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GRUM

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AERATION EFFECTS IN LABORATORY GRINDING

GRUM ORE COMPOSITE SAMPLE

GRUM - YUKON TERRITORY

CONTENTS

SUMMARY

A carefully conducted laboratory test program was performed on a sample of Grum ore to determine if aeration during grinding influenced metallurgical results. The program, which was specifically designed to magnify possible aeration effects, failed to indicate significant metallurgical variances in paired tests.

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INTRODUCTION

The Cyprus Anvil Mining Corporation is currently studying the feasibility of modifying their concentrator design to increase the fineness of grind of the flotation feed.

The feasibility studies are based on extensive laboratory and pilot plant data generated by several competent sources over the last two years. While there can be no doubt of the veracity of the pilot plant data, it has been suggested that some of the laboratory data could be biased due to the testwork being carried out in a sealed laboratory grinding mill.

Mr. L. P. Taggart of the Cyprus Anvil Feasibility and Development Group requested that we design and execute a short series of tests on a Grum ore composite to determine if indeed there existed some discernable difference between tests carried out in a sealed and open mill.

The test design was carefully selected to provide conditions which would clearly demonstrate any "aeration in grinding" effects. Cyanide levels were reduced to about half the normal

dosage for Grum ores at 150 g/tonne and grinding times were increased by using a 2.0 kg charge. Both of these reasons should actually enhance the possibility of detection of aeration effects.

The test program design was approved by Mr. Taggart in early April. Testwork was completed by Mid-April and the report compiled by Month end.

THE TEST PROGRAM

1. Test Program Objectives

The program objectives as defined by Mr. L. P. Taggart were as follows:

(a) To carry out pairs of laboratory flotation tests under conditions of strict control to determine if aeration during grinding exerted any influence on metallurgical results.

(b) To perform the work on a sample of Grum ore supplied by Lakefield Research of Canada. Similar studies were planned and were to be executed at Cyprus Anvil Mine, Faro on samples of Faro ore.

(c) To complete the work and to provide a final report by May 8, 1980.

2. Ore Samples Used In The Program

The sample used in the program was provided by Lakefield Research of Canada Ltd. and pertained to a composite of ore types made up for the purpose of pilot plant studies in 1977.

The individual test charges, pre-packaged in plastic pouches at Lakefield, were not purged with nitrogen and thus were subject to some oxidation. The metal content of the ore sample was known from previous studies. Averaged calculated head assays for the six tests were as shown below. (Table 1)

TABLE 1

Chemical Composition - Grum Composite

Grum Composite	Pb	Zn
	4.71	9.11

3. Test Procedures

The objectives of the program were achieved by using the open circuit cleaner test with some tests being provided with aeration during grinding. Reagents and other conditions were kept absolutely constant during the testwork.

Open Circuit Cleaner Tests

The laboratory flotation test procedure consisted of grinding the pre-prepared 2.0 kg ore samples for various times in a 21.5 ø x 40.5 cm laboratory rod mill with 25 kg of steel rods (See Appendix I). The grinding stage, which was carried out at 65% solids for thirty minutes, was conducted in the presence of soda ash and cyanide. In half of the tests the rod mill remained sealed during the grinding stage as is normal procedure. In the remainder of the tests however the grinding was interrupted every ten minutes, the lid of the mill removed for one minute to provide some aeration, and then replaced and grinding continued.

