	23.8	9.4	-
	Kason U'Size	100.00	2.24	3.48	-	100.0	100.0	-
PP-23	Pb Cl. Conc.	2.92	62.6	4.20	-	76.2	3.2	-
	Zn Cl. Conc.	6.67	0.82	50.1	-	2.3	86.3	-
	Zn Comb. Tail.	90.41	0.57	0.45	-	21.5	10.5	-
	Kason U'Size	100.00	2.40	3.87	-	100.0	100.0	-
PP-24	Pb Cl. Conc.	2.56	67.9	3.52	-	74.8	2.4	-
	Zn Cl. Conc.	6.25	0.61	51.8	-	1.6	84.8	-
	Zn Comb. Tail.	91.19	0.60	0.54	-	23.6	12.8	-
	Kason U'Size	100.00	2.32	3.82	-	100.0	100.0	-
PP-25	Pb Cl. Conc.	2.76	67.3	3.22	-	77.1	2.3	-
	Zn Cl. Conc.	6.59	0.66	50.9	-	1.8	87.3	-
	Zn Comb. Tail.	90.65	0.56	0.44	-	21.1	10.4	-
	Kason U'Size	100.00	2.41	3.84	-	100.0	100.0	-
PP-26	Pb Cl. Conc.	2.62	67.2	3.78	-	73.8	2.6	-
	Zn Cl. Conc.	6.09	1.55	49.8	-	4.0	80.6	-
	Zn Comb. Tail.	91.29	0.58	0.69	-	22.2	16.8	-
	Kason U'Size	100.00	2.38	3.76	-	100.0	100.0	-
PP-27	Pb Cl. Conc.	2.54	67.2	3.42	-	73.8	2.4	-
	Zn Cl. Conc.	5.50	0.99	50.8	-	2.4	77.7	-
	Zn Comb. Tail	91.96	0.60	0.78	-	23.8	19.9	-
	Kason U'Size	100.00	2.31	3.60	-	100.0	100.0	-
			NEW ORE SAMPLE					
PP-28	Pb Cl. Conc.	2.63	73.2	3.38	-	80.2	2.0	-
	Zn Cl. Conc.	7.07	0.84	53.3	-	2.5	86.0	-
	Zn Comb. Tail.	90.30	0.46	0.58	-	17.3	12.0	-
	Kason U'Size	100.00	2.40	4.38	-	100.0	100.0	-

Summary - Continued

8.6. Metallurgical Results - Cont'd

New Ore Sample - Cont'd

Test No.	Product	Weight %	Assays, %, g/tonne			% Distribution		
			Pb	Zn	Ag	Pb	Zn	Ag
PP-29	Pb Cl. Conc.	2.77	70.0	3.72	-	77.9	2.4	-
	Zn Cl. Conc.	6.30	0.53	55.0	-	1.3	81.2	-
	Zn Comb. Tail.	90.93	0.57	0.77	-	20.8	16.4	-
	Kason U'Size	100.00	2.49	4.27	-	100.0	100.0	-
PP-30	Pb Cl. Conc.	2.98	70.8	3.58	-	79.4	2.5	-
	Zn Cl. Conc.	6.02	0.49	55.6	-	1.1	77.8	-
	Zn Comb. Tail.	91.00	0.57	0.93	-	19.5	19.7	-
	Kason U'Size	100.00	2.66	4.30	-	100.0	100.0	-
PP-31	Pb Cl. Conc.	2.60	77.6	1.86	-	82.2	1.1	-
	Zn Cl. Conc.	6.98	0.56	54.3	-	1.6	86.9	-
	Zn Comb. Tail.	90.42	0.44	0.58	-	16.2	12.0	-
	Kason U'Size	100.00	2.45	4.36	-	100.0	100.0	-
PP-32	Pb Cl. Conc.	2.42	77.0	2.10	-	79.4	1.2	-
	Zn Cl. Conc.	6.95	0.57	54.6	-	1.7	87.0	-
	Zn Comb. Tail.	90.63	0.49	0.57	-	18.9	11.8	-
	Kason U'Size	100.00	2.35	4.36	-	100.0	100.0	-
PP-33	Pb Cl. Conc.	2.65	73.4	2.87	-	80.7	1.7	-
	Zn Cl. Conc.	7.13	0.47	55.0	-	1.4	89.1	-
	Zn Comb. Tail.	90.22	0.48	0.45	-	17.9	9.2	-
	Kason U'Size	100.00	2.41	4.40	-	100.0	100.0	-
PP-34	Pb Cl. Conc.	2.80	69.5	3.28	-	81.1	2.1	-
	Zn Cl. Conc.	6.93	0.44	55.5	-	1.3	87.6	-
	Zn Comb. Tail.	90.27	0.47	0.50	-	17.6	10.3	-
	Kason U'Size	100.00	2.40	4.39	-	100.0	100.0	-
PP-35	Pb Cl. Conc.	2.60	74.7	2.12	-	82.3	1.3	-
	Zn Cl. Conc.	6.94	0.42	55.5	-	1.2	89.1	-
	Zn Comb. Tail.	90.46	0.43	0.46	-	16.5	9.6	-
	Kason U'Size	100.00	2.36	4.32	-	100.0	100.0	-

