



THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

DEPARTMENT OF METALLURGY AND MINERAL PROCESSING

MM 590-FINAL YEAR PROJECT REPORT

THE EFFECT OF GRIND AND INCREASED RESIDENCE TIME ON THE FLOATABILITY OF MUFULIRA COPPER ORE

BY

SINKALA SUWILANJI

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THE SUBMISSION OF THIS REPORT WAS THE PARTIAL FULFILMENT TO OBTAIN THE BACHELOR'S DEGREE OF MINERAL SCIENCE (B. Min.Sc.) OF THE UNIVERSITY OF ZAMBIA, SCHOOL OF MINES.

BY

SINKALA SUWILANJI

FEBRUARY 2008

SIGNATURES

IEAD OF DEPARTMENT: MR. C.V. LUNGU
NTERNAL EXAMINER: MR. J. MANCHISI
EXTERNAL EXAMINER: PROF. D.J. SIMBI

DEDICATION

To my sweetest Mum and Dad for them being there for me, their patience and encouragement rendered through out my entire years of study.

My brothers, sisters and friends for giving me your support, care, inspiration and the confidence you thus gave me to go on.

ACKNOWLEDGEMENTS

I wish to express my indebtedness to the following people for their assistance in one way or another without which this the project would not have been a success.

I am grateful to all the Metallurgists at Mufulira Concentrator, for their invaluable advice particularly Mr. Sichivula, Mr. Sikaona and Mr. Jose Chamanika.

I would also like to express my appreciation to Mr. J.Manchisi, my project supervisor and lecturer, for sharing his time in giving me advice on the composition, and arrangement and making helpful and valuable comments of this project.

ABSTRACT

The purpose of this project was to evaluating the effect of grind time and increased residence time on the floatability of the Mufulira copper ore on a laboratory scale. The project was proposed mainly because of periodic fluctuations in the mineralogy of this complex copper sulphide ore. The aim was therefore to address this problem and generally improve the flotation performance of the Mufulira concentrator.

Systematic sampling was employed where copper ore samples were cut from six different selected conveyor belts each feeding the ball mills. Grinding time was done from 15 to 40 minutes at an interval of 5 minutes. Thereafter, flotation testworks were carried out to determine the effect of increased residence time on the flotation performance. However, 25 minutes grind time was the optimum mesh of grind with corresponding copper recovery of 94.8% and a grade of 24.9%. At 4 minutes rougher and 8 minutes scavenger was the optimum residence time with copper recovery and grade of 88.9% and 21.2% respectively. All other parameters were kept constant such as reagent dose rate at 30 gram per litre and pulp density except for time which was under evaluation. It is recommended that the optimum mesh of grind should be 25 minutes at flotation time of 4 minutes rougher and 8 minutes scavenger and testworks should be done at a decreased grind time and decreased residence time to determine the floatability of the Mufulira copper ore.

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ABBREVIATIONS

Cum. Cumulative

TCu. Total copper

AICu Acid insoluble copper

ASCu Acid soluble copper

Tails Tailings

%wt weight percent

Conc concentrate

SIPX Sodium isopropyl xanthate

PAX Potassium Amyl xanthate

R Rougher

S Scavenger

MIN Minutes

CHAPTER ONE

1.1 INTRODUCTION

For a long time, the study of size reduction was based on energy consumption during grinding. This is because of the fact that size reduction operation prior to flotation is accompanied by large cost due to the high power consumption.

Therefore, this report is based on laboratory grinding and flotation testwork carried at Mopani Copper Mine, in Mufulira.

1.2 BACKGROUND

Basically, Mufulira concentrator treats copper sulphide ore from the east section of the mine, at a rate approximately 250 000 to 300 000 tonnes of ore per month. The Mufulira ore consists of chalcopyrite, chalcocite and bornite as disseminated particle in fine grained, siliceous rock. Other minerals presenting small content in the ore are malachite, covellite, chrysocolla and some native copper.

The Mufulira concentrator produces high-grade copper concentrate which is subsequently sent to the Mufulira smelter. The operations of the concentrator are maintained and effectively controlled with the aim of achieving their target setting.

The project was formulated because of the fluctuations in the mineralogy of the complex copper sulphide ore over a short period of time. Therefore, the technical management at Mufulira concentrator formulated this study in order to evaluate the effect of grind time and the increased residence time on the floatability of the Mufulira copper ore in view to improving the flotation performance.

1.3 OBJECTIVE

The main objectives of this study were to

- determine the effect of grind time on the flotation performance, and subsequently
- determine the effect of increased residence time on the flotation performance.

1.4 PLANT DESCRIPTION

The Mufulira concentrator is sub-divided into the east crushing plant; the milling, flotation, filter plant as well as the tailing pump house and tailing dump.

1.4.1 Crushing Plant

The purpose of crushing is to reduce the run of mine ore to the size that can be milled cost effectively. Ore crushed by the primary crushers to less than 150mm underground is hoisted into the surface bin and a series of conveyors or networks facilitates the delivery of the ore from the shaft bins to standard bin. The smooth flow of the ore on the conveyors is influenced by the vibratory feeders under the bin. However, moisture content must be less than or equal to 2.00% H₂O for the ore hoisted in the surface bin. There are two types of crushers currently being used and these are the Hydrocone H6800 and the Standard Symons cone crusher. The ore is screened whereby the oversize is recirculated in the closed circuit operation with the crusher. The screened undersize which is the final product of this operation is conveyed to the milling section in the fine storage bins.