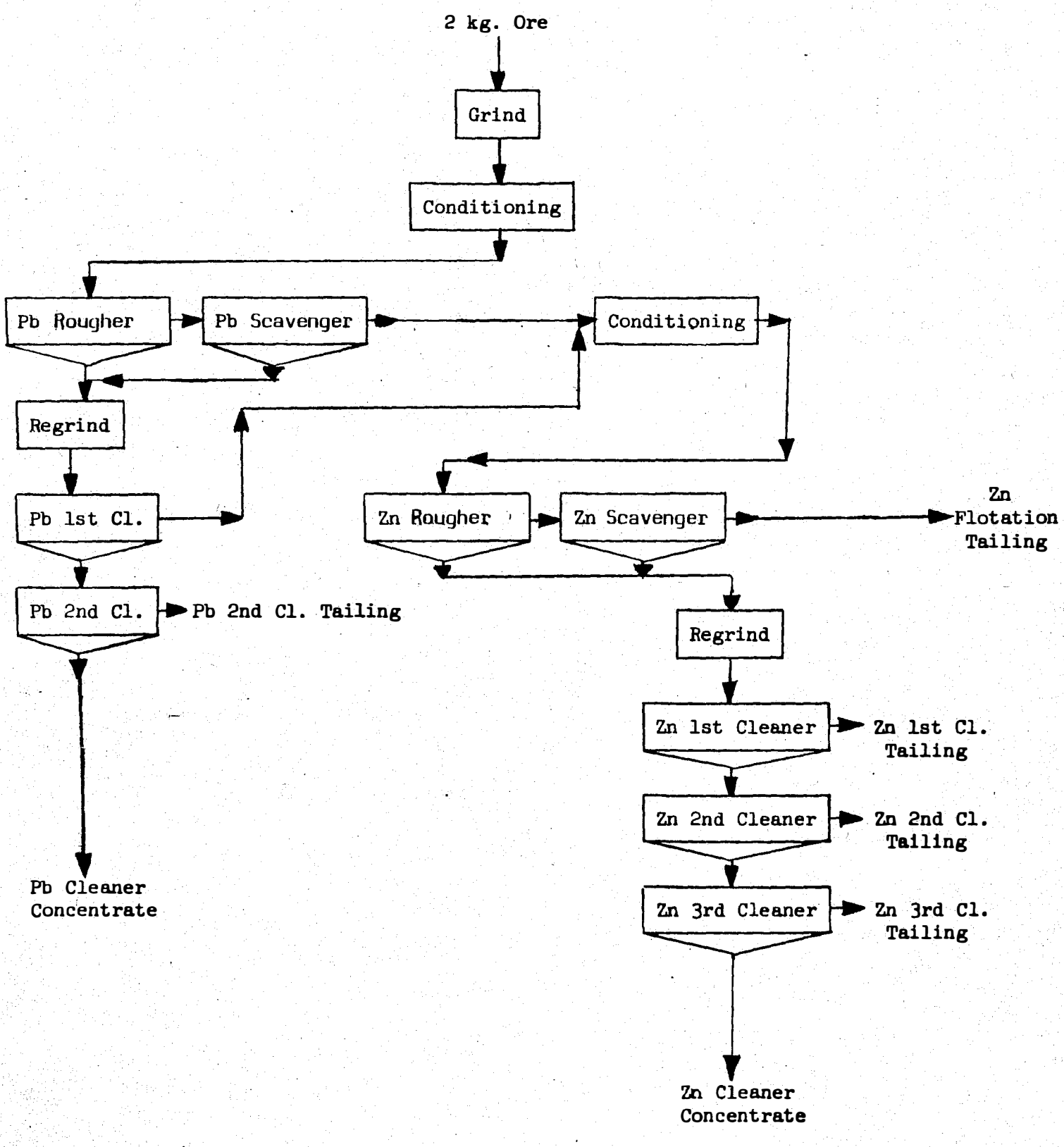
Following additions of Z-11 and MIBK, and allowing for a short conditioning period, the lead rougher-scavenger concentrates were floated. The lead rougher concentrates were reground in a 21.5 ø x 18.0 cm ball mill for twenty minutes with 10 kg of steel balls with soda ash and cyanide. The lead cleaning then proceeded for two stages. The lead first cleaner tail was filtered, weighed wet and added to the lead scavenger tailings prior to conditioning with lime.

The zinc conditioning was carried out in a lime modulated circuit for eight minutes and $CuSO_4$ added to activate the zinc minerals; conditioning time with $CuSO_4$ was four minutes. The zinc was then floated with Z-11 in the presenoe of DOW 1012 as a frother.