DISCUSSION

1. Primary Grind

1.1. Operation

The primary grind consisted of a Hendy mill in closed-circuit with a 50.8 mm P50 Dorr cyclone. The circuit was stable during the testwork and the required fineness of grind was readily produced.

1.2. Fineness of Grind

During the course of the testwork the following grinds were examined:

a) In tests PP1 to PP3, PP15 to PP19 and PP26 to PP30 the ore was ground to 55 % - 60 % passing 200 mesh (K_{80} = 130 µm).

b) In tests, PP4 to PP10, PP24 to PP25, and PP31 to PP35 the ore was ground to 88 % - 91 % passing 200 mesh (K_{80} = 40 - 55 µm).

c) In tests PP11 and PP12 the ore was ground to 97 % passing 200 mesh (K_{80} = 30 µm).

d) In tests PP20 to PP23 the ore was ground to 78 % passing 200 mesh (K_{80} = 75 to 77 µm).

The required fineness of grind was obtained by adjusting the steel ball load distribution, the pulp density in the cyclone feed and the mill feed rate using mathematical formulas described in the literature. Typical product size distributions in the cyclone overflow at different fineness of grind are shown in tables No. 1a and b.

ribution at Different Fineness of Grind -

Medium (Test 21)			Fine (Test 9)		
% Retained		% Pass.	% Retained		% Pass.
Ind.	Cum.	Cum.	Ind.	Cum.	Cum.
-	-	-	-	-	-
0.5	0.5	99.5	-	-	-
0.9	1.4	98.6	0.1	0.1	99.9
2.6	4.0	96.0	0.4	0.5	99.5
5.8	9.7	90.3	1.6	2.1	97.9
10.4	20.1	79.9	4.4	6.5	93.5
14.4	34.5	65.5	9.0	15.5	84.5
12.3	46.8	53.2	11.0	26.5	73.5
53.2	100.0	-	73.5	100.0	-
100.0	-	-	100.0	-	-

Fine (Test 32)		
% Retained		% Pass.
Ind.	Cum.	Cum.
0.1	0.1	99.9
0.2	0.3	99.7
0.8	1.1	98.9
2.1	3.2	96.8
8.2	11.4	88.6
8.7	20.1	79.9
17.1	37.2	62.8
62.8	100.0	-
100.0	-	-

ead 1st cleaner scavenger
containing 250 kilograms mixed
ss of regrind was obtained by
clone feed.
egrind mill was varied from

inc first cleaner scavenger
ning 110 kilograms of 12.7 mm
city from test PP23 to test PP35
one underflow in these tests was
It should be noted that the feed
hour to 120 kilograms per hour,
eness of the reground zinc
not be measured, because the
ter on the Energy-Demand meter.

rmine the effect of grinding
metallurgical results.
pilot plant sample produced
ere acceptable and clearly
he lead and zinc metallurgy.

Discussion.- Continued

4.1. General - Cont'd

The following differences between laboratory and pilot plant results were considered to be important:

1. The laboratory results indicated (Table No. 2) that the fineness of grind in the range tested had no appreciable effect on the final lead and zinc metallurgical results.