1.4.2 Milling

The purpose of the milling is to reduce the crushing plant product to the size that can be floated cost effectively. The milling section receives crusher product at a minimum size of 70% passing 9.51mm. The product is fed into the ball mills which also operate in closed circuit with the hydrocyclone. The overflow from the cyclone goes for flotation

whereas the underflow is fed back to the ball mill for regrind. This is aimed at 55% passing 75microns with the pulp density in the range of 1240-1600 gram per litre (gpl).

1.4.3 Flotation

This section consists of a three stage process i.e. the rougher, cleaner and scavenger. It is in this section where reagents are utilized and these are sodium isopropyl xanthate (SIPX) and potassium amyl xanthate (PAX) for the rougher and scavenger respectively. Aerofroth 65 and beta-froth 65 are the frothers used. Lime is added as a modifier to raise the pH of the pulp in the range of 10.5-12.5.

THE CURRENT CONCENTRATOR CIRCUIT

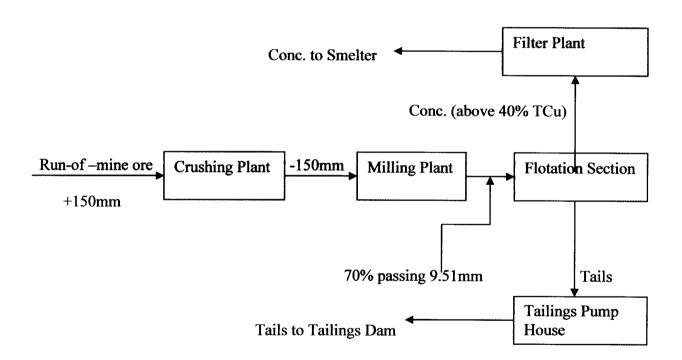


FIG.1. Material flow diagram for Mufulira Concentrator

CHAPTER TWO

2.0 Literature Review

2.1 Grinding

This is the last stage in the process of comminution where particles are reduced in size by a combination of impact and abrasion either wet or dry. It is performed in rotating cylindrical vessels mainly made of steel and are called tumbling vessels. These comprises of loose grinding media, which are free to move inside the mill, thus grinding the particle. The grinding media may be steel rods or balls hard rock or in some cases the ore it self (Wills, 1988).

Naturally, most minerals are finely disseminated and intimately associated with the gangue. Before separation can be under taken, the mineral must be initially "unlocked or liberated". While, this is achieved by crushing and grinding, to be specific grinding prior to flotation size reduction is up to some extent. It has been observed that grinding should be done at the optimum mesh of grind which is the particle size at which there is maximum profitability (Deelder, 1996).

Grinding is the most energy intensive operation in mineral processing and accounts for about 50% of the concentrator's energy consumption. Therefore over grinding and under grinding should be avoided to reduce difficulties faced in the flotation of slimes and coarse material respectively. Hence, there is a lower and upper size limit for the particle to be floated. Size reduction to a relatively coarse size does not liberate the mineral particle, flotation recoveries in this case will be poor as the particle size will not be small enough to be lifted by the air bubbles during flotation.

Grinding with a tumbling mill is influenced by a variety of factors which include speed of the mill load of grinding media and material, pulp level, size distribution of grinding media and solid-liquid ratio and circulating load.

i. Speed of mill.

The speed must not be too high because this brings about centrifuging of the charge and thus grinding does not take place. At the same time the speed must not be too low because this will promote the production of slimes. An action called cateracting action must result from the speed of the mill accompanying a free fall of grind media for favourable impact giving a high capacity and efficiency.

ii. Load of grind media and material.

Increasing these will require more power until the maximum value is achieved and the power requirements decreases with increasing load as the center of the load approaches the axis of rotation.

iii. Pulp level.

This will require high power if the pulp level is high. The lower pulp level entails greater freedom of movement of grinding media hence more effective grinding. Therefore, the ball mills should be filled slightly more than half full with the materials and balls.

iv. Solid-liquid ratio (Pulp dilution)

Too dilute a pulp increases metal to metal contact, giving increased steel consumption and reduced efficiency. Therefore, ball mills should operate between 65-80% solids by weight depending on the ore. The viscosity of the pulp increases with the fineness of the particle, fine grind circuit may need lower pulp densities.

v. Circulating load.

In order to achieve grinding to required size in a single step might result in wasteful over grinding. To avoid over grinding and giving an effective grinding, the residence time for material to be in the mill must be short.

Generally, increased circulating load results due to the average size of entering feed becoming lower, interstitial loading is improved with closed adjustment of solid-liquid ratio.

In practice, ores are ground to an optimum mesh of grind determined by laboratory and pilot scale test work to produce an economic "degree of liberation" which is the percentage of the mineral occurring as the particle in the ore in relation to the total content. This can be high if there are weak boundaries between mineral and gangue particles. The optimum mesh of grind is the particle size at which the most economic recovery can be obtained. This depends not only on the grindability which is the ease with which the ore can be comminuted but also the ease with which the comminuted ore can be floated (Wills, 1988).

2.2 SIEVE ANALYSIS

Size control is important in order to check the quality of grinding, the extent to which values are liberated from the gangue at various particle sizes and to aid specific examination of ore constituents. Size analysis of the ground ore shows whether mineral particles are properly liberated and how grinding affect recovery of the mineral values from the ore.

