Terra Search Pty Ltd

A.B.N. 59 011 073 939

Specialists in Mineral Exploration:

Geology and Computing

EPM13049 ROCKLANDS GROUP PROJECT ANNUAL REPORT FOR THE TWELVE MONTH PERIOD ENDING 7th OCTOBER 2008

APPENDIX 16.3

Technical Studies Relevant to Preliminary Feasibility Study : CuDeco Simulation Study Final Report

Prepared for Cudeco Limited
November 2008

Document#CDU2008003
TS Shelf Ref #2008/16

Townsville, November 2008

JKTech Pty Ltd
Isles Road
Indooroopilly Qld 4068
AUSTRALIA
Telephone + 61 7 3365 5842
Facsimile + 61 7 3365 5900
E-mail jktech@jktech.com.au
Internet www.jktech.com.au

25 March 2008

CuDeco Limited
Cloncurry
Queensland

Attention: Mr Paul Keran/Mr Peter Hutchison

Re: Report - JKTech Job No 07388

Dear Paul/Peter

Enclosed please find the final report by Suzy Stark and reviewed by Chris Bailey, titled 'CuDeco Simulation Study Report'.

If you have any queries about the report please do not hesitate to contact either Suzy or myself.

Regards

Dan Alexander
Operations Manager
JKTech

CuDeco Simulation Study Report

CuDeco Limited

May-2008

JKTech Job No. 07388

JKTech Pty Ltd

CuDeco Simulation Study Report

Suzy Stark

Submitted to

CuDeco Limited

JKTech Job No. 07388 - May-2008

SUMMARY

CuDeco Limited (CuDeco) requested that JKTech conduct a simulation study of the proposed comminution circuit for the CuDeco Copper project. This is a greenfield project. The purpose of the study was to investigate and compare the possible comminution circuit options. Preliminary testwork on samples of copper ore has already been carried out. The results of the tests on two different samples were used in this simulation study. The test results for the samples identified as 'LMDH025 8-82/29-77' (Ore Type 1) and 'LMDH 006' (Ore Type 2) were used.

The scope of work for the simulation study included finding suitable base case JKSimMet model parameters from the JKTech database to develop a model of each of the possible circuit options. The models were used as the basis for conducting simulations and comparing the performance of the various circuit configurations for a number of different throughputs. Throughputs of 3 Mtpa and 5 Mtpa were simulated for Ore Type 1 and throughputs of 1, 2 and 3 Mtpa were simulated for Ore Type 2. The circuit must achieve a final grind size P_{80} of 150 µm.

The circuit configurations investigated were:

- *SAB: SAG mill followed by a cyclone – ball mill secondary circuit*
- *AB: AG mill followed by a cyclone – ball mill secondary circuit*
- *Single Stage AG: AG mill in closed circuit with a cyclone*
- *SABC: SAG mill with recycle crusher followed by a cyclone – ball mill secondary circuit.*

The single stage AG mill in configuration was not simulated for Ore Type 2.

The results of the simulations indicated that the size of the mills required varied between the different scenarios and for the different ore types.

For Ore Type 1, the predicted SAG mill size varied with dimensions ranging from 6.0 m diameter x 3.1 m long (internal dimensions) to 7.3 m diameter x 3.6 m long, depending on the particular circuit configuration. The corresponding predicted power for the SAG mill varied between 1336 and 1675 kW for the lower throughput and 2297 and 2822 kW for the higher throughput.

The predicted AG mill dimensions were larger, varying from 8.5 m diameter x 4.5 m long to 10.5 m diameter x 5.2 m long. The power requirements ranged from 3452 – 3981 kW for the lower throughput to 5704 – 5782 kW for the higher throughput.

The predicted ball mill dimensions varied from 4.8 m diameter x 5.4 m long to 7.0 m diameter x 7.2 m long. Power requirements were between 1766 and 3893 kW for the lower throughput and between 3014 and 6291 kW for the higher throughput.

For Ore Type 2, the simulations were conducted at lower throughputs and so the predicted equipment sizes and power requirements are generally lower. The predicted SAG mill size ranged from 4.4 m diameter x 2.2 m long (internal dimensions) to 6.6 m diameter x 3.2 m long, depending on the circuit configuration. The corresponding SAG mill power varied between 526 and 2062 kW.

As for Ore Type 1, the predicted AG mill size for Ore Type 2 was larger than the SAG mill, with dimensions varying from 6.0 m diameter x 2.9 m long to 8.1 m diameter x 4.1 m long. The power requirements ranged from 1071 to 3147 kW.

The predicted ball mill dimensions varied from 3.5 m diameter x 3.8 m long to 5.6 m diameter x 6.5 m long. Power requirements were between 572 and 3096 kW.

Based on the simulations carried out to predict the performance of the CuDeco circuit, a number of conclusions can be drawn:

- *The circuit performance when the circuit is operating with a SAG mill upstream of the ball mill – cyclone (SAB) compared with its performance when there is an AG mill upstream of the ball mill – cyclone (AB) highlight a number of key differences in operation. The AG mill power requirement is higher than the corresponding SAG mill, and the resulting predicted transfer T_{80} is much finer for the AG mill. However, the ball mill power requirement for the AB configuration is lower than for the SAB configuration, and so the overall power requirements per tonne of feed is approximately the same.*
- *The installation of a recycle crusher on the SAG mill has little effect in changing the predicted circuit performance. The SAG mill power reduces marginally for a marginal increase in the transfer T_{80} and the ball mill power increases slightly. The overall power requirement remains approximately constant, which indicates that the circuit efficiency is not affected significantly by the installation of the recycle crusher. This is typical of SAG mills operating with ores with moderate or low impact resistance.*
- *Power figures for the pebble crusher are estimates only since there was no JK drop weight data to fully develop a model of the crusher power requirements. The figures are to allow for the slight increase in power required when a pebble crusher is installed. Overall conclusions should not be affected by the reduced accuracy of these estimates, since the relative power consumption of the crusher is small compared with the mills.*
- *The results for the single stage AG mill circuit performance indicate that the circuit efficiency is significantly increased for this configuration. These results are overly optimistic in predicting the performance of the AG mill since the model parameters are better suited to the mill operating as a primary SAG mill upstream of a ball mill – cyclone. The results should be used with caution*.
- *A comparison of circuit efficiencies for all configurations indicate that the circuit operates at marginally higher efficiencies when it is processing the second ore type, 'LMDH 006' compared with the first ore type, 'LMDH025 8-82/29-77'. This is due to the fact that the second ore type has a lower Bond ball mill work index, giving lower ball mill power draws, which more than compensates for its lower SAG mill parameters which give higher SAG mill power draws.*

TABLE OF CONTENTS

Page No

APPENDICES

LIST OF TABLES

Page No

LIST OF FIGURES

Page No

1. INTRODUCTION

Mr Peter Hutchison of CuDeco Limited (CuDeco) has requested that JKTech conduct a simulation study of the proposed comminution circuit for the CuDeco Copper project. This is a greenfield project.

The purpose of the study is to investigate and compare the possible comminution circuit options. Preliminary testwork on samples of copper ore has already been carried out. The results of the tests on two different samples are to be used in this simulation study. The test results for the samples identified as 'LMDH025 8-82/29-77' and 'LMDH 006' are to be used in the simulations.

2. SCOPE OF WORK

The scope of work for the simulation study was to:

- Find suitable base case JKSimMet model parameters from the JKTech database which are appropriate for use in the CuDeco circuit AG/SAG mill and ball mill models.
- Use the base case model as the basis for conducting simulations to predict the comminution circuit performance for the circuit options specified.
- Compare the performance of the various circuit configurations for a number of different throughputs. The circuit must achieve a final grind size P_{80} of 150 µm.
- Present the results in a final report.

3. SPECIFICATIONS

CuDeco have provided a number of specifications regarding the operation of the circuit. These are as follows:

- For the first ore type, 'LMDH025 8-82/29-77', the circuit performance is to be investigated at two feed rates of 3 Mtpa and 5Mtpa. This equates to 375 and 625 dry tph respectively for the specified operating hours of 8000 per annum.
- Circuit configurations to be investigated for this ore type are:
  - SAB: SAG mill followed by a cyclone – ball mill secondary circuit
  - AB: AG mill followed by a cyclone – ball mill secondary circuit
  - Single Stage AG: AG mill in closed circuit with a cyclone
  - SABC: SAG mill with recycle crusher followed by a cyclone – ball mill secondary circuit.
- For the second ore type, 'LMDH 006', the circuit performance is to be investigated at three feed rates of 1, 2 and 3 Mtpa. This equates to 125, 250 and 375 dry tph respectively for the specified operating hours of 8000 per annum.
- Circuit configurations to be investigated for this ore type are:
  - SAB: SAG mill followed by a cyclone – ball mill secondary circuit
  - AB: AG mill followed by a cyclone – ball mill secondary circuit
  - SABC: SAG mill with recycle crusher followed by a cyclone – ball mill secondary circuit.

- No single stage AG mill circuit option is to be investigated for this ore type.
- For all cases, the circuit must achieve a final grind size P_{80} of 150 µm.

4. JKTECH METHODOLOGY

Research at the Julius Kruttschnitt Mineral Research Centre (JKMRC) over the past four decades has resulted in the creation of mathematical models of various comminution and concentration devices used in minerals and coal beneficiation. Of these, the models of comminution and classification devices have been incorporated into the software simulation package JKSimMet. More than 300 JKSimMet packages are in use around the world.

To make use of the models in JKSimMet, the general form of the model must be tailored to match the specific application required. This is achieved by adjusting the model parameters which are of two types, those dependent on ore characteristics and those dependent on machine characteristics.

In general, the ore specific parameters are determined by laboratory tests.

For optimisation studies, machine dependent parameters are calculated by non-linear least squares fitting techniques from plant survey data. However, for design studies, sampling the plant is not possible so machine dependent parameters are "borrowed" from other operations. JKTech has established a large database of these parameters suitable for use in most design situations.

5. GRINDING CIRCUIT DATA

The CuDeco grinding circuit configured in AB/SAB mode is shown schematically in Figure 1. The AB/SAB circuit consists of an AG/SAG mill followed by a ball mill in closed circuit with a hydrocyclone cluster. Discharge from the AG/AG mill passes over a trommel and the undersize proceeds to the ball mill – cyclone circuit.

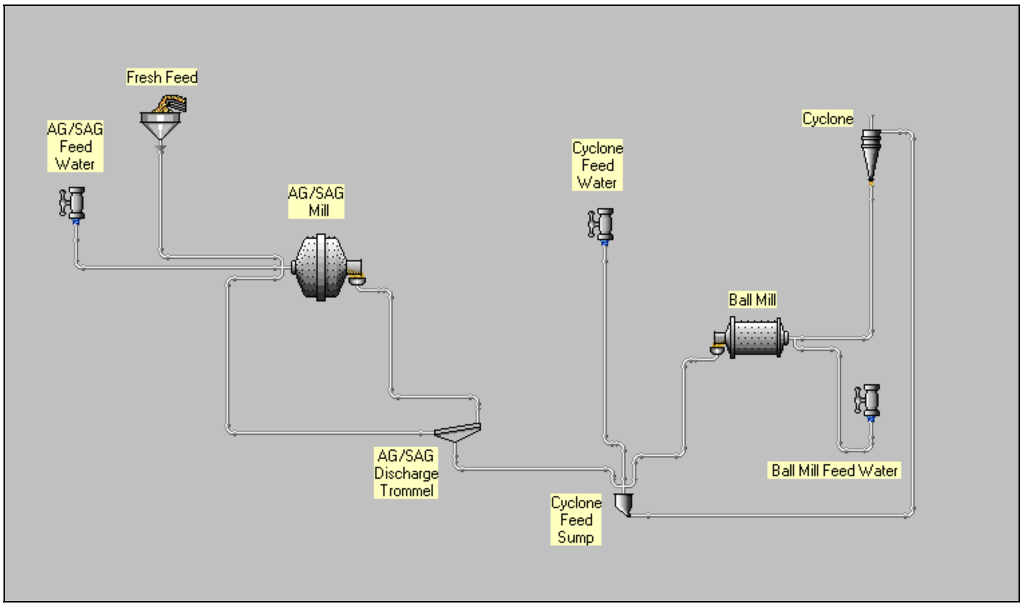


Figure 1: CuDeco Grinding Circuit Schematic – SAB/AB Option

Trommel oversize is recycled directly to the AG/SAG mill feed. Two separate scenarios are considered for this configuration – with the primary mill operating either as a SAG mill (with balls) or as an AG mill (without balls).

The single stage AG mill circuit configuration is as shown in Figure 2. It consists of a single stage AG mill operating in closed circuit with a hydrocyclone cluster. Discharge from the AG mill passes over a trommel and the undersize proceeds to the cyclone. Trommel oversize is recycled to the AG mill feed. Cyclone underflow also recycles to the AG mill feed.

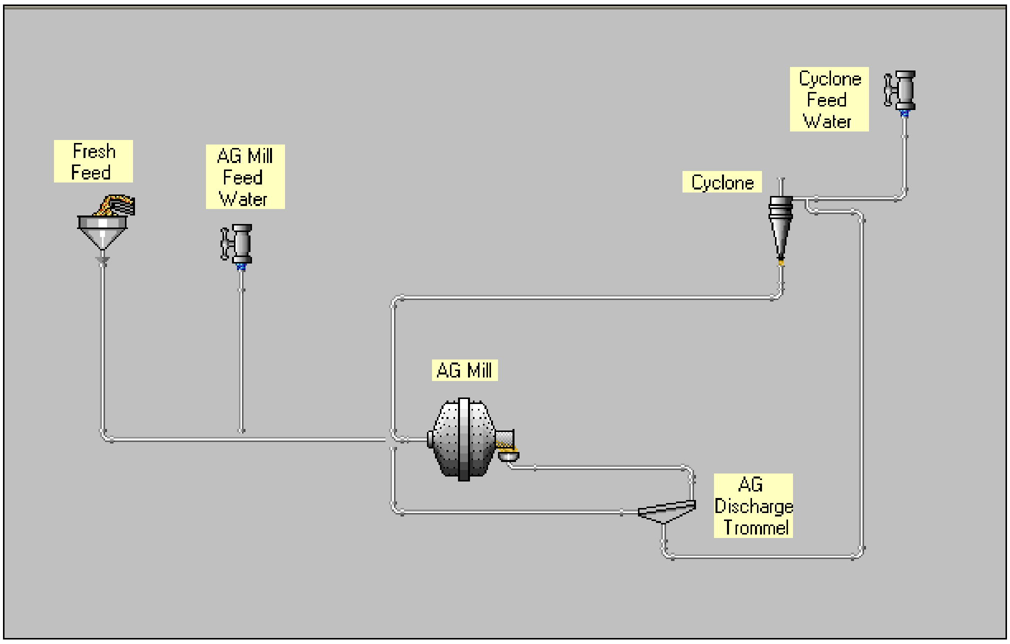


Figure 2: CuDeco Grinding Circuit Schematic – Single Stage AG Mill Option

A schematic diagram of the CuDeco grinding circuit with the pebble crusher option included is shown in Figure 3.

The SABC circuit consists of a SAG mill followed by a ball mill in closed circuit with a hydrocyclone cluster. Discharge from the SAG mill passes over a trommel and the undersize proceeds to the ball mill – cyclone circuit. Trommel oversize is passed through a pebble crusher before reporting back to the SAG feed.

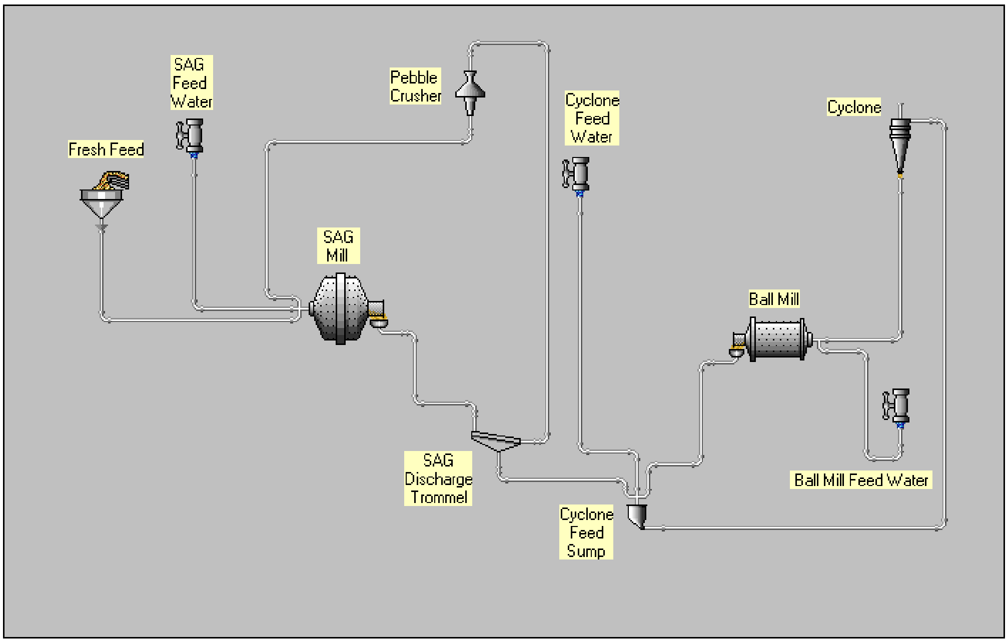


Figure 3: CuDeco Grinding Circuit Schematic – SABC Option

In cases which include a ball mill, it is assumed to be an overflow mill with a recirculating load of approximately 250%. The recirculating load of the single stage AG mill option is much lower than 250%.

All water additions to the plant, including sprays and wash water, are assumed to be included in one of the main water addition points as shown in each diagram.

Fresh feed to the mill has a feed size F_{80} of approximately 67.7 mm which was calculated using the measured DWi and a primary crusher CSS of 150 mm.

Details of the ore parameters are provided in the following section.

5.1 Ore Parameters

Three samples of copper ore from CuDeco were submitted to JKTech for comminution testing in June, 2007. Two reports were generated after completion of this testing and both are included in Appendix 1. As requested by the client, two samples are to be used as the basis for the simulations. These are the samples identified as ‘LMDH025 8-82/29-77’ and ‘LMDH 006’.

The JK Drop Weight parameters were derived from the SMC test results and are summarised in Table 1 below. t_a was also calculated using the SMC data.

Table 1: JK Drop Weight and SMC Test Results

Ore Type	Specific Gravity	Breakage Parameter A	Breakage Parameter b	A*b	Abrasion Parameter T_a	Drop Weight Index Dwi
LMDH025 8-82/29-77	2.65	61.5	1.34	82.4	0.81	3.2
LMDH006	3.08	74.0	1.00	74.0	0.63	4.13

The Bond ball mill tests were carried out at a closing sieve size of 106 µm. Results from the Bond Ball Mill Work Index tests are summarised in Table 2.

Table 2: Bond Ball Mill Work Index Test Results

Ore Type	F_{80} µm	P_{80} µm	Grindability (g/rev)	Bond Ball Mill Work Index kWh/t	Closing Sieve Size µm
LMDH025 8-82/29-77	2265	77	1.292	14.6	106
LMDH006	2217	78	1.534	12.9	106

These ore specific parameters have been used in the simulation models of the CuDeco circuit for each ore type.

6. SELECTION OF BASE CASE MODEL PARAMETERS

6.1 Introduction

Before conducting simulations on the CuDeco grinding circuit, it was first necessary to set up suitable base case models of each circuit option using appropriate model parameters for each of the items of equipment. The models were then able to be used to make predictions of circuit performance at different feed rates and for the two different ore types.

Suitable base case parameters for the ball mill were taken from the JKTech database. The base case selected was from a mill operating under similar conditions as the proposed CuDeco ball mill ie: downstream of a SAG mill and in closed circuit with a cluster of hydrocyclones. The base case was also processing an ore type not too different from the two simulated here. It was considered that the model parameters for this ball mill were suitable for use in the base case model of the CuDeco grinding circuit.

The SAG mill variable rates model was used in the simulations and the breakage rate equations within it were developed using all of the data available in the JKTech database. As a result, the equations represent a set of breakage rates which are an average of the database. When survey data is available, these breakage rates are customised to the particular mill by fitting. In design cases or when no operating data is available, such as is the case here, the database average breakage rates are used.

Parameters for all other pieces of equipment were either available from ore testing, or were assumed to be typical values.

The equipment model parameters for all items of equipment are presented and discussed in more detail in the following section.

6.2 Equipment Model Parameters

Breakage in the ball mill was modelled using the Perfect Mixing Ball Model within JKSimMet, using four knot points.

The four knot points used in the model are included in Table 3. The ball mill breakage / discharge (R/D*) curve displays the “classic” shape, which is a smooth increase in rate with increasing size up to a point where the curve reaches a maximum. The rate then decreases with further increases in size, indicating that the grinding rate reduces for very coarse particles. Note that although the fourth knot point is higher than the third, the spline interpolation between the points means that the curve rolls over between these two points and is decreasing again for the coarser particles.

Table 3: Ball Mill Model Parameters

Parameter	Value
ln(R/D*) at 0.075 mm	-2.13
ln(R/D*) at 0.300 mm	0.600
ln(R/D*) at 1.18 mm	2.71
ln(R/D*) at 4.75 mm	2.82

The appearance function in the ball mill model is used to describe the breakage pattern of the ore at ball mill sizes. For the purpose of this study, the default appearance function was considered appropriate since most of the breakage properties of the ore lie in the typical range and the assumption that it breaks in a typical pattern is reasonable.

The range of dimensions used in the simulation study for the CuDeco ball mill are compared with the original mill dimensions in Table 4 below. Note that mill dimensions specified are inside liner dimensions. The range of mill dimensions for each ore type are specified separately. Ore Type 1 refers to LMDH025 8-82/29-77 and Ore Type 2 refers to LMDH 006.

Table 4: Ball Mill Dimensions

Parameter		CuDeco Mill for Ore Type 1	CuDeco Mill for Ore Type 2	Original Mill
Diameter (inside liners)	m	4.8 - 7.0	3.5 - 5.6	3.627
Belly Length (inside liners)	m	5.4 - 7.6	3.8 - 6.5	-
Ball Load	vol %	30	30	40
Ball Top Size	mm	50	50	50
Fraction Critical Speed		0.7 - 0.76	0.7 - 0.76	0.7

The variable rates AG/SAG mill model was used to simulate the performance of the AG and SAG mill in the CuDeco circuit. Ore specific parameters for the AG/SAG mill model were available from SMC testing and are included in Table 1. Default machine specific parameters were used, as is typical for design cases.

The dimensions of the AG and SAG mill included in Table 5 are a summary of the range of dimensions simulated in the study, shown separately for each ore type. Note that mill dimensions specified are internal dimensions, and the length and diameters specified are inside the grinding zone. They do not include the discharge zone of the mill.

Table 5: AG/ SAG Mill Dimensions

Ore Type		Ore Type 1		Ore Type 2	
Parameter		SAG Mill	AG Mill	SAG Mill	AG Mill
Diameter (inside liners)	m	5.8 - 7.3	8.5 - 10.5	4.4 - 6.6	6.0 - 8.1
Belly Length (inside liners)	m	3.0 - 3.6	4.5 - 5.2	2.2 - 3.2	2.9 - 4.1
Feed Trunion Diameter	m	1.5	1.5	1.5	1.5
Feed End Cone Angle	degrees	15	15	15	15
Discharge End Cone Angle	degrees	15	15	15	15
Grate Aperture	mm	20	20	20	20
Grate Open Area Fraction	%	8	7.5 - 10	8	10
Pebble Port Aperture	mm	50	-	50	-
Pebble Port Fraction	%	0 - 10	0	0 - 10	0
Weighted Radius of Grates		0.75	0.75	0.75	0.75
Ball Load	vol %	10	0	9.5 - 10	0
Ball Top Size	mm	100	-	100	-
Total Load	vol %	25	25	25	25
Fraction Critical Speed		0.75	0.75	0.75	0.75

The hydrocyclone and AG/SAG discharge trommel were modelled using the simple efficiency curve model. Model parameters are included in Table 6 below and are typical values in each case for the type of classifier being modelled.

Table 6: Hydrocyclone and SAG Discharge Trommel Parameters

Parameter		Hydrocyclones	Discharge Trommel	
			Without Crusher	With Crusher
Sharpness of Efficiency Curve	Alpha	1.8	10	
Initial Dip in Efficiency Curve	Beta	0	0	
Water Split to Fine Product	%	65	99.98	
Corrected D50 - d50c	mm	0.160 - 0.710	12	10

Note that, regardless of ore type, the corrected D50 for the hydrocyclones was between 0.160 and 0.165 mm for all cases except the single stage AG mill simulations. The corrected D50 for the hydrocyclones in the two single stage AG mill simulations were 0.68 and 0.71 mm for the low throughput and high throughput cases respectively.

The machine parameters used in the crusher model are included in Table 7 and are typical for a cone crusher used in a recycle pebble crushing application. In the absence of any JK drop weight test data, the default appearance function and Ecs data were used. As a result, any power predictions are estimates only and have been included for the purpose of making some allowance for the crusher power draw only in order to compare the options more realistically. More accurate calculation of the crusher power is outside the scope of this project and will require some JK drop weight test data or some other means of estimating power requirements.

Table 7: Crusher Model Parameters

Parameter		Value	
		Low Tput	High Tput
Closed Side Setting	mm	8	
K1		0.8*CSS	
K2		2.5*CSS	
K3		2.3	
t10		15	
Crusher No Load Power	kW	50	80

7. SIMULATIONS

7.1 Introduction

Once the base case model was set up, simulations were performed to predict the performance of the circuit for two different ore types. A number of different configurations were simulated for each ore type, and a number of different feed rates were simulated for each configuration.

The general approach to carrying out the simulations was firstly to adjust the SAG mill diameter and length for the given fresh feed rate until the total load was close to 25%. Changes to the ball load for the SAG mill, or to the discharge grate open area fraction for the AG mill, allowed some finer adjustments in the total load so that it met the model constraint of being within 0.3% of the design load of 25%. Finally, the cyclone d50c value and ball mill dimensions were adjusted until the final product specification of 80% passing 150 µm was met at close to 250% circulating load.

The exception to this was for the single stage AG mill. In these cases a 250% circulating load was not possible to achieve while still keeping the total load in the

AG mill to within 0.3% of 25%. Generally the 250% circulating load specification only applies to the typical Bond application of a ball mill in closed circuit with cyclones. The circulating loads for the single stage AG mill simulations are much lower.

The size distribution of the fresh feed to the circuit for each ore type is presented graphically in Figure 4. The size distribution used was adjusted from the base case model feed size distribution so that the required F_{80} was achieved. The simulated feed F_{80} for each ore type was calculated using the measured DWi and an assumed primary crusher CSS of 150 mm.

The key parameters of the circuit feed for each ore type are presented in Table 8. The features of the size distributions are within the usual ranges for a 'typical' SAG feed size distribution.

Table 8: Circuit Feed Key Parameters for Both Ore Types

Feed Parameter		Ore Type 1	Ore Type 2
Lower Flowrate	dry tph	375	125
Higher Flowrate	dry tph	625	375
Moisture	%	3.5	3.5
Feed F_{80}	µm	67.7	81.1
% Passing 10 mm		36.7	32.3
% Passing 1 mm		12.6	11.6

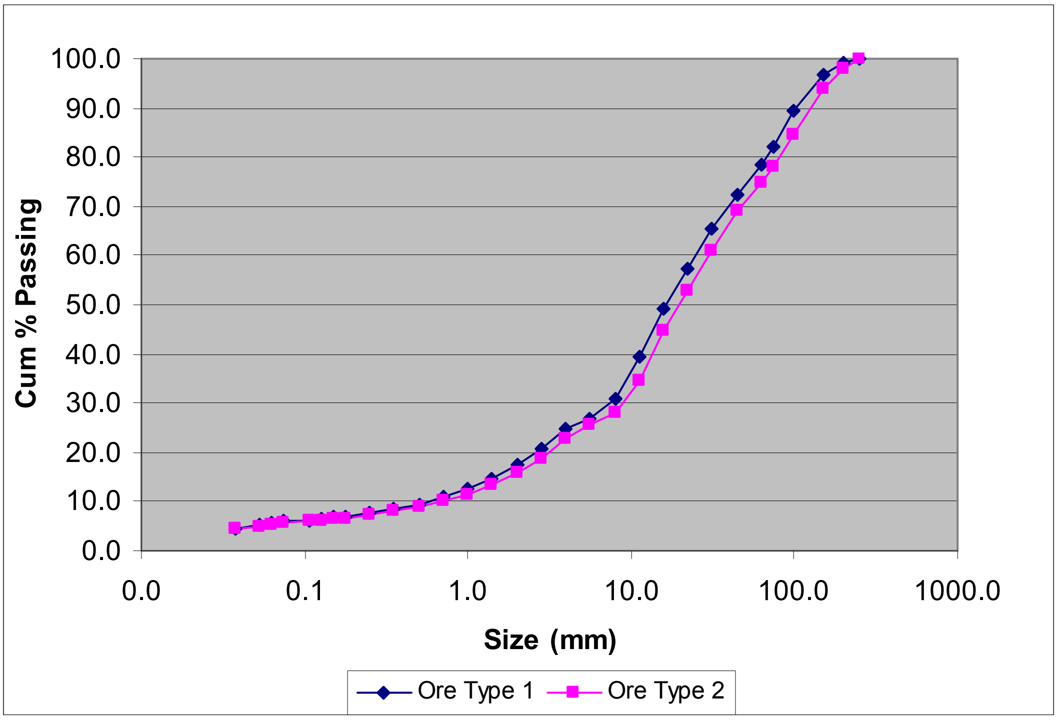


Figure 4: Simulated Feed Size Distributions for Each Ore Type

For the first ore type – 'LMDH025 8-82/29-77' (Ore Type 1) – four circuit configurations were simulated. The four circuit configurations simulated were:

- SAB: SAG mill followed by a cyclone – ball mill secondary circuit

- AB: AG mill followed by a cyclone – ball mill secondary circuit
- Single Stage AG: AG mill in closed circuit with a cyclone
- SABC: SAG mill with recycle crusher followed by a cyclone – ball mill secondary circuit.

Note that the original scope included an additional configuration of a single stage SAG mill operating in closed circuit with a cyclone. This option was investigated in some preliminary simulations but the results were considered unrealistically optimistic and so the AB configuration was included instead. The model parameters used in the SAG mill model do not really apply to the single stage SAG milling scenario. The default breakage rates used are mainly derived from SAG mills operating in the more typical configuration in which it is upstream of a ball mill or similar and it's role is as a primary mill which aims to produce a coarse grind for a high tonnage. The rates don't apply as well to the single stage SAG mill which aims to produce a fine product. Similarly, the results for the single stage AG mill should be used with some caution.

The predicted circuit performance was simulated for each case using two feed rates of 375 tph and 625 tph.

For the second ore type – 'Combined LMDH 006' (Ore Type 2) – three circuit configurations were simulated. The three circuit configurations simulated were:

- SAB: SAG mill followed by a cyclone – ball mill secondary circuit
- AB: AG mill followed by a cyclone – ball mill secondary circuit
- SABC: SAG mill with recycle crusher followed by a cyclone – ball mill secondary circuit.

The predicted circuit performance for each configuration was simulated at three feed rates of 125, 250 and 375 tph.

All simulations were compared with respect to overall power consumption and required equipment sizes in order to identify the more viable option or options based on the model predictions.

7.2 Circuit Simulation Results

7.2.1 Simulation Results for Ore Type 1: LMDH025 8-82/29-77

A summary of the simulation results for Ore Type 1 is presented in Table 9. The full set of simulated size distributions for each case is included in Appendices 2 and 3.

Table 9 presents the results for each simulation, including the calculated powers, required mill dimensions, transfer size and product size. The power requirements for the SAG mill and ball mill have been calculated using the Morrell power formula (1996). Power figures for the pebble crusher are estimates only and are included to ensure that some allowance is made for pebble crusher power requirements.

It should be noted that all dimensions specified are internal dimensions, including mill lengths and diameters. It should also be noted that the SAG mill dimensions specified are the dimensions inside the grinding zone and do not include the discharge zone.

As shown in Table 9, eight simulations in total were carried out. The first four simulations are the results for each of the possible circuit configurations at the lower throughput. In each case, the circuit achieves a final grind size P_{80} of 150 μm with a throughput of 375 tph and with a circulating load of close to 250%. The final four simulations are the results for each of the possible circuit configurations at the higher throughput of 625 tph.

The exception to the 250% circulating load specification is the single stage AG mill configuration which has a much lower circulating load of 88% for the lower throughput (Simulation 3) and 93% for the higher throughput (Simulation 7). The reason for this deviation from 250% was already discussed in Section 7.1.

For Simulation 1 in which the circuit is operating in SAB configuration with no recycle crusher, the model predicts that the size of the SAG mill required is 6.2 m diameter x 3.2 m long (internal dimensions). The SAG mill power requirement is 1675 kW. The transfer size (T_{80}) of the material from the SAG mill for this case is 985 µm. The model predicts that the ball mill dimensions required are 6.0 m diameter x 6.3 m long (internal dimensions) with a mill power requirement of 3569 kW. This equates to an overall power requirement of 5244 kW or a calculated circuit specific comminution energy (Ecs) of 14.0 kWh/t.

In Simulation 5 the circuit is operating in the same configuration except at the higher throughput. The predicted size of the SAG mill increases to 7.3 m diameter x 3.6 m long, with a T_{80} of 983 µm. The SAG mill power for this case is 2822 kW. The predicted size of the downstream ball mill for this scenario is 7.0 m diameter x 7.1 m long with a power requirement of 5881 kW. Overall, the power requirement for this case is 8703 kW, which equates to a calculated circuit Ecs of 13.9 kWh/t, indicating that the circuit is operating at essentially the same efficiency as the lower throughput case.

Simulations 2 and 6 investigate the circuit performance when it is operating in AB configuration. Simulation 2 predicts the performance of the circuit at the lower throughput and Simulation 6 at the higher throughput. In the case of Simulation 2, the predicted AG mill dimensions are much larger than those predicted for the Simulation 1 SAG mill. The predicted dimensions are 8.5 m diameter x 4.5 m long. The resultant AG mill transfer size T_{80} is very fine at 368 µm and this results in a greatly reduced predicted ball mill size of 4.8 m diameter x 5.4 m long. The resultant power requirement for the ball mill is 1766 kW, which means that the overall predicted power requirement of 5219 kW is very close to that of Simulation 1. The calculated circuit Ecs is 13.9 kWh/t.

In Simulation 6, the AG mill dimensions increase to 10.0 m diameter x 5 m long, with a transfer T_{80} of 381 µm and a predicted power requirement of 5704 kW. The predicted dimensions of the downstream ball mill are 5.5 m diameter x 6.6 m long. The power requirement for the ball mill is predicted to be 3014 kW, which means that the total power requirement for this scenario is 8718 kW. This results in a calculated circuit Ecs of 13.9 kWh/t, which is approximately the same as for all of the other cases so far.

In Simulations 3 and 7, the performance of the circuit when it is operating in the single stage AG configuration is investigated. The predicted dimensions of the AG mill in these cases are 8.7 m diameter x 4.9 m long (lower throughput case) and 10.5 m diameter x 5.2 m long (higher throughput case). The predicted power draws are 3981 and 5782 kW respectively, which means that the calculated circuit Ecs values are 10.6 kWh/t and 9.3 kWh/t. The results indicate that the circuit efficiency is significantly increased for this configuration. These results are overly optimistic in predicting the performance of the AG mill since the model parameters are better suited to the mill operating as a primary SAG mill upstream of a ball mill – cyclone. The results should be used with caution.