Table No. 2

Effect of Fineness of Primary Grind on Lead and Zinc Metallurgical Results - PP Sample No. 1 Laboratory Test Results

Test	Primary Grind		Regrind Time		Product	Weight	Assays, %		% Distributi	
No.	Time Min.	% Pass. 200 m	Pb	Zn		%	Pb	Zn	Pb	Z
L-2	20	71.6	20	20	Pb Cl. Conc.	3.39	51.7	4.96	73.2	4.
					Pb 1st Cl. Conc.	6.43	28.7	7.40	77.2	12.
					Zn Cl. Conc.	4.21	0.55	52.7	1.0	57.
					Zn Ro. Conc.	14.40	1.05	22.6	6.3	83.
					Zn Flot. Tail.	79.17	0.50	0.20	16.5	4.
L-3	30	86.0	20	20	Pb Cl. Conc.	3.51	49.0	4.96	72.2	4.
					Pb 1st Cl. Conc.	6.60	27.5	7.27	76.1	12.
					Zn Cl. Conc.	5.08	0.49	53.7	1.0	69.
					Zn Ro. Conc.	16.82	1.06	19.8	7.5	84.
					Zn Flot. Tail.	76.58	0.51	0.18	16.4	3.
L-4	40	91.6	20	20	Pb Cl. Conc.	3.50	50.5	4.80	73.8	4.
					Pb 1st Cl. Conc.	6.70	27.9	7.06	78.1	12.
					Zn Cl. Conc.	4.35	0.45	51.20	0.8	57.
					Zn Ro. Conc.	15.73	1.07	20.70	7.0	84.
					Zn Flot. Tail.	77.57	0.46	0.16	14.9	3.

2. The zinc assays of the zinc flotation tailing were two to three times lower as compared to those of the pilot plant tests. This strongly indicated that the zinc losses in the tailing may come from the zinc that was floated in the lead rougher circuit and was rejected during lead cleaning.

Discussion - Continued

4.1. General - Cont'd

3. The laboratory test results indicated (Table No. 3) that with a finer lead concentrate regrind the lead concentrate grade increased but that the recovery decreased.

Table No. 3

Effect of Fineness of Lead and Zinc Concentrate Regrind Using Coarse Primary Grind

Test	Primary Grind		Regr. Time, Min.		Product	Weight	Assays, %		% Distr.	
No.	Time Min.	% minus 200 m	Lead	Zinc		%	Pb	Zn	Pb	Zn
L-5	20	71.6	30	30	Pb Cl. Conc.	3.13	55.4	4.15	72.0	3.
					Pb 1st Cl. Conc.	5.98	30.8	6.69	76.4	10.
					Zn Cl. Conc.	5.42	0.57	50.0	1.3	70.
					Zn Ro. Conc.	16.56	1.09	19.80	7.6	85.
					Zn Flot. Tail.	77.46	0.50	0.17	16.0	3.
L-6	20	71.6	40	40	Pb Cl. Conc.	2.82	59.6	3.09	70.8	2.
					Pb 1st Cl. Conc.	5.44	33.3	5.94	76.2	8.
					Zn Cl. Conc.	3.77	0.53	51.50	0.80	50.
					Zn Ro. Conc.	15.18	1.16	22.50	7.4	87.
					Zn Flot. Tail.	79.38	0.49	0.19	16.4	3.
L-7	20	71.6	60	60	Pb Cl. Conc.	2.34	63.7	2.09	64.6	1.
					Pb 1st Cl. Conc.	5.07	33.9	5.32	74.5	7.
					Zn Cl. Conc.	4.33	0.61	51.30	1.1	57.
					Zn Ro. Conc.	13.15	1.23	25.7	7.0	88.
					Zn Flot. Tail.	81.78	0.52	0.22	18.5	4.

The most significant factor in the flotation response of the ore was the oxidation. As the pilot plant sample was oxidized, the selectivity between lead, zinc and pyrite was difficult to control. Therefore, the satisfactory results obtained in the pilot plant were possible by maintaining close control of the rougher and cleaning conditions in both the lead and the zinc circuits. The evaluation of the effect of the size reduction on the lead and zinc metallurgical results is rather difficult especially when the fineness of lead and zinc concentrate regrind was varied.