Standard test sieves are used for sieve analysis. Laboratory sieves consists of woven wire, which results in square aperture with small tolerance (Kelly, 1982). There are different types of sieve series. These series differ mainly in their relationship between aperture and wire size. They include US sieve series, international test sieve series and British standard series. Sieve analysis is accomplished by passing a known weight of sample material through the stack of test sieves and the entire stack shaken. The weight retained

on each sieve is then used to determine the percentage weight in each size fraction. Sieving can be carried out on dry or wet material.

Sieving when applied to irregularly shaped particle is complicated because "near mesh" particles may pass only when presented in favorable position. This in many cases causes the blinding and obstruction of the sieve aperture and thus reduces the effective area of the sieving medium. Blinding is most serious with sieves of very small aperture size (Wills, 1988). Therefore, the effectiveness of a sieving test depends on the amount of material put on the sieve and the type of movement imparted to the sieve. The charge material should not be too large, so that each particle is given a chance to meet an aperture in the most favourable position, for sieving in a reasonable time. On the other hand, the charge must contain enough particles to be representative of the bulk sample (Wills, 1988).

2.3 FROTH FLOTATION

Froth flotation is a means of treating a pulp of finely ground ore so that valuable or desired mineral is obtained in a concentrate which will be amenable to further process. The process involves imparting a water repellent (hydrophobic) character to the desired mineral with the aid of chemicals that are called collectors or promoters under favourable conditions, these chemically coated particles becomes attached to the air bubbles rising through a pulp and will thus float to the surface.

This is the cheapest and most extensively used process for the separation of chemically similar mineral and to concentrate ore for economical smelting.

Floatable minerals can be classified into non polar and polar type. The difference between the two types is based on the surface bonding. The surfaces of the non polar mineral have relatively weak molecular bonds, difficult to hydrate, and in consequence such mineral are hydrophobic. The ores containing these minerals for beneficiation

usually require the addition of non specific collector to their pulp to aid the natural hydrophobicity of the floatable fraction.

Polar minerals have a strong covalent or ionic surface bonding and exhibit high free energies at their surface. These species are hydrophilic (water seeking) and need surface modifiers to render them amenable to flotation.

In froth flotation, the mineral is transferred to the froth or float fraction, leaving the gangue in the pulp. This is referred to as direct flotation which is the most widely practiced flotation process. The other types of flotation are bulk, reverse and differential flotation.

Froth flotation, therefore, consist of producing condition in which air bubbles form, or are introduced to the slurry of ground ore in water and the desired minerals are made to attach themselves to the bubbles. Air bubbles only continue to support the mineral if they form a stable froth, otherwise, they will burst and drop the mineral. These conditions can be achieved by using numerous chemical reagents.

2.3.1 Flotation reagents in general

For flotation to be effective, reagents must be added to the pulp. In general, the reagents are interfacial surface tension modifiers and/or flocculants (Crozier, 1992). Usually, these reagents are classified under five heading which are:

- Collector
- Frother
- Activator
- Modifier

i) Collector

Collectors are organic compounds used in flotation, which render selected mineral water repellent by absorption of molecules or ions on to the mineral surface, reducing the stability of the hydrated layer, separating the mineral surface from the air bubble to the level that attachment of the particle to the bubble can be made on contact.

Collectors may be non-ionizing or ionizing compound. Ionizing collectors are mostly widely used in sulphide flotation. They are usually sodium and potassium salts of certain acids. They dissociate into ions in water and have chemical structures which are heteropolar: i.e. the molecules contain a non polar hydrocarbon group and a polar group.

The non polar parts of the molecules are oriented towards the water phase and the polar orient itself towards the mineral surface. The non polar hydrocarbon radial has pronounced water repellent properties and hence they render the mineral surface hydrophobic by keeping water away from the mineral surface. Non ionizing collectors which are non polar compounds are practically insoluble in water. They render the mineral water repellent by its surface with a thin film.

Collectors are used in small amounts, substantially those necessary to form a monomolecular layer on particle surface. An increase in concentration apart from the cost tends to float other minerals, thus, reducing selectivity. An excessive concentration of the collector can have an adverse effect on the recovery of the valuable mineral, due to the development of multi-layer on the particle, reducing the proportion of hydrocarbon radicals (non polar group) oriented into the bulk solution. The hydrophobicity of the particles is thus reduced, and hence their floatability (Wills, 1988).

ii) Frother

These are surface active reagents that aid the formation and stabilization of air induced flotation froths. They concentrate at the air-water interface, helping to keep the air bubbles dispersed and preventing their coalescence.

The other functions of frothers are to:

- reduce the surface tension of the air-liquid interface in order that a stable bubble is produced in the system.
- influence the kinetics of bubble-particle adhesion.

- thin the liquid layer by interacting with the collector.
- stabilizes the bubble-particle aggregates.(Kelly,1982)



iii) Activator

Activators are reagents that alter the chemical nature of the mineral surfaces so that they become hydrophobic due to the action of the collector. They are generally soluble salts, which ionizes in solution, the ion then reaching the mineral surface. A good example, if the mineral to be floated is an oxide in nature, an activator to form a pseudo-sulphide layer around the mineral can activate it surface. This will then render the mineral amenable to the action of a collector.

iv) Modifier

These are reagents used in flotation to modify the action of the collector, either by intensifying or reducing its water-repellent effect on the mineral surface. Thus, they make the collector action more selective towards certain minerals. These are classed as the regulating agents which also include the activators, depressants and pH modifiers i.e. lime. The same modifiers can perform as a depressant or activator or both depending on the condition under which it used.