Table 9: Ore Type 1 Summary of Results – Circuit Details and Predicted Results

Circuit Section	Parameter	Sim 1 - SAB	Sim 2 - AB	Sim 3 - Single Stage AG	Sim 4 - SABC	Sim 5 - SAB High Tput	Sim 6 - AB High Tput	Sim 7 - Single Stage AG High Tput	Sim 8 - SABC High Tput
New Feed	Throughput (tph)	375	375	375	375	625	625	625	625
	F80 (mm)	67.68	67.68	67.68	67.68	67.68	67.68	67.68	67.68
SAG/AG Mill	Mill Feed Water Addition (tph)	151.9	151.5	128.9	168.0	253.3	253.2	223.8	278.6
	Mill Discharge % Solids	70	70	70	70	70	70	70	70
	Mill Ball Load (%)	10	0	0	10	10	0	0	10
	Ball Top Size (mm)	100	-	-	100	100	-	-	100
	Fraction CS	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	Total Mill Load (%)	25.19	25.13	25.18	25.19	25.21	24.98	25.27	25.04
	Mill Discharge Grate Size (mm)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
	Mill Discharge Grate Open Area Fraction	0.080	0.100	0.080	0.080	0.080	0.100	0.075	0.080
	Mill Pebble Port Fraction of Open Area	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.10
	Pebble Port Size (mm)	0.00	0.00	0.00	50.00	0.00	0.00	0.00	50.00
	Weighted Radius	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	Mill Diameter (m)	6.2	8.5	8.7	5.8	7.3	10	10.5	6.8
	Mill Length (m)	3.2	4.5	4.9	3.0	3.6	5	5.2	3.5
	Mill Power (kW)	1675	3452	3981	1336	2822	5704	5782	2297
Pebble Crusher	Pebble Crusher CSS (mm)	-	-	-	8.0	-	-	-	8.0
	Throughput (tph)	-	-	-	48.8	-	-	-	78.0
	Product P80 (mm)	-	-	-	8.755	-	-	-	8.793
	Pebble Crusher Power (kW)	-	-	-	88.4	-	-	-	140.9
SAG/AG Discharge Screen	Discharge Screen D50 (mm)	12.0	12.0	12.0	10.0	12.0	12.0	12.0	10.0
	Undersize P80 (mm)	0.985	0.368	0.280	1.091	0.983	0.381	0.317	1.043
Ball Mill	Mill Feed Water Addition (tph)	59	60	-	58	97	98	-	97
	Mill Discharge P80 (mm)	0.443	0.531	-	0.417	0.447	0.543	-	0.419
	Mill Discharge % Solids	72.00	72.00	-	72.00	72.00	72.00	-	72.00
	Mill Ball Load Fraction	0.30	0.30	-	0.30	0.30	0.30	-	0.30
	Ball Size (mm)	50	50	-	50	50	50	-	50
	Fraction CS	0.70	0.70	-	0.76	0.70	0.70	-	0.76
	Mill Diameter (m)	6.0	4.8	-	6.1	7.0	5.5	-	7.0
	Mill Length (m)	6.3	5.4	-	6.6	7.1	6.6	-	7.6
	Mill Power (kW)	3569	1766	-	3893	5881	3014	-	6291
Cyclones	Cyclone Feed Water Addition (tph)	345.9	348.3	155.0	328.5	574.0	575.8	257.6	549.4
	Cyclone OF P80 (mm)	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
	Cyclone OF %Solids	39.66	39.54	55.76	39.75	39.76	39.69	55.35	39.73
	Cyclone UF % Solids	75.40	75.44	66.05	75.37	75.37	75.39	66.48	75.38
	Cyclone Water Split to OF (%)	65	65	65	65	65	65	65	65
Grinding Circuit	Recirculating Load (%)	251%	253%	88%	250%	250%	251%	93%	250%
Operating Work Index (kWh/t)		17.97	17.88	13.64*	17.92	17.90	17.93	11.89*	17.66
Total Power Consumed (kW)		5244	5218	3981	5317	8703	8718	5782	8729
Calculated Circuit Specific Comminution Energy (kWh/t)		14.0	13.9	10.6*	14.2	13.9	13.9	9.2*	14.0

*** Considered to be overly optimistic**

In Simulations 4 and 8, the performance of the circuit when it is operating in the SABC configuration is investigated. The predictions for Simulation 4 indicate that the size of the SAG mill required is 5.8 m diameter x 3.0 m long. The transfer T_{80} is 1091 µm and the predicted power draw is 1336 kW. The corresponding ball mill for this scenario is predicted to be 6.1 m diameter and 6.6 m long, with a power draw of 3893 kW. The overall power requirement for this case is 5317 kW, which equates to a calculated circuit Ecs of 14.2 kWh/t. Note that this includes an allowance for the pebble crusher power requirement, which is indicative only. However, the power requirement of the pebble crusher relative to the mills is very small so the overall conclusions should not be affected by the inaccuracy of this figure.

In Simulation 8, the predicted size of the SAG mill increases to 6.8 m diameter x 3.5 m long. In this case, the transfer T_{80} is 1043 µm and the SAG mill power requirement is 2297 kW. The corresponding ball mill is predicted to be 7.0 m diameter x 7.6 m long, and the power requirement is 6291 kW. Overall, the power requirement for this case including the pebble crusher is 8729 kW, which equates to a calculated Ecs of 14.0 kWh/t.

A comparison overall circuit efficiency for each case is achieved by comparing the calculated circuit Ecs values for each simulation. As Table 9 shows, the values indicate that the overall circuit efficiency for all cases is reasonably close. All values are in the 13.9 to 14.2 kWh/t range. The exceptions to this are the simulations which investigate the circuit performance when it is operating in the single stage AG mill configuration. The calculated circuit Ecs values for these two simulations are significantly lower than the others, as already discussed, and are overly optimistic.

7.2.2 Simulation Results for Ore Type 2: LMDH 006

A summary of the simulation results for Ore Type 2 is presented in Table 10. The full set of simulated size distributions for each case is included in Appendices 4, 5 and 6.

Table 10 presents the results for each simulation for Ore Type 2 and includes the calculated powers, required mill dimensions, transfer size and product size. The power requirements for the SAG mill and ball mill have been calculated using the Morrell power formula (1996). Power figures for the pebble crusher are estimates only and are included to ensure that some allowance is made for pebble crusher power requirements.

Once again, all dimensions specified are internal dimensions. The SAG mill dimensions specified are the dimensions inside the grinding zone and do not include the discharge zone.

As shown in Table 10, nine simulations were carried out for Ore Type 2. Each of three circuit configurations were simulated at three different feed rates. The three circuit configurations are SAB, AB and SABC and these were investigated at 125, 250 and 375 tph. In each case, the circuit achieves a final grind size P_{80} of 150 µm.

For Simulations 1, 4 and 7 in which the circuit is operating in SAB configuration with no recycle crusher, the model predicts that the size of the SAG mill required varies from 4.8 m diameter x 2.4 m long to 6.6 m diameter x 3.2 m long (internal dimensions). The size of the mill increases with increasing throughput.

The SAG mill power requirement is between 700 and 2062 kW. The transfer size (T_{80}) of the material from the SAG mill is between 978 and 1026 µm. The model predicts that the ball mill dimensions required are from 4.0 m diameter x 4.6 m long to 5.6 m diameter x 6.0 m long (internal dimensions) with a mill power requirement ranging between 959 and 2860 kW. This equates to a calculated circuit specific comminution energy (Ecs) of between 13.1 and 13.3 kWh/t for this circuit configuration. This is lower than the Ecs of this circuit configuration when processing Ore Type 1, which is mainly due to the fact that Ore Type 2 has a lower Bond ball mill WI. It also has lower drop weight parameters, indicating a higher resistance to breakage in the SAG mill, but the lower Bond ball mill WI more than compensates for the higher specific comminution energy requirement in the SAG mill.

Table 10: Ore Type 2 Summary of Results – Circuit Details and Predicted Results

Circuit Section	Parameter	Sim 1 - SAB 125tph	Sim 2 - AB 125tph	Sim 3 - SABC 125tph	Sim 4 - SAB 250tph	Sim 5 - AB 250tph	Sim 6 - SABC 250tph	Sim 7 - SAB 375tph	Sim 8 - AB 375tph	Sim 9 - SABC 375tph
New Feed	Throughput (tph)	125	125	125	250	250	250	375	375	375
	F80 (mm)	81.06	81.06	81.06	81.06	81.06	81.06	81.06	81.06	81.06
SAG/AG Mill	Mill Feed Water Addition (tph)	50.85	50.54	57.5	101.6	101.1	114.0	152.4	151.9	170.1
	Mill Discharge % Solids	70	70	70	70	70	70	70	70	70
	Mill Ball Load (%)	9.5	0	10	10	0	10	10	0	10
	Ball Top Size (mm)	100	-	100	100	-	100	100	-	100
	Fraction CS	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	Total Mill Load (%)	25.11	24.92	25.15	25.16	25.02	25.20	25.05	25.2	24.70
	Mill Discharge Grate Size (mm)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
	Mill Discharge Grate Open Area Fraction	0.080	0.100	0.080	0.080	0.100	0.080	0.080	0.100	0.080
	Mill Pebble Port Fraction of Open Area	0.00	0.00	0.10	0.00	0.00	0.10	0.00	0.00	0.10
	Pebble Port Size (mm)	0.00	0.00	50.00	0.00	0.00	50.00	0.00	0.00	50.00
	Weighted Radius	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	Mill Diameter (m)	4.8	6	4.4	5.8	7.2	5.4	6.6	8.1	6.2
	Mill Length (m)	2.4	2.9	2.2	2.9	3.7	2.7	3.2	4.1	3.0
	Mill Power (kW)	700	1071	526	1361	2119	1065	2062	3147	1650
Pebble Crusher	Pebble Crusher CSS (mm)	-	-	8.0	-	-	8.0	-	-	8.0
	Throughput (tph)	-	-	19.8	-	-	37.3	-	-	53.8
	Product P80 (mm)	-	-	8.615	-	-	8.652	-	-	8.679
	Pebble Crusher Power (kW)	-	-	96.04	-	-	110	-	-	123.1
SAG/AG Discharge Screen	Discharge Screen D50 (mm)	12.0	12.0	10.0	12.0	12.0	10.0	12.0	12.0	10.0
	Undersize P80 (mm)	1.026	0.409	1.178	1.004	0.392	1.114	0.978	0.398	1.067
Ball Mill	Mill Feed Water Addition (tph)	20	20	19	39	39	39	58	58	58
	Mill Discharge P80 (mm)	0.463	0.491	0.429	0.457	0.514	0.427	0.453	0.516	0.424
	Mill Discharge % Solids	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00
	Mill Ball Load Fraction	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
	Ball Size (mm)	50	50	50	50	50	50	50	50	50
	Fraction CS	0.70	0.70	0.76	0.70	0.70	0.76	0.70	0.70	0.76
	Mill Diameter (m)	4.0	3.5	4.2	5.0	4.2	5.0	5.6	4.7	5.6
	Mill Length (m)	4.6	3.8	4.6	5.3	4.5	5.8	6.0	5.2	6.5
	Mill Power (kW)	959	572	1082	1913	1059	2091	2860	1611	3096
Cyclones	Cyclone Feed Water Addition (tph)	114.9	115.1	108.1	229.6	230.1	217.3	344.4	344.9	326.6
	Cyclone OF P80 (mm)	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
	Cyclone OF %Solids	39.70	39.72	39.72	39.73	39.73	39.71	39.74	39.73	39.73
	Cyclone UF % Solids	75.39	75.38	75.38	75.38	75.38	75.38	75.38	75.38	75.38
	Cyclone Water Split to OF (%)	65	65	65	65	65	65	65	65	65
Grinding Circuit	Recirculating Load (%)	250%	250%	250%	250%	250%	250%	250%	250%	250%
Operating Work Index (kWh/t)		16.99	16.82	16.46	16.76	16.27	16.16	16.80	16.24	16.20
Total Power Consumed (kW)		1659	1643	1704	3274	3178	3266	4922	4758	4869
Calculated Circuit Specific Comminution Energy (kWh/t)		13.3	13.1	13.6	13.1	12.7	13.1	13.1	12.7	13.0

Simulations 2, 5 and 8 investigate the circuit performance when it is operating in AB configuration. The predicted AG mill dimensions are much larger than those predicted for the SAG mill simulations. The predicted dimensions vary from 6.0 m diameter x 2.9 m long to 8.1 m diameter x 4.1 m long. The resultant AG mill transfer size T_{80} is very fine and is predicted to vary between 398 and 409 µm. This results in a greatly reduced ball mill of between 3.5 m diameter x 3.8 m long and 4.7 m diameter x 5.2 m long. The predicted power requirement for the ball mill is between 572 and 1611 kW. The calculated circuit Ecs is predicted to vary from 12.7 to 13.1 kWh/t which is lower than the SAB circuit configuration.

In Simulations 3, 6 and 9, the performance of the circuit when it is operating in the SABC configuration is investigated. The predictions indicate that the size of the SAG mill required ranges from 4.4 m diameter x 2.2 m long to 6.2 m diameter x 3.0 m long. The transfer T_{80} varies between 1067 and 1178 µm and the predicted power draw is from 526 to 1650 kW. The corresponding predicted ball mill size for this circuit ranges from 4.2 m diameter x 4.6 m long to 5.6 m diameter x 6.5 m long, with a power draw of between 1082 and 3096 kW. The overall power requirement for this case equates to a calculated circuit Ecs of between 13.0 and 13.6 kWh/t. Note that this includes an allowance for the pebble crusher power requirement, which is indicative only. However, the power requirement of the pebble crusher relative to the mills is very small so the overall conclusions should remain valid.

As Table 10 shows, a comparison of the calculated circuit Ecs values for each simulation indicate that the overall circuit efficiency for all cases is reasonably close. The values range from 12.7 to 13.6 kWh/t. As a general rule, the lower throughputs result in a marginally lower circuit efficiency for all configurations. A comparison of the specific comminution figures for each of the configuration option indicates that the circuit efficiencies are very close for all cases.

7.3 Ball Mill Power Predictions

As part of the simulation process, a check of the results against those predicted when using the traditional Bond modelling methods is routinely carried out. This involves comparing the model predicted ball mill power with the Bond power required for the same duty.

The standard Bond equation relates the power required to the throughput, work index, feed and product sizes. The various efficiency factors are then applied, as necessary, according to the standard Bond procedure as outlined in the Bond paper (1961). The JKSimMet model calculates the power required to turn a mill of given dimensions and with the given load at the given speed. It is independent of throughput, feed or product size. A comparison of the Bond and model powers for the ball mill for each of the simulations carried out for Ore Type 1 is presented in Table 11 below.

Table 11: Ore Type 1 Ball Mill Power Requirements - Model vs Bond

Mill Power	Calculation Method	Sim 1 - SAB	Sim 2 - AB	Sim 3 - Single Stage AG	Sim 4 - SABC	Sim 5 - SAB High Tput	Sim 6 - AB High Tput	Sim 7 - Single Stage AG High Tput	Sim 8 - SABC High Tput
Ball Mill Power (kW)	Model	3569	1766	-	3893	5881	3014	-	6291
	Bond	3289	2180	-	3394	5477	3715	-	5580

Table 12 shows a comparison of the Bond and model powers for the ball mill for each of the simulations carried out for Ore Type 2.

Table 12: Ore Type 2 Ball Mill Power Requirements - Model vs Bond

Mill Power	Calculation Method	Sim 1 - SAB 125tph	Sim 2 - SAB 250tph	Sim 3 - SAB 375tph	Sim 4 - AB 125tph	Sim 5 - AB 250tph	Sim 6 - AB 375tph	Sim 7 - SABC 125tph	Sim 8 - SABC 250tph	Sim 9 - SABC 375tph
Ball Mill Power (kW)	Model	959	1912	2860	572	1059	1611	1082	2091	3096
	Bond	981	1949	2899	698	1336	2023	1022	2011	2979

It can be seen that the predictions made by Bond all agree within approximately 10% of the model predicted power. The general discrepancy may be due in part to the fact that the Bond method assumes a feed size distribution which is the typical shape of the size distribution of a rod or ball mill discharge. However, typically a discharge stream from an AG or SAG mill will have a larger proportion of coarse material than the typical Bond distribution as well as a larger proportion of fine material. As a result, the model predicted powers may be different from the figures Bond would predict.

The Morrell power formula is used in the model since it has been shown in operations to be correct to within 7% of the measured power draw.

8. CONCLUSIONS

Simulations were carried out using the JKSimMet model to predict the performance of the CuDeco circuit for a number of different circuit configurations at a number of different throughputs and for two different ore types. A number of conclusions can be drawn, as follows:

- The circuit performance when the circuit is operating with a SAG mill upstream of the ball mill – cyclone (SAB) compared with its performance when there is an AG mill upstream of the ball mill – cyclone (AB) highlight a number of key differences in operation. The AG mill power requirement is higher than the corresponding SAG mill and the resulting transfer T_{80} is much finer for the AG mill. However, the ball mill power requirement for the AB configuration is lower than for the SAB configuration and so the overall power requirements per tonne of feed is approximately the same.
- The installation of a recycle crusher on the SAG mill has little effect in changing the predicted circuit performance. The SAG mill power reduces marginally for a marginal increase in the transfer T_{80} and the ball mill power increases slightly. The overall power requirement remains approximately constant, which indicates that the circuit efficiency is not affected significantly by the installation of the recycle crusher. This is typical of SAG mills operating with ores with moderate or low impact resistance.
- Power figures for the pebble crusher are estimates only since there was no JK drop weight data to fully develop a model of the crusher power requirements. The figures are included to allow for the slight increase in power required when a pebble crusher is installed. Overall conclusions should not be affected by the reduced accuracy of these estimates, since the relative power consumption of the crusher is small compared with the mills.
- The results for the single stage AG mill circuit performance indicate that the circuit efficiency is significantly increased for this configuration. These results are overly optimistic in predicting the performance of the AG mill since the model parameters are better suited to the mill operating as a primary SAG mill upstream of a ball mill – cyclone. The results should be used with caution.

- A comparison of circuit efficiencies for all configurations indicate that the circuit operates at marginally higher efficiencies when it is processing the second ore type, 'LMDH 006' compared with the first ore type, 'LMDH025 8-82/29-77'. This is due to the fact that the second ore type has a lower Bond ball mill WI, giving lower ball mill power draws, which more than compensates for its lower SAG mill parameters which give higher SAG mill power draws.

9. REFERENCES

Morrell S, 1996 Power draw of wet tumbling mills and its relationship to charge dynamics – Part 2: an empirical approach to modelling of mill power draw *Trans Inst Min Metall*, 105, C54-C62, Jan-Apr.

Rowland Jr C A and Kjos D M, 1978 "Rod and Ball Mills" Ch 12 in "Mineral Processing Plant Design" (Eds: Mular and Bhappu), SME.

Bond, F.C., 1961. "Crushing and Grinding Calculations Parts I and II", British *Chemical Engineering*, Vol 6, Nos 6 and 8

10. DISCLAIMER

All JKTech reports are subject to the standard JKTech Pty Ltd disclaimer as follows:

1. JKTech Pty Ltd and University staff operating with JKTech Pty Ltd make reasonable efforts to ensure an accurate understanding of client requirements. The information in this report is based on that understanding and JKTech Pty Ltd strives to be accurate in its advice.

2. While reasonable care has been taken in the preparation of this report/proposal, this report/proposal and all information, assumptions, and recommendations herein are published, given, made, or expressed without any responsibility whatsoever on the part of JKTech Pty Ltd, whether arising by way of negligence, breach of contract, breach of statutory duty or otherwise.

3. No warranty or representation of accuracy or reliability in respect of the report/proposal is given by JKTech Pty Ltd or its directors, employees, servants, agents, consultants, successors in title and assigns.

4. If liability is not, by law, capable of exclusion, then JKTech Pty Ltd accepts liability to the minimum level set by that law.

5. This disclaimer shall apply to liability to any person whatsoever, irrespective of how such liability arises, whether by use of this report/proposal by that person or you or any other person or otherwise.

6. JKTech Pty Ltd is not responsible in any way whatsoever for the error neglect or default of others upon whom it has placed reliance in the preparation of this report/proposal.

7. You shall indemnify JKTech Pty Ltd and its directors, employees, servants, agents, consultants, successors in title and assigns against any claim made against any or all of them by third parties arising out of the disclosure of the report/proposal, whether directly or indirectly, to a third party.

Appendix 1 CuDeco Comminution Tests Reports

JKTech Pty Ltd
Isles Road
Indooroopilly Qld 4068
AUSTRALIA
Telephone + 61 7 3365 5842
Facsimile + 61 7 3365 5900
E-mail jktech@jktech.com.au
Internet www.jktech.com.au

COMMINUTION TEST REPORT (BATCH 1)

on

Samples of Drill Core

from

CuDECO Ltd

Tested at

JKTech Pty Ltd, Brisbane, Queensland

for

CuDECO Ltd

JKTech Job No. 07264 - July 2007

JKTech Pty Ltd

COMMINUTION TEST REPORT (BATCH 1)

on

Samples of Drill Core

from

CuDECO Ltd

JKTech Job No. 07264 - July 2007

Submitted to

CuDECO Ltd

Tested at JKTech Pty Ltd, Brisbane, Queensland

TABLE OF CONTENTS

Page No

APPENDICES

Page No

TABLE OF FIGURES

Page No

TABLE OF TABLES

Page No

1 INTRODUCTION

Three samples of Copper Ore from CuDECO Ltd were received by JKTech on June 26, 2007 for Comminution Testing. The samples were identified as LMDH006 141-154m (19.1kg), LMDH006 113-124m (19.1kg), LMDH025 8-82m (12.6kg) and LMDH025 29-77m (7.6kg).

The latter two samples were composited for testing; both of these sample contained large amounts of free copper. Since the presence of this free copper would have rendered the tests results meaningless, the most obvious large particles of free copper were removed prior to testing. However, smaller particles of free copper remained in the sample tested.

The samples were to be subjected to SMC, Bond Ball, Bond Rod and Bond Abrasion Testing. Test work and reporting were completed on April 30, 2008.

2 THE SMC TEST

2.1 INTRODUCTION

The standard JKTech drop-weight test provides ore specific parameters for use in the JKSimMet Mineral Processing Simulator software. In JKSimMet, these parameters are combined with equipment details and operating conditions to analyse and/or predict SAG/autogenous mill performance. The same test procedure also provides ore type characterisation for the JKSimMet crusher model.

The SMC (SAG Mill Comminution) test was developed by Steve Morrell of SMC Testing Pty Ltd (SMCT) to provide a cost effective means of obtaining these parameters from drill core or in situations where limited quantities of material are available. The ore specific parameters have been calculated from the test results and are supplied to CuDECO Ltd in this report as part of the standard procedure.

2.2 DESCRIPTION OF THE SMC PROCEDURE

2.2.1 General

The SMC test is a precision test, which uses particles that are either cut from drill core using a diamond saw to achieve close size replication or else selected from crushed material so that particle mass variation is controlled within a prescribed range. The particles are then broken at a number of prescribed impact energies. The high degree of control imposed on both the size of particles and the energies used to break them, means that the test is largely free of the repeatability problems that plague tumbling mill rock characterisation tests. Such tests usually suffer from variations in feed size (which is not closely controlled) and energy input, often assumed to be constant when in reality it can be highly variable (Levin, 1989).

2.2.2 Outline of the Procedure

The test normally uses cut pieces of quartered (slivered) drill core. Whole core or half core can be used, but when received in this form it needs to be first quartered as a preliminary step in the procedure. Once quartered, any broken or tapered ends of the quartered lengths are cut, to square them off. Before the lengths of quartered core are cut to produce the pieces for the drop-weight testing, each one is weighed in air and then in water, to obtain a density measurement and a measure of its mass per unit length.

The test calls for a prescribed target volume for the core pieces, chosen so that their volume is equivalent to the mean volume of particles in one of the standard drop-weight test size fractions. The size fraction targeted depends on the original core diameter and the choice is made so as to ensure that pieces of the correct volume have “chunky” rather than “slabby” proportions.

Having measured the density of the core, the target volume can be translated into a target mass and with the average mass per unit length value also known, an average cutting interval can be determined for the core.

Sufficient pieces of the quartered core are cut to generate 100 particles. These are divided into five groups of 20. Each group is then broken in the drop-weight tester at a different specific energy level. Within each group the three possible orientations of the particles are equally represented (as far as possible, given that there are 20 particles). The orientations prescribed for testing are shown in Figure 1.

Figure 1 - Orientations of Pieces for Breakage

The rest height of the drop-head (gap) is recorded for each particle. After breaking all 20 particles in a group, the broken product is sieved at a sieve size that is one tenth of the original particle size. Thus the percent passing mass gives a direct reading of the t10 value at that energy level.

If only bulk sample is available or if the core is too friable for cutting, then the particle selection method is used. In this case, particles are selected so that their individual masses lie within ±30% of the target mass and the mean mass for each set of 20 lies within ±10% of the target mass. This method is also normally used for cores with diameters exceeding 70 mm, where the particle masses are too large to achieve the highest prescribed energy level.

2.3 DROP-WEIGHT INDEX RESULTS

The results of the SMC tests on the LMDH025 from CuDECO Ltd are given in Table 1. This table includes the average rock density and the drop-weight index that is the direct result of the test procedure. It also includes the derived estimates of parameters A and b.

In the case of the LMDH025 from CuDECO Ltd, the A and b estimates are based on a correlation using the database of all results so far accumulated by SMCT.

Table 1 - SMC Test Results

Sample Designation	JKTech Code	SG	SMC Test Dwi	SMC Test Derived Values A	SMC Test Derived Values b
LMDH006 141 - 154 m	JKT2194-1	2.90	6.2	67.0	0.70
LMDH006 113-124 m	JKT2194-2	3.08	4.1	74.0	1.00
Combined LMDH025 8-82 m and LMDH025 29-77 m	JKT2194-5	2.65	3.2	61.5	1.34

For the entire population of over 3,500 rock samples so far tested, the majority of DWi values lie in the range 2 to 12, soft ores being at the low end of the scale and hard ores at the high end. The DW_i results for the LMDH025 from CuDECO Ltd ranged from 3.2 to 6.2 giving an average of 4.5. This places them over a wide range of values of the DWi range. A histogram of DWi values from the SMCT database is shown in Figure 2 for comparison.

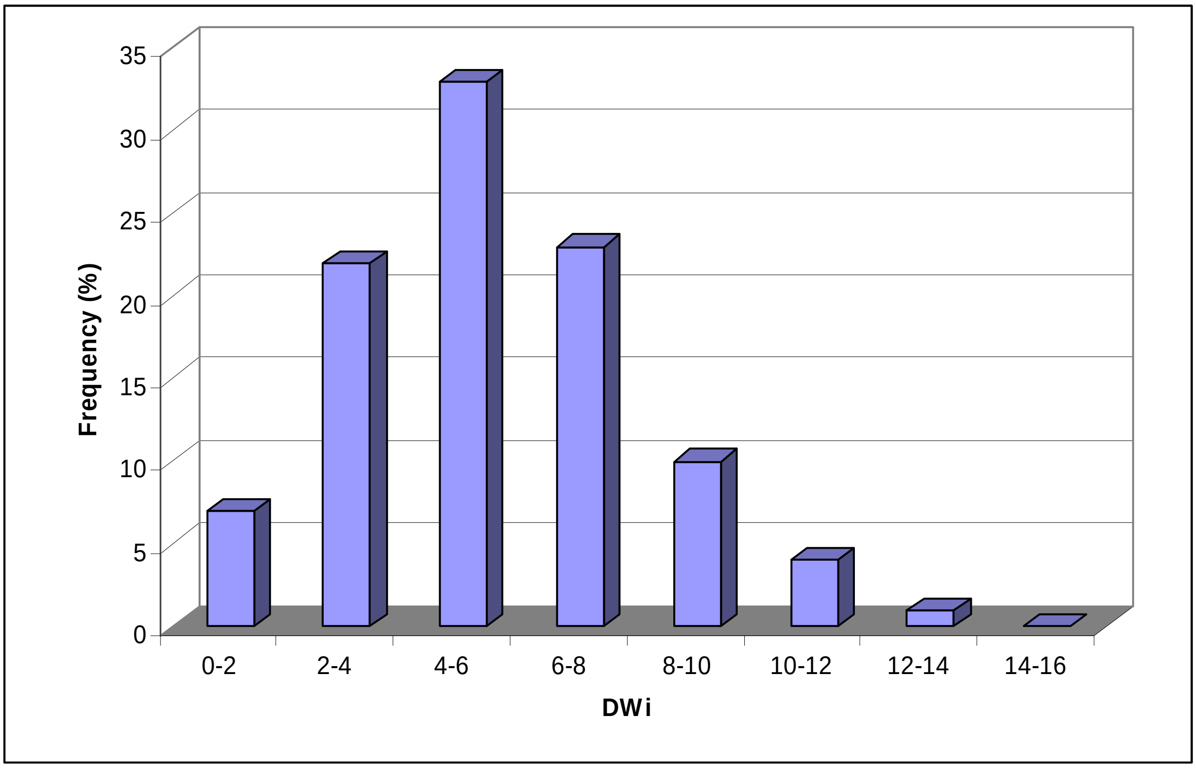


Figure 2 – Distribution of DWi Values in the SMC Test Database

A cumulative graph of DWi values from the SMC Database is also shown in Figure 3 below. The DWi range of 3.2 to 6.2 for these samples places them in the percentile range 24-58 percentile range. These figures represent the percentages of all ores tested that are softer than the samples in question.

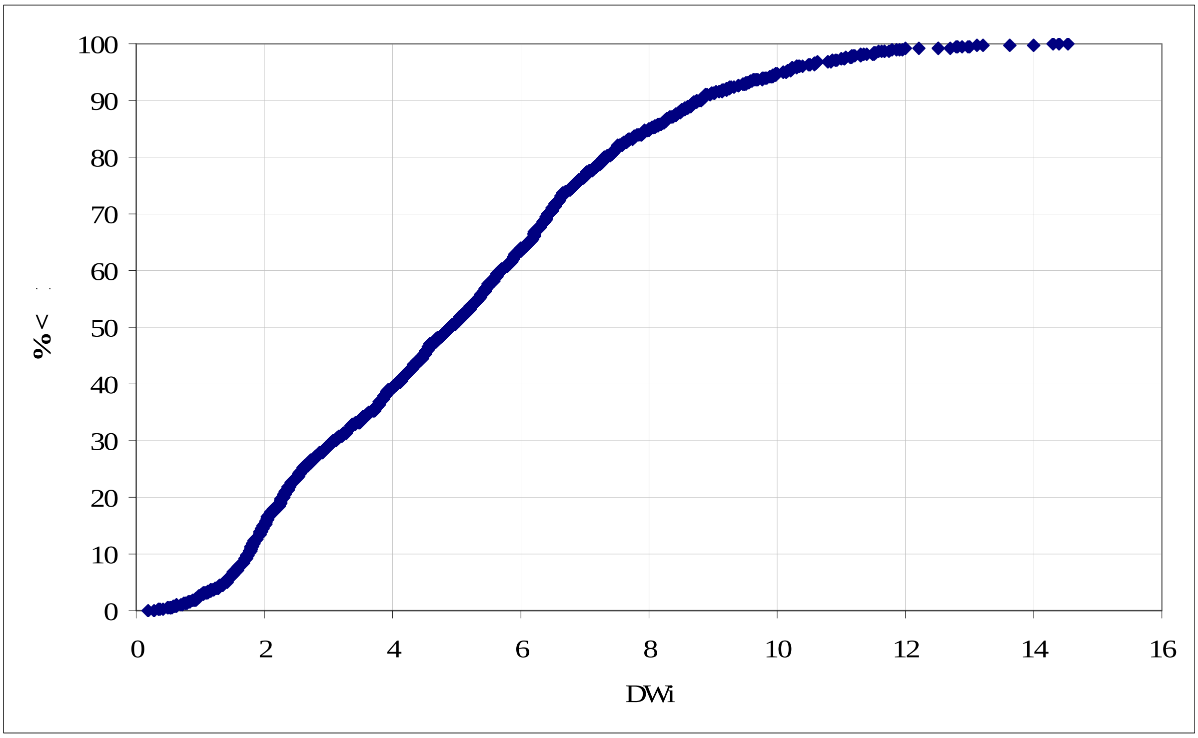


Figure 3 - Cumulative Distribution of DWi Values in SMC Test Database

The value of A*b, which is also a measure of resistance to impact breakage, is calculated and presented in Table 2 along with indicators of how each A*b value compares with the accumulated values in the JKTech DW database (from full drop-weight testing). These indicators are the Category (eg “soft” etc), the Rank (how many out of 2,200 recordings in database are harder) and the % of database values that are harder. Note that in contrast to the DWi, a high value of A*b means that an ore is soft whilst a low value means that it is hard.

Table 2 – Derived Values for A*b and t10 at 1 kWh/t

Sample Designation	JKTech Code	A*b				t10 @ 1 kWh/t			
		Value	Category	Rank	%	Value	Category	Rank	%
LMDH006 141 - 154 m	JKT2194-1	46.9	medium	1103	48.6%	33.7	medium	1206	53.2%
LMDH006 113-124 m	JKT2194-2	74.0	soft	1706	75.2%	46.8	soft	1887	83.2%
Combined LMDH025 8-82 m and LMDH025 29-77 m	JKT2194-5	82.4	soft	1797	79.2%	45.4	soft	1850	81.5%

The calculated value of t_{10} at an Ecs of 1 kWh/t is also shown in Table 2. This is again accompanied by Category, Rank and the % of values in the database that are harder, so each can be seen against the yard-stick of all other samples in the JKTech database.

The derived A*b values range from 46.9 to 82.4 giving an average of 67.8, while the t_{10} at 1 kWh/t values ranged from 33.7 to 46.8 giving an average of 42.0.

In Figure 4 and Figure 5 below, histogram style frequency distributions for the A*b values and for the t_{10} at 1 kWh/t values in the JKTech DW database are shown respectively.