Discussion - Continued

4.1. General - Cont'd

The difference in the metallurgical results at different fineness of primary grind and concentrate regrind may be more pronounced on regular ore. This is evident from the results shown in Table No. 4 below.

Table No. 4

Comparison of Standard Laboratory Test Results on Normal and Oxidized Cyprus Anvil Ore

Test No.		Product	Weight %	Assays, %		% Distribution	
				Pb	Zn	Pb	Zn
3*	Normal (laboratory sample)	Pb Cl. Conc.	3.51	73.1	3.38	86.3	2.8
		Pb 1st Cl. Conc.	6.80	41.6	6.49	95.2	10.3
		Zn Cl. Conc.	7.48	0.48	49.10	1.2	85.4
		Zn Ro. Conc.	16.74	0.36	22.50	1.9	87.7
		Zn Flot. Tail.	76.46	0.11	0.11	2.9	2.0
ML-2	Oxidized (PP Sample)	Pb Cl. Conc.	3.39	51.7	4.96	73.2	4.3
		Pb 1st Cl. Conc.	6.43	28.7	7.40	77.2	12.2
		Zn Cl. Conc.	4.21	0.55	52.70	1.0	57.1
		Zn Ro. Conc.	14.40	1.05	22.6	6.3	83.7
		Zn Flot. Tail.	79.17	0.50	0.20	16.3	4.1

* Progress Report No. 5

Test No. 3 was conducted on the Cyprus Anvil normal ore and test ML-2 on the pilot plant sample. The conditions for both tests were the same. These results clearly demonstrated the differences in the flotation responses of normal and oxidized ores.

Discussion - Continued

4.1. General - Cont'd

It should be pointed out that specific changes introduced in the pilot plant could have contributed to the improved metallurgical results. Some of these are:

1. In tests with a coarse primary grind, appreciable amounts of plus 35 mesh product were contained in the cyclone overflow. This product was screened out and recycled to the mill. The fraction was light (2.8 cm^3/ g specific gravity) and contained 2.4 % Pb and 3.5 % Zn. Normally, this material would be passed to the flotation circuit and would not float because of the size. Screening and regrinding of this material would result in improved lead and zinc concentrate recoveries.
2. The low pulp density in both lead and zinc cleaning stages improved the cleaning efficiency.

4.2. Evaluation of Results

4.2.1. Preliminary Tests

A series of eight preliminary tests were conducted to investigate the following variables:

1. Flowsheet configuration. The point at which the lead and the zinc first cleaner tailings respectively were introduced into the circuits as well as the cleaning times were varied in these tests. The final flowsheet (see SUMMARY) was established after test PP7 and was not changed throughout the remainder of the testwork.
2. Level and point of reagent additions were extensively changed in these tests to establish optimum quantities and positions. High soda ash (8 kg/tonne) and cyanide (0.3 kg/t) additions in the lead flotation were required for treatment of bulk sample No. 1. Collector R-242, tested in the initial pilot plant runs, was omitted in tests PP9 to PP35. Froth removal in the zinc rougher stage was difficult and high frother additions were required to maintain a reasonable froth discharge.

Discussion - Continued

4.2.1. Preliminary Tests - Cont'd

3. Low pulp densities in the lead cleaning stages improved the concentrate grade markedly.

Typical results obtained in these tests are summarized in Table No. 5 below. The conditions established in tests PP7 and PP8 were maintained unchanged throughout the remainder of the testwork and only the fineness of primary grind and lead and zinc concentrate regrinds were varied.