The zinc rougher scavenger concentrates were then reground in the laboratory ball mill for twenty minutes with lime and a small amount of $CuSO_4$. Cleaning was then carried out at increasing pH levels for three stages. Figure 1 is a schematic of the laboratory flowsheet indicating the various test stages.

Figure No. 1

Laboratory Flowsheet



ANALYSIS AND DISCUSSION OF RESULTS

A detailed review of the test data, especially the metal and weight distributions indicated that the tests had been performed in a uniform fashion.

Some problems were detected with the data from test no. 3 but despite a detailed analysis no errors in calculation or method were identified. It is possible that the manipulation of the lead first cleaner stage on that test was less than ideal; certainly the weight destribution of the lead products were too low compared to the other tests in the program.

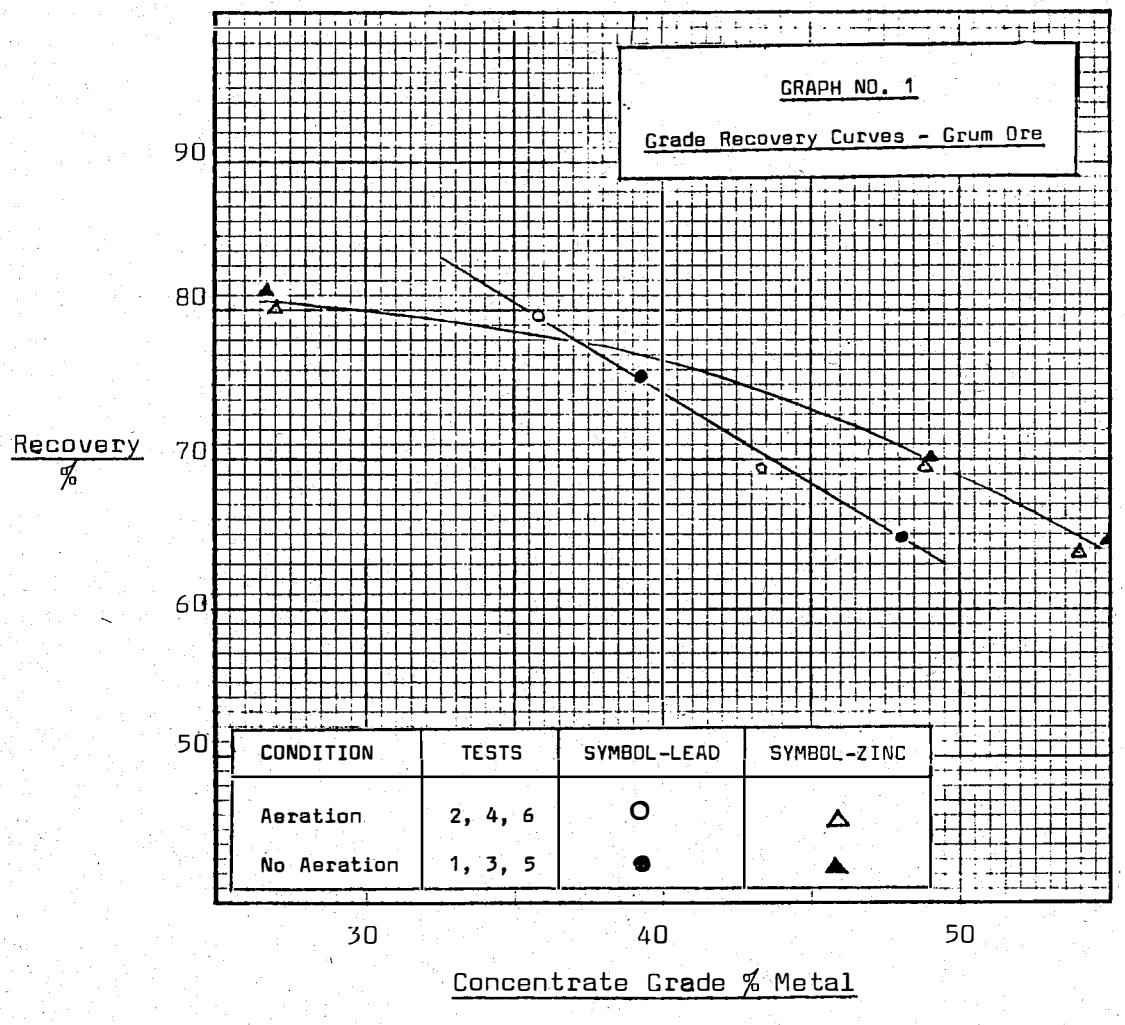
Evidence of test program uniformity was derived from the reproducibility of the calculated lead assays for the test. The small deviation value indicates the degree of test precision.