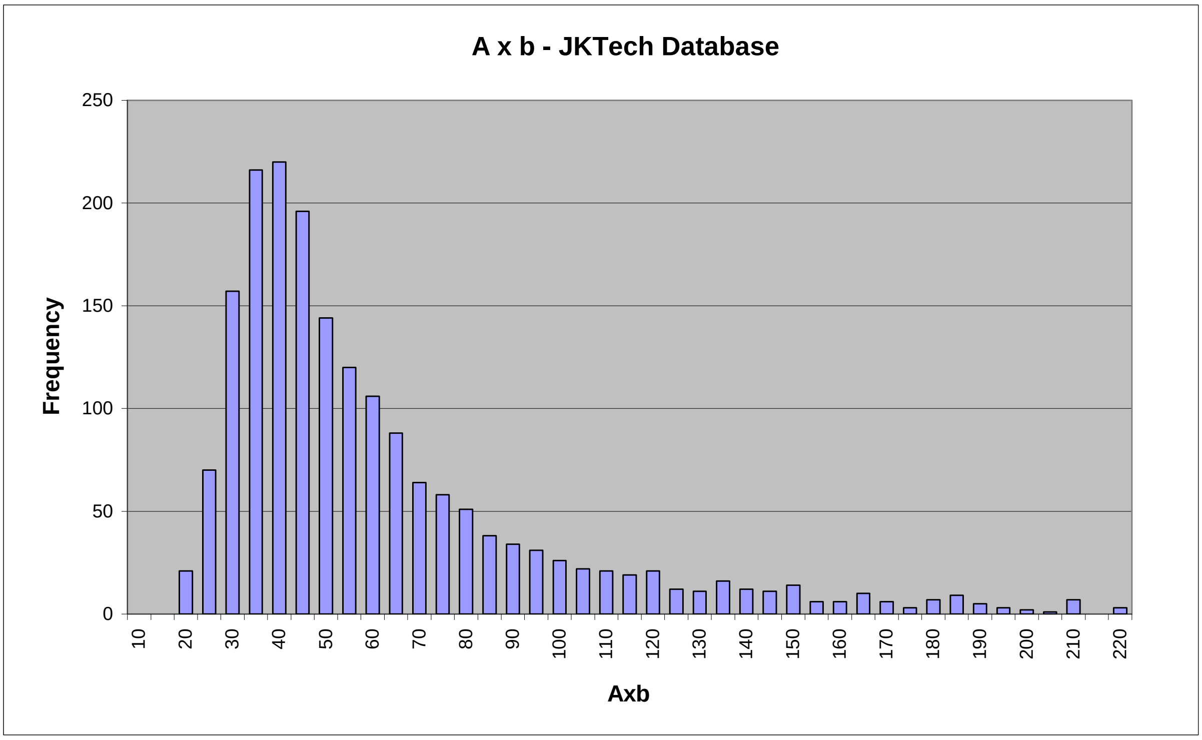


Figure 4 - Frequency Distribution of A*b in the JKTech Database

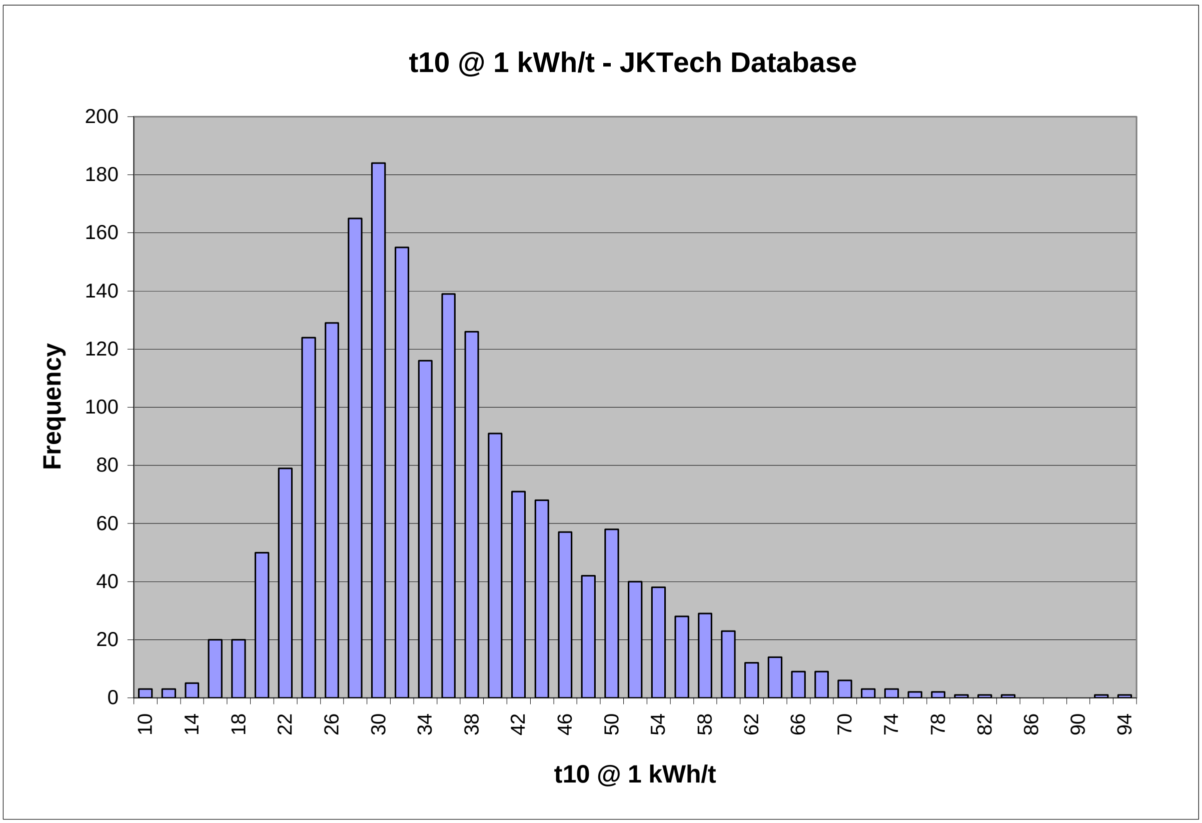


Figure 5 - Frequency Distribution of t10@1kWh/t in the JKTech Database

3 THE BOND ROD MILL WORK INDEX TEST

3.1 BOND ROD MILL WORK INDEX TEST PROCEDURE

This section provides a brief description of the Bond rod mill work index test procedure.

Feed is prepared by stage crushing to 12.7 mm (0.5 inch) and the size distribution determined by wet and dry sieving.

A sub-sample of the feed is separated by riffling until enough material to provide 1250 ml tightly packed in a 2000 ml measuring cylinder is available. The sub-sample is weighed and ground dry in a 305 by 610 mm batch, tilting rod mill with wave type liners operating at 46 rpm with a standard rod charge.

To equalise segregation at the ends of the mill, it is operated horizontal for 8 revolutions, tipped up 5° for one revolution then down 5° for one revolution. This cycle is repeated continuously throughout each grinding period.

After a predetermined number of revolutions (normally 100), the mill is emptied and all the material less than the test sieve size is removed, and weighed. Fresh, unsegregated feed is added to the charge to bring its mass back to match that of the original feed and it is returned to the mill.

This material is ground for a number of revolutions calculated to produce a 100% circulating load after which the charge is again dumped and sized on the test sieve. The number of revolutions is calculated from the previous cycle to produce test sieve undersize equal to the weight of the new feed added to the mill.

The grinding cycles are continued until the net mass of test sieve undersize produced per revolution reaches equilibrium. The average of net mass per revolution from the last three cycles is taken as the rod mill grindability (*Grp*) in g/revolution.

The product is also sized and the P80 determined.

The work index *Wi* is calculated from the following equation:

$$W_i = \frac{68.4}{P_1^{0.23} \times Gbp^{0.625}\left(\frac{10}{\sqrt{P_{80}}} - \frac{10}{\sqrt{F_{80}}}\right)}$$

where	W_i	=	Work Index (kWh/tonne)
	P_1	=	Test sieve aperture (μm)
	Gbp	=	Grindability (g/revolution)
	F_{80}	=	80% passing size of feed (μm)
	P_{80}	=	80% passing size of product (μm)

The *Wi* value for this material is for an average overflow rod mill of 2.44 m (8 ft) in internal diameter grinding wet in open circuit.

Complete details of the test procedure and the application of the results in the calculation of rod mill power requirements and size are given in Bond (1961).

3.2 BOND ROD MILL WORK INDEX TEST RESULTS

The results of the test are summarised in Table 3 and given in detail in APPENDIX B .

Table 3 - Summary of Bond Rod Mill Work Index Test Results for Three Samples

Sample Name	JKTech Sample No	Bond Rod Mill Data				
		F80 µm	P80 µm	Grindability g/revolution	Aperture µm	Work Index kWh/tonne
LMDH006 141 - 154 m	JKT2194-1	9,575	878	10.362	1,180	13.2
LMDH006 113-124 m	JKT2194-2	8,423	896	14.719	1,180	11.1
Combined LMDH025 8-82 m and LMDH025 29-77 m	JKT2194-5	9,310	864	12.439	1,180	11.7

4 THE BOND BALL MILL WORK INDEX TEST

4.1 INTRODUCTION

The Bond ball mill work index test results are used to calculate the power needed for ball milling the ore under test, from a known feed F80 to a required product P80. From this information, the sizes of ball mills required to process the ore at a particular feed rate can be calculated.

4.2 BOND BALL MILL WORK INDEX TEST PROCEDURE

This section provides a brief description of the Bond ball mill work index test procedure.

Feed is prepared by stage crushing to 3.35 mm (6 mesh Tyler) and the size distribution determined by wet and dry sieving.

A sub-sample of the feed is separated by riffling until enough material to provide 700 ml tightly packed in a 1000 ml measuring cylinder is available. The sub-sample is weighed and ground dry in a 305 by 305 mm batch ball mill operating at 70 rpm with a standard ball charge.

After a predetermined number of revolutions (normally 100), the mill is emptied and all the material less than the test sieve size is removed and weighed. Fresh, unsegregated feed is added to the charge to bring its mass back to that of the original feed before returning it to the mill.

This material is ground for a number of revolutions calculated to produce a 250% circulating load after which the charge is again dumped and sized on the test sieve. The number of revolutions is calculated from the previous cycle to produce test sieve undersize equal to 1/3.5 of the total charge in the mill.

The grinding cycles are continued until the net mass of test sieve undersize produced per revolution reaches equilibrium. The average of net mass per revolution from the last three cycles is taken as the ball mill grindability (*Gbp*) in g/revolution. The product is also sized and the P80 determined.

The work index *Wi* is calculated from the following equation:

$$W_i = \frac{49.05}{P_1^{0.23} \times Gbp^{0.82}\left(\frac{10}{\sqrt{P_{80}}} - \frac{10}{\sqrt{F_{80}}}\right)}$$

where	W_i	=	Work Index (kWh/tonne)
	P_1	=	Test sieve aperture (μm)
	Gbp	=	Grindability (g/revolution)
	F_{80}	=	80% passing size of feed (μm)
	P_{80}	=	80% passing size of product (μm)

The *Wi* value for this material is for an average overflow ball mill of 2.44 m (8 ft) in internal diameter.

Complete details of the test procedure and the application of the results in the calculation of ball mill power requirements and size are given in Bond (1961).

4.3 BOND BALL MILL WORK INDEX TEST RESULTS

The results of the test are summarised in Table 4 and given in detail in APPENDIX C .

Table 4 - Summary of Bond Ball Mill Work Index Test Results for Three Samples

Sample Name	JKTech Sample No	Bond Ball Mill Data				
		F80 µm	P80 µm	Grindability g/revolution	Aperture µm	Work Index kWh/tonne
LMDH006 141 - 154 m	JKT2194-1	2,332	79	1.257	106	15.2
LMDH006 113-124 m	JKT2194-2	2,217	78	1.534	106	12.9
Combined LMDH025 8-82 m and LMDH025 29-77 m	JKT2194-5	2,265	77	1.292	106	14.6

5 THE BOND ABRASION INDEX TEST

5.1 INTRODUCTION

JKTech does not offer this test directly but subcontracts the work to Amdel when required. The Bond abrasion Index test requires 3 kg of material in the 19+12.7 mm size range.

Complete details of the test procedure and the application of the results are given in Bond (1961).

5.2 BOND ABRASION INDEX TEST RESULTS

The results of the test are summarised in Table 4 and given in detail in APPENDIX D .

Table 5 - Summary of Bond Abrasion Index Test Results for Three Samples

Sample Name	JKTech Sample No	Bond Abrasion Index
LMDH006 141 - 154 m	JKT2194-1	0.2349
LMDH006 113-124 m	JKT2194-2	0.2710
Combined LMDH025 8-82 m and LMDH025 29-77 m	JKT2194-5	0.0721

6 REFERENCES

Andersen, J. and Napier-Munn, T.J., 1988, “Power Prediction for Cone Crushers", Third Mill Operators' Conference, Aus.I.M.M (Cobar, NSW), May 1988, pp 103 - 106

Leung, K. 1987. "An Energy-Based Ore Specific Model for Autogenous and Semi-Autogenous Grinding Mills." Ph.D. Thesis. University of Queensland (unpublished)

Leung, K., Morrison, R.D. and Whiten, W.J., 1987. "An Energy Based Ore Specific Model for Autogenous and Semi-autogenous Grinding", Copper *87*, Vina del Mar, Vol. 2, pp 71 - 86

Morrell, S. 1996. "Power Draw of Wet Tumbling Mills and Its Relationship to Charge Dynamics - Parts I and II", *Transaction Inst. Min. Metall.* (Sect C: Mineral Process Extr. Metall.), 105, 1996, pp C43-C62

Bond, F.C., 1961. "Crushing and Grinding Calculations Parts I and II", British *Chemical Engineering*, Vol 6, Nos 6 and 8

7 DISCLAIMER

All JKTech Pty Ltd reports are subject to a standard disclaimer as follows:

1. JKTech Pty Ltd and University staff operating with JKTech Pty Ltd make reasonable efforts to ensure an accurate understanding of client requirements. The information in this report is based on that understanding and JKTech Pty Ltd strives to be accurate in its advice.

2. While reasonable care has been taken in the preparation of this report/proposal, this report/proposal and all information, assumptions, and recommendations herein are published, given, made, or expressed without any responsibility whatsoever on the part of JKTech Pty Ltd, whether arising by way of negligence, breach of contract, breach of statutory duty or otherwise.

3. No warranty or representation of accuracy or reliability in respect of the report/proposal is given by JKTech Pty Ltd or its directors, employees, servants, agents, consultants, successors in title and assigns.

4. If liability is not, by law, capable of exclusion, then JKTech Pty Ltd accepts liability to the minimum level set by that law.

5. This disclaimer shall apply to liability to any person whatsoever, irrespective of how such liability arises, whether by use of this report/proposal by that person or you or any other person or otherwise.

6. JKTech Pty Ltd is not responsible in any way whatsoever for the error neglect or default of others upon whom it has placed reliance in the preparation of this report/proposal.

7. You shall indemnify JKTech Pty Ltd and its directors, employees, servants, agents, consultants, successors in title and assigns against any claim made against any or all of them by third parties arising out of the disclosure of the report/proposal, whether directly or indirectly, to a third party.

APPENDICES

APPENDIX A BACKGROUND TO THE SMC TEST

A 1 HOW THE SMC TEST RESULTS ARE USED

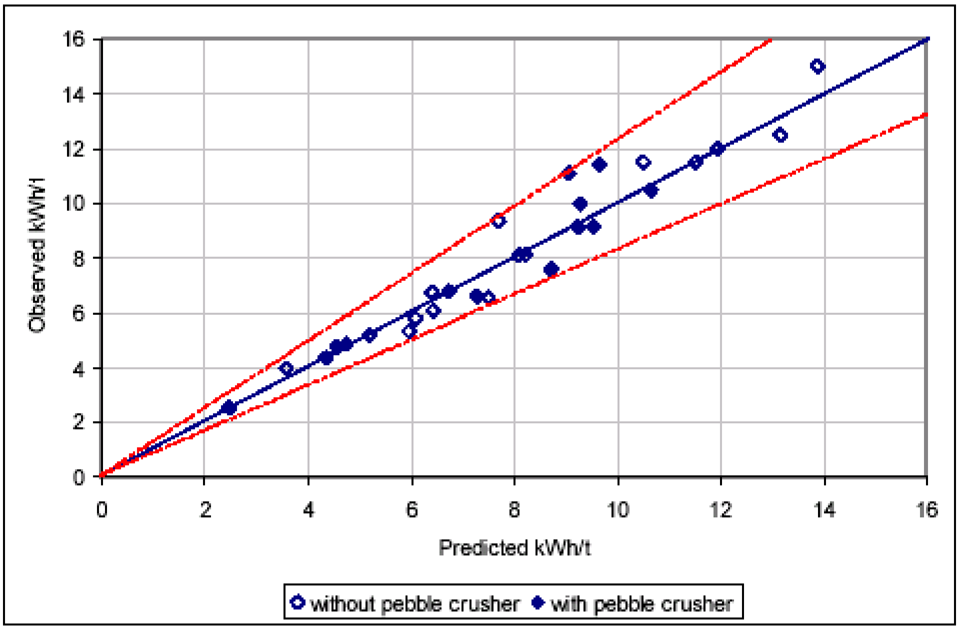
The SMC test generates a relationship between specific input energy (kWh/t) and the percent of broken product passing a specified sieve size. The results are used to determine the drop-weight index (DWi), which is a measure of the strength of the rock when broken under impact conditions. The DWi is directly related to the JK rock breakage parameters A and b and hence can be used to estimate the values of these parameters.

Provision of a relatively low cost method of estimating the A and b parameters opens the possibility of incorporating these data into mine and mill planning operations. However a number of full drop-weight tests is still recommended for any particular orebody, to ensure that an accurate correlation between the DWi and the A and b parameters is available. The number of full drop-weight tests required for a given orebody will depend on its variability and should at least cover the major recognised ore types.

The A and b parameters are used in AG/SAG mill models, such as those in JKSimMet, for predicting how the rock will break inside the mill. From this description the models can predict what the throughput, power draw and product size distribution will be (Napier-Munn et al (1996)). Modelling also enables a detailed flowsheet to be built up of the comminution circuit response to changes in ore type. It also allows optimisation strategies to be developed to overcome any deleterious changes in circuit performance predicted from differences in ore type when such changes are indicated by the SMC test. These strategies can include both changes to how mills are operated (eg ball load, speed etc) and changes to feed size distribution through modification of blasting practices and primary crusher operation (mine-to-mill).

The mine to mill models require information on rock mass competence such as provided by the point load index. The DWi is correlated with the point load index and hence can also be used in blast fragmentation modelling where direct measurements of point load index are not available.

The DW_i is related to the resistance of a rock to breakage under impact. SMCT has developed a series of equations that relate the DW_i to the specific energy (kWh/t) requirements of complete AG and SAG mill circuits. These equations take into consideration factors such as ball charge, feed size, aspect ratio, whether the mill is operated with or without a pebble crusher and whether it is closed with a fine classifier such as a cyclone. The ability of these equations to predict AG/SAG mill circuit specific energy is illustrated in App. Fig. 1. The data shown cover 19 different operations and include Cu, Au, Ni and Pb/Zn ores.



App. Fig. 1 - Mill Power Prediction Based on DWi

It should be noted that the parameter ta, which is the parameter representing the low energy abrasion component of breakage, is not yielded by the SMC test. This parameter is derived from a tumbling test that is carried out as part of the full drop-weight test. The fact that it is also required as an input to the JKSimMet SAG/AG models provides a further reason for ensuring that some full drop-weight tests are also performed to represent at least the main rock types of an orebody.

A 2 IMPACT COMMINUTION THEORY

When a rock fragment is broken, the degree of breakage can be characterised by the "t10" parameter. The t10 value is the percentage of the original rock mass that passes a screen aperture one tenth of the original rock fragment size. This parameter allows the degree of breakage to be compared across different starting sizes.

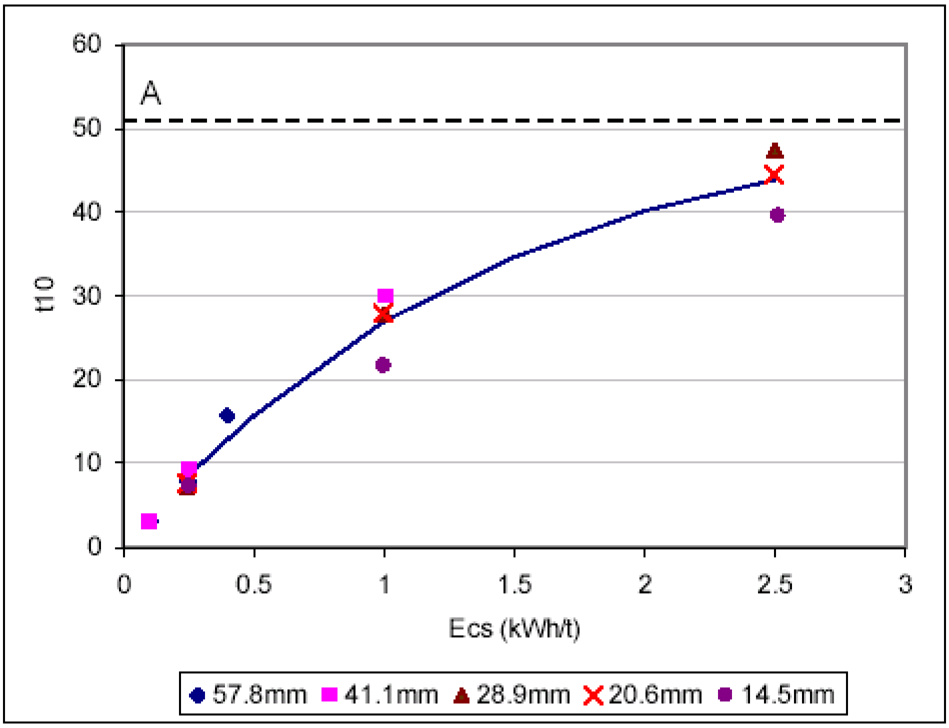
The specific comminution energy (Ecs) has the units kWh/t and is the energy applied during impact breakage. As the impact energy is varied, so does the t10 value vary in response. Higher impact energies produce higher values of t10, which of course means products with finer size distributions.

The equation describing the relationship between the t10 and Ecs is given below.

$t10 = A (1 - e^{-b.Ecs})$

As can be seen from this equation, there are two rock breakage parameters A and b that relate the t10 (size distribution index) to the applied specific energy (Ecs). These parameters are ore specific and are normally determined from a full drop-weight test.

A typical plot of t10 vs. Ecs from a drop-weight test is shown in App. Fig. 2. The relationship is characterised by the two-parameter equation above, where t10 is the dependent variable.

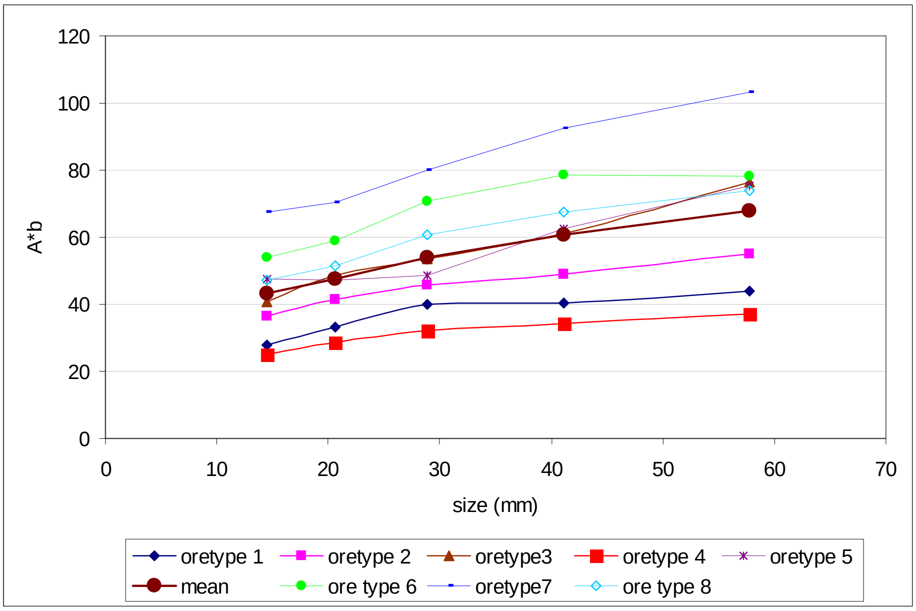


App. Fig. 2 - Typical t10 v Ecs Plot

The t10 can be thought of as a "fineness index" with larger values of t10 indicating a finer product size distribution. The value of parameter A is the limiting value of t10. This limit indicates that at higher energies, little additional size reduction occurs as the Ecs is increased beyond a certain value. A*b is the slope of the curve at 'zero' input energy and is generally regarded as an indication of the strength of the rock, lower values indicating a higher strength.

The A and b parameters can also be used with equation 1 to generate a table of Ecs values, given a range of t10 values. Such a table is used in crusher modelling to predict the power requirement of the crusher given a feed and a product size specification.

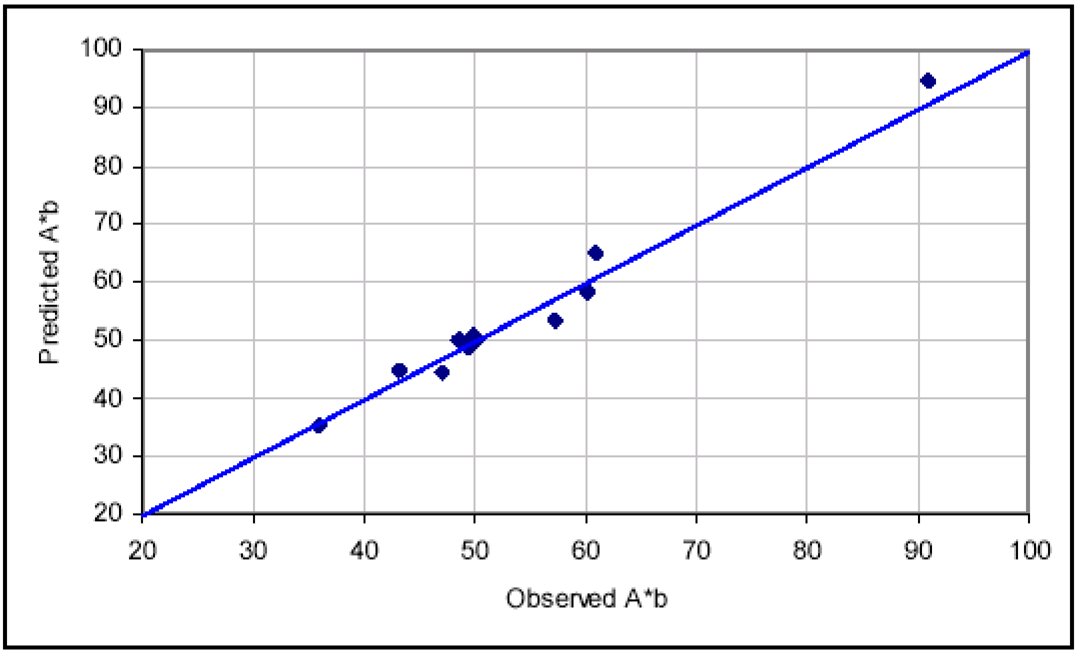
The DWi can be used to estimate the JK rock breakage parameters A and b by utilizing the fact that there is usually a pronounced (and ore specific) trend to decreasing rock strength with increasing particle size. This trend is illustrated in App. Fig. 3, which shows a plot of A*b versus particle size for a number of different rock types.



App. Fig. 3 - Size Dependence of A*b for a Range of Ore Types

In the case of a conventional drop-weight test these values are effectively averaged and a mean value of A and b is reported. The SMC test uses a single size and makes use of relationships such as that shown in App. Fig. 3 to predict the A and b of the particle size that has the same value as the mean for a full drop-weight test.

An example of this is illustrated in App. Fig. 4 where the observed values of the product A*b are plotted against those predicted using the DWi. Each of the data points in App. Fig. 4 is a result from a different ore type within an orebody.



App. Fig. 4 – Predicted v Observed A*b

APPENDIX B BOND ROD MILL WORK INDEX RESULTS

JKTech BOND ROD MILL WORK INDEX

Sample Name **LMDH006 141 - 154 m**

Client **CuDECO**

BOND ROD MILL WORK INDEX **13.2** **kWh/tonne**
12.0 **kWh/short ton**

TEST DATA

Grinding Stage	Mill Revolutions	Gross Product (g)	Net Product (g)	100% Recycle	Grindability g/rev	Circulating Load, %
1	100	1283.4	725.6	935.3	7.26	91.2
2	129	1457.2	1165.5	895.7	9.03	68.4
3	99	1312.0	980.7	928.8	9.91	87.0
4	94	1255.4	957.2	941.6	10.18	95.5
5	92	1235.7	950.3	946.1	10.33	98.6
6	92	1241.9	961.0	944.7	10.45	97.6
7	90	1210.4	928.1	951.9	10.31	103

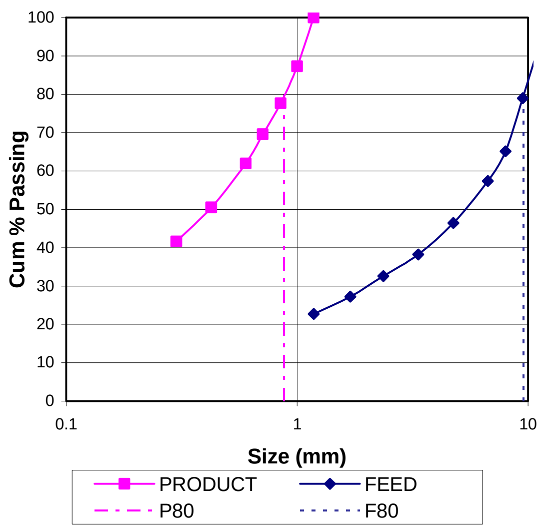
Mass of Original Feed (g)	2,454
Closing Seive Size (μm)	1180
Percent -1,180 μm in Feed	22.73
Feed F_{80} (μm)	9,575
Product P_{80} (μm)	878

<u>Averages for last 3 grinding stages</u>

Mass -1,180 μm produced per rev (g)	10.36
Circulating Load (%)	100

FEED and PRODUCT SIZINGS

FEED		PRODUCT	
Screen Aperture (mm)	Cumulative Wt % Passing	Screen Aperture (mm)	Cumulative Wt % Passing
12.5	100.0	1.18	100.0
11.2	93.1	1.00	87.3
9.50	79.0	0.850	77.7
8.00	65.2	0.710	69.6
6.70	57.4	0.600	61.9
4.75	46.4	0.425	50.5
3.35	38.3	0.300	41.6
2.36	32.6		
1.70	27.2		
1.18	22.7		



JKMRC Commercial Division

JKTech Sample Number:	JKT2194 -1
JKTech Job Number:	7264
Tested By:	Jeffrey Parkes
Date Tested:	07/10/07

JKTech BOND ROD MILL WORK INDEX

Sample Name **LMDH006 113 - 124 m**

Client **CuDECO**

BOND ROD MILL WORK INDEX 11.1 kWh/tonne
10.1 kWh/short ton

TEST DATA

Grinding Stage	Mill Revolutions	Gross Product (g)	Net Product (g)	100% Recycle	Grindability g/rev	Circulating Load, %
1	100	1832.6	1172.8	808.4	11.73	39.7
2	69	1442.7	970.6	908.8	14.07	77.5
3	65	1334.0	962.4	936.8	14.81	92.0
4	63	1242.5	898.8	960.4	14.27	106.1
5	67	1303.6	983.5	944.7	14.68	96.5
6	64	1283.8	948.0	949.8	14.81	99.5
7	64	1269.4	938.7	953.5	14.67	102

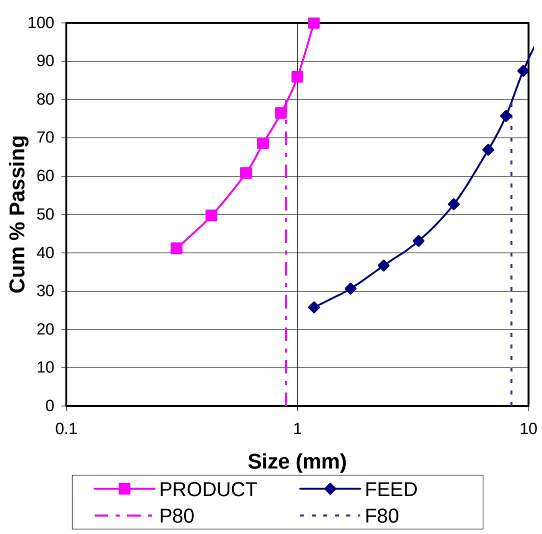
Mass of Original Feed (g)	2,561
Closing Seive Size (µm)	1180
Percent -1,180 µm in Feed	25.76
Feed F_{80} (µm)	8,423
Product P_{80} (µm)	896

Averages for last 3 grinding stages

Mass -1,180 µm produced per rev (g)	14.72
Circulating Load (%)	99

FEED and PRODUCT SIZINGS

FEED		PRODUCT	
Screen Aperture (mm)	Cumulative Wt % Passing	Screen Aperture (mm)	Cumulative Wt % Passing
12.5	100.0	1.18	100.0
11.2	96.6	1.00	85.9
9.50	87.5	0.850	76.5
8.00	75.7	0.710	68.6
6.70	66.9	0.600	60.8
4.75	52.7	0.425	49.7
3.35	43.1	0.300	41.1
2.36	36.6		
1.70	30.6		
1.18	25.8		



JKMRC Commercial Division

JKTech Sample Number:	JKT2194 - 2
JKTech Job Number:	07264
Tested By:	Jeffrey Parkes
Date Tested:	07/10/07

JKTech BOND ROD MILL WORK INDEX

Sample Name **Combined LMDH Sample**

Client **CuDeco Ltd**

BOND ROD MILL WORK INDEX 11.7 kWh/tonne
10.7 kWh/short ton

TEST DATA

Grinding Stage	Mill Revolutions	Gross Product (g)	Net Product (g)	100% Recycle	Grindability g/rev	Circulating Load, %
1	100	1526.2	976.4	580.7	9.76	31.1
2	59	1142.0	722.5	686.3	12.25	75.2
3	56	1024.7	710.8	718.6	12.69	95.2
4	57	993.0	711.4	727.3	12.48	101.4
5	58	991.9	719.0	727.6	12.40	101.7
6	59	1009.6	736.9	722.7	12.49	98.1
7	58	998.4	720.9	725.8	12.43	100

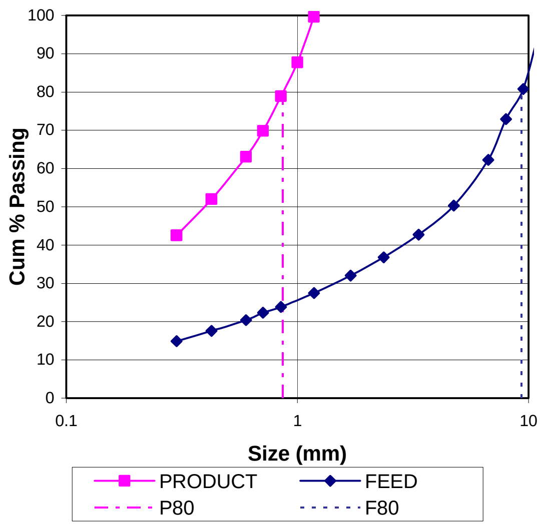
Mass of Original Feed (g)	2,000
Closing Seive Size (µm)	1180
Percent -1,180 µm in Feed	27.49
Feed F_{80} (µm)	9,310
Product P_{80} (µm)	864

<u>Averages for last 3 grinding stages</u>

Mass -1,180 µm produced per rev (g)	12.44
Circulating Load (%)	100

FEED and PRODUCT SIZINGS

FEED		PRODUCT	
Screen Aperture (mm)	Cumulative Wt % Passing	Screen Aperture (mm)	Cumulative Wt % Passing
12.5	100.0	1.18	99.7
11.2	96.2	1.00	87.7
9.50	80.8	0.850	78.9
8.00	72.9	0.710	69.9
6.70	62.2	0.600	63.1
4.75	50.3	0.425	52.0
3.35	42.7	0.300	42.5
2.36	36.8		
1.70	32.0		
1.18	27.5		
0.850	23.8		
0.710	22.3		
0.600	20.4		
0.425	17.6		
0.300	14.9		



JKMRC Commercial Division

JKTech Sample Number:	JKT2194-5
JKTech Job Number:	7264
Tested By:	M Alexander
Date Tested:	07/31/07