Table No. 5

Preliminary Test Results

Test No.	Product	Weight %	Assays, %		% Distribution		Test Conditions
			Pb	Zn	Pb	Zn	
3	Pb Cl. Conc. Zn Cl. Conc. Zn Comb. Tail.	3.04 5.87 91.09	59.4 0.43 0.55	4.43 53.50 0.50	77.4 1.1 21.5	3.6 84.2 12.2	Standard Flowsheet Short cleaning times
	Cyclone O'Flow	100.00	2.33	3.73	100.0	100.0	
6	Pb Cl. Conc. Zn Cl. Conc. Zn Comb. Tail.	3.06 5.96 90.98	59.6 0.37 0.60	3.04 54.10 0.61	76.3 0.9 22.8	2.4 83.3 14.3	Modified Flowsheet Increased cleaning Times
	Cyclone O'Flow	100.0	2.39	3.87	100.0	100.0	
7	Pb Cl. Conc. Zn Cl. Conc. Zn Comb. Tail.	2.74 5.47 91.79	66.2 0.41 0.58	3.80 51.7 0.99	76.6 0.9 22.5	2.7 73.6 23.7	As for test No. 6 Low pulp density
	Cyclone O'Flow	100.00	2.37	3.84	100.0	100.0	

Discussion - Continued

4.2.2. Effect of Fineness of Primary Grind and Lead Concentrate Regrind on Grade and Recovery of Lead

In tests PP9 to PP35 the fineness of the primary grind was varied from 55 % passing 200 mesh to 97 % passing 200 mesh. At the same time the fineness of the lead concentrate regrind was changed from 53 % to 92 % passing 20 μm. The results and conditions for the representative tests are summarized in table No. 6 below.

Table No. 6

Effect of Fineness of Pb Concentrate Regrind on Concentrate Grade and Recovery

Test No. PP	Sample No.	Primary Grind Fineness % Pass. 200 m	Pb Regrind		Lead Final Concentrate				
			% Pass. 20 μm	K_{80} μm Product	Weight %	Assays, %		% Distribution	
						Pb	Zn	Pb	Zn
9	1	92.0	91	20.4	2.58	69.1	2.40	75.8	1.6
10	1	91.7	84	18.0	2.61	68.2	2.82	76.7	1.9
11	1	96.7	85	18.0	2.86	67.5	2.30	76.6	1.6
18	1	60.4	52	35.7	2.85	61.6	5.06	72.3	3.7
19	1	55.2	53	43.8	2.66	64.3	4.08	72.1	2.8
20	1	77.2	52	42.4	2.50	66.2	3.88	71.9	2.6
25	1	85.9	87	18.0	2.76	67.3	3.22	77.1	2.3
29	2	59.1	68	26.0	2.77	70.0	3.72	77.9	2.4
30	2	57.8	67	26.0	2.98	70.8	3.58	79.4	2.5
31	2	82.7	87	16.5	2.60	77.6	1.86	82.2	1.1
35	2	92.1	83	18.0	2.60	74.7	2.12	82.3	1.3

The results obtained indicated that increasing the fineness of the primary grind and using a fine lead concentrate regrind improved the grade of the final lead concentrate as well as the overall lead recovery. There was no evidence, however, of changes in the grade of the lead rougher concentrate or in the weight recovery when the fineness of the primary grind was changed. The selectivity between lead and zinc improved with increasing fineness of the primary grind.

Discussion - Continued

4.2.3. Effect of Fineness of Lead Concentrate Regrind Using Coarse Primary Grind

In a series of tests PP15 to PP27 attempts were made to determine the effect of the fineness of lead concentrate regrind on the grade and recovery of lead when using a coarse primary grind.

The results obtained in these tests are compared in Table No. 7.

Table No. 7

Effect of Fineness of Lead Concentrate Regrind Using Coarse Primary Grind - Sample No. 1

Test	Primary Grind	Pb Regrind		Lead Final Concentrate				
No.	% Pass.	% Pass.	K_{80}	Weight	Assays, %		% Distribution	
PP	200 m	20 µm	Product	%	Pb	Zn	Pb	Zn
15	56.9	66.5	36.5	2.74	63.0	4.01	73.2	2.9
16	60.3	89.9	20.0	2.84	63.6	2.40	73.5	1.7
17	59.4	79.0	25.6	2.57	67.6	3.17	72.2	2.1
26	54.1	58.0	40.3	2.62	67.2	3.78	73.8	2.6
27	53.5	57.5	40.3	2.54	67.2	3.42	73.8	2.4

Lead concentrate grade and lead recovery could not be directly related to the changes in the fineness of grind. The only trend that could be established was the better zinc rejection with a finer product.