2.3.2 EFFECT OF GRINDING ON FLOTATION

Many factors influence the flotation process. According to Matis and Zouboulis, (1995) among the principal factors are particle size, pulp aeration, bubble mineralization, agitation intensity, residence time of bubble in the pulp, pulp density. Others includes the specific gravity of the particle, presence of slimes, hydration of the surface, and adsorbed layer of flotation reagents (Matis and Zouboulis, 1995)

Grinding has the obligation exercise close control on product size. Undergrinding of the ore will of course result in the product that is too coarse with the degree of liberation too low for economic separation while over-grinding needlessly reduces the particle size of the substantially liberated major constituents usually the gangue and may reduce the particle size of the minor constituent (usually the mineral) below the size required for most efficient separation.

2.3.3 Flotation of large particles

In froth flotation, the particle size upper limit is 200-300 micron, whereas the lower limit is 5-10 micron with the desired mineral exposed at part of the particle's surface. Therefore, if the particle exceeds the upper limit in a given instance, they can not be floated under the prevailing condition. The upper size limit defines the size at which the air bubbles can no longer physically lift the particles to the surface. The probability of the particle being detached from the air bubble is high due to the heaviness of the particle as a result the larger particle are retained at the bottom of the flotation cell and this will lead to the loss of the valuable mineral in the tailing fraction. However, in order to recover the valuable mineral that reports to the tailing, a further regrind or liberation will be required and this entails an extra cost because grinding alone is the highest cost operation (Wills, 1988).

On the other hand there are essential conditions necessary for the flotation of large particles. This includes the following:

- Particle surfaces must be rendered as water repellent as possible by the use of increased amount of collector.
- Increased pulp aeration must be employed in order to produce favourable condition for "group" flotation of large particles by several bubbles.

2.3.4 Flotation of extreme fine particles

According to Glembtskii (1972), the extremely fine slimes particles which are present in the pulp have profound effect on flotation.

The following phenomena are apparent when slimes are present in the pulp:

- It becomes significant with the increasing demand for minerals and the continuously declining grade of available ore.
- Low particle momentum
- Contamination of the froth product by small gangue fraction due to physical entrainment.
- Low probability of particle collision (Pc)

Pf= Pc. Pa. Pd

Where Pf = flotation probability

Pc = probability of particle-bubble collision

Pa = probability of particle-bubble attachment

Pd = probability of particle-bubble detachment

- There is undesirable coating of air-bubble surface by slime particle. This will
 prevent normal sized flotation particles from adhering to these coated air bubble
 thus hindering flotation of valuable.
- There is also an undesirable coating of a valuable particle with ultra fine gangue slime. This will render the valuable particle surface hydrophilic, thus suppressing flotation because slimes are generally hydrated in many ways.

2.3.5 Air

Air used in flotation is either induced by the action of the impeller of the flotation machine or super charged i.e. it is introduced through the internal blower. The role of air in flotation is to provide the necessary bubble, which in turn generate the froth which will act as separating medium to segregate and remove the valuable mineral from the gangue. (Arbiter, 1985)

CHAPTER THREE

3.0 EXPRIMENTAL PROCEDURE

The testwork was done on laboratory batch grinding and flotation basis for the Mufulira copper ore.

3.1 Apparatus

- One meter long sample cutter
- Buckets
- Scoops
- Electric balance
- Nest of sieves and sieve shaker machine
- Laboratory ball mill. Mill steel balls of 0.1153kg on average as grinding media and volume of 7.5litre.
- Laboratory Denver flotation machine (1500 RPM)
- Flotation cell 5000 cm³ capacity
- Drying oven
- Measuring cylinder (1000ml), stop watch, wash bottle, syringes, funnel, flotation collection plates, paddle, sample envelop, brush and washing detergent and plastic bags.

3.2 Reagents

Xanthate collectors were used, especially for easy to treat ore where selectivity is not an issue. These were in powder and pellet form, and are readily soluble in water and were made up to 6ml at 1% strength. The following are the reagents which were used:

- Sodium Isopropyl Xanthate (SIPX) the most widely used in the flotation of sulphide minerals of copper.
- Potassium Amyl Xanthate (PAX) the most powerful and least selective xanthate.
 Often used as a scavenger collector following a more selective rougher collector.

 Aero-frother 65 is a polyglycol that exhibits strength and longevity in flotation circuits.

3.3 Sample preparation

The technique employed during sampling was called a systematic sampling. Copper ore samples were cut from six different selected conveyor belts each feeding the ball mills. A one meter sample cutter was struck along the stopped belt and all the ore confined within the one meter was collected and put into the buckets. Samples were taken to the Analytical Laboratory Service for crushing to 100% passing 2mm and after which the product was stored in covered buckets to prevent contamination, oxidation and surface ageing of the minerals. Homogenization of the fresh ore was done manually using a scoop upon pouring the ore on the preparation bench.