APPENDIX C BOND BALL MILL WORK INDEX RESULTS

JKTech BOND BALL MILL WORK INDEX

Sample Name **LMDH006 141-154 m**

Client **CuDECO Ltd**

BOND BALL MILL WORK INDEX **15.2 kWh/tonne**
13.8 kWh/short ton

TEST DATA

Grinding Stage	Mill Revolutions	Gross Product (g)	Net Product (g)	250% Recycle	Grindability g/rev	Circulating Load, %
1	100	215.2	93.8	339.9	0.938	486
2	362	401.4	380.7	322.0	1.052	214
3	306	411.0	372.4	321.0	1.217	207
4	306	409.0	369.4	321.2	1.207	209
5	266	371.4	332.0	324.8	1.248	240
6	260	362.2	326.5	325.7	1.256	248
7	259	362.8	327.9	325.7	1.266	248

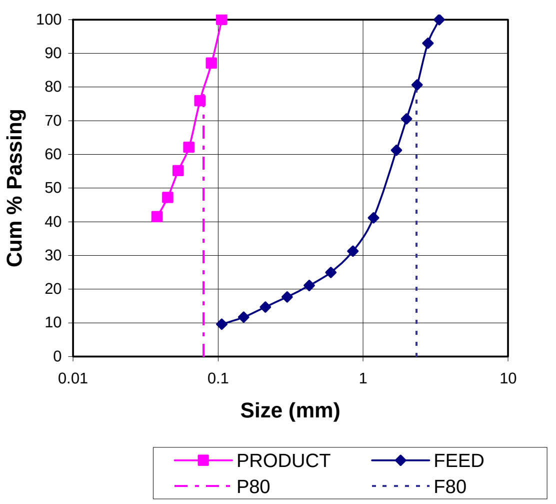
Mass of Original Feed (g)	1,262
Closing Seive Size (µm)	106
Percent -106 um in Feed	9.62
Feed F_{80} (µm)	2,332
Product P_{80} (µm)	79

Averages for last 3 grinding stages

Mass -106 µm produced per rev (g)	1.257
Circulating Load (%)	245

FEED and PRODUCT SIZINGS

FEED		PRODUCT	
Screen Aperture (mm)	Cumulative Wt % Passing	Screen Aperture (mm)	Cumulative Wt % Passing
3.35	100.0	0.106	100.0
2.80	93.0	0.090	87.1
2.36	80.6	0.075	75.9
2.00	70.6	0.063	62.1
1.70	61.2	0.053	55.2
1.18	41.1	0.045	47.2
0.850	31.3	0.038	41.5
0.600	25.0		
0.425	21.1		
0.300	17.7		
0.212	14.7		
0.150	11.7		
0.106	9.6		



JKMRC Commercial Division

JKTech Sample Number:	JKT 2194-1
JKTech Job Number:	07264
Tested By:	Jeffrey Parkes
Date Tested:	19/7/2007

JKTech BOND BALL MILL WORK INDEX

Sample Name **LMDH006 113-124 m**
Client **CuDECO Ltd**

BOND BALL MILL WORK INDEX **12.9 kWh/tonne**
11.7 kWh/short ton

TEST DATA

Grinding Stage	Mill Revolutions	Gross Product (g)	Net Product (g)	250% Recycle	Grindability g/rev	Circulating Load, %
1	100	316.9	175.4	343.2	1.754	317
2	196	334.9	301.0	341.2	1.535	294
3	222	391.1	355.2	335.2	1.600	238
4	210	369.8	327.8	337.5	1.561	257
5	216	369.8	330.1	337.5	1.528	257
6	221	369.7	330.1	337.5	1.493	257
7	226	382.1	342.4	336.2	1.515	245
8	222	386.3	345.3	335.7	1.555	242
9	216	372.4	331.0	337.2	1.532	254

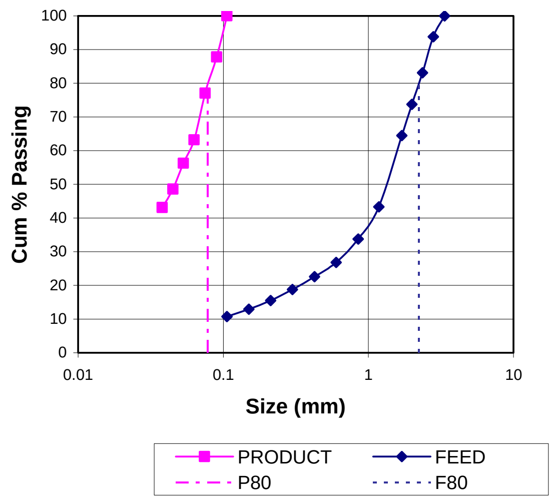
Mass of Original Feed (g)	1,320
Closing Seive Size (µm)	106
Percent -106 um in Feed	10.72
Feed F_{80} (µm)	2,217
Product P_{80} (µm)	78

Averages for last 3 grinding stages

Mass -106 µm produced per rev (g)	1.534
Circulating Load (%)	247

FEED and PRODUCT SIZINGS

FEED		PRODUCT	
Screen Aperture (mm)	Cumulative Wt % Passing	Screen Aperture (mm)	Cumulative Wt % Passing
3.35	100.0	0.106	100.0
2.80	93.8	0.090	87.9
2.36	83.1	0.075	77.1
2.00	73.7	0.063	63.2
1.70	64.5	0.053	56.3
1.18	43.3	0.045	48.6
0.850	33.8	0.038	43.2
0.600	26.8		
0.425	22.6		
0.300	18.8		
0.212	15.5		
0.150	12.9		
0.106	10.7		



JKTech Sample Number:	JKT 2194-2
JKTech Job Number:	07264
Tested By:	Jeffrey Parkes
Date Tested:	19/7/2007

JKTech BOND BALL MILL WORK INDEX

Sample Name **Combined LMDH Sample**
Client **CuDeco Ltd**

BOND BALL MILL WORK INDEX 14.6 kWh/tonne
13.3 kWh/short ton

TEST DATA

Grinding Stage	Mill Revolutions	Gross Product (g)	Net Product (g)	250% Recycle	Grindability g/rev	Circulating Load, %
1	100	301.2	154.0	281.1	1.540	273
2	183	411.7	372.2	266.6	2.034	173
3	131	244.4	190.4	288.6	1.453	359
4	199	301.9	269.9	281.0	1.356	272
5	207	307.4	267.8	280.3	1.294	265
6	217	319.6	279.3	278.7	1.287	251
7	217	322.8	280.9	278.3	1.295	248

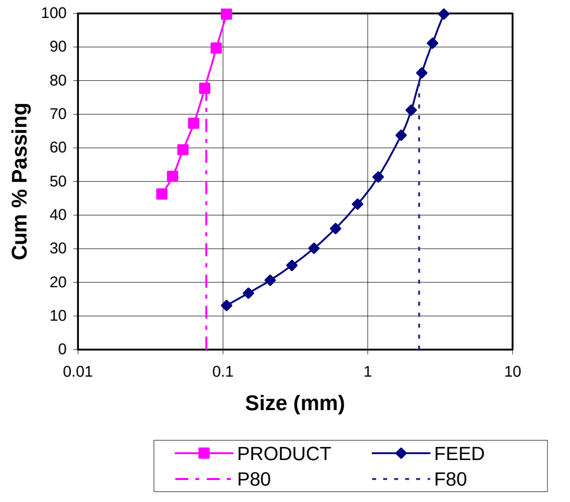
Mass of Original Feed (g)	1,122
Closing Seive Size (µm)	106
Percent -106 um in Feed	13.11
Feed F_{80} (µm)	2,265
Product P_{80} (µm)	77

Averages for last 3 grinding stages

Mass -106 µm produced per rev (g)	1.292
Circulating Load (%)	255

FEED and PRODUCT SIZINGS

FEED		PRODUCT	
Screen Aperture (mm)	Cumulative Wt % Passing	Screen Aperture (mm)	Cumulative Wt % Passing
3.35	99.8	0.106	99.8
2.80	91.1	0.090	89.7
2.36	82.3	0.075	77.7
2.00	71.2	0.063	67.3
1.70	63.7	0.053	59.4
1.18	51.4	0.045	51.5
0.850	43.3	0.038	46.3
0.600	36.0		
0.425	30.2		
0.300	25.0		
0.212	20.6		
0.150	16.8		
0.106	13.1		



JKTech Sample Number:	JKT2194-5
JKTech Job Number:	07264
Tested By:	M Alexander
Date Tested:	1/08/07

APPENDIX D BOND ABRASION INDEX RESULTS

amdel
www.amdel.com

WORKSHEET FOR ABRASION INDEX

SAMPLE: JK 2194 - 1 **JOB NO.** N2550CO07

TECHNICIAN: R.L. **DATE:** 23/7/07

Weight of Paddle before test	____________94.1275
Weight of Paddle after test	____________93.8926
Weight loss = ABRASION INDEX	____________ 0.2349

MP-FORM-013 Issue date 14 April 2005

www.amdel.com

WORKSHEET FOR ABRASION INDEX

SAMPLE: JK 2194 - 2 **JOB NO.** N2550CO07

TECHNICIAN: T.L. **DATE:** 24/7/07

Weight of Paddle before test	____________94.0011
Weight of Paddle after test	____________93.7301
Weight loss = ABRASION INDEX	____________ 0.2710

MP-FORM-013 Issue date 14 April 2005

www.amdel.com

WORKSHEET FOR ABRASION INDEX

SAMPLE:	JK 2194 - 5	JOB NO.	N2550CO07
TECHNICIAN:	D.N.	DATE:	25/7/07

Weight of Paddle before test	____________94.2235
Weight of Paddle after test	____________94.1514
Weight loss = ABRASION INDEX	____________ 0.0721

MP-FORM-013 Issue date 14 April 2005

JKTech Pty Ltd
Isles Road
Indooroopilly Qld 4068
AUSTRALIA
Telephone *+ 61 7 3365 5842*
Facsimile *+ 61 7 3365 5900*
E-mail *jktech@jktech.com.au*
Internet *www.jktech.com.au*

COMMINUTION TEST REPORT (BATCH 2)

on

Samples of Drill Core

from

CuDECO Ltd

Tested at

JKTech Pty Ltd, Brisbane, Queensland

for

CuDECO Ltd

JKTech Job No. 07264 - October 2007

JKMRC Technology Transfer

JKTech Pty Ltd

COMMINUTION TEST REPORT (BATCH 2)

on

Samples of Drill Core

from

CuDECO Ltd

JKTech Job No. 07264 - October 2007

Submitted to

CuDECO Ltd

Tested at JKTech Pty Ltd, Brisbane, Queensland

TABLE OF CONTENTS

Page No

APPENDICES

Page No

TABLE OF FIGURES

Page No

TABLE OF TABLES

Page No

1 INTRODUCTION

Five samples of Copper Ore from CuDECO Ltd were received by JKTech on September 18, 2007 for Comminution Testing. The samples were identified as samples tested. The samples were to be subjected to SMC, Bond Ball, Bond Rod, Bond Crushing Work Index and Bond Abrasion Testing. Test work and reporting were completed on April 30, 2008.

2 THE SMC TEST

2.1 INTRODUCTION

The standard JKTech drop-weight test provides ore specific parameters for use in the JKSimMet Mineral Processing Simulator software. In JKSimMet, these parameters are combined with equipment details and operating conditions to analyse and/or predict SAG/autogenous mill performance. The same test procedure also provides ore type characterisation for the JKSimMet crusher model.

The SMC (SAG Mill Comminution) test was developed by Steve Morrell of SMC Testing Pty Ltd (SMCT) to provide a cost effective means of obtaining these parameters from drill core or in situations where limited quantities of material are available. The ore specific parameters have been calculated from the test results and are supplied to CuDECO Ltd in this report as part of the standard procedure.

2.2 DESCRIPTION OF THE SMC PROCEDURE

2.2.1 General

The SMC test is a precision test, which uses particles that are either cut from drill core using a diamond saw to achieve close size replication or else selected from crushed material so that particle mass variation is controlled within a prescribed range. The particles are then broken at a number of prescribed impact energies. The high degree of control imposed on both the size of particles and the energies used to break them, means that the test is largely free of the repeatability problems that plague tumbling mill rock characterisation tests. Such tests usually suffer from variations in feed size (which is not closely controlled) and energy input, often assumed to be constant when in reality it can be highly variable (Levin, 1989).

2.2.2 Outline of the Procedure

The test normally uses cut pieces of quartered (slivered) drill core. Whole core or half core can be used, but when received in this form it needs to be first quartered as a preliminary step in the procedure. Once quartered, any broken or tapered ends of the quartered lengths are cut, to square them off. Before the lengths of quartered core are cut to produce the pieces for the drop-weight testing, each one is weighed in air and then in water, to obtain a density measurement and a measure of its mass per unit length.

The test calls for a prescribed target volume for the core pieces, chosen so that their volume is equivalent to the mean volume of particles in one of the standard drop-weight test size fractions. The size fraction targeted depends on the original core diameter and the choice is made so as to ensure that pieces of the correct volume have "chunky" rather than "slabby" proportions.

Having measured the density of the core, the target volume can be translated into a target mass and with the average mass per unit length value also known, an average cutting interval can be determined for the core.

Sufficient pieces of the quartered core are cut to generate 100 particles. These are divided into five groups of 20. Each group is then broken in the drop-weight tester at a different specific energy level. Within each group the three possible orientations of the particles are equally represented (as far as possible, given that there are 20 particles). The orientations prescribed for testing are shown in Figure 1.

Figure 1 - Orientations of Pieces for Breakage

The rest height of the drop-head (gap) is recorded for each particle. After breaking all 20 particles in a group, the broken product is sieved at a sieve size that is one tenth of the original particle size. Thus, the percent passing mass gives a direct reading of the t10 value at that energy level.

If only bulk sample is available or if the core is too friable for cutting, then the particle selection method is used. In this case, particles are selected so that their individual masses lie within ±30% of the target mass and the mean mass for each set of 20 lies within ±10% of the target mass. This method is also normally used for cores with diameters exceeding 70 mm, where the particle masses are too large to achieve the highest prescribed energy level.

2.3 DROP-WEIGHT INDEX RESULTS

The results of the SMC tests on the samples tested from CuDECO Ltd is given in Table 1. This table includes the average rock density and the drop-weight index that is the direct result of the test procedure. It also includes the derived estimates of parameters A and b that are required for JKSimMet comminution modelling.

Also presented in this table is the Mia parameter developed by SMCT. This parameter represents the coarse particle component (down to 750 µm), of the overall comminution energy and can be used together with the Mib (fine particle component) to estimate the total energy requirements of a conventional comminution circuit.

In the case of the samples tested from CuDECO Ltd, the A and b estimates are based on a correlation using the database of all results so far accumulated by SMCT.

Table 1 - SMC Test Results

Sample Designation	JKTech Code	SG	SMC Test	SMC Test Derived Values		
			Dwi	Mia (KWh/t)	A	b
LMDH 033	JK2215-5	2.93	3.9	11.5	63.3	1.19

Note: For more details on how the Mia parameter is derived and used, go to the JKTech website at http://www.jktech.com.au/Products_Services/Laboratory-Services/Comminution-Testing/SMC-Test/index.htm and click on the link to download Steve Morrell's paper on this subject.

For the entire population of over 3,500 rock samples so far tested, the majority of DWi values lie in the range 2 to 12, soft ores being at the low end of the scale and hard ores at the high end. The DW_i results for the samples tested from CuDECO Ltd are equal to 3.9. This places them over a wide range of values of the DWi range. A histogram of DWi values from the SMCT database is shown in Figure 2 for comparison.

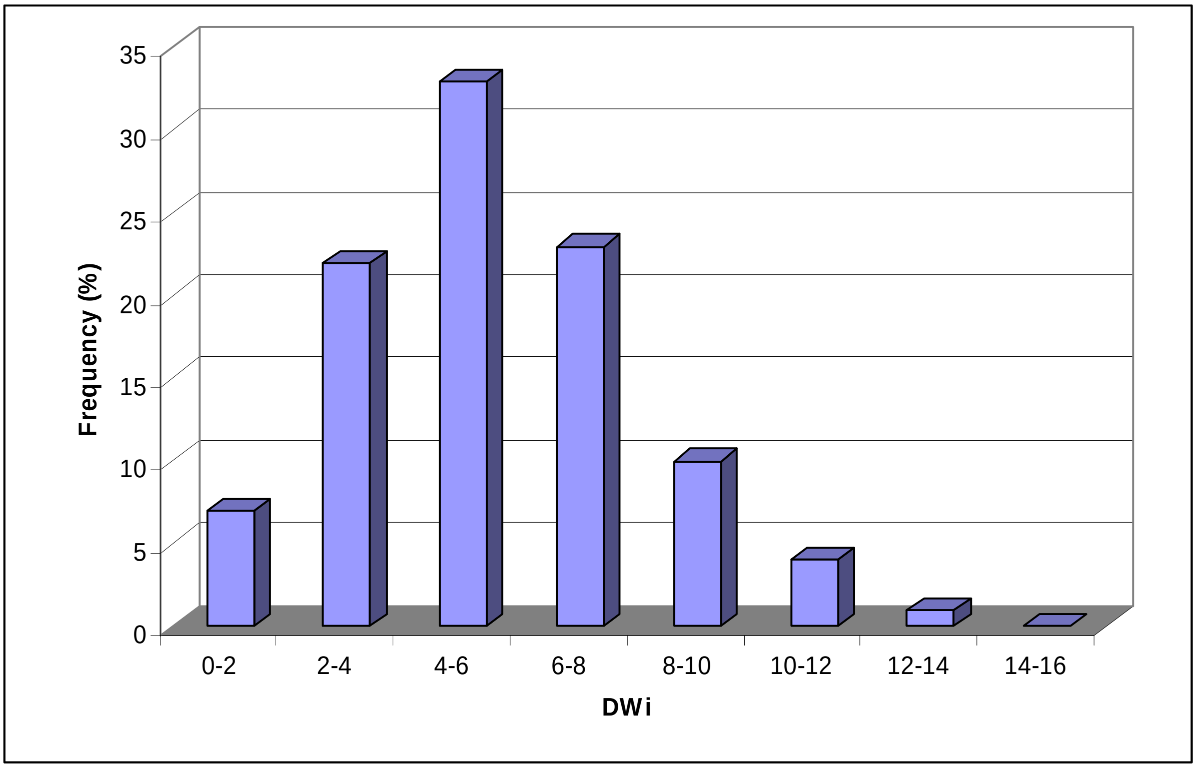


Figure 2 – Distribution of DWi Values in the SMC Test Database

A cumulative graph of DWi values from the SMC Database is also shown in Figure 3 below. The DWi range of 3.9 for these samples places it at the 28th percentile point of the SMC Testing data base. These figures represent the percentages of all ores tested that are softer than the samples in question.

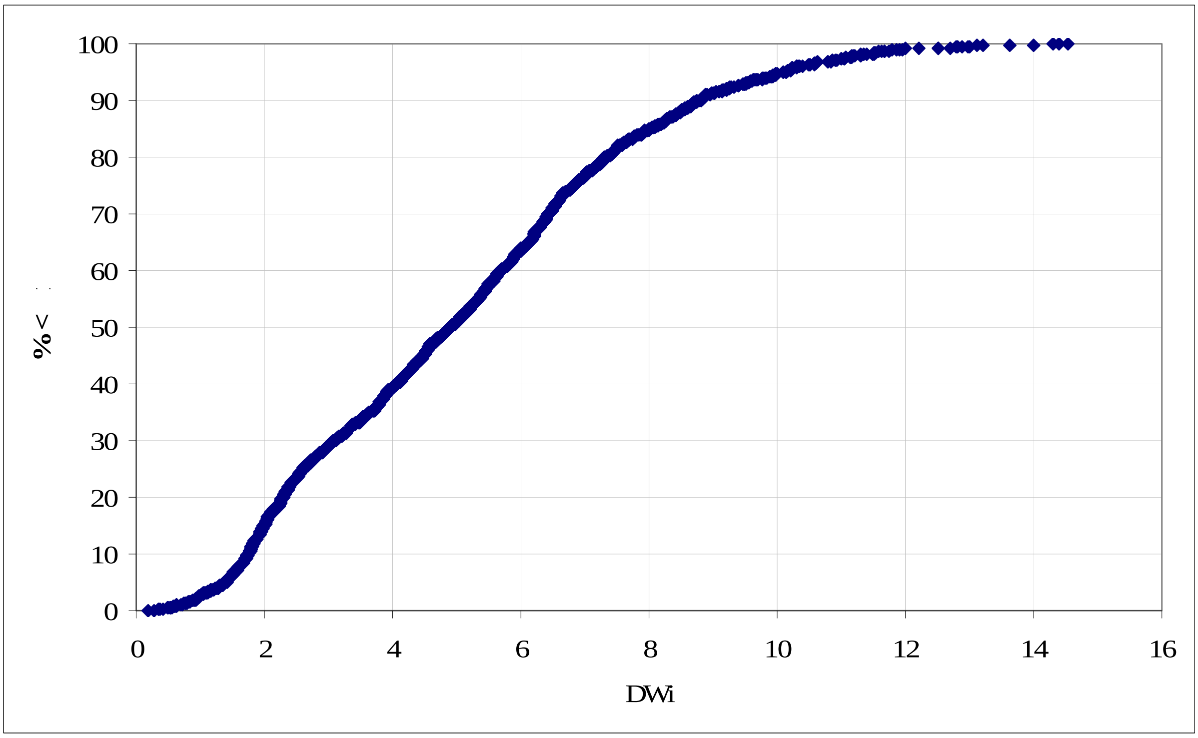


Figure 3 - Cumulative Distribution of DWi Values in SMC Test Database

The value of A*b, which is also a measure of resistance to impact breakage, is calculated and presented in Table 2 along with indicators of how each A*b value compares with the accumulated values in the JKTech DW database (from full drop-weight testing). These indicators are the Category (eg "soft" etc), the Rank (how many out of 2,304 recordings in database are harder) and the % of database values that are harder. Note that in contrast to the DWi, a high value of A*b means that an ore is soft whilst a low value means that it is hard.

Table 2 – Derived Values for A*b and t10 at 1 kWh/t

Sample Designation	JKTech Code	A*b				t10 @ 1 kWh/t			
		Value	Category	Rank	%	Value	Category	Rank	%
LMDH 033	JK2215-5	75.3	soft	1749	75.9%	44.0	soft	1834	79.6%

The calculated value of t_{10} at an Ecs of 1 kWh/t is also shown in Table 2. This is again accompanied by Category, Rank and the % of values in the database that are harder, so each can be seen against the yard-stick of all other samples in the JKTech database.

The derived A*b value is equal to 75.3, while the t_{10} at 1 kWh/t value is equal to 44.0.

In Figure 4 and Figure 5 below, histogram style frequency distributions for the A*b values and for the t_{10} at 1 kWh/t values in the JKTech DW database are shown respectively.

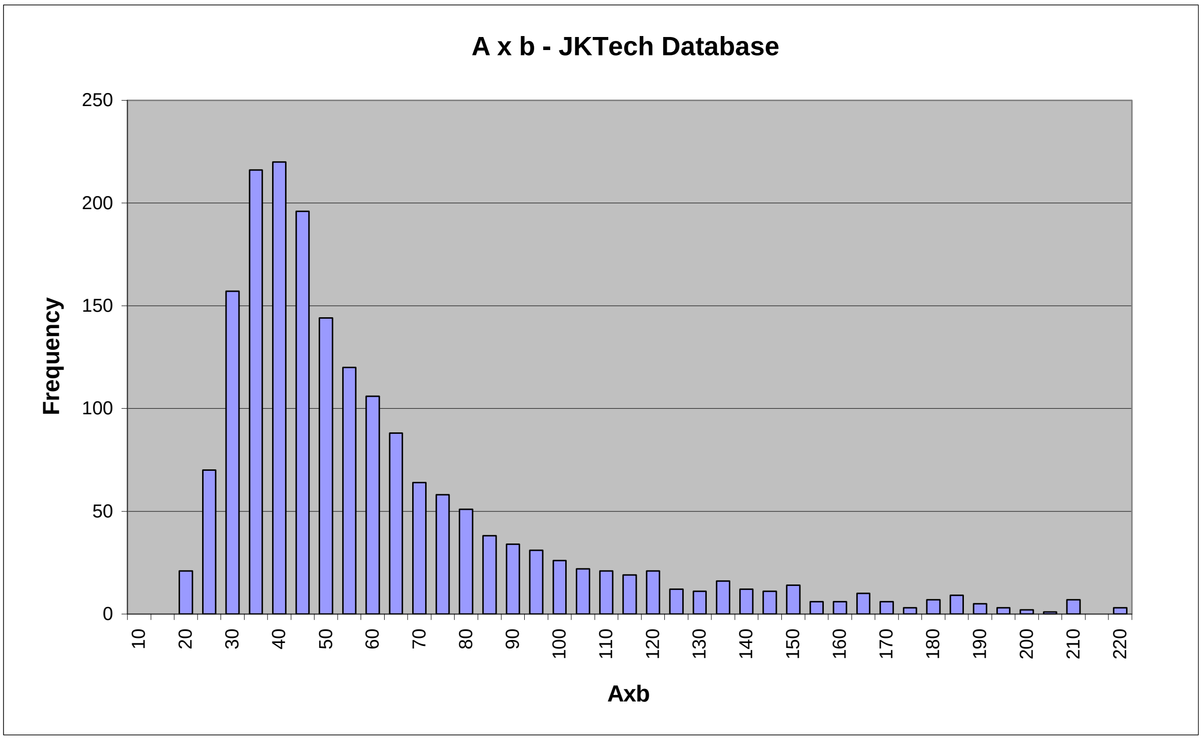


Figure 4 - Frequency Distribution of A*b in the JKTech Database

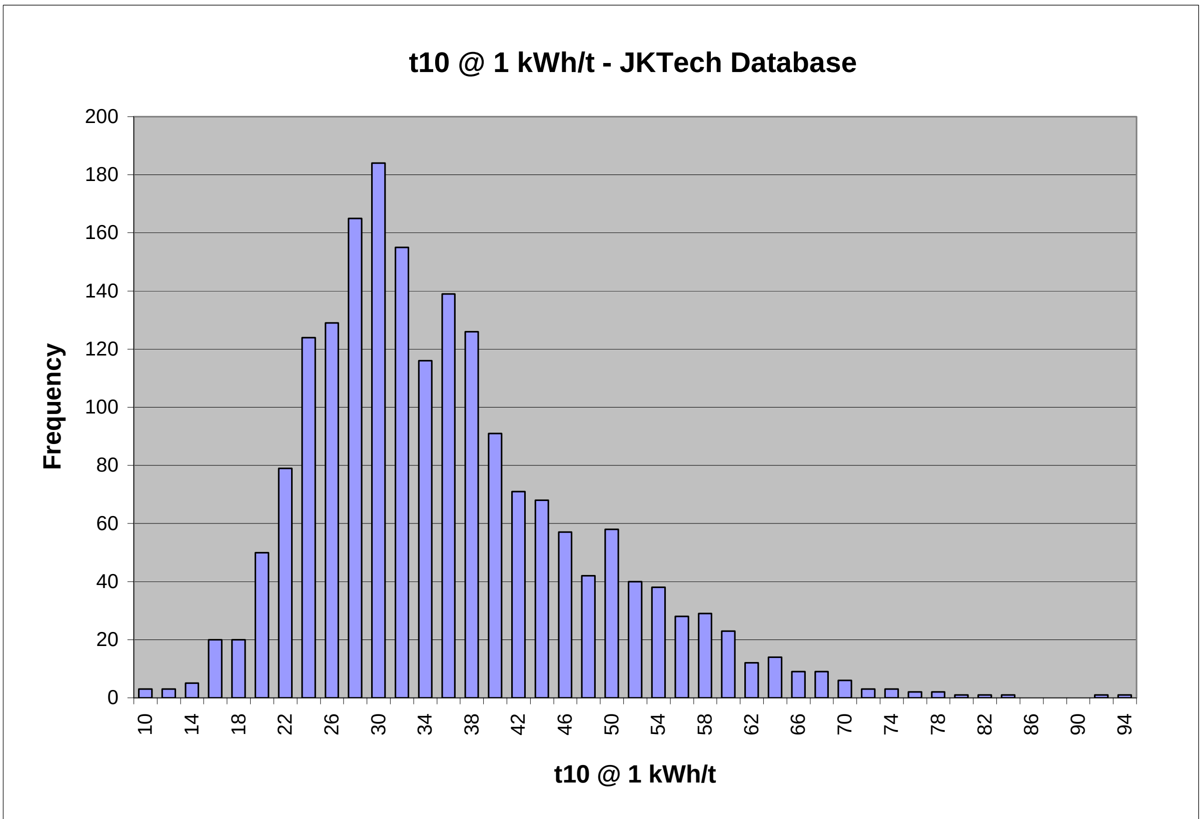


Figure 5 - Frequency Distribution of t10@1kWh/t in the JKTech Database

3 THE BOND ROD MILL WORK INDEX TEST

3.1 BOND ROD MILL WORK INDEX TEST PROCEDURE

This section provides a brief description of the Bond rod mill work index test procedure.

Feed is prepared by stage crushing to 12.7 mm (0.5 inch) and the size distribution determined by wet and dry sieving.

A sub-sample of the feed is separated by riffling until enough material to provide 1250 ml tightly packed in a 2000 ml measuring cylinder is available. The sub-sample is weighed and ground dry in a 305 by 610 mm batch, tilting rod mill with wave type liners operating at 46 rpm with a standard rod charge.

To equalise segregation at the ends of the mill, it is operated horizontal for 8 revolutions, tipped up 5° for one revolution then down 5° for one revolution. This cycle is repeated continuously throughout each grinding period.

After a predetermined number of revolutions (normally 100), the mill is emptied and all the material less than the test sieve size is removed and weighed. Fresh, unsegregated feed is added to the charge to bring its mass back to match that of the original feed and it is returned to the mill.

This material is ground for a number of revolutions calculated to produce a 100% circulating load after which the charge is again dumped and sized on the test sieve. The number of revolutions is calculated from the previous cycle to produce test sieve undersize equal to the weight of the new feed added to the mill.

The grinding cycles are continued until the net mass of test sieve undersize produced per revolution reaches equilibrium. The average of net mass per revolution from the last three cycles is taken as the rod mill grindability (*Grp*) in g/revolution.

The product is also sized and the P80 determined.

The work index *Wi* is calculated from the following equation:

$$W_i = \frac{68.4}{P_1^{0.23} \times Gbp^{0.625}\left(\frac{10}{\sqrt{P_{80}}} - \frac{10}{\sqrt{F_{80}}}\right)}$$

where	W_i	=	Work Index (kWh/tonne)
	P_1	=	Test sieve aperture (μm)
	Gbp	=	Grindability (g/revolution)
	F_{80}	=	80% passing size of feed (μm)
	P_{80}	=	80% passing size of product (μm)

The *Wi* value for this material is for an average overflow rod mill of 2.44 m (8 ft) in internal diameter grinding wet in open circuit.

Complete details of the test procedure and the application of the results in the calculation of rod mill power requirements and size are given in Bond (1961).

3.2 BOND ROD MILL WORK INDEX TEST RESULTS

The results of the test are summarised in Table 3 and given in detail in APPENDIX B .

Table 3 - Summary of Bond Rod Mill Work Index Test Results for the Sample Tested.

Sample Name	JKTech Sample No	Bond Rod Mill Data				
		F80 µm	P80 µm	Grindability g/revolution	Aperture µm	Work Index kWh/tonne
LMDH 031 CC	JK2215-1	n/a	n/a	n/a	n/a	n/a
LMDH 031 HBX	JK2215-2	n/a	n/a	n/a	n/a	n/a
LMDH 633/38 Nat Cu	JK2215-3	n/a	n/a	n/a	n/a	n/a
LMDH 031 DBX	JK2215-4	n/a	n/a	n/a	n/a	n/a
LMDH 033	JK2215-5	8,740	901.1121	16.247	1,180	10.4

4 THE BOND BALL MILL WORK INDEX TEST

4.1 INTRODUCTION

The Bond Ball Mill Work Index test results are used to calculate the power needed for ball milling the ore under test, from a known feed F80 to a required product P80. From this information, the sizes of ball mills required to process the ore at a particular feed rate can be calculated.

4.2 BOND BALL MILL WORK INDEX TEST PROCEDURE

This section provides a brief description of the Bond ball mill work index test procedure.

Feed is prepared by stage crushing to 3.35 mm (6 mesh Tyler) and the size distribution determined by wet and dry sieving.

A sub-sample of the feed is separated by riffling until enough material to provide 700 ml tightly packed in a 1000 ml measuring cylinder is available. The sub-sample is weighed and ground dry in a 305 by 305 mm batch ball mill operating at 70 rpm with a standard ball charge.

After a predetermined number of revolutions (normally 100), the mill is emptied and all the material less than the test sieve size is removed and weighed. Fresh, unsegregated feed is added to the charge to bring its mass back to that of the original feed before returning it to the mill.

This material is ground for a number of revolutions calculated to produce a 250% circulating load after which the charge is again dumped and sized on the test sieve. The number of revolutions is calculated from the previous cycle to produce test sieve undersize equal to 1/3.5 of the total charge in the mill.

The grinding cycles are continued until the net mass of test sieve undersize produced per revolution reaches equilibrium. The average of net mass per revolution from the last three cycles is taken as the ball mill grindability (*Gbp*) in g/revolution. The product is also sized and the P80 determined.

The work index *Wi* is calculated from the following equation:

$$W_i = \frac{49.05}{P_1^{0.23} \times Gbp^{0.82}\left(\frac{10}{\sqrt{P_{80}}} - \frac{10}{\sqrt{F_{80}}}\right)}$$

where W_i = Work Index (kWh/tonne)

P_1 = Test sieve aperture (μm)

Gbp = Grindability (g/revolution)

F_{80} = 80% passing size of feed (μm)

P_{80} = 80% passing size of product (μm)

The *Wi* value for this material is for an average overflow ball mill of 2.44 m (8 ft) in internal diameter.

Complete details of the test procedure and the application of the results in the calculation of ball mill power requirements and size are given in Bond (1961).

4.3 BOND BALL MILL WORK INDEX TEST RESULTS

The results of the test are summarised in Table 4 and given in detail in APPENDIX C .

Table 4 - Summary of Bond Ball Mill Work Index Test Results for Sample Tested.

Sample Name	JKTech Sample No	Bond Ball Mill Data				
		F80 µm	P80 µm	Grindability g/revolution	Aperture µm	Work Index kWh/tonne
LMDH 031 CC	JK2215-1	n/a	n/a	n/a	n/a	n/a
LMDH 031 HBX	JK2215-2	n/a	n/a	n/a	n/a	n/a
LMDH 633/38 Nat Cu	JK2215-3	n/a	n/a	n/a	n/a	n/a
LMDH 031 DBX	JK2215-4	n/a	n/a	n/a	n/a	n/a
LMDH 033	JK2215-5	2,072	80	1.944	106	10.8

5 DENSITY MEASUREMENTS

5.1 SPECIFIC GRAVITY RESULTS

Several pieces of each sample were weighed in air and the weighed in water to determine the specific gravity by water displacement. Results are summarized in Table 5 and detailed in APPENDIX D .

The AMDEL measurements conducted as part of the Bond Impact Crushing Work Index tests are also given in Table 5.

Table 5 - Summary of Specific Gravity Values for the Samples Tested.

Sample Name	JKTech Sample No	Water Immersion Density (g/cm3)	AMDEL Density (g/cm3)
LMDH 031 CC	JK2215-1	2.92	3.44
LMDH 031 HBX	JK2215-2	3.33	3.33
LMDH 633/38 Nat Cu	JK2215-3	2.93	3.07
LMDH 031 DBX	JK2215-4	2.98	3.02
LMDH 033	JK2215-5	2.76	n/a

6 BOND IMPACT CRUSHING WORK INDEX TEST

The Bond Impact Crushing Work Index test is not carried out at JKTech but is sub-contracted to other laboratories when required by the Client. In this case, the sample was prepared at JKTech and sent to Amdel for testing.