Discussion - Continued

4.2.4. Effect of Fineness of Primary Grind on the Grade and Recovery of Zinc

The relationship between primary grind and zinc metallurgical results was difficult to establish. There may be numerous interactions that affect this system as shown by means of two examples:

1. There may exist an optimum fineness in the primary circuit that regulates the amount of zinc displaced in the lead circuit. As fine regrinding of the lead concentrate improves the liberation of the Pb-Zn minerals, it may at the same time affect the flotation characteristic of the fine zinc that is entering the zinc circuit via the Pb cleaner tailing.
2. The advanced state of oxidation made the zinc rougher flotation sensitive, resulting in fluctuations in the weight recovery. This in turn interfered with the control of the zinc regrinding circuit.

Table No. 8

Effect of Zinc Primary Grind on Zinc Flotation

Test	Sample	Primary Grind	Zn Regrind		Zinc Final Concentrate				
No.		% Pass.	% Pass.	K_{80}	Weight	Assays, %		% Distribution	
PP	No.	200 m	20 µm	Product	%	Pb	Zn	Pb	Zn
9	1	92.9	83.0	20.0	6.56	0.43	52.5	1.2	88.8
10	1	91.7	83.0	20.0	6.24	0.34	52.0	0.9	85.6
15	1	56.9	27.0	62.0	6.56	1.22	50.0	3.4	85.2
16	1	60.3	37.0	52.0	6.55	1.10	51.4	2.9	85.4
23	1	78.4	67.0	24.0	6.67	0.82	50.1	2.3	86.3
24	1	89.5	79.0	20.0	6.25	0.61	51.8	1.6	84.8
25	1	85.9	75.0	22.0	6.59	0.66	50.9	1.8	87.3
26	1	54.1	42.0	50.0	6.09	1.55	49.8	4.0	80.6
27	1	53.5	42.0	50.0	5.50	0.99	50.8	2.4	77.7
28	2	56.1	49.0	40.6	7.07	0.84	53.3	2.5	86.0
31	2	82.7	66.0	25.0	6.98	0.56	54.3	1.6	86.9
33	2	92.7	79.0	20.5	7.13	0.47	55.0	1.4	89.2
35	2	92.1	74.0	22.0	6.94	0.42	55.5	1.2	89.1

The results shown in Table No. 8 suggest an increased zinc recovery with an increase in the fineness of primary grind. The concentrate grade was not affected.

Discussion - Continued

4.2.5. Effect of Zinc Concentrate Regrind Using a Coarse Primary Grind

In tests PP15 to PP27, attempts were made to evaluate the effect of various regrinding sizes on the grade and recovery of zinc. The conditions and results for these tests are summarized in table No. 9 below.

Table No. 9

Effect of Fineness of Zinc Concentrate Regrind Using Coarse Primary Grind - Sample No. 1

Test No. PP	Primary Grind % Pass. 200 m	Zn Regrind		Zinc Final Concentrate				
		% Pass. 20 µm	K_{80} Product	Weight %	Assays, %		% Distribution	
					Pb	Zn	Pb	Zn
15	56.9	27	62	6.56	1.22	50.0	3.4	85.1
16	60.3	37	52	6.55	1.10	51.4	2.9	85.4
17	59.4	28	66	6.02	0.94	50.9	2.4	80.2
26	54.1	42	50	6.09	1.55	49.8	4.0	80.6
27	53.5	42	50	5.50	0.99	50.8	2.4	77.7

Because of the variable weight recovery in the zinc rougher circuit it was not possible to achieve a fine product.

The insignificant changes in the concentrate grades were not attributable to the differences in fineness of grind.

SAMPLING

1. Grinding and Flotation Circuits

The grinding and flotation circuits were operated 4 to 6 hours to obtain equilibrium conditions before samples were removed for analyses.

2. Assay Samples

Composite samples of the grinding and flotation circuit products were taken at 20 to 30 minute intervals during the test period. The sampling was conducted with individual sample cutters of approximately 400 milliliters capacity with 12.7 mm by 150 mm openings. Several of the circuit products were sampled in 250 ml or 500 ml capacity plastic cups. The samples were accumulated for the duration of the sample period, and were then filtered and dried.