TABLE 2

Precision of Calculated Head Assay

	Metal %	Standard Deviation
Lead	4.71	0.09
Zinc	9.11	0.04

Despite the minor inconsistencies in data, which incidentally surround every program of this type, an average of all data, including the suspect no. 3 test, failed to show evidence of any significant effect due to aeration in grinding. Graph No. 1 below indicates the mean grade-recovery data for tests with aeration during grinding (light symbols), and tests without aeration (dark symbols) for both lead and zinc circuits.



CONCLUSIONS

1. The premise that comparative tests performed in a sealed grinding mill yield superior results, when compared to parallel tests in open mills, is not supported by data generated by this program.

2. Very possibly the foundation of the original premise is not applicable to grinding operations performed in the presence of cyanide, at a pH at which significant sodium cyanide dissociation takes place. (eg. above pH 9.0) The work of Muir and Carlson concerning oxygen demand of grinding pulps and the critical nature of the CN^- ion as a surface oxidation block, relates directly to these results.

APPENDIX I

DETAILS OF EQUIPMENT USED IN FLOTATION TESTS

APPENDIX I

Details of Equipment Utilized in Testwork

A. Grinding

Rod Mill	-Steel Containers 21.5 cm ø x 40.5 cm. Charge 25 kg steel rods approx. 2.0 cm ø.
Ball Mill	-Steel Container 21.5 cm ø x 18 cm. Charge 5 kg steel balls - graded charge 0.5 - 3.0 cm ø.
Drive for Mills	-Twin rolls, one driven, one idle. Both 12.5 ø x 122 cm.
	-Motor 0.37 KWH at 1725 RPM full load.
	-Mill Speed approximately 80 RPM.

B. Flotation

Denver D2 Flotation Machine	- Used for roughing and scavenger at 1500 RPM with a 5.5 L stainless steel tank.
	-For first cleaner work with a 2.5 L stainless steel tank.
Denver D1 Flotation Machine	-Used for all cleaning stages for both lead and zinc flotation at 1500 RPM with a 2.5 L stainless steel tank.

C. Instrumentation

Orion Specific Ion Meter 401	-Used for pH control on the rougher and scavenger circuits.
Fisher Digital pH Meter 609	-Used for pH control on the cleaning circuits.

APPENDIX II

TECHNICAL DETAILS OF FLOTATION TESTS 1 - 6 INCLUSIVE

For each test are shown details of reagents used, and essential test parameters, assays for each test, a metallurgical balance, grade recovery data and a tailings screen analysis.