The test is carried out on 20 rock pieces in the -76+51mm size range. All the particles chosen for this test need to have two reasonably parallel faces.

The test apparatus consists of two bicycle wheels that have heavy weights attached at one point along their rim. The wheels are turned in opposite directions so that the weights are held at equal heights above their stable resting point. A single particle is suspended at a point between the wheels.

When the weights are released, they simultaneously collide with the parallel faces of the particle from opposite sides. The energy input is known from the height and mass of the weights, and the resistance to breakage is assessed by sieve sizing the broken fragments.

Table 6 - Summary of Bond Impact Crushing Work Index Values for the Samples Tested.

Sample Name	JKTech Sample No	Bond Crushing Work Index		
		Impact Strength Joules/mm	Average Ore SG	Work Index kWh/tonne
LMDH 031 CC	JK2215-1	5.70	10.6	2.5
LMDH 031 HBX	JK2215-2	8.90	14.0	4.2
LMDH 633/38 Nat Cu	JK2215-3	7.90	23.8	4.7
LMDH 031 DBX	JK2215-4	10.80	21.8	6.3
LMDH 033	JK2215-5	n/a	n/a	n/a

The Bond impact crushing work index determined for these samples is as shown in Table 6 above. The detailed results for the test are given in APPENDIX E .

7 BOND ABRASION INDEX TEST

The Bond Abrasion Index test is not carried out at JKTech but is sub-contracted to other laboratories when required by the Client. In this case, the sample was prepared at JKTech and sent to Amdel for testing. The test is carried out on 3 kg of -19+12.7 mm rock sample.

Table 7 - Summary of Bond Abrasion Index Values for the Samples Tested.

Sample Name	JKTech Sample No	Bond Abrasion Index
LMDH 031 CC	JK2215-1	n/a
LMDH 031 HBX	JK2215-2	n/a
LMDH 633/38 Nat Cu	JK2215-3	n/a
LMDH 031 DBX	JK2215-4	n/a
LMDH 033	JK2215-5	0.0900

The Bond impact crushing work index determined for these samples is as shown in Table 7 above. The test method and detailed results for this test are given in APPENDIX E .

8 REFERENCES

Andersen, J. and Napier-Munn, T.J., 1988, “Power Prediction for Cone Crushers", Third Mill Operators' Conference, Aus.I.M.M (Cobar, NSW), May 1988, pp 103 - 106

Leung, K. 1987. "An Energy-Based Ore Specific Model for Autogenous and Semi-Autogenous Grinding Mills." Ph.D. Thesis. University of Queensland (unpublished)

Leung, K., Morrison, R.D. and Whiten, W.J., 1987. "An Energy Based Ore Specific Model for Autogenous and Semi-autogenous Grinding", Copper *87*, Vina del Mar, Vol. 2, pp 71 - 86

Morrell, S. 1996. "Power Draw of Wet Tumbling Mills and Its Relationship to Charge Dynamics - Parts I and II", *Transaction Inst. Min. Metall.* (Sect C: Mineral Process Extr. Metall.), 105, 1996, pp C43-C62

Bond, F.C., 1961. "Crushing and Grinding Calculations Parts I and II", British *Chemical Engineering*, Vol 6, Nos 6 and 8

Morrell, S., 2007, “A method for predicting the specific energy requirement of comminution circuits and assessing their energy utilisation efficiency”

9 DISCLAIMER

All JKTech Pty Ltd reports are subject to a standard disclaimer as follows:

1. JKTech Pty Ltd and University staff operating with JKTech Pty Ltd make reasonable efforts to ensure an accurate understanding of client requirements. The information in this report is based on that understanding and JKTech Pty Ltd strives to be accurate in its advice.

2. While reasonable care has been taken in the preparation of this report/proposal, this report/proposal and all information, assumptions, and recommendations herein are published, given, made, or expressed without any responsibility whatsoever on the part of JKTech Pty Ltd, whether arising by way of negligence, breach of contract, breach of statutory duty or otherwise.

3. No warranty or representation of accuracy or reliability in respect of the report/proposal is given by JKTech Pty Ltd or its directors, employees, servants, agents, consultants, successors in title and assigns.

4. If liability is not, by law, capable of exclusion, then JKTech Pty Ltd accepts liability to the minimum level set by that law.

5. This disclaimer shall apply to liability to any person whatsoever, irrespective of how such liability arises, whether by use of this report/proposal by that person or you or any other person or otherwise.

6. JKTech Pty Ltd is not responsible in any way whatsoever for the error neglect or default of others upon whom it has placed reliance in the preparation of this report/proposal.

7. You shall indemnify JKTech Pty Ltd and its directors, employees, servants, agents, consultants, successors in title and assigns against any claim made against any or all of them by third parties arising out of the disclosure of the report/proposal, whether directly or indirectly, to a third party.

APPENDICES

APPENDIX A BACKGROUND TO THE SMC TEST

A 1 HOW THE SMC TEST RESULTS ARE USED

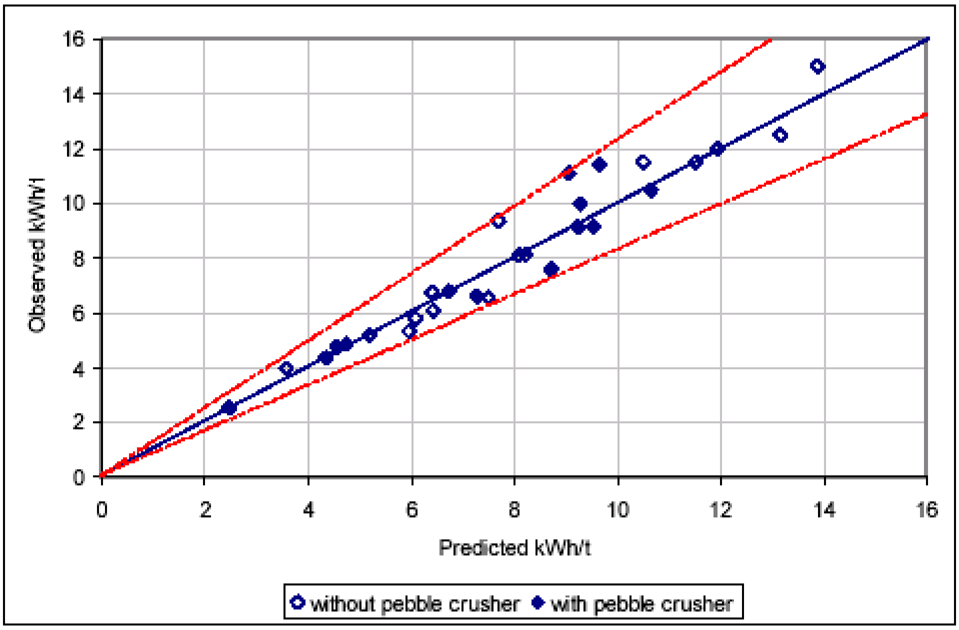
The SMC test generates a relationship between specific input energy (kWh/t) and the percent of broken product passing a specified sieve size. The results are used to determine the drop-weight index (DWi), which is a measure of the strength of the rock when broken under impact conditions. The DWi is directly related to the JK rock breakage parameters A and b and hence can be used to estimate the values of these parameters.

Provision of a relatively low cost method of estimating the A and b parameters opens the possibility of incorporating these data into mine and mill planning operations. However a number of full drop-weight tests is still recommended for any particular orebody, to ensure that an accurate correlation between the DWi and the A and b parameters is available. The number of full drop-weight tests required for a given orebody will depend on its variability and should at least cover the major recognised ore types.

The A and b parameters are used in AG/SAG mill models, such as those in JKSimMet, for predicting how the rock will break inside the mill. From this description the models can predict what the throughput, power draw and product size distribution will be (Napier-Munn et al (1996)). Modelling also enables a detailed flowsheet to be built up of the comminution circuit response to changes in ore type. It also allows optimisation strategies to be developed to overcome any deleterious changes in circuit performance predicted from differences in ore type when such changes are indicated by the SMC test. These strategies can include both changes to how mills are operated (eg ball load, speed etc) and changes to feed size distribution through modification of blasting practices and primary crusher operation (mine-to-mill).

The mine to mill models require information on rock mass competence such as provided by the point load index. The DWi is correlated with the point load index and hence can also be used in blast fragmentation modelling where direct measurements of point load index are not available.

The DW_i is related to the resistance of a rock to breakage under impact. SMCT has developed a series of equations that relate the DW_i to the specific energy (kWh/t) requirements of complete AG and SAG mill circuits. These equations take into consideration factors such as ball charge, feed size, aspect ratio, whether the mill is operated with or without a pebble crusher and whether it is closed with a fine classifier such as a cyclone. The ability of these equations to predict AG/SAG mill circuit specific energy is illustrated in App. Fig. 1. The data shown cover 19 different operations and include Cu, Au, Ni and Pb/Zn ores.



App. Fig. 1 - Mill Power Prediction Based on DWi

It should be noted that the parameter ta, which is the parameter representing the low energy abrasion component of breakage, is not yielded by the SMC test. This parameter is derived from a tumbling test that is carried out as part of the full drop-weight test. The fact that it is also required as an input to the JKSimMet SAG/AG models provides a further reason for ensuring that some full drop-weight tests are also performed to represent at least the main rock types of an orebody.

A 2 IMPACT COMMINUTION THEORY

When a rock fragment is broken, the degree of breakage can be characterised by the "t10" parameter. The t10 value is the percentage of the original rock mass that passes a screen aperture one tenth of the original rock fragment size. This parameter allows the degree of breakage to be compared across different starting sizes.

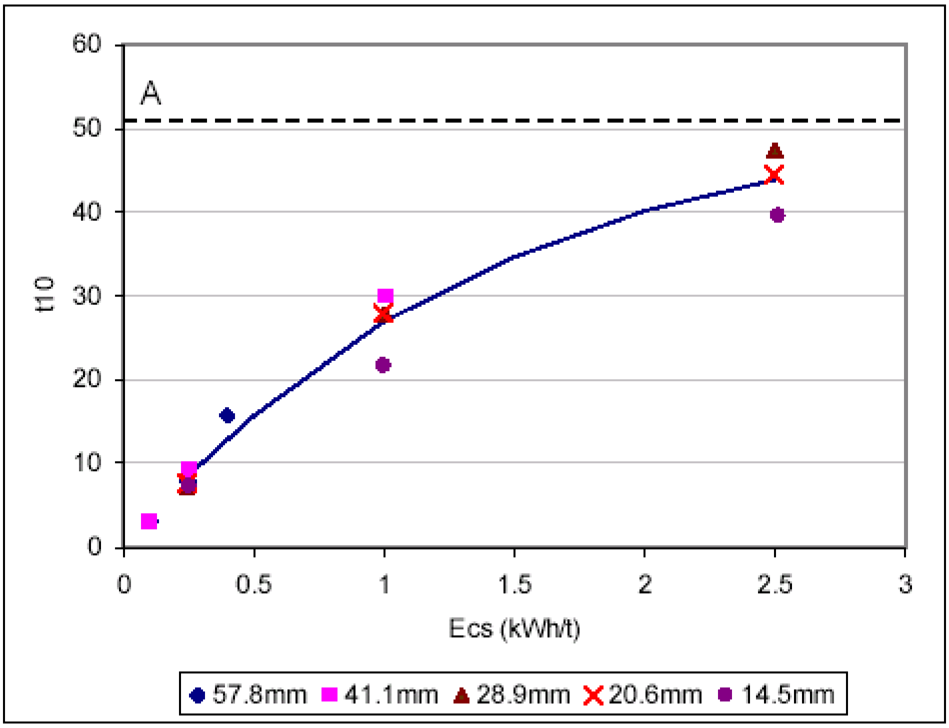
The specific comminution energy (Ecs) has the units kWh/t and is the energy applied during impact breakage. As the impact energy is varied, so does the t10 value vary in response. Higher impact energies produce higher values of t10, which of course means products with finer size distributions.

The equation describing the relationship between the t10 and Ecs is given below.

$$t10 = A (1 - e^{-b.Ecs})$$

As can be seen from this equation, there are two rock breakage parameters A and b that relate the t10 (size distribution index) to the applied specific energy (Ecs). These parameters are ore specific and are normally determined from a full drop-weight test.

A typical plot of t10 vs. Ecs from a drop-weight test is shown in App. Fig. 2. The relationship is characterised by the two-parameter equation above, where t10 is the dependent variable.

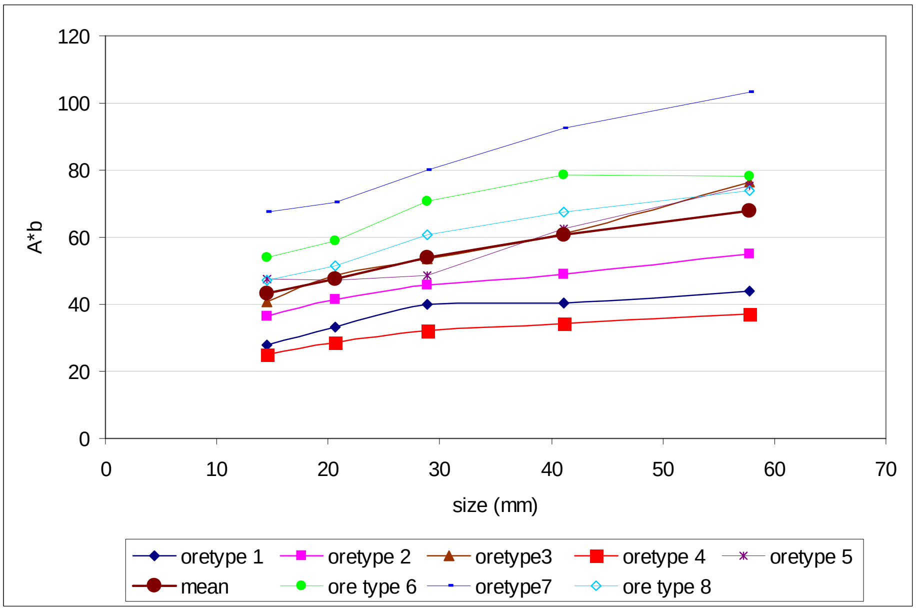


App. Fig. 2 - Typical t10 v Ecs Plot

The t10 can be thought of as a "fineness index" with larger values of t10 indicating a finer product size distribution. The value of parameter A is the limiting value of t10. This limit indicates that at higher energies, little additional size reduction occurs as the Ecs is increased beyond a certain value. A*b is the slope of the curve at 'zero' input energy and is generally regarded as an indication of the strength of the rock, lower values indicating a higher strength.

The A and b parameters can also be used with equation 1 to generate a table of Ecs values, given a range of t10 values. Such a table is used in crusher modelling to predict the power requirement of the crusher given a feed and a product size specification.

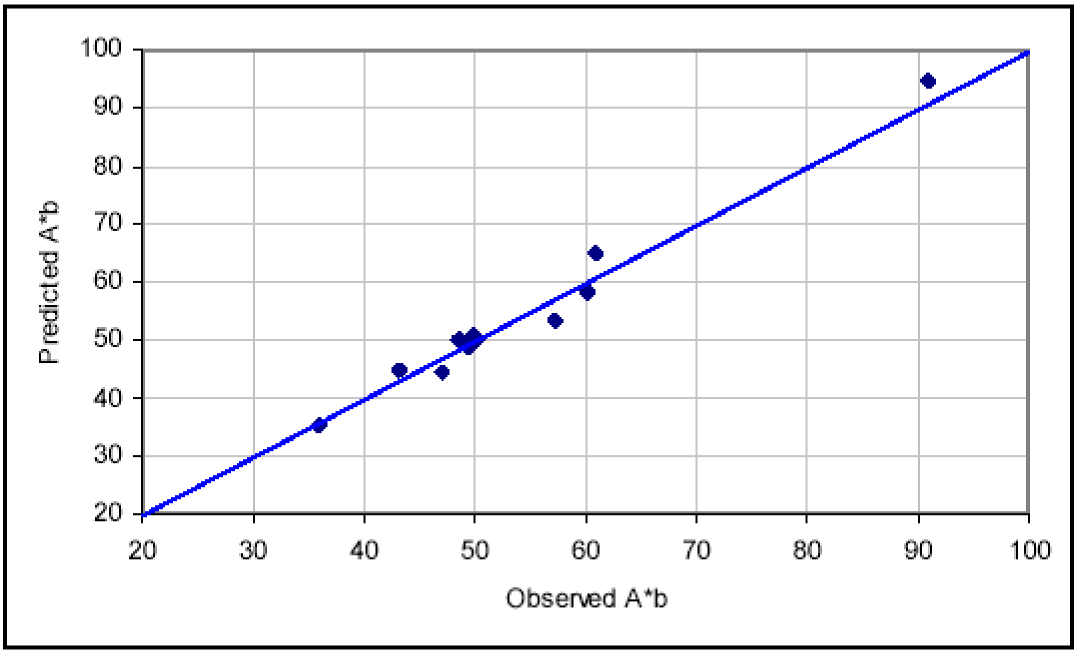
The DWi can be used to estimate the JK rock breakage parameters A and b by utilizing the fact that there is usually a pronounced (and ore specific) trend to decreasing rock strength with increasing particle size. This trend is illustrated in App. Fig. 3, which shows a plot of A*b versus particle size for a number of different rock types.



App. Fig. 3 - Size Dependence of A*b for a Range of Ore Types

In the case of a conventional drop-weight test these values are effectively averaged and a mean value of A and b is reported. The SMC test uses a single size and makes use of relationships such as that shown in App. Fig. 3 to predict the A and b of the particle size that has the same value as the mean for a full drop-weight test.

An example of this is illustrated in App. Fig. 4 where the observed values of the product A*b are plotted against those predicted using the DWi. Each of the data points in App. Fig. 4 is a result from a different ore type within an orebody.



App. Fig. 4 – Predicted v Observed A*b

APPENDIX B BOND ROD MILL WORK INDEX RESULTS

JKTech BOND ROD MILL WORK INDEX

Sample Name **LMDH 033**

Client **CuDECO Ltd (Peter Hutchinson)**

BOND ROD MILL WORK INDEX **10.4** **kWh/tonne**
9.4 **kWh/short ton**

TEST DATA

Grinding Stage	Mill Revolutions	Gross Product (g)	Net Product (g)	100% Recycle	Grindability g/rev	Circulating Load, %
1	100	1741.8	1246.3	791.8	12.46	33.5
2	64	1345.1	974.0	876.3	15.22	72.9
3	58	1225.3	938.7	901.8	16.19	89.8
4	56	1201.8	940.8	906.8	16.80	93.5
5	56	1177.8	921.8	911.9	16.46	97.5
6	55	1137.9	886.9	920.4	16.13	104.4
7	57	1163.2	920.8	915.0	16.15	100

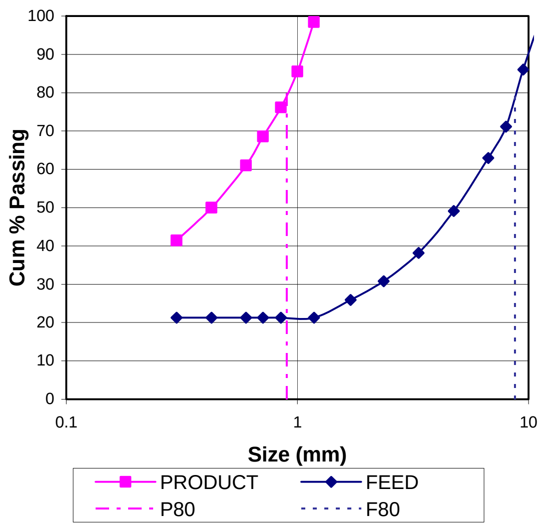
Mass of Original Feed (g)	2,326
Closing Seive Size (µm)	1180
Percent -1,180 µm in Feed	21.30
Feed F_{80} (µm)	8,740
Product P_{80} (µm)	901

<u>Averages for last 3 grinding stages</u>

Mass -1,180 µm produced per rev (g)	16.25
Circulating Load (%)	101

FEED and PRODUCT SIZINGS

FEED		PRODUCT	
Screen Aperture (mm)	Cumulative Wt % Passing	Screen Aperture (mm)	Cumulative Wt % Passing
12.5	100.0	1.18	98.4
11.2	98.3	1.00	85.5
9.50	86.1	0.850	76.1
8.00	71.2	0.710	68.6
6.70	63.0	0.600	61.0
4.75	49.1	0.425	50.0
3.35	38.2	0.300	41.5
2.36	30.8		
1.70	25.9		
1.18	21.3		
0.850			
0.710			
0.600			
0.425			
0.300			



JKTech Sample Number: JK 2215 - 5
JKTech Job Number: 7264
Tested By: Snezana Bajic
Date Tested: 10.11.2007.

APPENDIX C BOND BALL MILL WORK INDEX RESULTS

JKTech BOND BALL MILL WORK INDEX

Sample Name **LMDH 033**

Client **CuDECO Ltd (Peter Hutchinson).**

BOND BALL MILL WORK INDEX **10.8 kWh/tonne**
9.8 kWh/short ton

TEST DATA

Grinding Stage	Mill Revolutions	Gross Product (g)	Net Product (g)	250% Recycle	Grindability g/rev	Circulating Load, %
1	100	443.1	212.8	328.3	2.128	217
2	154	381.1	308.4	338.5	2.003	268
3	169	392.9	330.4	336.5	1.955	257
4	172	403.0	338.6	334.9	1.968	248
5	170	397.5	331.4	335.8	1.949	253
6	172	399.4	334.2	335.5	1.943	251
7	173	401.2	335.6	335.2	1.940	250

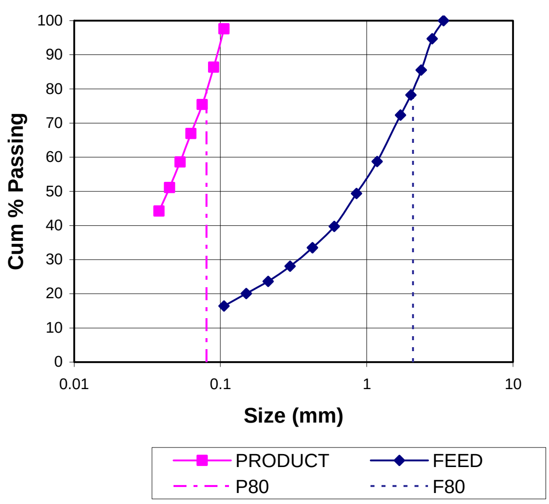
Mass of Original Feed (g)	1,404
Closing Seive Size (µm)	106
Percent -106 um in Feed	16.41
Feed F_{80} (µm)	2,072
Product P_{80} (µm)	80

Averages for last 3 grinding stages

Mass -106 µm produced per rev (g)	1.944
Circulating Load (%)	251

FEED and PRODUCT SIZINGS

FEED		PRODUCT	
Screen Aperture (mm)	Cumulative Wt % Passing	Screen Aperture (mm)	Cumulative Wt % Passing
3.35	100.0	0.106	97.6
2.80	94.7	0.090	86.4
2.36	85.5	0.075	75.4
2.00	78.2	0.063	66.9
1.70	72.3	0.053	58.6
1.18	58.7	0.045	51.1
0.850	49.3	0.038	44.2
0.600	39.7		
0.425	33.5		
0.300	28.1		
0.212	23.7		
0.150	20.1		
0.106	16.4		



JKTech Sample Number:	2215-5
JKTech Job Number:	07264
Tested By:	Can Ozer
Date Tested:	22/10/2007

APPENDIX D DENSITY RESULTS

JN 07264 CuDECO Specific Gravity

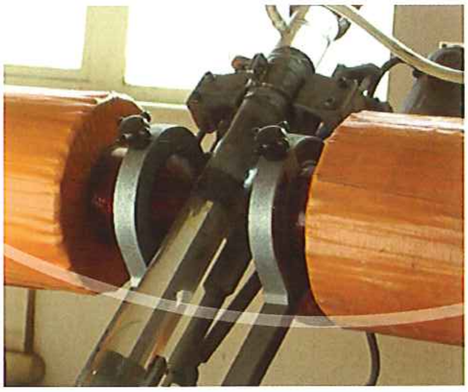
LMDH 031 CC; JK2215-1			LMDH 031 HBX; JK2215-2			LMDH 633/38 Nat Cu; JK2215-3			LMDH 031 DBX; JK2215-4			LMDH 033; JK2215-5		
Dry weight	Wet weight	Specific Gravity	Dry weight	Wet weight	Specific Gravity	Dry weight	Wet weight	Specific Gravity	Dry weight	Wet weight	Specific Gravity	Dry weight	Wet weight	Specific Gravity
938.34	617.48	**2.92**	871.51	561.25	**2.81**	820.78	516.68	**2.70**	926.98	615.71	**2.98**	114.76	79.4	**3.25**
773.46	468.16	**2.53**	1091.13	752.77	**3.22**	1040.29	705.48	**3.11**	984.24	660.76	**3.04**	216.55	142.15	**2.91**
865.94	565.92	**2.89**	1269.17	944.26	**3.91**	917.2	600.07	**2.89**	984.19	655.84	**3.00**	167.15	100.25	**2.50**
989.5	666.28	**3.06**	1001.97	679.75	**3.11**	849.46	542.86	**2.77**	954.96	634.08	**2.98**	249.92	157.59	**2.71**
936.36	614.15	**2.91**	1133.69	807.22	**3.47**	786.31	578.45	**3.78**	984.35	658.46	**3.02**	177.58	118.82	**3.02**
884.59	590.86	**3.01**	1107.28	775.47	**3.34**	906.64	604.94	**3.01**	947.43	626.93	**2.96**	220.94	151.16	**3.17**
908.92	585.41	**2.81**	1116.83	787.39	**3.39**	834.65	514.57	**2.61**	944.57	623.73	**2.94**	163.43	102.43	**2.68**
1142.89	819.11	**3.53**	1158.78	831.38	**3.54**	954.34	631.03	**2.95**	976.76	649.66	**2.99**	203.18	118.82	**2.41**
828.93	503.89	**2.55**	1045.73	716.46	**3.18**	826.19	514.98	**2.65**	978.81	655.15	**3.02**	227.55	136.91	**2.51**
971.46	649.98	**3.02**	1086.99	758.95	**3.31**	894.11	576.36	**2.81**	943.65	617.43	**2.89**	223.3	130.55	**2.41**
	Average:	**2.92**		Average:	**3.33**		Average:	**2.93**		Average:	**2.98**		Average:	**2.76**
	Std Dev	**0.28**		Std Dev	**0.29**		Std Dev	**0.34**		Std Dev	**0.04**		Std Dev	**0.31**

APPENDIX E AMDEL REPORT (BAI & BICWI)

JKTECH PTY LTD





amdel

MINERAL LABORATORIES

COMMINUTION TESTING FOR JKTECH

Report No. N2645CO07 12 October 2007

AMDEL LIMITED
A.B.N. 30 008 127 802
Mineral Services Laboratory
PO Box 338
TORRENSVILLE PLAZA SA 5031
AUSTRALIA

Telephone (Aust): (08) 8416 5200
(Int): 61 8 8416 5200
Facsimile (Aust): (08) 8352 8243
(Int): 61 8 8352 8243

www.amdel.com

A.B.N. 30 008 127 802

Telephone	(Aust):	(08) 8416 5200	Gate 1 Osman Place	PO Box 338
	(Int):	61 8 8416 5200	Thebarton	Torrensville Plaza
Facsimile	(Aust):	(08) 8352 8243	South Australia 5031	South Australia 5031
	(Int):	61 8 8352 8243	AUSTRALIA	AUSTRALIA

12 October 2007

JKTECH Pty Ltd
Isles Rd
Indooroopilly, QLD, 4068

Attention: Mr John Dixon

REPORT N2645CO07

COMMINUTION TESTING FOR JKTECH

YOUR REFERENCE:	RJKT00663/Job07264
SAMPLE IDENTIFICATION:	As Listed
DATE RECEIVED:	8/10/07
PROJECT MANAGER:	Tien Ly

Dirk Smith
Manager, Mineral Processing

TL

1. INTRODUCTION

Mr John Dixon, of JKTech Pty Ltd, requested Amdel Limited to conduct impact crushing work index on four core samples and abrasion index tests on one sample.

All samples were returned to the client on completion of the testing program.

2. PROCEDURE AND RESULTS

Details of test procedures and reference information are included in Appendix 1.

3. RESULTS

Results for these tests are presented in detail in Appendix 2 and have been summarised in Table 1 and 2.

TABLE 1: IMPACT CRUSHING WORK INDEX RESULTS SUMMARY

Sample Description	Impact Crushing Work Index, kWh/tone		
	Ave	Max	Min
JK2215 – 1	5.7	10.6	2.5
JK2215 – 2	8.9	14.0	4.2
JK2215 - 3	7.9	23.8	4.7
JK2215 - 4	10.8	21.8	6.3

TABLE 2: ABRASION INDEX RESULTS SUMMARY

Sample ID	Weigh Loss (g)
JK2215 - 5	0.0900

3.1 Disclaimer

The standard Bond crushing work index test requires *crushed rocks* in the –76+51mm size range. The samples tested in this program were not generated by crushing and do not comply with the standard test requirements. Therefore the results from the test work that doesn't meet the standard procedures should not be used in the normal way. These facts should be highlighted to any parties interpreting the data.

APPENDIX 1:

COMMINUTION TEST PROCEDURES AND REFERENCE INFORMATION

BOND IMPACT CRUSHING WORK INDEX

This test is used to determine the work index of an ore for calculating primary crusher power.

Test Method

In this test, pieces of rock are broken using twin pendulum hammers which simultaneously impact on opposing faces of each rock piece. The impact crushing work index is calculated from the energy required to break each rock, the thickness of the rock and the specific gravity.

Test Result

The work index (kWh/tonne) determined from this test is applicable to a primary crusher.

Sample Requirement

The standard Bond test is carried out on up to 20 rock pieces (if available) selected as passing a 76 mm square aperture screen and being retained on a 51 mm square aperture screen. The specimens should not be slabby or needle shaped.

References

BOND, F.C. (1946), "Crushing Tests by Pressure and Impact", Trans. AIME, Vol. 169, pp. 58 to 65.

BOND, F.C. (1961) "Crushing and Grinding Calculations", Brit. Chem. Eng., Vol. 6, No. 6 and 8.

AVERAGE CRUSHING WORK INDICES
(kWh/short ton or ft-lb/inch thickness)

Material	No. Tests	Average	Range
Basalt	15	20.2	9.9-34.8
Bauxite	8	5.3	2.5-12.2
Calcite	4	8.2	5.8-12.2
Cement clinker	3	4.2	1.4-8.8
Cement raw Material	35	11.7	3.6-27.4
Clay	4	4.8	3.7-6.1
Copper-nickel matte	3	6.3	5.7-7.2
Copper-nickel ore	3	14.1	10.7-17.4
Copper ore	227	12.4	1.8-40.2
Copper silver ore	4	16.0	13.0-18.8
Coral	3	8.6	7.9-9.5
Diorite	11	20.1	13.3-27.3
Dolomite	24	12.8	5.4-31.4
Ferrochrome alloy	13	9.5	1.9-24.5
Ferromanganese	6	4.8	3.2-9.0
Ferrosilicon	6	7.1	3.3-11.43
Fullers earth	3	1.3	0.1-.3.
Gabbro	7	18.6	16.7-21.2
Gneiss	7	15.9	8.0-23.7
Gold ore	15	17.5	3.7-34.2
Granite	63	15.7	6.7-38.0
Gravel	11	16.7	6.9-26.8
Gypsum rock	6	.9	4.3-11.7
Ilmenite	3	12.7	10.7-16.4
Iron ore, unidentified	77	10.0	2.3-33.6
Hematite	64	9.6	2.0-29.4
Magnetite	44	10.1	0.4-19.2
Taconite	30	4.9	9.3-27.3
Lead ore	4	15.5	11.0-21.8
Lead-zinc ore	11	9.3	5.5-14.3
Limestone	178	11.1	3.3-27.6
Manganese ore	3	5.3	0.4-8.9
Molybdenum ore	24	12.5	5.8-18.6
Nickel ore	8	10.1	2.1-19.0
Oil shale	7	15.8	11.5-20.2
Phosphate rock	7	3.3	0.5-11.7
Quartz	11	12.8	6.8-22.1
Quartzite	17	12.9	5.2-19.1
Sandstone	7	13.1	6.5-28.6
Schist	6	12.5	4.1-23.5
Shale	7	10.6	5.8-19.0
Silica rock	6	9.4	4.2-15.9
Slag	10	12.8	1.3-21.9
Stone	8	16.9	10.4-27.5
Tin ore	3	18.0	16.6-19.5
Trap rock	95	19.0	4.9-55.5
Zinc-lead ore	4	10.5	4.5-16.3
TOTAL	1115		

Weiss, N.L. (Ed), SME Mineral Processing Handbook, Society of Mining Engineers, New York, 1985

BOND ABRASION INDEX

This test is used to determine the abrasiveness of an ore in relation to metal wear in crushing and grinding.

Test Method

The ore sample, in the size range minus 19.0 plus 12.7 mm, is tumbled in a drum and cascades over a hardened steel paddle which rotates concentrically within the drum. The tumbled ore is replaced with fresh ore after each 15 minutes and the test continues for a total period of one hour.

Test Result

The weight (g) lost by the paddle for the full test period is the abrasion index.

Sample Requirement

Minimum of 3 kg of minus 19.0 plus 12.7 mm ore.

References

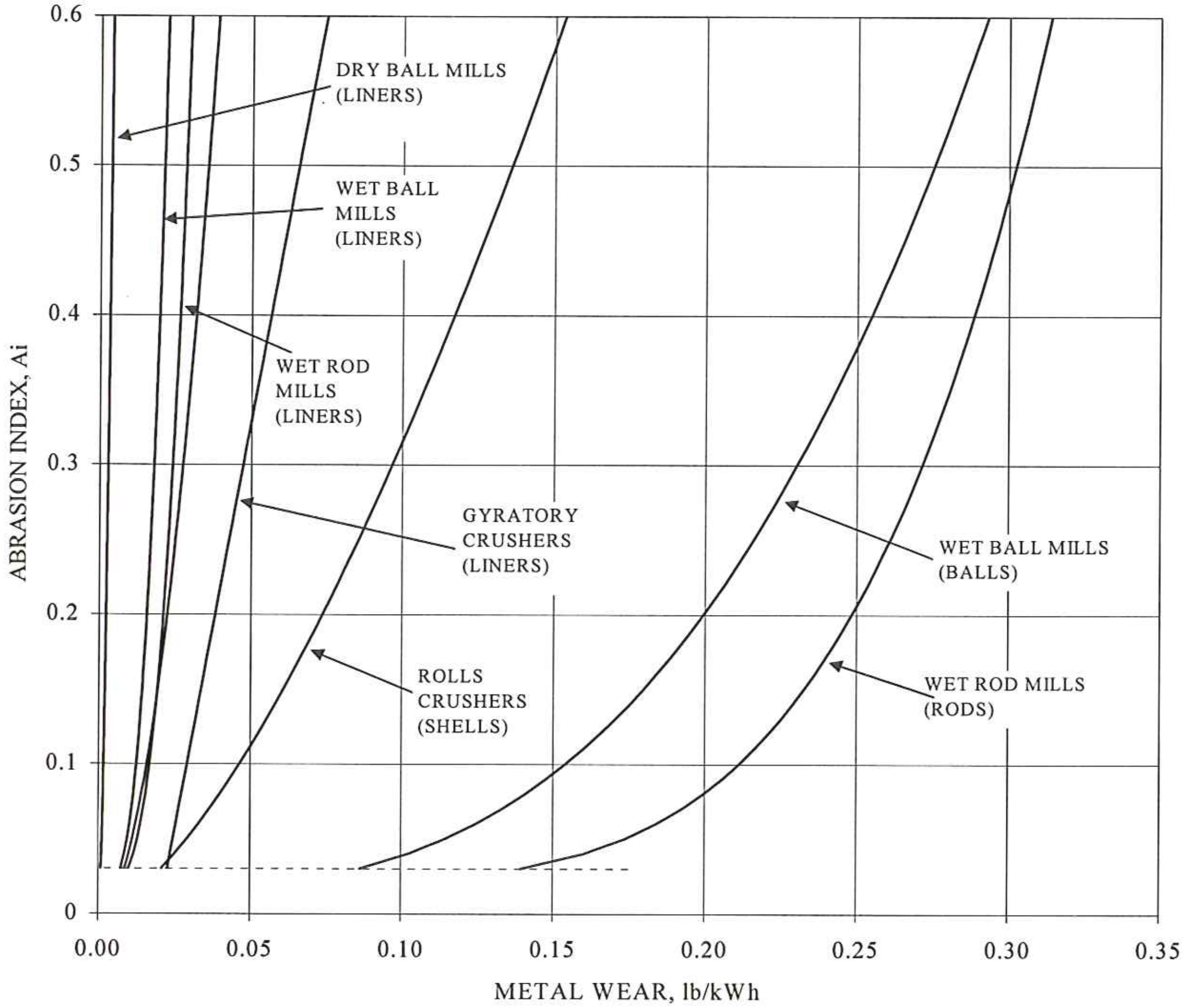
BOND, F.C. (1963), "Metal Wear in Crushing and Grinding", 54th Ann. Mtg. of Amer. Inst. Chem. Engrs., Houston, Texas.