3.4 Grind and Sieving

Wet grinding was carried out in the laboratory ball mill. The charge to the mill included of 2000g of ore, 1500ml of water and mill balls of different sizes. The pulp density of 57.1% solid was maintained or kept constant for every test. Grinding time evaluation was done at the following times; 15, 20, 25, 30, 35 and 40 minutes for every 2000g respectively. After grinding, the ball mill discharge was wet screened passing through 45 microns which provided a removal of slimes and loss of dust. The oversize (what was retained on the +45 micron) was then dried, weighed and screened on the nest of sieve (250, 180, 150, 150, 125, 106, 90, 75, 63, 45 microns) were arranged in the decreasing order from the top to the bottom on the sieve shaker machine. The undersize (-45 microns) was however weighed and then discarded.

From the sieve analysis, the cumulative weight percent passing was computed. All the tests work were done in duplicates.

3.5 Flotation Testwork

The Denver laboratory flotation machine was used for each test. Ground ore sample from the ball mill was immediately placed in a 5000ml flotation cell and more water was added to make up to the mark with the pulp density of 33.3% solids by weight. This was followed by vigorous agitation to keep all solid in suspense, at an impeller speed of 1500 rpm.

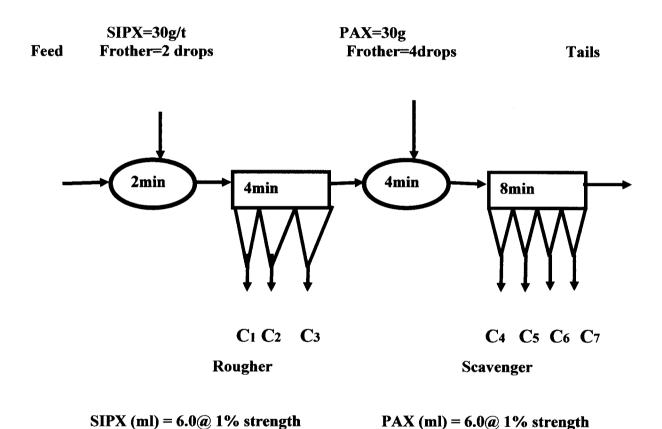


Figure 3.1: The Mufulira standard differential laboratory flowsheet for copper ore.

To simulate plant practice a differential mode for the Mufulira ore was used. This is where sulphides are recovered in the rougher and scavenger stages under the addition of different chemical reagents.

Sulphide Roughing

Initially, the collector was prepared and the required amount was accurately measured and added to the slurry. The collector sodium isopropyl xanthate (SIPX) was added then conditioned for the desired period (standard is 2min) and with only a minute remaining of the collector conditioning time, the desire amount of sulphides frother (aero-frother65 with only 2drops) was added.

After the conditioning time, air was introduced into the cell by opening the valve on the stand pipe.

However, using plastic paddles, the froth being generated into the cell was pulled by running the paddles across the pulp surface (the froth falls into the plates) for the desired period of 10 seconds interval. Water was added occasionally to the cell to maintain the pulp level; hence, froth collection period was for 4, 5, 6 and 7 minutes for every 2000g ground ore respectively.

Air addition to the cell was removed by closing the air valve on the stand pipe. Samples collected in the plates as the sulphide concentrate using appropriate prepared labels were identified and taken for drying in oven.

Sulphide scavenging

The procedure employed in roughing stage was the same as in scavenging stage but only differed in terms of chemical reagents addition and the conditioning time. Potassium Amyl Xanthate (PAX) and aero-froth 65 were added and 4min of conditioning time. The sulphide scavenger concentrate was collected for 8, 9, 10 and 11 minutes.

Samples generated from the laboratory were analyzed for total copper (TCu) and acid soluble (ASCu), which are analytical estimates for the total copper content in the ore. The

copper sulphide minerals are estimated as acid insoluble which is the difference between the TCu and ASCu estimate.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This chapter presents a discussion of results and the main findings that were obtained in this study. The main parameters that were considered are the effect of grind time and increased residence time on flotation performance of Mufulira copper sulphide ore.

4.1 SEIVE ANALYSIS

From the graph below, an estimated optimum grinding time was approximately 17 minutes which gave 55% solids passing 75 μ m. It also shows that, any increase in grind time results in more finely particles being produced i.e. more particles passes 75 μ m, therefore size distribution is important prior to flotation.

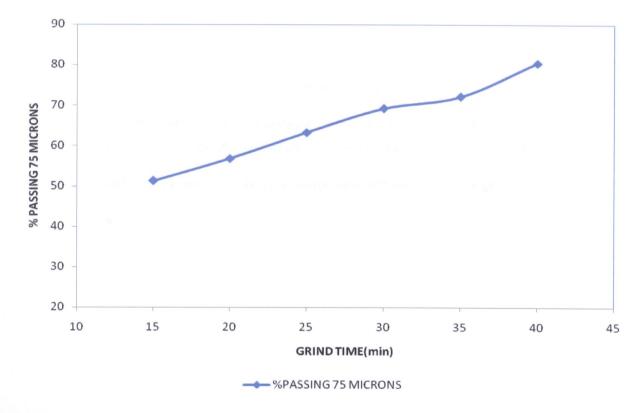


Figure 4.1: Percentage of solids passing 75µm plotted against grind time

4.2 THE EFFECT OF GRIND TIME ON FLOTATION PERFORMANCE

Figures 4.1-4.3 below show, the effect of grind time on copper recovery and grade at constant residence time of 4 minutes rougher and 8 minutes scavenger.