TEST NO. 1

PURPOSE: Study Effects of Aeration During Grinding - No Aeration

PROCEDURE: Grind and Float Lead and Zinc Concentrates: Regrind and Clean to Final Grade

FEED: Grum Pilot Plant Composite - 2.0 kg

GRIND: Fine

	Reagents Added - g/tonne						Time, Minutes			pH*	
	Na_2CO_3	NaCN	Z-11	$CuSO_4$	$Ca(OH)_2$		Grind	Cond.	Froth	Start	End
Primary Grind	2000	150					30				
Lead Ro/Sc			75					2	8	9.4	9.3
Lead Regrind	1000	150					20				
Lead 1st Cleaner			10					2	10	10.2	10.1
Lead 2nd Cleaner	500							2	5	10.5	10.4
Lead 3rd Cleaner											
Zinc Conditioning				500				10		11.0	11.0
Zinc Ro/Sc			70					2	13	11.0	11.0
Zinc Regrind				200	500		20				
Zinc 1st Cleaner			10					2	8	11.5	11.5
Zinc 2nd Cleaner								2	5	12.0	12.0
Zinc 3rd Cleaner											

* Unless otherwise noted - pH values obtained by $Ca(OH)_2$ additions.

TEST NO. 1

METALLURGICAL RESULTS

PRODUCT	WEIGHT	ASSAYS %			DISTRIBUTION %		
	%	Pb	Zn		Pb	Zn	
1. Pb Cleaner Conc 2	7.86	43.99	12.08		72.81	10.41	
2. Pb Cleaner Tail 2	2.22	15.67	14.69		7.32	3.57	
3. Zn Cleaner Conc 2	9.57	1.63	56.20		3.29	58.99	
4. Zn Cleaner Tail 2	3.11	3.19	33.86		2.09	11.56	
5. Zn Cleaner Tail 1	12.60	2.54	7.60		6.74	10.50	
6. Final Tails	64.64	0.57	0.70		7.76	4.96	
Calculated Head	100.0	4.75	9.12		100.00	100.00	

CALCULATED GRADES AND RECOVERIES

Products 1 and 2		37.76	-		80.13	-	
Products 3 and 4		-	50.72		-	70.55	
Products 3 to 5		-	29.23		-	81.05	

SCREEN ANALYSES - FLOTATION TAILINGS

MESH SIZE TYLER	APERTURE MICRONS	% RETAINED		% PASSING
		INDIVIDUAL	CUMULATIVE	CUMULATIVE
+70	210	.1	.1	99.9
100	150	.16	.26	99.74
150	105	1.4	1.66	98.34
200	74	6.78	8.44	91.56
325	44	16.18	24.62	75.38
-325	-	75.38	100.00	-

TEST NO. 2

PURPOSE: Study Effects of Aeration During Grinding - Aeration

PROCEDURE: Grind and Float Lead and Zinc Concentrates: Regrind and Clean to Final Grade

FEED: Grum Pilot Plant Composite - 2.0 kg

GRIND: Fine

	Reagents Added - g/tonne						Time, Minutes			pH*	
	Na_2CO_3	NaCN	Z-11	$CuSO_4$	$Ca(OH)_2$		Grind	Cond.	Froth	Start	End
Primary Grind	2000	150					30				
Lead Ro/Sc			75					2	8	8.9	9.3
Lead Regrind	1000	150					20				
Lead 1st Cleaner			10					2	10	10.4	10.3
Lead 2nd Cleaner	500							2	5	10.7	10.5
Lead 3rd Cleaner											
Zinc Conditioning				500						11.0	11.0
Zinc Ro/Sc			70					2	13	11.0	11.0
Zinc Regrind				200	500		20				
Zinc 1st Cleaner			10					2	8	11.5	11.4
Zinc 2nd Cleaner								2	5	12.0	12.0
Zinc 3rd Cleaner											

* Unless otherwise noted - pH values obtained by $Ca(OH)_2$ additions.