AVERAGE ABRASION INDICES

Material	No. Tests	Average	Range
Aluminium oxide	2	0.86	0.58-1.14
Basalt	5	0.45	0.19-0.83
Bauxite	11	0.02	0.003-0.12
Beryllium ore	2	0.45	0.45-0.45
Cement clinker	15	0.08	0.009-0.17
Cement raw mix	37	0.05	0.001-0.83
Clay, calcined	2	0.04	0.004-0.07
Copper-nickel matte	2	0.002	0.001-0.003
Copper-nickel ore	2	0.46	0.43-0.49
Copper ore	112	0.26	0.002-0.91
Copper silver ore	2	0.62	0.58-0.65
Dolomite	8	0.03	0.01-0.07
Feldspar	2	0.19	0.07-0.30
Ferrochrome alloy	3	0.35	0.27-0.52
Ferromanganese	2	0.25	0.18-0.32
Fullers earth	2	0.001	0.00-0.001
Gold ore	4	0.48	0.30-0.71
Granite	18	0.40	0.10-0.78
Gravel	6	0.29	0.11-0.43
Iron ore, unidentified	33	0.25	0.01-0.98
Hematite	38	0.37	0.00-1.79
Limonite	6	0.13	0.01-0.23
Magnetite	18	0.48	0.11-0.83
Taconite	15	0.60	0.32-0.85
Lead-zinc ore	9	0.21	0.03-0.41
Limestone	52	0.05	0.00-0.65
Magnesite	3	0.08	0.04-0.10
Marble	3	0.01	0.002-0.04
Molybdenum ore	8	0.41	0.13-0.68
Nickel ore	5	0.03	0.01-0.06
Oil shale	3	0.015	0.01-0.02
Phosphate rock	2	0.015	0.01-0.02
Quartzite	7	0.69	0.19-0.99
Schist	2	0.12	0.11-0.13
Shale	2	0.004	0.003-0.005
Silica rock	4	0.29	0.06-0.83
Silver ore	2	0.74	0.72-0.76
Slag	9	0.28	0.01-0.52
Slate	2	0.003	0.003-0.003
Stone	5	0.22	0.07-0.32
Tin ore	4	0.24	0.03-0.35
Trap rock	18	0.35	0.02-0.70
TOTAL	487		

Weiss, N.L. (Ed), *SME Mineral Processing Handbook*
Society of Mining Engineers, New York, 1985

ABRASION INDEX PLOTTED AGAINST METAL WEAR in lb/kWh



BOND, F.C., *Metal Wear in Crushing and Grinding,*
54th Ann. Mtg., American Inst. Chem. Engrs., Houston, Texas, 1963.

APPENDIX 2:

COMMINUTION TEST RESULTS

IMPACT WORK INDEX

SampleTested	JK2215-1

IMPACT WORK INDEX

5.7	kWh/tonne (average)
5.2	kWh/short ton (average)

Specimen No.	Thickness mm	Impact Energy joules	Work Index kWh/tonne
1	57	9.3	2.5
2	61	25.1	6.4
3	59	16.3	4.3
4	61	41.5	10.6
5	58	20.5	5.5
6	61	16.3	4.2
7	57	12.6	3.4
8	61	20.5	5.2
9	58	12.6	3.4
10	59	30.2	8.0
11	55	16.3	4.6
12	50	20.5	6.4
13	54	16.3	4.7
14	60	16.3	4.2
15	57	16.3	4.4
16	60	35.6	9.2
17	57	16.3	4.4
18	60	35.6	9.2
19	58	16.3	4.4
20	62	35.6	8.9

SG of Specimens	3.44	Maximum Work Index	10.6
		Minimum Work Index	2.5
		Standard Deviation	2.3

Printed	11/10/07
Job No.	N2645CO07
Technician	DN
Test Date	10/10/07
File ref	N2645/ICWI

Comments

NON-STANDARD MATERIAL FOR BOND CRUSHING WORK INDEX. RESULTS SHOULD NOT BE USED IN THE SAME WAY AS A BOND WORK INDEX

amdel

ImpactWorkIndex.xls 11Oct2007 Version 5

IMPACT WORK INDEX

SampleTested	**JK2215-2**

IMPACT WORK INDEX

8.9 **kWh/tonne (average)**

8.1 **kWh/short ton (average)**

Specimen No.	Thickness mm	Impact Energy joules	Work Index kWh/tonne
1	57	35.6	10.1
2	60	47.6	12.8
3	55	35.6	10.4
4	60	41.5	11.1
5	56	35.6	10.2
6	58	25.1	7.0
7	57	20.5	5.8
8	61	47.6	12.6
9	57	20.5	5.8
10	61	20.5	5.4
11	57	25.1	7.1
12	62	16.3	4.2
13	57	16.3	4.6
14	61	35.6	9.4
15	57	41.5	11.7
16	62	35.6	9.2
17	56	35.6	10.2
18	62	54.1	14.0
19	57	20.5	5.8
20	61	41.5	10.9

SG of Specimens	3.33	Maximum Work Index	14.0
		Minimum Work Index	4.2
		Standard Deviation	3.0

Printed	11/10/07
Job No.	N2645CO07
Technician	DN
Test Date	10/10/07
File ref	N2645/ICWI

Comments

NON-STANDARD MATERIAL FOR BOND CRUSHING WORK INDEX. RESULTS SHOULD NOT BE USED IN THE SAME WAY AS A BOND WORK INDEX

amdel

ImpactWorkIndex.xls 11Oct2007 Version 5

IMPACT WORK INDEX

SampleTested	JK2215-3

IMPACT WORK INDEX

7.9	kWh/tonne (average)
7.2	kWh/short ton (average)

Specimen No.	Thickness mm	Impact Energy joules	Work Index kWh/tonne
1	55	16.3	5.2
2	61	20.5	5.9
3	56	25.1	7.8
4	61	20.5	5.9
5	55	75.1	23.8
6	60	35.6	10.4
7	55	16.3	5.2
8	60	47.6	13.8
9	58	41.5	12.5
10	60	25.1	7.3
11	60	25.1	7.3
12	61	20.5	5.9
13	56	30.2	9.4
14	61	20.5	5.9
15	58	16.3	4.9
16	60	20.5	6.0
17	56	16.3	5.1
18	59	20.5	6.1
19	57	16.3	5.0
20	61	16.3	4.7

SG of Specimens	3.07	Maximum Work Index	23.8
		Minimum Work Index	4.7
		Standard Deviation	4.5

Printed	11/10/07
Job No.	N2645CO07
Technician	DN
Test Date	10/10/07
File ref	N2645/ICWI

amdel

ImpactWorkIndex.xls 11Oct2007 Version 5

Comments

NON-STANDARD MATERIAL FOR BOND CRUSHING WORK INDEX. RESULTS SHOULD NOT BE USED IN THE SAME WAY AS A BOND WORK INDEX

IMPACT WORK INDEX

SampleTested	JK2215-4		
IMPACT WORK INDEX			
	10.8	kWh/tonne (average)	
	9.8	kWh/short ton (average)	

Specimen No.	Thickness mm	Impact Energy joules	Work Index kWh/tonne
1	58	20.5	6.3
2	56	30.2	9.5
3	60	35.6	10.5
4	57	30.2	9.4
5	60	25.1	7.4
6	57	30.2	9.4
7	63	67.9	19.1
8	57	20.5	6.4
9	59	35.6	10.7
10	60	60.8	18.0
11	61	41.5	12.0
12	58	25.1	7.7
13	61	75.1	21.8
14	58	30.2	9.2
15	60	30.2	8.9
16	57	20.5	6.4
17	61	41.5	12.0
18	56	47.6	15.0
19	62	30.2	8.6
20	57	25.1	7.8

SG of Specimens	3.02	Maximum Work Index	21.8
		Minimum Work Index	6.3
		Standard Deviation	4.4

Printed	11/10/07
Job No.	N2645CO07
Technician	DN
Test Date	10/10/07
File ref	N2645/ICWI

amdel

ImpactWorkIndex.xls 11Oct2007 Version 5

Comments

NON-STANDARD MATERIAL FOR BOND CRUSHING WORK INDEX. RESULTS SHOULD NOT BE USED IN THE SAME WAY AS A BOND WORK INDEX amdel

WORKSHEET FOR ABRASION INDEX

SAMPLE: JK 2215-5 **JOB NO.** N2645CO07

TECHNICIAN: D.N. **DATE:** 9 – 10 - 07

Weight of Paddle before test	___________94.6591
Weight of Paddle after test	___________94.5691
Weight loss = ABRASION INDEX	___________ 0.0900

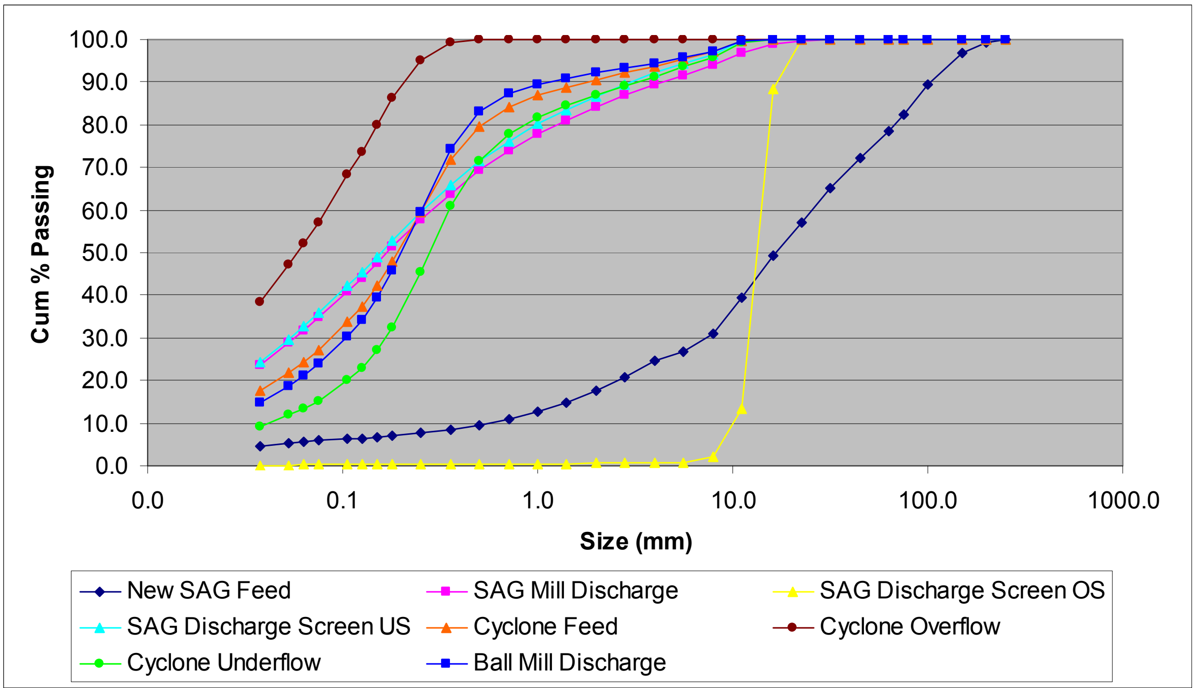
Appendix 2 Simulated Stream Data – Ore Type 1

Simulation Cases 1 to 4 - Lower Circuit Throughput (375 tph)

Ore Type 1 Simulated Stream Data – Simulation Case 1

SAB Lower Throughput

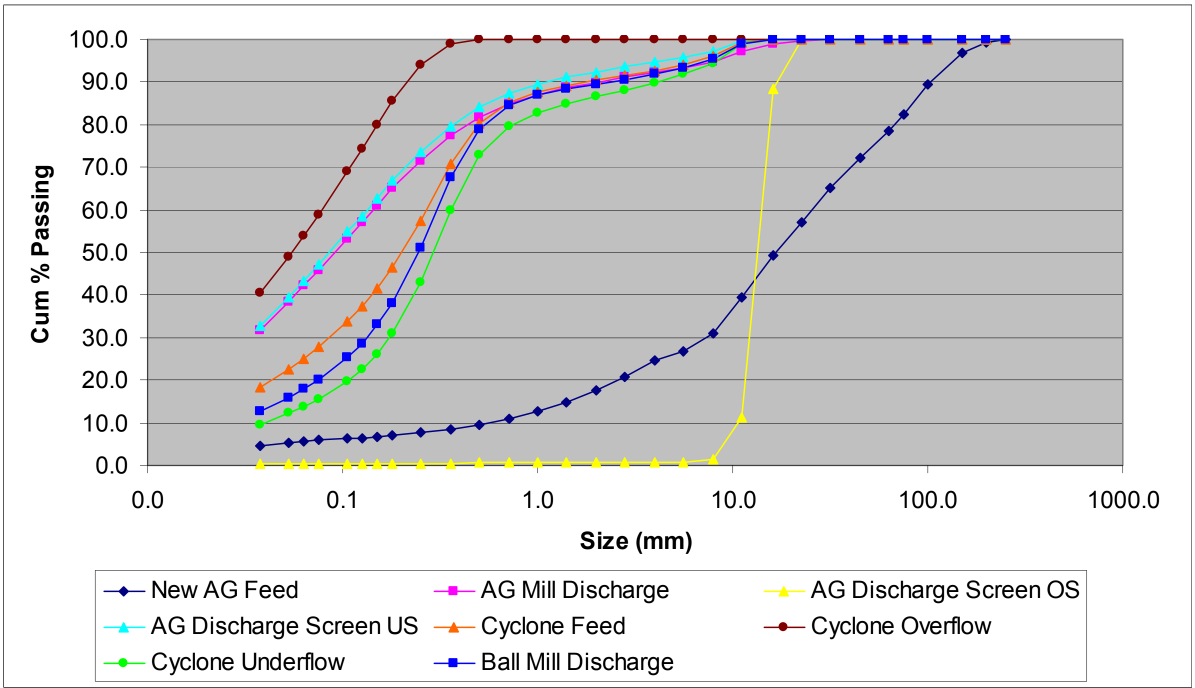
	New SAG Feed	SAG Mill Discharge	SAG Discharge Screen OS	SAG Discharge Screen US	Cyclone Feed	Cyclone Overflow	Cyclone Underflow	Ball Mill Discharge
	Sim	Sim	Sim	Sim	Sim	Sim	Sim	Sim
Solids (t/h)	375.0	386.3	11.3	375.0	1316.0	374.9	941.3	941.3
Solids SG (t/m³)	2.65	2.65	2.65	2.65	2.7	2.7	2.7	2.7
Liquid (t/h)	13.6	165.5	0.0	165.5	877.5	570.4	307.1	366.1
% Solids	96.5	70.0	99.8	69.4	60.0	39.7	75.4	72.0
80.00% passes (mm)	67.680	1.245	15.390	0.985	0.513	0.150	0.857	0.443
Size (mm)	Cumulative Percent Passing							
250.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
200.0	99.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0
150.0	96.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
100.0	89.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0
75.0	82.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0
63.0	78.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0
45.0	72.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0
31.5	65.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0
22.4	57.2	99.8	100.0	100.0	100.0	100.0	100.0	100.0
16.0	49.3	99.0	88.4	100.0	100.0	100.0	100.0	100.0
11.2	39.6	96.9	13.5	99.5	99.5	100.0	99.3	99.5
8.0	31.0	94.0	2.0	96.6	97.1	100.0	95.9	97.3
5.6	26.7	91.6	0.8	94.4	95.4	100.0	93.5	95.8
4.0	24.6	89.5	0.7	92.1	93.8	100.0	91.3	94.4
2.8	20.9	86.9	0.6	89.5	92.2	100.0	89.0	93.2
2.0	17.4	84.2	0.5	86.7	90.6	100.0	86.8	92.1
1.4	14.7	81.1	0.5	83.5	88.9	100.0	84.4	91.0
1.0	12.6	77.8	0.5	80.2	86.9	100.0	81.7	89.6
0.710	10.9	74.0	0.4	76.2	84.2	100.0	77.9	87.4
0.500	9.5	69.3	0.4	71.4	79.7	99.9	71.6	83.0
0.355	8.6	63.9	0.4	65.8	71.8	99.2	60.8	74.1
0.250	7.8	57.7	0.3	59.4	59.6	95.1	45.4	59.6
0.180	7.1	51.3	0.3	52.8	47.8	86.2	32.5	45.8
0.150	6.7	47.6	0.3	49.1	42.2	80.0	27.2	39.5
0.125	6.4	44.0	0.3	45.4	37.5	73.7	23.0	34.3
0.106	6.2	40.9	0.2	42.2	33.7	68.2	20.0	30.3
0.075	6.0	34.8	0.2	35.9	27.2	57.2	15.3	23.8
0.063	5.8	31.8	0.2	32.8	24.4	52.0	13.4	21.1
0.053	5.4	28.9	0.2	29.7	21.9	47.1	11.8	18.8
0.038	4.7	23.6	0.1	24.3	17.6	38.5	9.3	15.0
0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



Ore Type 1 Simulated Stream Data – Simulation Case 2

AB Lower Throughput

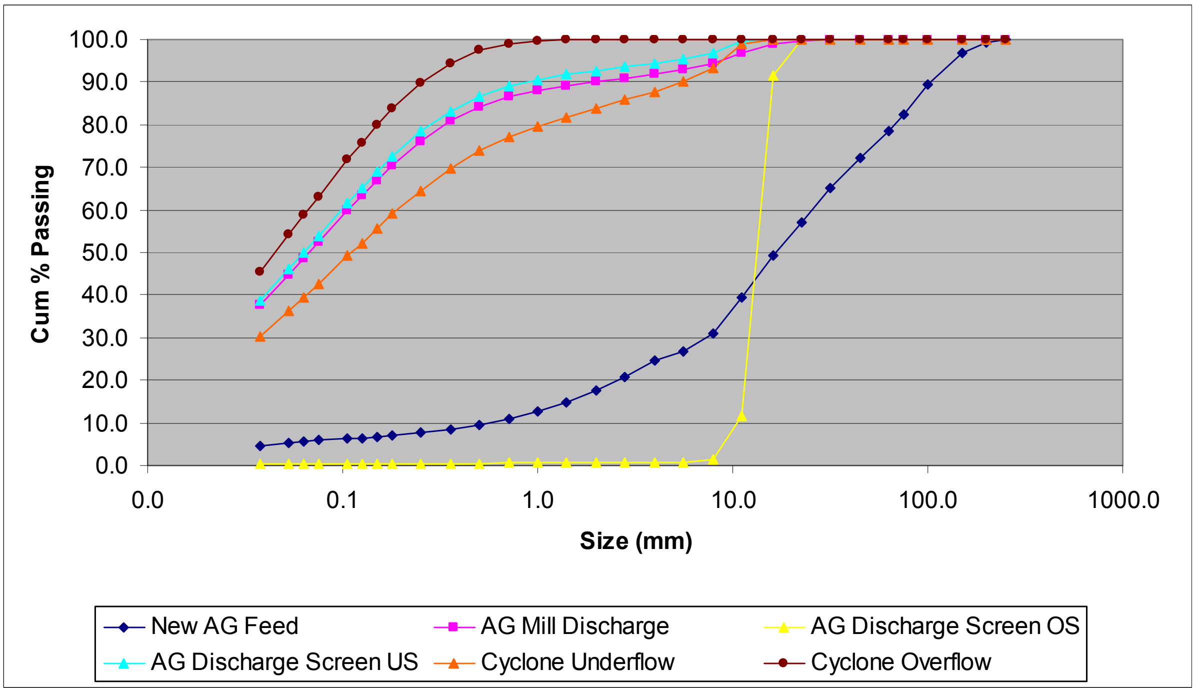
	New AG Feed	AG Mill Discharge	AG Discharge Screen OS	AG Discharge Screen US	Cyclone Feed	Cyclone Overflow	Cyclone Underflow	Ball Mill Discharge
	Sim	**Sim**	**Sim**	**Sim**	**Sim**	**Sim**	**Sim**	**Sim**
Solids (t/h)	375.0	385.4	10.4	375.0	1323.0	374.9	948.3	948.3
Solids SG (t/m³)	2.65	2.65	2.65	2.65	2.7	2.7	2.7	2.7
Liquid (t/h)	13.6	165.2	0.0	165.1	882.1	573.4	308.7	368.8
% Solids	96.5	70.0	99.7	69.4	60.0	39.5	75.4	72.0
80.00% passes (mm)	67.680	0.434	15.440	0.368	0.492	0.150	0.750	0.531
Size (mm)	**Cumulative Percent Passing**							
250.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
200.0	99.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0
150.0	96.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
100.0	89.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0
75.0	82.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0
63.0	78.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0
45.0	72.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0
31.5	65.3	99.9	100.0	100.0	100.0	100.0	100.0	100.0
22.4	57.2	99.7	100.0	100.0	100.0	100.0	100.0	100.0
16.0	49.3	99.0	88.4	100.0	100.0	100.0	100.0	100.0
11.2	39.6	97.1	11.2	99.5	99.2	100.0	98.9	99.1
8.0	31.0	94.8	1.5	97.3	96.0	100.0	94.4	95.5
5.6	26.7	93.3	0.8	95.9	94.2	100.0	91.8	93.5
4.0	24.6	92.2	0.7	94.7	92.7	100.0	89.8	91.9
2.8	20.9	91.1	0.6	93.6	91.4	100.0	88.0	90.6
2.0	17.4	89.9	0.6	92.4	90.3	100.0	86.5	89.5
1.4	14.7	88.6	0.6	91.1	89.1	100.0	84.8	88.3
1.0	12.6	87.1	0.6	89.5	87.7	100.0	82.8	86.9
0.710	10.9	85.0	0.6	87.4	85.3	100.0	79.5	84.5
0.500	9.5	81.8	0.5	84.1	80.5	99.9	72.7	79.0
0.355	8.6	77.4	0.5	79.5	70.9	99.0	59.8	67.5
0.250	7.8	71.5	0.5	73.5	57.4	94.1	42.8	50.9
0.180	7.1	65.0	0.4	66.8	46.3	85.5	30.8	38.2
0.150	6.7	61.0	0.4	62.7	41.4	79.9	26.1	32.9
0.125	6.4	57.0	0.4	58.6	37.2	74.2	22.5	28.7
0.106	6.2	53.3	0.3	54.8	33.8	69.1	19.8	25.4
0.075	6.0	45.9	0.3	47.2	27.8	58.8	15.5	20.1
0.063	5.8	42.1	0.3	43.3	25.1	53.8	13.7	17.9
0.053	5.4	38.4	0.3	39.5	22.6	49.0	12.2	15.9
0.038	4.7	31.7	0.2	32.6	18.4	40.3	9.6	12.7
0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



Ore Type 1 Simulated Stream Data – Simulation Case 3

Single Stage AG Lower Throughput

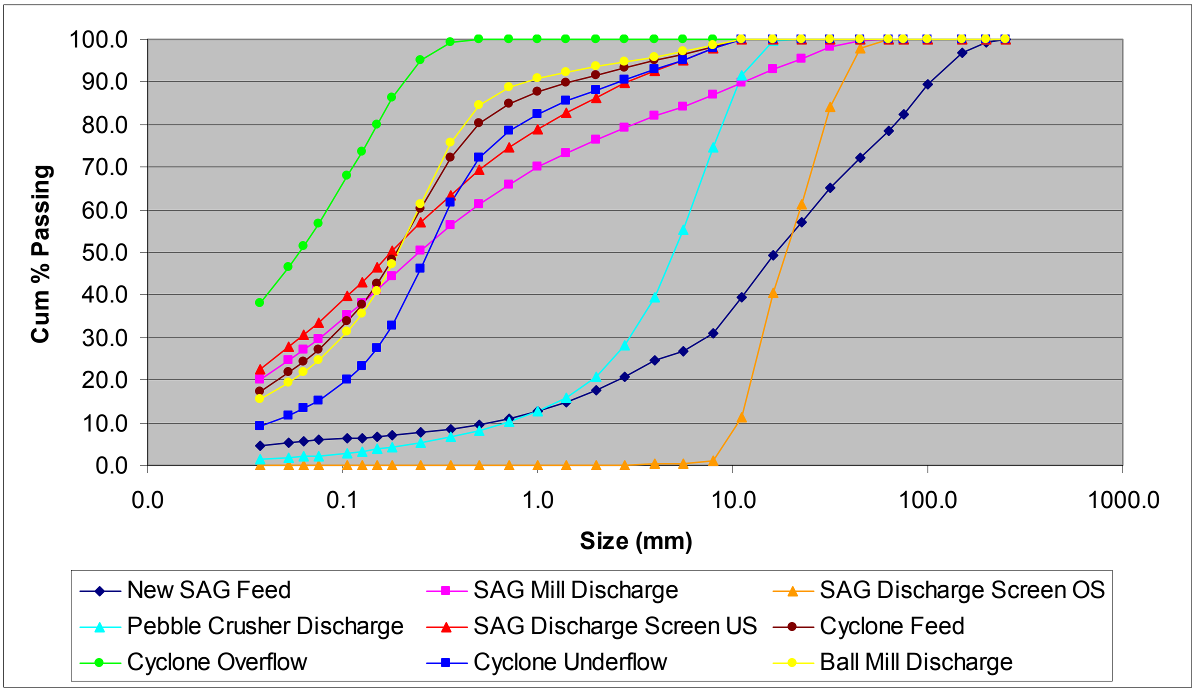
	New AG Feed	AG Mill Discharge	AG Discharge Screen OS	AG Discharge Screen US	Cyclone Underflow	Cyclone Overflow
	Sim	**Sim**	**Sim**	**Sim**	**Sim**	**Sim**
Solids (t/h)	375.0	706.6	19.9	686.7	311.7	375.0
Solids SG (t/m³)	2.7	2.7	2.7	2.7	2.7	2.7
Liquid (t/h)	13.6	302.8	0.1	302.8	160.2	297.6
% Solids	96.5	70.0	99.7	69.4	66.1	55.8
80.00% passes (mm)	67.680	0.331	15.190	0.280	1.043	0.150
Size (mm)	**Cumulative Percent Passing**					
250.0	100.0	100.0	100.0	100.0	100.0	100.0
200.0	99.1	100.0	100.0	100.0	100.0	100.0
150.0	96.9	100.0	100.0	100.0	100.0	100.0
100.0	89.3	100.0	100.0	100.0	100.0	100.0
75.0	82.2	100.0	100.0	100.0	100.0	100.0
63.0	78.4	100.0	100.0	100.0	100.0	100.0
45.0	72.3	100.0	100.0	100.0	100.0	100.0
31.5	65.3	100.0	100.0	100.0	100.0	100.0
22.4	57.2	99.8	100.0	100.0	100.0	100.0
16.0	49.3	99.0	91.7	100.0	100.0	100.0
11.2	39.6	97.0	11.7	99.5	98.9	100.0
8.0	31.0	94.3	1.5	96.9	93.3	100.0
5.6	26.7	92.8	0.7	95.6	90.2	100.0
4.0	24.6	91.8	0.6	94.5	87.8	100.0
2.8	20.9	90.9	0.6	93.5	85.7	100.0
2.0	17.4	90.1	0.6	92.7	83.8	100.0
1.4	14.7	89.2	0.6	91.7	81.8	99.9
1.0	12.6	88.1	0.6	90.6	79.7	99.7
0.7	10.9	86.6	0.5	89.1	77.2	99.0
0.5	9.5	84.3	0.5	86.7	73.8	97.4
0.355	8.6	80.9	0.5	83.2	69.7	94.5
0.250	7.8	76.2	0.5	78.4	64.6	89.9
0.180	7.1	70.6	0.4	72.6	59.0	83.9
0.150	6.7	67.0	0.4	68.9	55.7	80.0
0.125	6.4	63.2	0.4	65.1	52.2	75.7
0.106	6.2	59.8	0.4	61.5	49.1	71.8
0.075	6.0	52.4	0.3	53.9	42.7	63.2
0.063	5.8	48.5	0.3	50.0	39.5	58.6
0.053	5.4	44.7	0.3	46.0	36.2	54.1
0.038	4.7	37.5	0.2	38.6	30.3	45.5
0.000	0.0	0.0	0.0	0.0	0.0	0.0



Ore Type 1 Simulated Stream Data – Simulation Case 4

SABC Lower Throughput

	New SAG Feed	SAG Mill Discharge	SAG Discharge Screen OS	Pebble Crusher Discharge	SAG Discharge Screen US	Cyclone Feed	Cyclone Overflow	Cyclone Underflow	Ball Mill Discharge
	Sim	Sim	Sim	Sim	Sim	Sim	Sim	Sim	Sim
Solids (t/h)	375.0	423.8	48.8	48.8	375.0	1311.0	374.9	936.5	936.5
Solids SG (t/m³)	2.65	2.65	2.65	2.65	2.65	2.7	2.7	2.7	2.7
Liquid (t/h)	13.6	181.6	0.0	0.0	181.6	874.3	568.3	306.0	364.2
% Solids	96.5	70.0	99.9	99.9	67.4	60.0	39.8	75.4	72.0
80.00% passes (mm)	67.680	3.057	29.340	8.755	1.091	0.497	0.150	0.800	0.417
Size (mm)	Cumulative Percent Passing								
250.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
200.0	99.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
150.0	96.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
100.0	89.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
75.0	82.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
63.0	78.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
45.0	72.3	99.7	97.9	100.0	100.0	100.0	100.0	100.0	100.0
31.5	65.3	98.2	84.3	100.0	100.0	100.0	100.0	100.0	100.0
22.4	57.2	95.5	61.3	100.0	100.0	100.0	100.0	100.0	100.0
16.0	49.3	93.0	40.3	99.7	100.0	100.0	100.0	100.0	100.0
11.2	39.6	89.8	11.3	91.7	99.9	99.9	100.0	99.8	99.9
8.0	31.0	86.8	1.2	74.6	97.9	98.4	100.0	97.7	98.5
5.6	26.7	84.2	0.3	55.4	95.2	96.5	100.0	95.1	97.0
4.0	24.6	82.0	0.2	39.3	92.7	94.9	100.0	92.9	95.8
2.8	20.9	79.3	0.1	28.1	89.6	93.2	100.0	90.4	94.6
2.0	17.4	76.5	0.1	20.9	86.4	91.5	100.0	88.1	93.5
1.4	14.7	73.3	0.1	15.8	82.8	89.6	100.0	85.5	92.4
1.0	12.6	69.9	0.1	12.5	79.0	87.5	100.0	82.6	91.0
0.710	10.9	66.0	0.1	10.1	74.6	84.7	100.0	78.6	88.7
0.500	9.5	61.4	0.1	8.2	69.4	80.1	99.9	72.2	84.4
0.355	8.6	56.2	0.1	6.7	63.5	72.3	99.2	61.5	75.8
0.250	7.8	50.4	0.1	5.4	56.9	60.1	95.1	46.1	61.4
0.180	7.1	44.5	0.1	4.3	50.3	48.2	86.2	32.9	47.3
0.150	6.7	41.1	0.1	3.7	46.5	42.5	79.9	27.5	40.8
0.125	6.4	37.9	0.1	3.3	42.8	37.6	73.5	23.2	35.4
0.106	6.2	35.1	0.1	2.9	39.7	33.7	67.8	20.1	31.3
0.075	6.0	29.7	0.0	2.3	33.6	27.1	56.7	15.3	24.5
0.063	5.8	27.1	0.0	2.0	30.6	24.3	51.4	13.4	21.7
0.053	5.4	24.5	0.0	1.8	27.7	21.7	46.5	11.8	19.3
0.038	4.7	19.9	0.0	1.4	22.5	17.4	37.9	9.2	15.3
0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

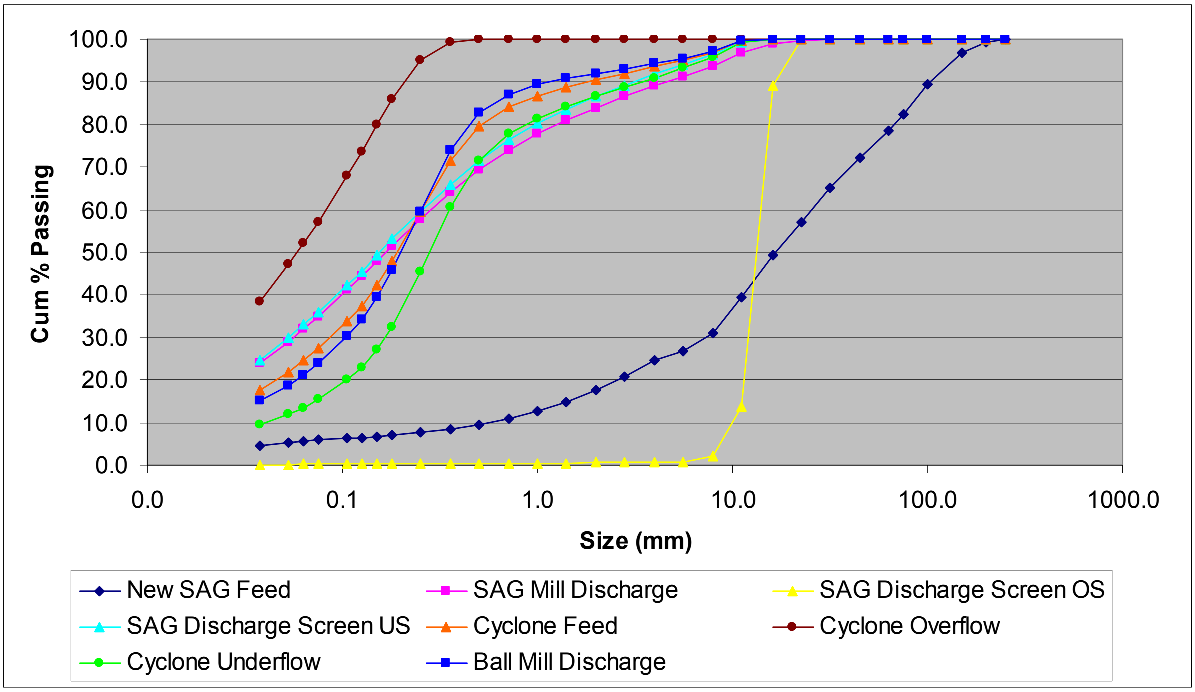


Appendix 3 Simulated Stream Data – Ore Type 1
Simulation Cases 5 to 8 - Lower Circuit Throughput (625 tph)