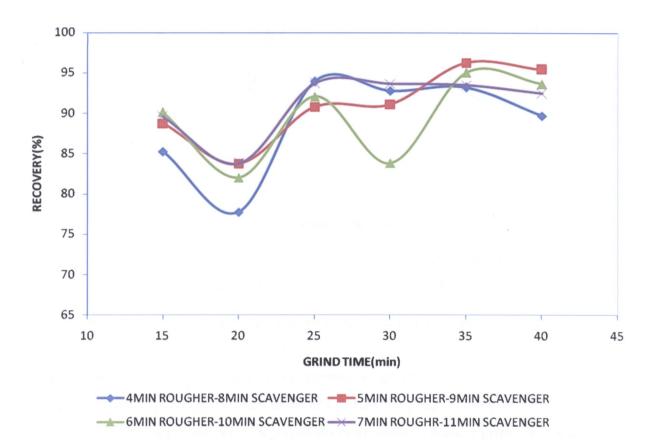


Figure 4.1: Recovery versus grind time at 4min rougher-8min scavenger

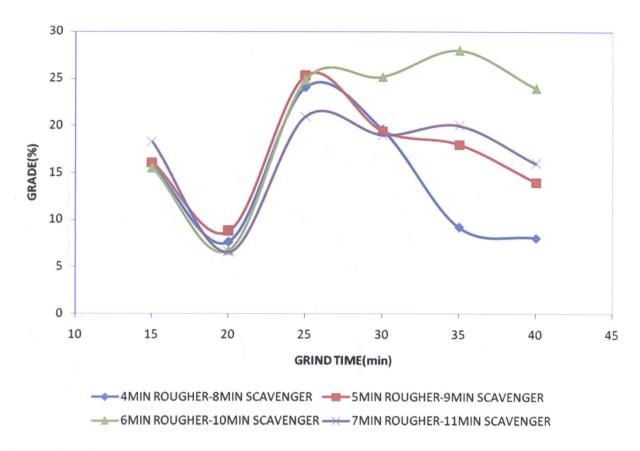


Figure 4.2: Grade against grind time at 4min rougher-8min scavenger

Generally, copper recovery increased with increase in grind time up to 25 minutes of grinding with a corresponding recovery of 94.8% and 24.9% grade. However, beyond 25 minutes grind time, copper recovery begun to decrease with increasing grind time and it also occurred at 35 minutes grind time, which gave a recovery of 94.6% but a low grade of 9.3%. This result in high cost of energy consumption hence slimes production which has a deleterious effect on flotation performance. A drop at 20 minutes grind time with copper recovery of 76% could be as a result of the hardness of the ore and also the discrepancies incurred during the test. Figure 4.3, the recovery and grade graph below shows that, at six different grind times from 15 – 40 minutes at an interval of 5 minutes, copper recovery decreases with an increase in grade. The 25 minutes grind time gave the highest recovery indicating that the degree of liberation is highest at this time having a copper recovery of 88.9% and a grade of 21.2% at a fixed residence time of 4 minutes rougher and 8 minutes scavenger.

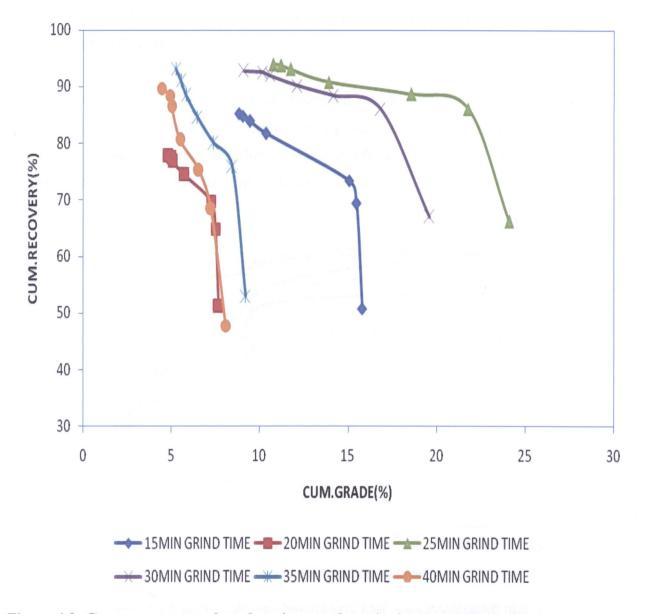


Figure 4.3: Copper recovery plotted against grade at 4 minutes rougher - 8 minutes scavenger

4.3 THE EFFECT OF INCREASED RESIDENCE TIME ON FLOTATION PERFORMANCE

In the determination of the effect of increased residence time on the flotation performance, flotation kinetics were determined by establishing the relationship between cumulative recovery of copper and flotation time at different grind times. The results for copper recovery and grade are shown below in Figures 4.4 and 4.5.

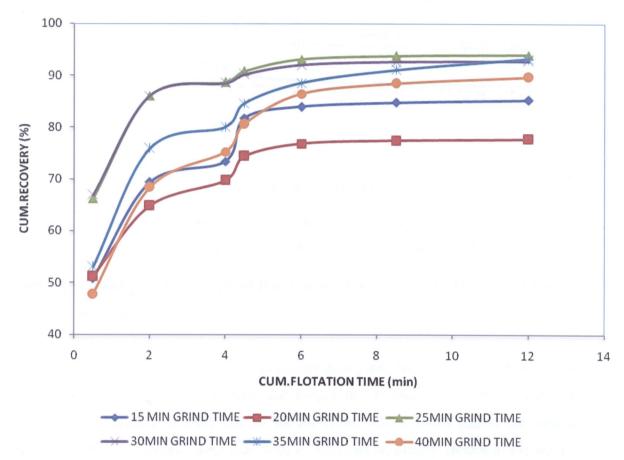


Figure 4.4: Cumulative recovery vs. flotation at a fixed residence time of 4 minutes Rougher-8 minutes scavenger

The uppermost curve which is the 25 minutes grind time represents the best flotation conditions with corresponding copper recovery of approximately 94.5% while the 20 minutes is the bottom most with approximately 79% copper recover. After 25 minutes of

grind time recovery significantly starts to decrease because of slime formation and this have a huge effect on the recovery even as residence time is increased.