TEST NO. 2

METALLURGICAL RESULTS

PRODUCT	WEIGHT	ASSAYS %			DISTRIBUTION %		
	%	Pb	Zn		Pb	Zn	
1. Pb Cleaner Conc 2	7.93	43.60	12.20		73.23	10.63	
2. Pb Cleaner Tail 2	2.22	14.13	16.42		6.63	4.00	
3. Zn Cleaner Conc 2	9.28	1.58	55.90		3.11	57.03	
4. Zn Cleaner Tail 2	2.35	2.70	30.17		1.35	7.80	
5. Zn Cleaner Tail 1	14.06	2.48	10.01		7.39	15.47	
6. Final Tails	64.17	0.61	0.72		8.29	5.08	
Calculated Head	100.0	4.72	9.10		100.00	100.00	

CALCULATED GRADES AND RECOVERIES

Products 1 and 2		37.16	-		79.86	-	
Products 3 and 4		-	50.70		-	64.83	
Products 3 to 5		-	28.44		-	80.30	

SCREEN ANALYSES - FLOTATION TAILINGS

MESH SIZE TYLER	APERTURE MICRONS	% RETAINED		% PASSING
		INDIVIDUAL	CUMULATIVE	CUMULATIVE
+70	210	.05	.05	99.95
100	150	.06	.11	99.89
150	105	.37	.48	99.52
200	74	5.57	6.05	93.95
325	44	18.03	24.08	75.92
-325	-	75.92	100.00	-

TEST NO. 3

PURPOSE: Study Effects of Aeration During Grinding - No Aeration

PROCEDURE: Grind and Float Lead and Zinc Concentrates: Regrind and Clean to Final Grades

FEED: Grum Pilot Plant Composite - 2.0 kg

GRIND: Fine

	Reagents Added - g/tonne					Time, Minutes			pH*	
	Na_2CO_3	NaCN	Z-11	$CuSO_4$	$Ca(OH)_2$	Grind	Cond.	Froth	Start	End
Primary Grind	2000	150				30				
Lead Ro/Sc			75				2	8	8.8	8.9
Lead Regrind	1000	150				20				
Lead 1st Cleaner			10				2	10	10.4	10.2
Lead 2nd Cleaner	500						2	5	10.5	10.4
Lead 3rd Cleaner										
Zinc Conditioning				500			10		11.0	11.0
Zinc Ro/Sc			70				2	13	11.0	11.0
Zinc Regrind				200	500	20				
Zinc 1st Cleaner			10				2	8	11.5	11.5
Zinc 2nd Cleaner							2	5	12.0	12.0
Zinc 3rd Cleaner										

* Unless otherwise noted - pH values obtained by $Ca(OH)_2$ additions.

TEST NO. 3

METALLURGICAL RESULTS

PRODUCT	WEIGHT	ASSAYS %			DISTRIBUTION %		
	%	Pb	Zn		Pb	Zn	
1. Pb Cleaner Conc 2	3.72	57.10	8.09		46.87	3.29	
2. Pb Cleaner Tail 2	3.13	27.64	16.25		19.12	5.57	
3. Zn Cleaner Conc 2	11.24	3.27	53.19		8.12	65.45	
4. Zn Cleaner Tail 2	3.86	5.43	21.11		4.62	8.91	
5. Zn Cleaner Tail 1	21.59	2.92	4.88		13.92	11.53	
6. Final Tails	56.46	0.59	0.85		7.35	5.25	
Calculated Head	100.0	4.53	9.14		100.00	100.00	

CALCULATED GRADES AND RECOVERIES

Products 1 and 2		43.63	-		65.99	-	
Products 3 and 4		-	45.00		-	74.36	
Products 3 to 5		-	21.39		-	85.88	

SCREEN ANALYSES - FLOTATION TAILINGS

MESH SIZE TYLER	APERTURE MICRONS	% RETAINED		% PASSING
		INDIVIDUAL	CUMULATIVE	CUMULATIVE
+70	210	.07	.07	99.93
100	150	.07	.14	99.86
150	105	1.15	1.29	98.71
200	74	6.12	7.41	92.59
325	44	16.18	23.59	76.41
-325	-	76.41	100.00	-

TEST NO. 4

PURPOSE: Study Effects of Aeration During Grinding - Aeration

PROCEDURE: Grind and Float Lead and Zinc Concentrates: Regrind and Clean to Final Grade