Ore Type 1 Simulated Stream Data – Simulation Case 5

SAB Higher Throughput

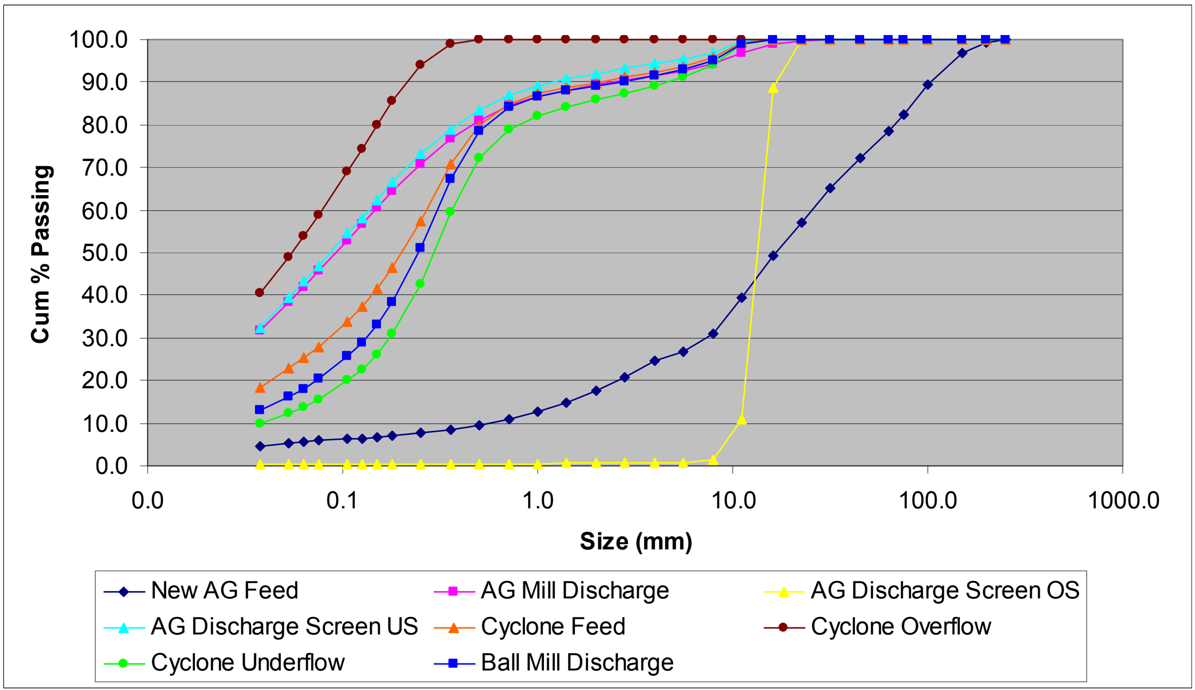
	New SAG Feed	SAG Mill Discharge	SAG Discharge Screen OS	SAG Discharge Screen US	Cyclone Feed	Cyclone Overflow	Cyclone Underflow	Ball Mill Discharge
	Sim	Sim	Sim	Sim	Sim	Sim	Sim	Sim
Solids (t/h)	625.0	644.1	19.1	625.0	2185.0	624.9	1560.0	1560.0
Solids SG (t/m^3)	2.65	2.65	2.65	2.65	2.7	2.7	2.7	2.7
Liquid (t/h)	22.7	276.1	0.0	276.0	1457.0	946.8	509.8	606.7
% Solids	96.5	70.0	99.8	69.4	60.0	39.8	75.4	72.0
80.00% passes (mm)	67.680	1.260	15.350	0.983	0.517	0.150	0.876	0.447
Size (mm)	Cumulative Percent Passing							
250.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
200.0	99.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0
150.0	96.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
100.0	89.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0
75.0	82.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0
63.0	78.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0
45.0	72.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0
31.5	65.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0
22.4	57.2	99.8	100.0	100.0	100.0	100.0	100.0	100.0
16.0	49.3	99.0	88.9	100.0	100.0	100.0	100.0	100.0
11.2	39.6	96.9	13.7	99.5	99.5	100.0	99.3	99.5
8.0	31.0	93.8	2.0	96.5	97.0	100.0	95.8	97.2
5.6	26.7	91.3	0.8	94.1	95.2	100.0	93.2	95.6
4.0	24.6	89.2	0.7	91.9	93.6	100.0	91.0	94.2
2.8	20.9	86.6	0.6	89.2	91.9	100.0	88.7	93.0
2.0	17.4	84.0	0.5	86.5	90.4	100.0	86.5	91.9
1.4	14.7	81.0	0.5	83.5	88.7	100.0	84.1	90.7
1.0	12.6	77.8	0.5	80.2	86.7	100.0	81.4	89.4
0.710	10.9	74.1	0.4	76.3	84.0	100.0	77.7	87.1
0.500	9.5	69.5	0.4	71.6	79.5	99.9	71.4	82.8
0.355	8.6	64.1	0.4	66.0	71.6	99.2	60.6	73.9
0.250	7.8	57.8	0.3	59.6	59.5	95.0	45.3	59.5
0.180	7.1	51.4	0.3	53.0	47.8	86.1	32.5	45.7
0.150	6.7	47.8	0.3	49.2	42.3	80.0	27.2	39.5
0.125	6.4	44.2	0.3	45.6	37.5	73.7	23.0	34.3
0.106	6.2	41.1	0.2	42.3	33.8	68.1	20.0	30.3
0.075	6.0	35.0	0.2	36.0	27.3	57.2	15.4	23.8
0.063	5.8	32.0	0.2	32.9	24.5	52.0	13.5	21.1
0.053	5.4	29.0	0.2	29.9	22.0	47.1	11.9	18.8
0.038	4.7	23.8	0.1	24.5	17.7	38.6	9.4	15.0
0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



Ore Type 1 Simulated Stream Data – Simulation Case 6

AB Higher Throughput

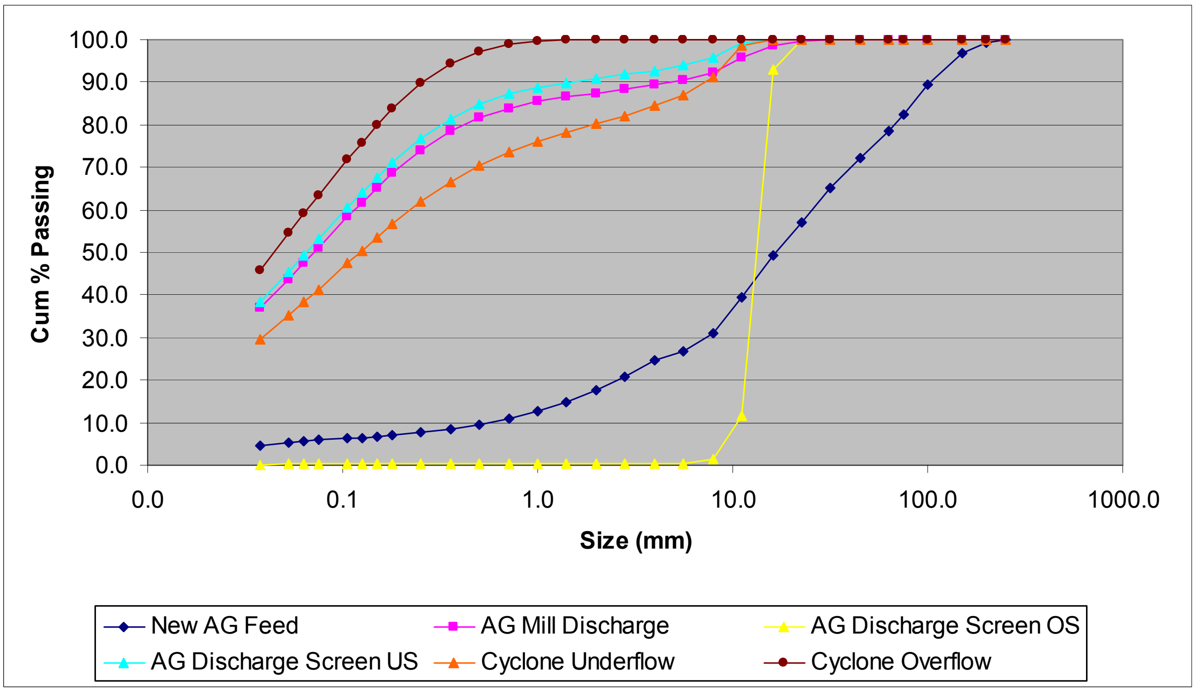
	New AG Feed	AG Mill Discharge	AG Discharge Screen OS	AG Discharge Screen US	Cyclone Feed	Cyclone Overflow	Cyclone Underflow	Ball Mill Discharge
	Sim	Sim	Sim	Sim	Sim	Sim	Sim	Sim
Solids (t/h)	625.0	643.9	18.9	625.0	2191.0	624.9	1566.0	1566.0
Solids SG (t/m³)	2.65	2.65	2.65	2.65	2.7	2.7	2.7	2.7
Liquid (t/h)	22.7	275.9	0.0	275.9	1461.0	949.5	511.3	609.1
% Solids	96.5	70.0	99.8	69.4	60.0	39.7	75.4	72.0
80.00% passes (mm)	67.680	0.456	15.410	0.381	0.499	0.150	0.799	0.543
Size (mm)	**Cumulative Percent Passing**							
250.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
200.0	99.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0
150.0	96.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
100.0	89.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0
75.0	82.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0
63.0	78.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0
45.0	72.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0
31.5	65.3	99.9	100.0	100.0	100.0	100.0	100.0	100.0
22.4	57.2	99.7	100.0	100.0	100.0	100.0	100.0	100.0
16.0	49.3	98.9	88.9	100.0	100.0	100.0	100.0	100.0
11.2	39.6	96.8	11.1	99.5	99.1	100.0	98.8	99.0
8.0	31.0	94.3	1.4	97.0	95.7	100.0	94.0	95.2
5.6	26.7	92.7	0.7	95.5	93.8	100.0	91.3	93.1
4.0	24.6	91.6	0.6	94.3	92.3	100.0	89.2	91.5
2.8	20.9	90.4	0.6	93.2	91.0	100.0	87.4	90.2
2.0	17.4	89.3	0.5	92.0	89.9	100.0	85.9	89.1
1.4	14.7	88.0	0.5	90.7	88.7	100.0	84.2	87.9
1.0	12.6	86.5	0.5	89.1	87.3	100.0	82.1	86.5
0.710	10.9	84.4	0.5	86.9	84.9	100.0	78.8	84.1
0.500	9.5	81.2	0.5	83.6	80.1	99.9	72.2	78.7
0.355	8.6	76.7	0.5	79.0	70.7	99.0	59.4	67.4
0.250	7.8	71.0	0.4	73.1	57.4	94.1	42.7	51.1
0.180	7.1	64.5	0.4	66.4	46.5	85.5	30.9	38.5
0.150	6.7	60.5	0.4	62.3	41.6	79.9	26.2	33.2
0.125	6.4	56.6	0.3	58.2	37.3	74.2	22.6	29.0
0.106	6.2	53.0	0.3	54.5	34.0	69.1	19.9	25.7
0.075	6.0	45.6	0.3	47.0	28.0	58.9	15.6	20.4
0.063	5.8	41.9	0.2	43.1	25.3	53.9	13.8	18.1
0.053	5.4	38.2	0.2	39.4	22.8	49.0	12.3	16.1
0.038	4.7	31.6	0.2	32.5	18.5	40.4	9.7	12.9
0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



Ore Type 1 Simulated Stream Data – Simulation Case 7

Single Stage AG Higher Throughput

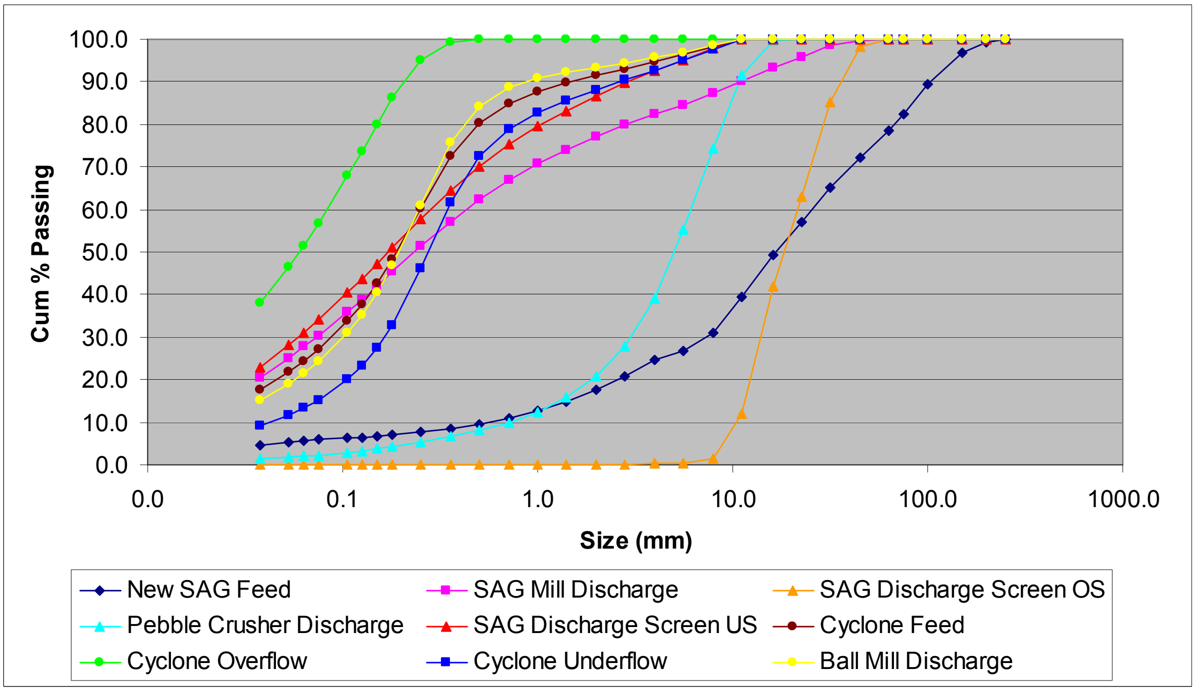
	New AG Feed	AG Mill Discharge	AG Discharge Screen OS	AG Discharge Screen US	Cyclone Underflow	Cyclone Overflow
	Sim	Sim	Sim	Sim	Sim	Sim
Solids (t/h)	625.0	1209.0	45.4	1163.0	538.3	625.0
Solids SG (t/m³)	2.7	2.7	2.7	2.7	2.7	2.7
Liquid (t/h)	22.7	518.0	0.1	517.9	271.4	504.1
% Solids	96.5	70.0	99.8	69.2	66.5	55.4
80.00% passes (mm)	67.680	0.418	15.090	0.317	1.943	0.150
Size (mm)	**Cumulative Percent Passing**					
250.0	100.0	100.0	100.0	100.0	100.0	100.0
200.0	99.1	100.0	100.0	100.0	100.0	100.0
150.0	96.9	100.0	100.0	100.0	100.0	100.0
100.0	89.3	100.0	100.0	100.0	100.0	100.0
75.0	82.2	100.0	100.0	100.0	100.0	100.0
63.0	78.4	100.0	100.0	100.0	100.0	100.0
45.0	72.3	100.0	100.0	100.0	100.0	100.0
31.5	65.3	100.0	100.0	100.0	100.0	100.0
22.4	57.2	99.7	100.0	100.0	100.0	100.0
16.0	49.3	98.7	93.1	100.0	100.0	100.0
11.2	39.6	96.0	11.5	99.3	98.5	100.0
8.0	31.0	92.4	1.3	95.8	91.1	100.0
5.6	26.7	90.5	0.5	94.1	87.1	100.0
4.0	24.6	89.3	0.4	92.8	84.4	100.0
2.8	20.9	88.3	0.4	91.7	82.1	100.0
2.0	17.4	87.4	0.4	90.8	80.2	100.0
1.4	14.7	86.5	0.4	89.9	78.2	99.9
1.0	12.6	85.4	0.4	88.8	76.1	99.6
0.7	10.9	84.0	0.4	87.2	73.6	98.9
0.5	9.5	81.7	0.4	84.9	70.5	97.3
0.355	8.6	78.4	0.4	81.5	66.6	94.3
0.250	7.8	73.9	0.3	76.8	61.8	89.7
0.180	7.1	68.6	0.3	71.2	56.6	83.8
0.150	6.7	65.2	0.3	67.7	53.5	80.0
0.125	6.4	61.6	0.3	64.0	50.3	75.8
0.106	6.2	58.3	0.3	60.6	47.4	71.9
0.075	6.0	51.2	0.2	53.2	41.3	63.4
0.063	5.8	47.5	0.2	49.4	38.2	59.0
0.053	5.4	43.8	0.2	45.5	35.1	54.5
0.038	4.7	36.9	0.2	38.3	29.4	45.9
% Solids	0.0	0.0	0.0	0.0	0.0	0.0



Ore Type 1 Simulated Stream Data – Simulation Case 8

SABC Higher Throughput

	New SAG Feed	SAG Mill Discharge	SAG Discharge Screen OS	Pebble Crusher Discharge	SAG Discharge Screen US	Cyclone Feed	Cyclone Overflow	Cyclone Underflow	Ball Mill Discharge
	Sim	Sim	Sim	Sim	Sim	Sim	Sim	Sim	Sim
Solids (t/h)	625.0	703.0	78.0	78.0	625.0	2187.0	624.9	1562.0	1562.0
Solids SG (t/m³)	2.65	2.65	2.65	2.65	2.65	2.7	2.7	2.7	2.7
Liquid (t/h)	22.7	301.3	0.1	0.1	301.2	1458.0	947.9	510.4	607.6
% Solids	96.5	70.0	99.9	99.9	67.5	60.0	39.7	75.4	72.0
80.00% passes (mm)	67.680	2.895	28.750	8.793	1.043	0.494	0.150	0.789	0.419
Size (mm)	Cumulative Percent Passing								
250.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
200.0	99.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
150.0	96.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
100.0	89.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
75.0	82.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
63.0	78.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
45.0	72.3	99.7	98.1	100.0	100.0	100.0	100.0	100.0	100.0
31.5	65.3	98.4	85.3	100.0	100.0	100.0	100.0	100.0	100.0
22.4	57.2	95.9	63.1	100.0	100.0	100.0	100.0	100.0	100.0
16.0	49.3	93.5	42.0	99.7	100.0	100.0	100.0	100.0	100.0
11.2	39.6	90.3	12.0	91.6	99.9	99.9	100.0	99.8	99.9
8.0	31.0	87.2	1.2	74.3	97.9	98.3	100.0	97.7	98.5
5.6	26.7	84.6	0.3	55.1	95.1	96.4	100.0	95.0	96.9
4.0	24.6	82.4	0.2	39.1	92.7	94.8	100.0	92.7	95.7
2.8	20.9	79.8	0.1	27.9	89.7	93.1	100.0	90.3	94.5
2.0	17.4	77.0	0.1	20.8	86.6	91.4	100.0	88.0	93.4
1.4	14.7	74.0	0.1	15.7	83.2	89.6	100.0	85.5	92.2
1.0	12.6	70.7	0.1	12.4	79.5	87.6	100.0	82.7	90.9
0.710	10.9	67.0	0.1	10.0	75.3	84.8	100.0	78.8	88.6
0.500	9.5	62.4	0.1	8.1	70.2	80.3	99.9	72.4	84.3
0.355	8.6	57.2	0.1	6.6	64.3	72.4	99.2	61.6	75.6
0.250	7.8	51.3	0.1	5.3	57.7	60.1	95.1	46.1	61.1
0.180	7.1	45.4	0.1	4.2	51.0	48.1	86.2	32.9	46.9
0.150	6.7	42.0	0.1	3.7	47.2	42.4	79.9	27.4	40.5
0.125	6.4	38.7	0.1	3.3	43.5	37.5	73.5	23.1	35.1
0.106	6.2	35.9	0.1	2.9	40.3	33.7	67.8	20.1	31.0
0.075	6.0	30.4	0.0	2.2	34.2	27.1	56.8	15.3	24.3
0.063	5.8	27.7	0.0	2.0	31.2	24.3	51.5	13.4	21.5
0.053	5.4	25.1	0.0	1.7	28.2	21.7	46.6	11.8	19.1
0.038	4.7	20.5	0.0	1.4	23.0	17.5	38.0	9.2	15.2
0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

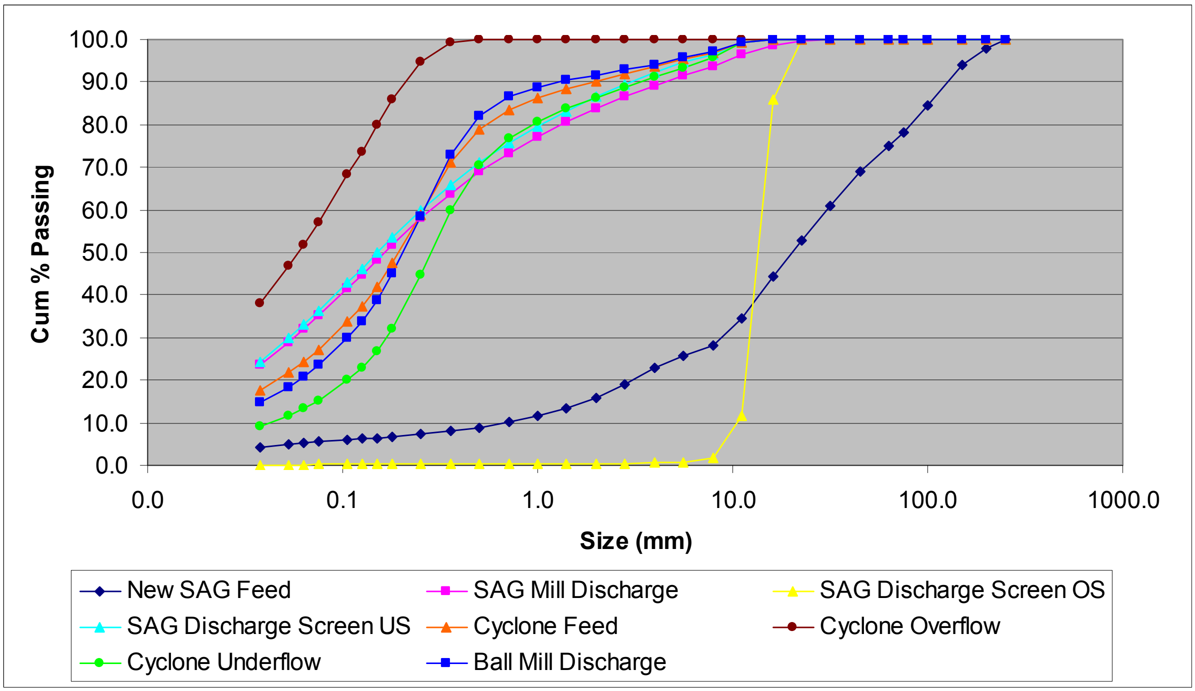


Appendix 4 Simulated Stream Data – Ore Type 2
Simulation Cases 1 to 3 - Lower Circuit Throughput (125 tph)

Ore Type 2 Simulated Stream Data – Simulation Case 1

SAB Lower Throughput (125 tph)

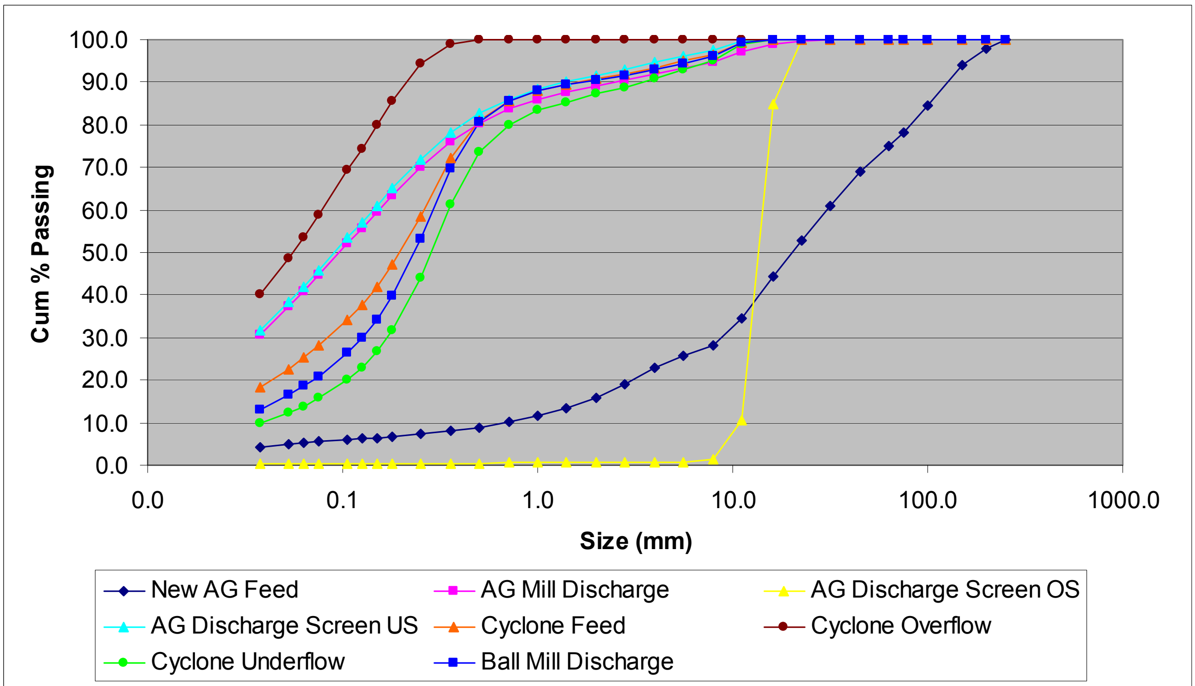
	New SAG Feed	SAG Mill Discharge	SAG Discharge Screen OS	SAG Discharge Screen US	Cyclone Feed	Cyclone Overflow	Cyclone Underflow	Ball Mill Discharge
	Sim	Sim	Sim	Sim	Sim	Sim	Sim	Sim
Solids (t/h)	125.0	129.3	4.3	125.0	438.1	125.0	313.1	313.1
Solids SG (t/m³)	3.08	3.08	3.08	3.08	3.1	3.1	3.1	3.1
Liquid (t/h)	4.5	55.4	0.0	55.4	292.1	189.8	102.2	121.8
% Solids	96.5	70.0	99.8	69.3	60.0	39.7	75.4	72.0
80.00% passes (mm)	81.060	1.327	15.610	1.026	0.544	0.150	0.932	0.463
Size (mm)	**Cumulative Percent Passing**							
250.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
200.0	97.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
150.0	94.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0
100.0	84.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0
75.0	78.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0
63.0	74.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
45.0	68.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
31.5	61.0	99.9	100.0	100.0	100.0	100.0	100.0	100.0
22.4	52.8	99.6	100.0	100.0	100.0	100.0	100.0	100.0
16.0	44.5	98.7	85.8	100.0	100.0	100.0	100.0	100.0
11.2	34.5	96.5	11.5	99.4	99.4	100.0	99.2	99.4
8.0	28.1	93.6	1.7	96.7	97.0	100.0	95.8	97.1
5.6	25.6	91.4	0.8	94.6	95.3	100.0	93.4	95.6
4.0	22.9	89.2	0.6	92.2	93.6	100.0	91.1	94.2
2.8	18.9	86.5	0.5	89.5	91.9	100.0	88.7	92.9
2.0	16.0	83.8	0.5	86.6	90.3	100.0	86.4	91.7
1.4	13.5	80.5	0.4	83.3	88.4	100.0	83.7	90.4
1.0	11.6	77.1	0.4	79.7	86.3	100.0	80.8	88.9
0.710	10.1	73.3	0.4	75.8	83.5	100.0	76.8	86.5
0.500	8.9	68.9	0.4	71.2	78.9	99.9	70.4	81.9
0.355	8.1	63.9	0.3	66.0	71.0	99.2	59.7	72.9
0.250	7.4	58.0	0.3	60.0	58.9	94.9	44.6	58.5
0.180	6.7	51.8	0.3	53.6	47.4	85.9	32.0	44.9
0.150	6.4	48.3	0.3	49.9	42.0	79.9	26.9	38.9
0.125	6.2	44.7	0.2	46.2	37.4	73.7	22.9	33.8
0.106	6.1	41.7	0.2	43.0	33.7	68.2	20.0	30.0
0.075	5.7	35.3	0.2	36.4	27.2	57.1	15.3	23.5
0.063	5.4	32.1	0.2	33.1	24.3	51.7	13.4	20.8
0.053	5.0	29.0	0.2	29.9	21.7	46.7	11.7	18.4
0.038	4.4	23.7	0.1	24.5	17.5	38.2	9.2	14.7
0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



Ore Type 2 Simulated Stream Data – Simulation Case 2

AB Lower Throughput (125 tph)

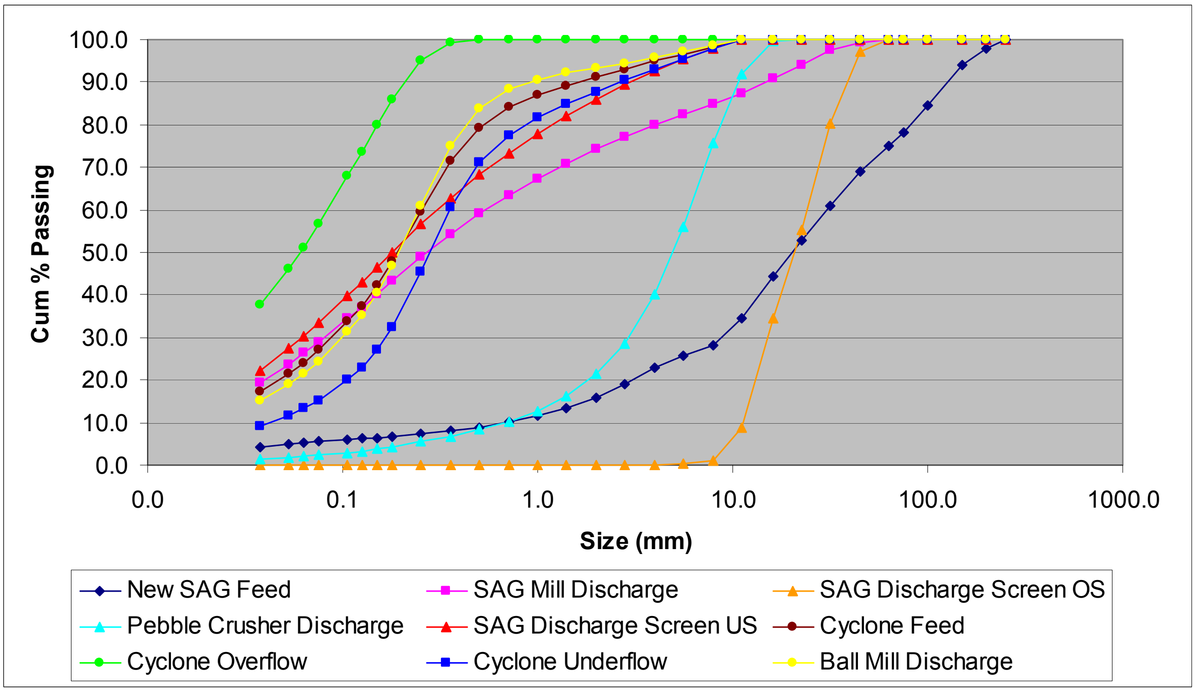
	New AG Feed	AG Mill Discharge	AG Discharge Screen OS	AG Discharge Screen US	Cyclone Feed	Cyclone Overflow	Cyclone Underflow	Ball Mill Discharge
	Sim	Sim	Sim	Sim	Sim	Sim	Sim	Sim
Solids (t/h)	125.0	128.5	3.5	125.0	437.8	125.0	312.8	312.8
Solids SG (t/m³)	3.08	3.08	3.08	3.08	3.1	3.1	3.1	3.1
Liquid (t/h)	4.5	55.1	0.0	55.1	291.8	189.7	102.1	121.6
% Solids	96.5	70.0	99.7	69.4	60.0	39.7	75.4	72.0
80.00% passes (mm)	81.060	0.484	15.680	0.409	0.478	0.150	0.708	0.491
Size (mm)	Cumulative Percent Passing							
250.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
200.0	97.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
150.0	94.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0
100.0	84.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0
75.0	78.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0
63.0	74.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
45.0	68.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
31.5	61.0	99.9	100.0	100.0	100.0	100.0	100.0	100.0
22.4	52.8	99.6	100.0	100.0	100.0	100.0	100.0	100.0
16.0	44.5	98.8	84.9	100.0	100.0	100.0	100.0	100.0
11.2	34.5	97.1	10.4	99.5	99.3	100.0	99.0	99.2
8.0	28.1	94.9	1.5	97.4	96.6	100.0	95.2	96.2
5.6	25.6	93.4	0.8	96.1	95.0	100.0	92.9	94.5
4.0	22.9	92.1	0.7	94.6	93.4	100.0	90.8	92.9
2.8	18.9	90.6	0.6	93.1	92.0	100.0	88.8	91.6
2.0	16.0	89.2	0.6	91.7	90.8	100.0	87.2	90.5
1.4	13.5	87.7	0.6	90.1	89.6	100.0	85.4	89.4
1.0	11.6	86.0	0.6	88.4	88.1	100.0	83.3	88.0
0.710	10.1	83.7	0.5	86.1	85.7	100.0	80.0	85.6
0.500	8.9	80.4	0.5	82.7	81.1	99.9	73.6	80.5
0.355	8.1	75.9	0.5	78.0	72.0	99.1	61.2	69.7
0.250	7.4	70.0	0.4	71.9	58.5	94.4	44.2	53.2
0.180	6.7	63.3	0.4	65.1	47.0	85.7	31.6	39.8
0.150	6.4	59.4	0.4	61.1	41.9	80.1	26.7	34.3
0.125	6.2	55.5	0.3	57.1	37.6	74.4	22.9	29.9
0.106	6.1	52.0	0.3	53.5	34.2	69.3	20.2	26.5
0.075	5.7	44.7	0.3	45.9	28.0	58.8	15.7	20.9
0.063	5.4	40.9	0.3	42.0	25.2	53.7	13.9	18.5
0.053	5.0	37.2	0.2	38.3	22.7	48.8	12.2	16.5
0.038	4.4	30.8	0.2	31.6	18.4	40.2	9.7	13.2
0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



Ore Type 2 Simulated Stream Data – Simulation Case 3

SABC Lower Throughput (125 tph)