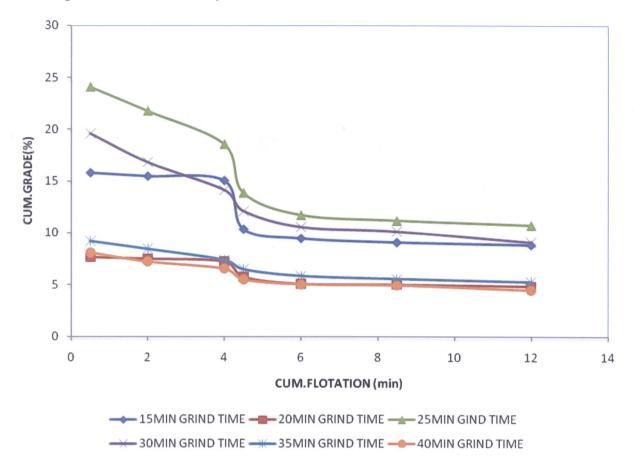


Figure 4.6: Cumulative grade against flotation time for TCu at 4min rougher-8min scavenger.

The figure above shows that, after 4 minute of roughing the recovery of copper increased with the decrease in grade. However, the longer the residence time the higher the recovery of the valuable mineral will be but the grade will be lower due to the gangue minerals that will be floated along side with it. This can be clearly shown in Figure 4.7 where 4 minutes rougher and 8 minutes scavenger has a copper recovery and grade of 88.9% and 21.2%TCu, respectively. While for the residence times of 5 minutes rougher – 9 minutes scavenger and 6 minutes rougher – 10 minutes scavenger the corresponding recoveries are 85.5% and 85.3 respectively. 7 minutes rougher – 11 minutes scavenger significantly decreased in both recovery and grade because the mineralized sulphide froth

which was carefully skimmed off became partially barren meaning that what remained in the flotation cell were literally tailings.

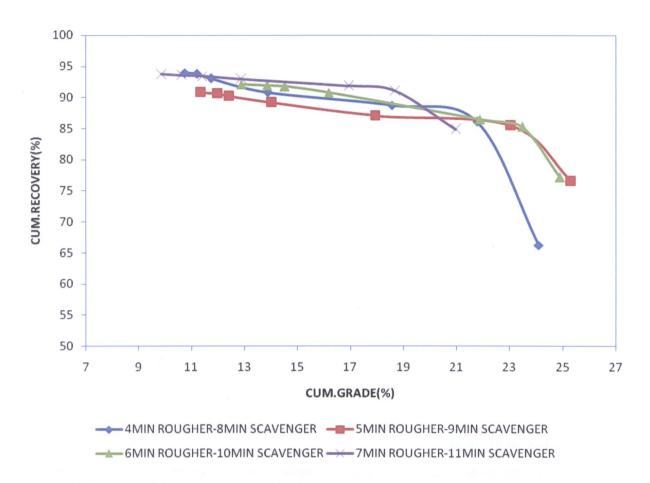


Figure 4.7: Relationship between cumulative copper recovery and grade at four different residence times.

However, the 4 minutes roughing and 8 minutes scavenging with recovery and grade of 88.9% and 21.2% respectively is relatively better than the other graphs. The other graphs show good recoveries which could be nearly the targets of the plant, but these cannot be the optimum residence time because of the lower grades obtained. The low grades could have been due to entrainment of gangue particles as sufficiently hydrophobic surface conditions could not be developed on the particle surfaces to overcome the hydrophilic tendency, thus lowering the floatability. These could also have been due to:

- (a) When batch laboratory flotation tests are carried out, a number of operations are undertaken and consequently experimental errors are inevitable. Thus a number of duplicate flotation tests always produce results which show some significant variance, as was the case in this test work. Some of the operations, which could have led to the discrepancies, are:
- (i) Variation in trying to skim or scoop the froth volume at a constant rate after every ten minutes. Hence, different concentration weights and grades of the repeat tests were obtained.
- (ii) Continuous variations in the pulp density from the beginning to the end of flotation as solids were continuously being removed with the froth and water added to maintain the cell pulp level. This resulted in a change in concentration of all the reagents and pH levels in the pulp.

CHAPTER FIVE

5.1 CONCLUSION

It can be concluded that;

- 1) The mesh of grind was determined to be 25 minutes grind time. This gave copper recovery of 94.8 % with a grade of 24.4% at a fixed residence time of 4 minutes rougher and 8 minutes scavenger.
- 2) The optimum residence time was determined to be 4 minutes rougher and 8 minutes scavenger, with copper recovery of 88.9% with a grade 21.3% at constant grind time of 25 minutes.