3. Pulp Density Samples

Pulp density samples were taken every 30 minutes in the grinding circuit and every hour in the flotation circuit. A direct-reading Marcy pulp balance, equipped with a one litre sample container was employed for these tests. The pulp densities were recorded in grams per litre.

4. Sample Preparation

The composite pulp samples were filtered in Denver vacuum filters. The filter cakes were transferred to pans, and oven-dried overnight at 80°C. The minus 12.5 mm ball mill feed sample was weighed prior to drying to obtain the moisture content.

4. Sample Preparation - Cont'd

The following procedure was employed in the assay sample preparation:

1. Weigh sample
2. Break up sample on 10 mesh screen
3. Riffle down to manageable size
4. Bag the reject portion
5. Pulverize in disc mill for 2 - 3 minutes
6. Screen sample on 100 mesh screen
7. Plus 100 mesh fraction ground with pestle and mortar, screened to 100 % passing 100 mesh, and mixed with remainder of minus 100 mesh fraction.
8. Minus 100 mesh fraction reduced by coning and quartering and submitted for assays.

REAGENTS

1. Reagent Suppliers

Abbreviation	Name	Suppliers
Na_2CO_3	Soda Ash	Allied Chemicals
NaCN	Sodium Cyanide	Nymoc Products Company
$Ca(OH)_2$	Hydrated Spray Lime	Guelph Dolime Limited
AX-343	Sodium iso-propyl xanthate	Cyanamid
D-1012	Poly Propylene glycol	Dow Chemicals
MIBC	Methyl iso-butyl carbinol	Dominion Cisco Limited
Z-200	isopropyl-ethylthionocarbamate	Dow Chemicals
D-1902	Vegetable Starch	Stein Hall
$CuSO_4$	Copper Sulphate	Bate Chemical Company Limited

2. Reagent Preparation

Reagent	Concentration
Na_2CO_3	10%-15%
NaCN	2%
$Ca(OH)_2$	10%
$CuSO_4$	10%
AX-343	1%
MIBC	100%
Z-200	100%
D-1012	100%
D-1902	2%

3. Reagent Feeders

Model "E" Clarkson feeders equipped with head tanks and automatic level control valves, and gravity feeders were used to add reagents to the circuit.

The frother, collectors Z-200 and R-208 were added in drops from gravity feeder bottles of 1 to 3 litre capacities. The reagent rate was measured in milliliters per minute and converted to grams per tonne of ball mill feed. The reagents added in drops were measured in drops per minute and converted to grams per tonne of mill feed, using a factor of grams per drop of each reagent.

METALLURGICAL CALCULATIONS

1. Two Product Formula

The metallurgical balances for the Pb and Zn rougher circuit, the scavenger circuit and for intermediate products were calculated using two product formula.

$$C = F \frac{(f-t)}{(c-t)}$$

Where: C = concentrate, weight %
F = Feed weight %
f = feed assays %
c = concentrate assays %
t = tailing assays %

2. Three Product Formula

Overall metallurgical balance was calculated for each test, using three product formula.

Product	Weight %	Assays, %	
		Pb	Zn
Feed	F	l_1	Z_1
Pb Conc.	L	l_2	Z_2
Zn Conc.	Z	l_3	Z_3
Tailing	T	l_4	Z_4

Metallurgical Calculations - Continued

2. Three Product Formula - Cont'd

$$L = F \times \frac{(l_1 - l_4)(Z_3 - Z_4) - (Z_1 - Z_4)(l_3 - l_4)}{(l_2 - l_4)(Z_3 - Z_4) - (Z_2 - Z_4)(l_3 - l_4)}$$

$$Z = F \times \frac{(l_2 - l_4)(Z_1 - Z_4) - (l_1 - l_4)(Z_2 - Z_4)}{(l_2 - l_4)(Z_3 - Z_4) - (Z_2 - Z_4)(l_3 - l_4)}$$

3. Work Index

Work indices were calculated using the relationship established by F.C. Bond in his Third Theory of Comminution. In order to obtain the 80 % passing size, the size analyses were plotted and the size moduli K_{80} were determined graphically.

$$\text{Work Index} = \frac{E}{10 \cdot \frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}}}$$

Where: E = Grinding energy (kilowatt-hours per metric tonne) consumed to grind material from F to P.