	New SAG Feed	SAG Mill Discharge	SAG Discharge Screen OS	Pebble Crusher Discharge	SAG Discharge Screen US	Cyclone Feed	Cyclone Overflow	Cyclone Underflow	Ball Mill Discharge
	Sim	**Sim**	**Sim**	**Sim**	**Sim**	**Sim**	**Sim**	**Sim**	**Sim**
Solids (t/h)	125.0	144.8	19.8	19.8	125.0	437.6	125.0	312.7	312.7
Solids SG (t/m³)	3.08	3.08	3.08	3.08	3.08	3.1	3.1	3.1	3.1
Liquid (t/h)	4.5	62.1	0.0	0.0	62.0	291.8	189.6	102.1	121.6
% Solids	96.5	70.0	100.0	100.0	66.8	60.0	39.7	75.4	72.0
80.00% passes (mm)	81.060	3.945	31.340	8.615	1.178	0.524	0.150	0.863	0.429
Size (mm)	**Cumulative Percent Passing**								
250.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
200.0	97.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
150.0	94.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
100.0	84.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
75.0	78.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
63.0	74.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
45.0	68.9	99.5	97.3	100.0	100.0	100.0	100.0	100.0	100.0
31.5	61.0	97.4	80.3	100.0	100.0	100.0	100.0	100.0	100.0
22.4	52.8	93.9	55.3	100.0	100.0	100.0	100.0	100.0	100.0
16.0	44.5	90.9	34.5	99.7	100.0	100.0	100.0	100.0	100.0
11.2	34.5	87.5	8.7	91.9	99.9	99.9	100.0	99.8	99.9
8.0	28.1	84.8	0.9	75.8	98.0	98.4	100.0	97.8	98.6
5.6	25.6	82.4	0.2	56.2	95.5	96.7	100.0	95.3	97.1
4.0	22.9	80.1	0.2	40.0	92.8	94.9	100.0	92.9	95.8
2.8	18.9	77.3	0.1	28.6	89.5	93.1	100.0	90.3	94.5
2.0	16.0	74.3	0.1	21.4	86.1	91.3	100.0	87.8	93.4
1.4	13.5	70.9	0.1	16.2	82.1	89.3	100.0	85.0	92.1
1.0	11.6	67.3	0.1	12.9	77.9	87.0	100.0	81.8	90.6
0.710	10.1	63.4	0.1	10.4	73.4	84.0	100.0	77.6	88.2
0.500	8.9	59.0	0.1	8.4	68.3	79.3	99.9	71.1	83.8
0.355	8.1	54.2	0.1	6.9	62.8	71.6	99.2	60.5	75.1
0.250	7.4	48.9	0.1	5.5	56.6	59.6	95.0	45.4	60.8
0.180	6.7	43.3	0.1	4.4	50.2	47.8	86.1	32.6	46.9
0.150	6.4	40.2	0.1	3.8	46.5	42.3	79.9	27.2	40.6
0.125	6.2	37.1	0.0	3.3	43.0	37.5	73.5	23.1	35.3
0.106	6.1	34.4	0.0	3.0	39.9	33.7	67.9	20.0	31.2
0.075	5.7	29.0	0.0	2.3	33.6	27.0	56.6	15.2	24.4
0.063	5.4	26.3	0.0	2.0	30.4	24.1	51.2	13.3	21.6
0.053	5.0	23.7	0.0	1.8	27.4	21.5	46.1	11.6	19.1
0.038	4.4	19.2	0.0	1.4	22.3	17.2	37.6	9.1	15.2
0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



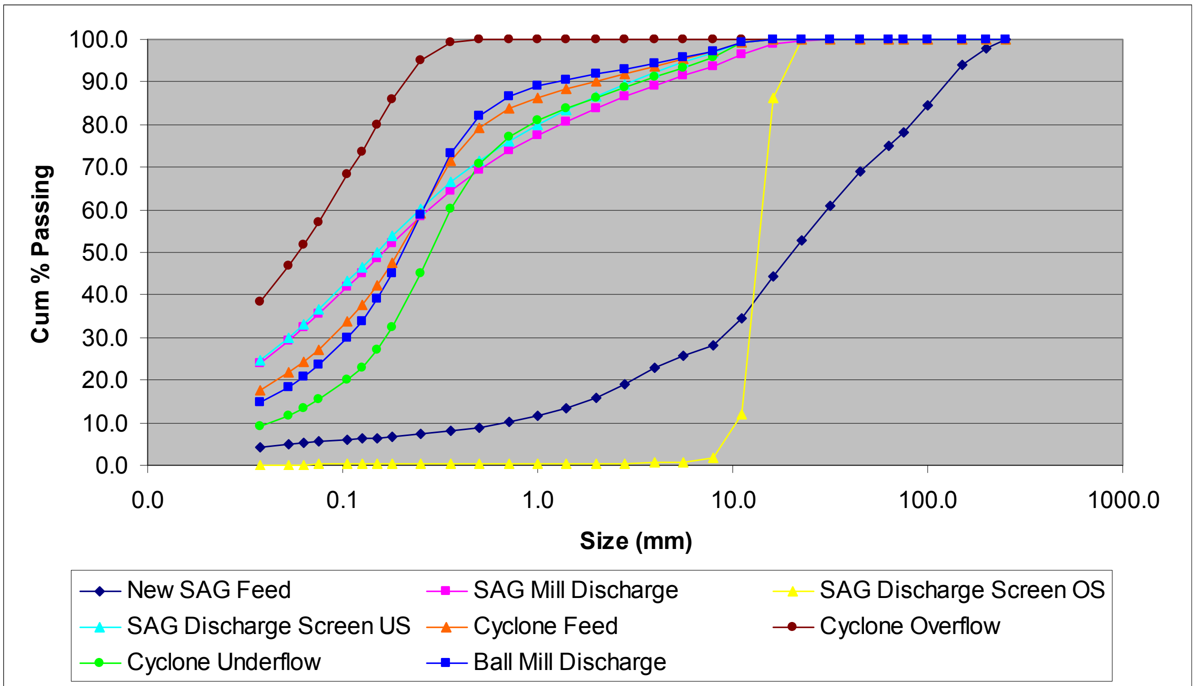
Appendix 5 Simulated Stream Data – Ore Type 2

Simulation Cases 4 to 6 - Medium Circuit Throughput (250 tph)

Ore Type 2 Simulated Stream Data – Simulation Case 4

SAB Medium Throughput (250 tph)

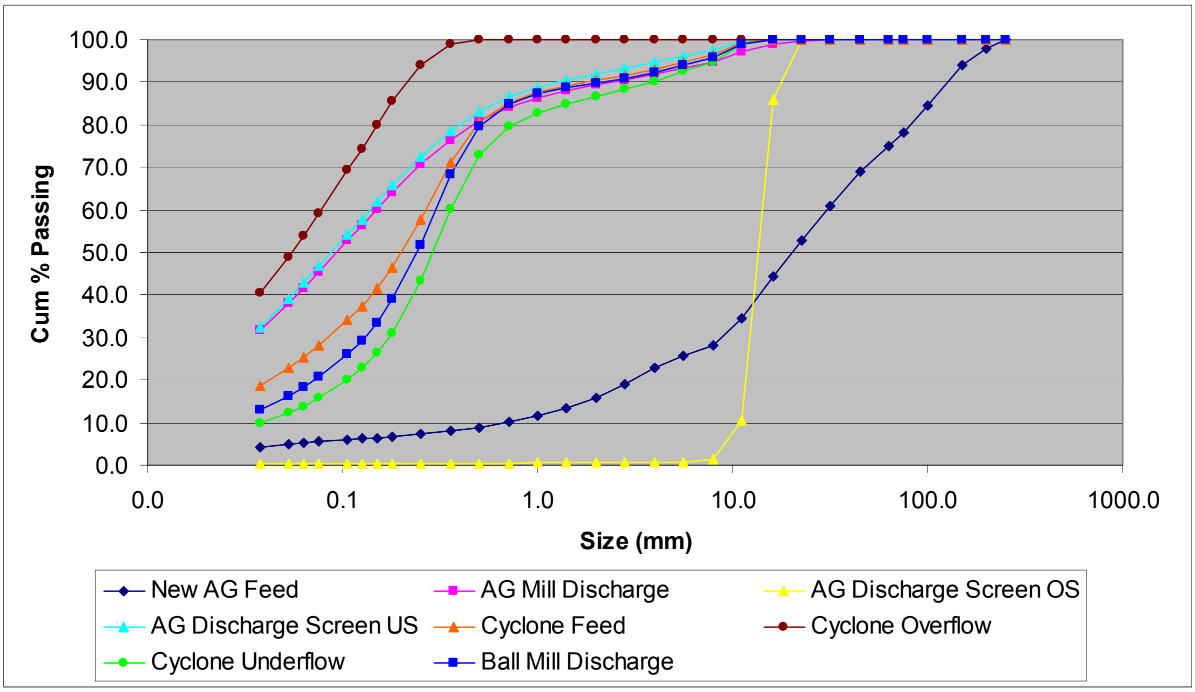
	New SAG Feed	SAG Mill Discharge	SAG Discharge Screen OS	SAG Discharge Screen US	Cyclone Feed	Cyclone Overflow	Cyclone Underflow	Ball Mill Discharge
	Sim	Sim	Sim	Sim	Sim	Sim	Sim	Sim
Solids (t/h)	250.0	258.2	8.2	250.0	875.0	250.0	625.0	625.0
Solids SG (t/m³)	3.08	3.08	3.08	3.08	3.1	3.1	3.1	3.1
Liquid (t/h)	9.1	110.7	0.0	110.7	583.3	379.2	204.2	243.1
% Solids	96.5	70.0	99.8	69.3	60.0	39.7	75.4	72.0
80.00% passes (mm)	81.060	1.304	15.570	1.004	0.531	0.150	0.913	0.457
Size (mm)	Cumulative Percent Passing							
250.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
200.0	97.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
150.0	94.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0
100.0	84.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0
75.0	78.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0
63.0	74.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
45.0	68.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
31.5	61.0	99.9	100.0	100.0	100.0	100.0	100.0	100.0
22.4	52.8	99.7	100.0	100.0	100.0	100.0	100.0	100.0
16.0	44.5	98.8	86.2	100.0	100.0	100.0	100.0	100.0
11.2	34.5	96.6	11.8	99.4	99.4	100.0	99.2	99.4
8.0	28.1	93.8	1.7	96.7	97.0	100.0	95.8	97.2
5.6	25.6	91.5	0.8	94.6	95.3	100.0	93.5	95.7
4.0	22.9	89.3	0.6	92.1	93.6	100.0	91.1	94.2
2.8	18.9	86.5	0.5	89.4	91.9	100.0	88.7	92.9
2.0	16.0	83.8	0.5	86.5	90.2	100.0	86.4	91.7
1.4	13.5	80.7	0.5	83.3	88.4	100.0	83.8	90.5
1.0	11.6	77.4	0.4	79.9	86.4	100.0	81.0	89.0
0.710	10.1	73.8	0.4	76.2	83.7	100.0	77.2	86.7
0.500	8.9	69.4	0.4	71.7	79.2	99.9	70.9	82.2
0.355	8.1	64.4	0.3	66.5	71.4	99.2	60.3	73.3
0.250	7.4	58.4	0.3	60.3	59.3	94.9	45.0	58.8
0.180	6.7	52.1	0.3	53.8	47.6	86.0	32.3	45.2
0.150	6.4	48.5	0.3	50.1	42.2	80.0	27.1	39.0
0.125	6.2	45.0	0.2	46.4	37.5	73.8	23.0	33.9
0.106	6.1	41.8	0.2	43.2	33.8	68.2	20.1	30.1
0.075	5.7	35.4	0.2	36.6	27.3	57.1	15.3	23.5
0.063	5.4	32.2	0.2	33.3	24.4	51.8	13.4	20.8
0.053	5.0	29.1	0.2	30.1	21.8	46.8	11.8	18.5
0.038	4.4	23.8	0.1	24.6	17.5	38.2	9.3	14.7
0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



Ore Type 2 Simulated Stream Data – Simulation Case 5

AB Medium Throughput (250 tph)

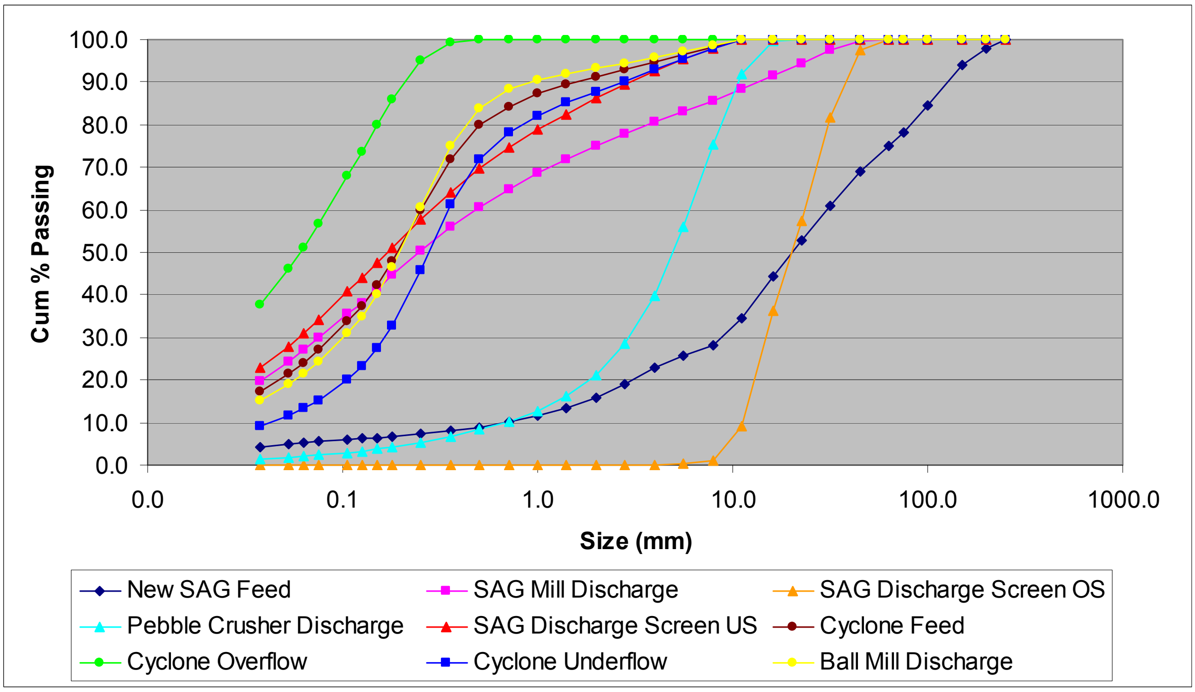
	New AG Feed	AG Mill Discharge	AG Discharge Screen OS	AG Discharge Screen US	Cyclone Feed	Cyclone Overflow	Cyclone Underflow	Ball Mill Discharge
	Sim	Sim	Sim	Sim	Sim	Sim	Sim	Sim
Solids (t/h)	250.0	257.1	7.1	250.0	875.0	249.9	625.0	625.0
Solids SG (t/m³)	3.08	3.08	3.08	3.08	3.1	3.1	3.1	3.1
Liquid (t/h)	9.1	110.2	0.0	110.1	583.3	379.2	204.2	243.1
% Solids	96.5	70.0	99.7	69.4	60.0	39.7	75.4	72.0
80.00% passes (mm)	81.060	0.464	15.600	0.392	0.488	0.150	0.748	0.514
Size (mm)	**Cumulative Percent Passing**							
250.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
200.0	97.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
150.0	94.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0
100.0	84.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0
75.0	78.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0
63.0	74.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
45.0	68.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
31.5	61.0	99.9	100.0	100.0	100.0	100.0	100.0	100.0
22.4	52.8	99.6	100.0	100.0	100.0	100.0	100.0	100.0
16.0	44.5	98.9	86.0	100.0	100.0	100.0	100.0	100.0
11.2	34.5	97.1	10.5	99.5	99.2	100.0	98.9	99.1
8.0	28.1	94.8	1.5	97.4	96.3	100.0	94.9	95.9
5.6	25.6	93.4	0.8	96.0	94.6	100.0	92.5	94.1
4.0	22.9	92.0	0.6	94.6	93.0	100.0	90.2	92.4
2.8	18.9	90.6	0.6	93.2	91.6	100.0	88.3	91.0
2.0	16.0	89.3	0.6	91.9	90.4	100.0	86.6	89.9
1.4	13.5	87.9	0.6	90.4	89.2	100.0	84.8	88.7
1.0	11.6	86.4	0.5	88.8	87.7	100.0	82.8	87.3
0.710	10.1	84.2	0.5	86.6	85.4	100.0	79.5	84.9
0.500	8.9	80.9	0.5	83.2	80.6	99.9	72.9	79.5
0.355	8.1	76.5	0.5	78.6	71.3	99.0	60.2	68.3
0.250	7.4	70.6	0.4	72.6	57.8	94.2	43.2	51.8
0.180	6.7	64.0	0.4	65.8	46.6	85.5	31.1	38.9
0.150	6.4	60.2	0.4	61.9	41.7	79.9	26.4	33.6
0.125	6.2	56.3	0.3	57.9	37.5	74.3	22.7	29.3
0.106	6.1	52.8	0.3	54.3	34.1	69.3	20.1	26.1
0.075	5.7	45.5	0.3	46.7	28.1	59.0	15.7	20.6
0.063	5.4	41.7	0.2	42.9	25.3	54.0	13.9	18.3
0.053	5.0	38.0	0.2	39.1	22.8	49.1	12.3	16.3
0.038	4.4	31.5	0.2	32.4	18.6	40.5	9.8	13.0
0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



Ore Type 2 Simulated Stream Data – Simulation Case 6

SABC Medium Throughput (250 tph)

	New SAG Feed	SAG Mill Discharge	SAG Discharge Screen OS	Pebble Crusher Discharge	SAG Discharge Screen US	Cyclone Feed	Cyclone Overflow	Cyclone Underflow	Ball Mill Discharge
	Sim	**Sim**	**Sim**	**Sim**	**Sim**	**Sim**	**Sim**	**Sim**	**Sim**
Solids (t/h)	250.0	287.3	37.3	37.3	250.0	875.6	250.0	625.6	625.6
Solids SG (t/m³)	3.08	3.08	3.08	3.08	3.08	3.1	3.1	3.1	3.1
Liquid (t/h)	9.1	123.1	0.0	0.0	123.1	583.7	379.4	204.3	243.3
% Solids	96.5	70.0	99.9	99.9	67.0	60.0	39.7	75.4	72.0
80.00% passes (mm)	81.060	3.630	30.680	8.652	1.114	0.509	0.150	0.836	0.427
Size (mm)	**Cumulative Percent Passing**								
250.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
200.0	97.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
150.0	94.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
100.0	84.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
75.0	78.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
63.0	74.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
45.0	68.9	99.5	97.5	100.0	100.0	100.0	100.0	100.0	100.0
31.5	61.0	97.7	81.7	100.0	100.0	100.0	100.0	100.0	100.0
22.4	52.8	94.4	57.3	100.0	100.0	100.0	100.0	100.0	100.0
16.0	44.5	91.6	36.2	99.7	100.0	100.0	100.0	100.0	100.0
11.2	34.5	88.2	9.3	91.8	99.9	99.9	100.0	99.8	99.9
8.0	28.1	85.5	1.0	75.5	98.0	98.4	100.0	97.8	98.5
5.6	25.6	83.1	0.3	56.0	95.5	96.6	100.0	95.3	97.1
4.0	22.9	80.7	0.2	39.8	92.8	94.9	100.0	92.8	95.7
2.8	18.9	77.9	0.1	28.5	89.5	93.0	100.0	90.2	94.4
2.0	16.0	75.1	0.1	21.3	86.3	91.3	100.0	87.8	93.3
1.4	13.5	71.9	0.1	16.1	82.6	89.3	100.0	85.1	92.0
1.0	11.6	68.5	0.1	12.8	78.7	87.2	100.0	82.0	90.5
0.710	10.1	64.8	0.1	10.3	74.5	84.3	100.0	78.1	88.2
0.500	8.9	60.6	0.1	8.4	69.6	79.8	99.9	71.7	83.8
0.355	8.1	55.8	0.1	6.8	64.2	72.0	99.2	61.1	75.1
0.250	7.4	50.3	0.1	5.4	57.8	59.8	95.1	45.8	60.6
0.180	6.7	44.6	0.1	4.3	51.2	47.9	86.1	32.7	46.6
0.150	6.4	41.3	0.1	3.8	47.5	42.3	79.9	27.3	40.3
0.125	6.2	38.1	0.1	3.3	43.8	37.5	73.6	23.1	35.0
0.106	6.1	35.4	0.1	3.0	40.7	33.7	67.9	20.1	30.9
0.075	5.7	29.8	0.0	2.3	34.2	27.0	56.6	15.2	24.1
0.063	5.4	27.0	0.0	2.0	31.0	24.1	51.2	13.3	21.3
0.053	5.0	24.3	0.0	1.8	28.0	21.5	46.2	11.7	18.9
0.038	4.4	19.8	0.0	1.4	22.8	17.2	37.6	9.1	15.0
0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



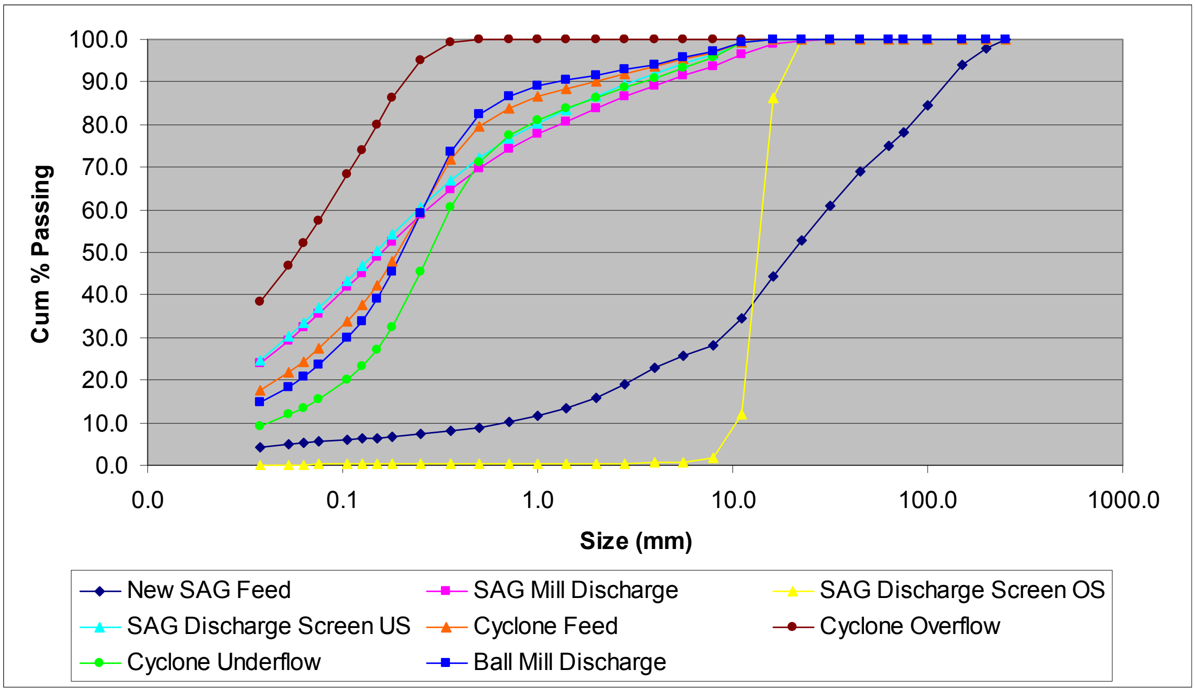
Appendix 6 Simulated Stream Data – Ore Type 2

Simulation Cases 7 to 9 - Higher Circuit Throughput (375 tph)

Ore Type 2 Simulated Stream Data – Simulation Case 7

SAB Higher Throughput (375 tph)

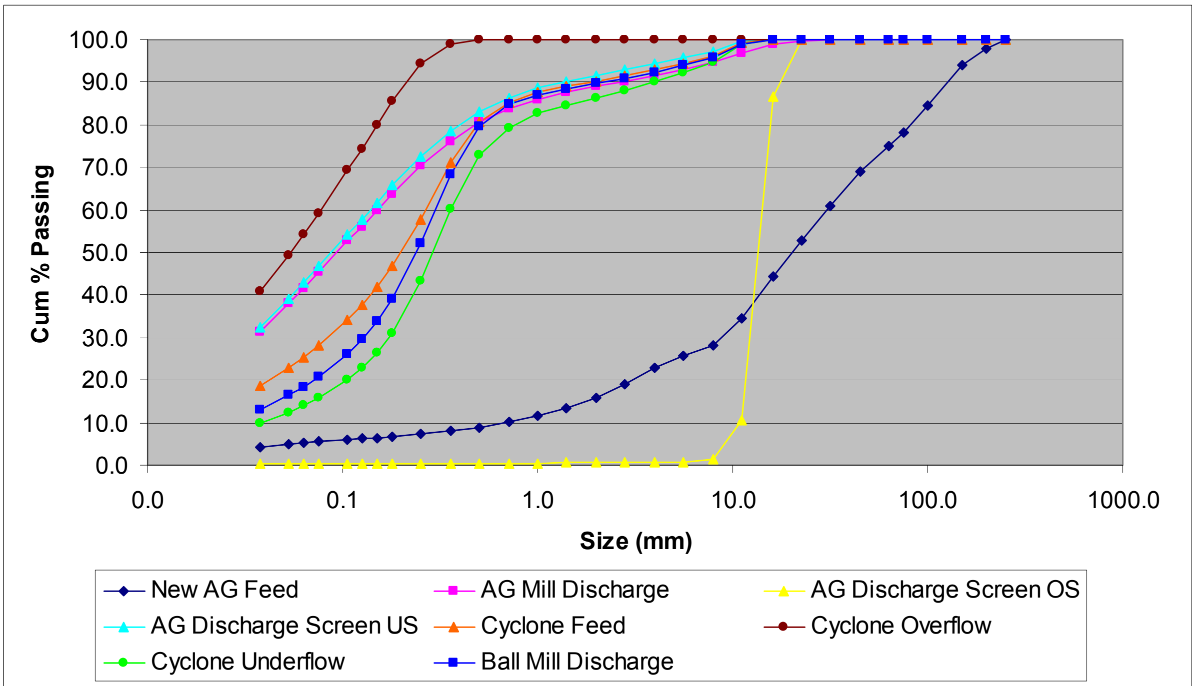
	New SAG Feed	SAG Mill Discharge	SAG Discharge Screen OS	SAG Discharge Screen US	Cyclone Feed	Cyclone Overflow	Cyclone Underflow	Ball Mill Discharge
	Sim	Sim	Sim	Sim	Sim	Sim	Sim	Sim
Solids (t/h)	375.0	387.3	12.3	375.0	1312.0	374.9	937.3	937.3
Solids SG (t/m³)	3.08	3.08	3.08	3.08	3.1	3.1	3.1	3.1
Liquid (t/h)	13.6	166.0	0.0	166.0	874.8	568.6	306.2	364.5
% Solids	96.5	70.0	99.8	69.3	60.0	39.7	75.4	72.0
80.00% passes (mm)	81.060	1.282	15.560	0.978	0.521	0.150	0.897	0.453
Size (mm)	Cumulative Percent Passing							
250.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
200.0	97.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
150.0	94.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0
100.0	84.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0
75.0	78.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0
63.0	74.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
45.0	68.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
31.5	61.0	99.9	100.0	100.0	100.0	100.0	100.0	100.0
22.4	52.8	99.7	100.0	100.0	100.0	100.0	100.0	100.0
16.0	44.5	98.8	86.4	100.0	100.0	100.0	100.0	100.0
11.2	34.5	96.6	12.0	99.4	99.4	100.0	99.2	99.4
8.0	28.1	93.7	1.7	96.7	97.0	100.0	95.8	97.1
5.6	25.6	91.5	0.8	94.5	95.3	100.0	93.4	95.6
4.0	22.9	89.2	0.6	92.1	93.6	100.0	91.0	94.2
2.8	18.9	86.5	0.5	89.3	91.8	100.0	88.6	92.8
2.0	16.0	83.8	0.5	86.5	90.2	100.0	86.3	91.7
1.4	13.5	80.8	0.5	83.4	88.5	100.0	83.9	90.5
1.0	11.6	77.7	0.4	80.2	86.5	100.0	81.1	89.0
0.710	10.1	74.2	0.4	76.6	83.9	100.0	77.4	86.8
0.500	8.9	69.8	0.4	72.1	79.5	99.9	71.3	82.4
0.355	8.1	64.8	0.4	67.0	71.7	99.2	60.7	73.6
0.250	7.4	58.8	0.3	60.7	59.5	95.0	45.3	59.0
0.180	6.7	52.4	0.3	54.1	47.8	86.2	32.5	45.3
0.150	6.4	48.8	0.3	50.4	42.3	80.1	27.2	39.1
0.125	6.2	45.2	0.2	46.7	37.6	73.9	23.1	34.0
0.106	6.1	42.1	0.2	43.5	33.9	68.4	20.1	30.1
0.075	5.7	35.6	0.2	36.8	27.4	57.3	15.4	23.5
0.063	5.4	32.4	0.2	33.5	24.5	52.0	13.5	20.8
0.053	5.0	29.3	0.2	30.3	21.9	46.9	11.8	18.4
0.038	4.4	24.0	0.1	24.8	17.6	38.4	9.3	14.7
0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



Ore Type 2 Simulated Stream Data – Simulation Case 8

AB Higher Throughput (375 tph)

	New AG Feed	AG Mill Discharge	AG Discharge Screen OS	AG Discharge Screen US	Cyclone Feed	Cyclone Overflow	Cyclone Underflow	Ball Mill Discharge
	Sim	Sim	Sim	Sim	Sim	Sim	Sim	Sim
Solids (t/h)	375.0	386.1	11.1	375.0	1312.0	374.9	937.4	937.4
Solids SG (t/m³)	3.08	3.08	3.08	3.08	3.1	3.1	3.1	3.1
Liquid (t/h)	13.6	165.5	0.0	165.5	874.9	568.7	306.2	364.5
% Solids	96.5	70.0	99.8	69.4	60.0	39.7	75.4	72.0
80.00% passes (mm)	81.060	0.475	15.580	0.398	0.490	0.150	0.760	0.516
Size (mm)	Cumulative Percent Passing							
250.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
200.0	97.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
150.0	94.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0
100.0	84.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0
75.0	78.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0
63.0	74.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
45.0	68.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
31.5	61.0	99.9	100.0	100.0	100.0	100.0	100.0	100.0
22.4	52.8	99.6	100.0	100.0	100.0	100.0	100.0	100.0
16.0	44.5	98.8	86.5	100.0	100.0	100.0	100.0	100.0
11.2	34.5	96.9	10.4	99.5	99.2	100.0	98.9	99.1
8.0	28.1	94.6	1.4	97.2	96.2	100.0	94.7	95.8
5.6	25.6	93.1	0.7	95.8	94.4	100.0	92.2	93.9
4.0	22.9	91.7	0.6	94.4	92.8	100.0	90.0	92.2
2.8	18.9	90.3	0.6	92.9	91.4	100.0	88.0	90.8
2.0	16.0	89.0	0.6	91.7	90.3	100.0	86.4	89.7
1.4	13.5	87.7	0.5	90.2	89.0	100.0	84.7	88.5
1.0	11.6	86.1	0.5	88.6	87.6	100.0	82.6	87.1
0.710	10.1	83.9	0.5	86.4	85.2	100.0	79.4	84.8
0.500	8.9	80.6	0.5	83.0	80.5	99.9	72.8	79.5
0.355	8.1	76.2	0.5	78.4	71.3	99.0	60.2	68.4
0.250	7.4	70.3	0.4	72.4	57.8	94.2	43.3	52.0
0.180	6.7	63.8	0.4	65.7	46.7	85.6	31.1	39.1
0.150	6.4	60.0	0.4	61.7	41.7	80.1	26.4	33.7
0.125	6.2	56.1	0.3	57.8	37.5	74.5	22.8	29.4
0.106	6.1	52.7	0.3	54.2	34.2	69.5	20.1	26.2
0.075	5.7	45.4	0.3	46.7	28.2	59.2	15.8	20.7
0.063	5.4	41.6	0.2	42.9	25.4	54.1	13.9	18.4
0.053	5.0	38.0	0.2	39.1	22.9	49.2	12.4	16.4
0.038	4.4	31.5	0.2	32.5	18.7	40.7	9.8	13.1
0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



Ore Type 2 Simulated Stream Data – Simulation Case 9

SABC Higher Throughput (375 tph)

	New SAG Feed	SAG Mill Discharge	SAG Discharge Screen OS	Pebble Crusher Discharge	SAG Discharge Screen US	Cyclone Feed	Cyclone Overflow	Cyclone Underflow	Ball Mill Discharge
	Sim	Sim	Sim	Sim	Sim	Sim	Sim	Sim	Sim
Solids (t/h)	375.0	428.8	53.8	53.8	375.0	1312.0	374.9	937.4	937.4
Solids SG (t/m³)	3.08	3.08	3.08	3.08	3.08	3.1	3.1	3.1	3.1
Liquid (t/h)	13.6	183.8	0.0	0.0	183.7	874.9	568.7	306.2	364.5
% Solids	96.5	70.0	99.9	99.9	67.1	60.0	39.7	75.4	72.0
80.00% passes (mm)	81.060	3.447	30.220	8.679	1.067	0.497	0.150	0.812	0.424
Size (mm)	Cumulative Percent Passing								
250.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
200.0	97.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
150.0	94.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
100.0	84.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
75.0	78.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
63.0	74.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
45.0	68.9	99.6	97.7	100.0	100.0	100.0	100.0	100.0	100.0
31.5	61.0	97.9	82.6	100.0	100.0	100.0	100.0	100.0	100.0
22.4	52.8	94.8	58.7	100.0	100.0	100.0	100.0	100.0	100.0
16.0	44.5	92.1	37.4	99.7	100.0	100.0	100.0	100.0	100.0
11.2	34.5	88.7	9.7	91.8	99.9	99.9	100.0	99.8	99.9
8.0	28.1	85.9	1.0	75.3	98.0	98.4	100.0	97.7	98.5
5.6	25.6	83.5	0.3	55.8	95.5	96.6	100.0	95.2	97.0
4.0	22.9	81.2	0.2	39.7	92.8	94.8	100.0	92.8	95.7
2.8	18.9	78.4	0.1	28.4	89.6	93.0	100.0	90.2	94.4
2.0	16.0	75.6	0.1	21.2	86.4	91.3	100.0	87.8	93.3
1.4	13.5	72.5	0.1	16.0	82.9	89.4	100.0	85.2	92.0
1.0	11.6	69.3	0.1	12.7	79.3	87.4	100.0	82.3	90.6
0.710	10.1	65.8	0.1	10.3	75.3	84.6	100.0	78.5	88.4
0.500	8.9	61.6	0.1	8.3	70.4	80.1	99.9	72.2	84.0
0.355	8.1	56.8	0.1	6.8	65.0	72.4	99.3	61.6	75.4
0.250	7.4	51.2	0.1	5.4	58.5	60.1	95.1	46.2	60.8
0.180	6.7	45.3	0.1	4.3	51.9	48.1	86.2	32.9	46.7
0.150	6.4	42.0	0.1	3.8	48.1	42.5	80.0	27.5	40.3
0.125	6.2	38.8	0.1	3.3	44.4	37.6	73.7	23.2	34.9
0.106	6.1	36.0	0.0	2.9	41.2	33.8	68.0	20.2	30.9
0.075	5.7	30.4	0.0	2.3	34.7	27.1	56.7	15.3	24.1
0.063	5.4	27.5	0.0	2.0	31.5	24.2	51.3	13.4	21.3
0.053	5.0	24.8	0.0	1.8	28.4	21.6	46.3	11.7	18.9
0.038	4.4	20.2	0.0	1.4	23.1	17.3	37.7	9.2	15.0
0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0