FEED: Grum Pilot Plant Composite - 2.0 kg

GRIND: Fine

	Reagents Added - g/tonne						Time, Minutes			pH*	
	Na_2CO_3	NaCN	Z-11	$CuSO_4$	$Ca(OH)_2$		Grind	Cond.	Froth	Start	End
Primary Grind	2000	150					30				
Lead Ro/Sc			75					2	8	9.3	9.3
Lead Regrind	1000	150					20				
Lead 1st Cleaner			10					2	10	10.4	10.3
Lead 2nd Cleaner	500							2	5	10.5	10.5
Lead 3rd Cleaner											
Zinc Conditioning				500				10		11.0	11.0
Zinc Ro/Sc			70					2	13	11.0	11.0
Zinc Regrind				200			20				
Zinc 1st Cleaner			10					2	8	11.5	11.5
Zinc 2nd Cleaner								2	5	12.0	12.0
Zinc 3rd Cleaner											

* Unless otherwise noted - pH values obtained by $Ca(OH)_2$ additions.

TEST NO. 4

METALLURGICAL RESULTS

PRODUCT	WEIGHT	ASSAYS %			DISTRIBUTION %		
	%	Pb	Zn		Pb	Zn	
1. Pb Cleaner Conc 2	5.98	49.50	10.43		62.26	6.80	
2. Pb Cleaner Tail 2	5.11	14.10	16.23		15.13	9.03	
3. Zn Cleaner Conc 2	13.63	2.27	49.38		6.50	73.31	
4. Zn Cleaner Tail 2	2.15	3.44	7.64		1.56	1.79	
5. Zn Cleaner Tail 1	12.75	2.11	3.17		5.66	4.40	
6. Final Tails	60.38	0.70	0.71		8.88	4.67	
Calculated Head	100.0	4.76	9.18		100.00	100.00	

CALCULATED GRADES AND RECOVERIES

Products 1 and 2		33.20	-		77.40	-	
Products 3 and 4		-	43.68		-	75.10	
Products 3 to 5		-	25.58		-	79.50	

SCREEN ANALYSES - FLOTATION TAILINGS

MESH SIZE TYLER	APERTURE MICRONS	% RETAINED		% PASSING
		INDIVIDUAL	CUMULATIVE	CUMULATIVE
+70	210	.07	.07	99.93
100	150	.08	.15	99.85
150	105	.17	.32	99.68
200	74	2.67	2.99	97.01
325	44	13.50	16.49	83.51
-325	-	83.51	100.00	-

TEST NO. 5

PURPOSE: Study Effects of Aeration During Grinding - No Aeration

PROCEDURE: Grind and Float Lead and Zinc Concentrates: Regrind and Clean to Final Grade

FEED: Grum Pilot Plant Composite - 2.0 kg

GRIND: Fine

	Reagents Added - g/tonne						Time, Minutes			pH*	
	Na_2CO_3	NaCN	Z-11	$CuSO_4$	$Ca(OH)_2$		Grind	Cond.	Froth	Start	End
Primary Grind	2000	150					30				
Lead Ro/Sc			75					2	8	9.1	9.3
Lead Regrind	1000	150					20				
Lead 1st Cleaner			10					2	10	10.5	10.4
Lead 2nd Cleaner	500							2	5	10.6	10.5
Lead 3rd Cleaner											
Zinc Conditioning				500				10		11.0	11.0
Zinc Ro/Sc			70					2	13	11.0	11.0
Zinc Regrind				200	500		20				
Zinc 1st Cleaner								2	8	11.5	11.5
Zinc 2nd Cleaner								2	5	12.0	12.0
Zinc 3rd Cleaner											

* Unless otherwise noted - pH values obtained by $Ca(OH)_2$ additions.