P = Size modulus K_{80} (i.e. size of aperture which would just allow 80 % of the material to pass through the aperture) of ground product

F = Size modulus K_{80} of feed to grinding

EQUIPMENT

06.5 mm Buchanan jaw crusher, driven
ed from minus 300 mm to minus 85 mm in

Model A.P.K. 20, impact crusher, driven
-belts. The gap between the impact
ain the required discharge particle size.

equipped with 12.7 mm screen was used
ecycled to the crusher.

rind. The Joshua Hendy ball mill was a
1130.3 mm diameter and 846.6 mm in
ent of the total grate area in the form
grate was conveyed by radial lifters
square lifter bars were installed at
15 horsepower motor; through sheaves,
he mill was 32 revolutions per minute
as equipped with a 230 mm trommel.

by a Sangamo Type ED30 demand Energy Meter,
tive meter. A nominal efficiency of 95 %
The no-load power of the mill was calculated
perating empty. The net power consumption was

forged steel balls, with diameters ranging

ll was controlled by an automatic weightometer
by the Merrick Scale Manufacturing Company.
quipped with a feed control gate, which main-
n). The feed rate was directly proportional
by a direct current variable speed motor
.R.

used as the lead concentrate regrind mill

sisted of two conical end sections, and 203 mm long
er of the center section was 876.3 mm between
wave or lifter bars. Pulp was discharged from
. The mill drive consisted of 7.5 H.P. motor
ears. The speed was 36 r.p.m. or 80 % of critical
mesh trommel screen.

Description of Equipment - Continued

2.2. Hardinge Conical Mill - Cont'd

b) Power Calculation

The gross power measured by a Sangamo Type of KYWP demand Energy Meter, equipped with a rate meter and a cumulative meter. A nominal efficiency of 95 % was assumed for the power transmission. The no-load power of the mill was calculated in the same manner, but with the mill operating empty. The net power consumption was equal to the gross power minus the no-load power.

c) Ball Charge

The steel charge consisted of forged steel balls, with diameter ranging from 12.7 mm to 25.4 mm.

2.3. Denver Mill

The small Denver mill was used as the zinc concentrate regrind mill.

The mill has an inside diameter of 305 mm and is 635 mm long. The mill shell was constructed of 12.7 mm steel plate and had no liners. The mill was driven by a 2 H.P. motor at 40 r.p.m., or 71 % of critical speed. The power consumption in the mill was not recorded. The mill was charged with 115 kg of 19 mm to 25.4 mm steel balls.

3. Hydrocyclones

3.1. P-50 Dorr Cyclone

A 50 mm P50 Dorr Cyclone was used to classify the Hendy mill discharge. The following dimensions were selected.

Inside diameter	50 mm
Inside height	305 mm
Vortex finder	15.9 mm
Apex nozzle	12.7 mm

Description of Equipment - Continued

5. Conditioners

Two Denver conditioners, 588 mm in diameter and 914.5 mm in height were employed in the circuit. The conditioning tank had three pulp discharge levels, offering a volume choice of 94, 121, 151.4 litres (static volume). The pulp agitation was imparted by two, three bladed propellers. A 127 mm diameter impeller was located at the bottom of the tank, with a 203.2 mm propeller located 305 mm above it. The conditioner drive unit consisted of 3 H.P. motor, equipped with v-belts and pulleys.

The lead rougher conditioner was operated at 94 litres capacity, and the zinc rougher conditioner was operated at 121 litres capacity.

6. Pumps

6.1. Linatex

A 25.4 mm linatex pump was used as the cyclone feed pump in the primary grind. The pump was powered by a 1.5 H.P. direct current, variable speed motor, controlled by a Boston gear Ratiotrol unit. The pump speed was varied according to the desired operating conditions.

6.2. Sala

Two 38 mm Sala pumps were used as the lead and zinc regrind cyclone feed pump. Several 38 mm Sala pumps were employed as transfer pump for pulp in the circuit.

6.3. Denver

Several 19 mm and 25.4 mm Denver vertical sand pumps were also used as pulp transfer pumps throughout the circuit.