TEST NO. 5

METALLURGICAL RESULTS

PRODUCT	WEIGHT	ASSAYS %			DISTRIBUTION %		
	%	Pb	Zn		Pb	Zn	
1. Pb Cleaner Conc 2	8.25	43.14	12.34		74.80	11.22	
2. Pb Cleaner Tail 2	2.31	12.30	15.11		5.98	3.85	
3. Zn Cleaner Conc 2	9.58	1.62	55.55		3.26	58.66	
4. Zn Cleaner Tail 2	1.95	3.11	30.45		1.27	6.54	
5. Zn Cleaner Tail 1	12.80	2.46	9.65		6.62	13.62	
6. Final Tails	65.11	0.59	0.85		8.07	6.10	
Calculated Head	100.0	4.76	9.07		100.00	100.00	

CALCULATED GRADES AND RECOVERIES

Products 1 and 2		36.39	-		80.78	-	
Products 3 and 4		-	51.31		-	65.20	
Products 3 to 5		-	29.39		-	78.82	

SCREEN ANALYSES - FLOTATION TAILINGS

MESH SIZE TYLER	APERTURE MICRONS	% RETAINED		% PASSING
		INDIVIDUAL	CUMULATIVE	CUMULATIVE
+70	210	.07	.07	99.93
100	150	.09	.16	99.84
150	105	.38	.54	99.46
200	74	5.84	6.38	93.62
325	44	19.96	26.34	73.66
-325	-	73.66	100.00	-

TEST NO. 6

PURPOSE: Study Effects of Aeration During Grinding - Aeration

PROCEDURE: Grind and Float Lead and Zinc Concentrates: Regrind and Clean to Final Grade

FEED: Grum Pilot Plant Composite - 2.0 kg

GRIND: Fine

	Reagents Added - g/tonne						Time, Minutes			pH*	
	Na_2CO_3	NaCN	Z-11	$CuSO_4$	$Ca(OH)_2$		Grind	Cond.	Froth	Start	End
Primary Grind	2000	150					30				
Lead Ro/Sc			75					2	8	9.1	9.4
Lead Regrind	1000	150					20				
Lead 1st Cleaner			10					2	10	10.6	10.3
Lead 2nd Cleaner	500							2	5	10.6	10.5
Lead 3rd Cleaner											
Zinc Conditioning				500				10		11.0	11.0
Zinc Ro/Sc			70					2	13	11.0	11.0
Zinc Regrind				200	500		20				
Zinc 1st Cleaner			10					2	8	11.5	11.5
Zinc 2nd Cleaner								2	5	12.0	12.0
Zinc 3rd Cleaner											

* Unless otherwise noted - pH values obtained by $Ca(OH)_2$ additions.

TEST NO. 6

METALLURGICAL RESULTS

PRODUCT	WEIGHT	ASSAYS %			DISTRIBUTION %		
	%	Pb	Zn		Pb	Zn	
1. Pb Cleaner Conc 2	7.29	47.82	11.79		73.59	9.47	
2. Pb Cleaner Tail 2	3.16	12.08	16.39		8.07	5.71	
3. Zn Cleaner Conc 2	9.82	1.62	56.10		3.36	60.73	
4. Zn Cleaner Tail 2	2.27	3.32	31.87		1.59	7.97	
5. Zn Cleaner Tail 1	14.61	2.06	6.74		6.36	10.86	
6. Final Tails	62.85	0.53	0.76		7.04	5.27	
Calculated Head	100.0	4.73	9.07		100.00	100.00	

CALCULATED GRADES AND RECOVERIES

Products 1 and 2		37.00	-		81.66	-	
Products 3 and 4		-	51.55		-	68.70	
Products 3 to 5		-	27.03		-	79.55	

SCREEN ANALYSES - FLOTATION TAILINGS

MESH SIZE TYLER	APERTURE MICRONS	% RETAINED		% PASSING
		INDIVIDUAL	CUMULATIVE	CUMULATIVE
+70	210	.08	.08	99.92
100	150	.09	.17	99.83
150	105	1.74	1.91	98.09
200	74	7.96	9.87	90.13
325	44	17.54	27.41	72.59
-325	-	72.59	100.00	-