5.2 RECOMMENDATIONS

- It is recommended that for an increased grind time, 25 minutes should be the optimum while for increased residence time, 4 minutes rougher and 8 minutes scavenger flotation time should be maintained.
- Mineralogical examinations should be carried out on the Mufulira copper ore
 together with its associated concentrates and final tailing. This will aid not only in
 positive identification of minerals but also the behavior of the same constituent
 minerals or how they will respond to ore treatment.
- Since the optimum grind time is dependent on the speed of mill, amount and size
 distribution of the grinding media, they must be a consistence in replacing the
 grinding media in order to improve the efficiency of grinding and also on the
 reduction of power consumption.
- Testworks should be done at a decreased grind time and decreased residence time to determine the floatability of the Mufulira copper ore.

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APPENDIX 1

REAGENT ADDITION CALCULATIONS

ADDITION OF COLLECTOR (SIPX)

Given, 1% solution strength Dose rate of 30g/ton Basing on 2000g of dry solids in the cell

Volume of reagents =
$$\frac{\left[Doserate \times Mass \ of \ solids\right]}{\left[\% strength \times 10^{6}\right]}$$
$$= \frac{\left[30 \times 2000\right]}{\left[0.01 \times 10^{6}\right]}$$
$$= 6ml$$

Note; this calculation is employed also for the addition of PAX

APPENDIX 2

TABLES FOR SEIVE ANALYSIS

SEIVE ANALYSIS

15 MINUTES GRIND TIME

Sieve size (microns)	weight (g)	weight (%)	cum. weight	% passing
250	20.00	3.86	3.86	100.00
180	57.00	11.00	14.86	89.00
150	37.00	7.14	22.01	81.85
125	47.00	9.07	31.08	72.78
106	40.00	7.72	38.80	65.06
90	52.00	10.04	48.84	55.02
75	19.00	3.67	52.51	51.35
63	33.00	6.37	58.88	44.98
45	13.00	2.51	61.39	42.47
-45	200.00	38.61	100.00	3.86
Total	518.00	100.00		

20 MINUTES GRIND TIME

Sieve size (microns)	weight (g)	weight (%)	cum. weight	% passing
250	3.00	0.60	0.60	100.00
180	21.00	4.17	4.77	95.83
150	27.00	5.37	10.14	90.46
125	43.00	8.55	18.69	81.91
106	43.00	8.55	27.24	73.36
90	61.00	12.13	39.36	61.23
75	22.00	4.37	43.74	56.86
63	44.00	8.75	52.49	48.11
45	17.00	3.38	55.86	44.73
-45	222.00	44.14	100.00	0.60
Total	503.00	100.00		

25 MINUTES GRIND TIME

Sieve size (microns)	weight (g)	weight (%)	cum. weight %	% passing
250	1.00	0.19	0.19	100.00
180	7.00	1.34	1.53	98.66
150	13.00	2.49	4.02	96.18
125	32.00	6.12	10.13	90.06
106	34.00	6.50	16.63	83.56
90	81.00	15.49	32.12	68.07
75	25.00	4.78	36.90	63.29
63	42.00	8.03	44.93	55.26
45	17.00	3.25	48.18	52.01
-45	271.00	51.82	100.00	0.19
Total	523.00	100.00		

30 MINUTES GRIND TIME

Sieve size (microns)	weight (g)	weight (%)	cum. weight %	% passing
250	0.00	0.00	0.00	100.00
180	2.00	0.39	0.39	99.61
150	5.00	0.98	1.37	98.63
125	14.00	2.75	4.12	95.88
106	26.00	5.10	9.22	90.78
90	80.00	15.69	24.90	75.10
75	30.00	5.88	30.78	69.22
63	50.00	9.80	40.59	59.41
45	21.00	4.12	44.71	55.29
-45	282.00	55.29	100.00	0.00
Total	510.00	100.00		

35 MINUTES GRIND TIME

Sieve size (microns)	weight (g)	weight (%)	cum. weight %	% passing
250	0.00	0.00	0.00	100.00
180	1.00	0.19	0.19	99.81
150	2.00	0.39	0.58	99.42
125	9.00	1.75	2.33	97.67
106	20.00	3.89	6.23	93.77
90	73.00	14.20	20.43	79.57
75	38.00	7.39	27.82	72.18
63	49.00	9.53	37.35	62.65
45	22.00	4.28	41.63	58.37
-45	300.00	58.37	100.00	0.00
Total	514.00	100.00		

40 MINUTES GRIND TIME

Sieve size (microns)	weight (g)	weight (%)	cum. weight %	% passing
250	0	0.00	0.00	100.00
180	1.00	0.20	0.20	99.80
150	1.00	0.20	0.40	99.60
125	5.00	0.99	1.38	98.62
106	15.00	2.96	4.35	95.65
90	52.00	10.28	14.62	85.38
75	25.00	4.94	19.57	80.43
63	61.00	12.06	31.62	68.38
45	27.00	5.34	36.96	63.04
-45	319.00	63.04	100.00	0.00
Total	506.00	100.00		

APPENDIX 3

TABLES AND GRAPHS ON FLOTATION PERFORMANCE

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15MINUTES GRIND TIME 4MINUTES ROUGHER-8MINUTE SCAVENGER

TOTAL		Tail 4	Ç	C7	G		C5	C4		Ca	· ·	3	-	<u></u>			TRACTICA	1		
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FRACTION

CUMULATIVE

(MIN) TIME

TCu WEIGHT(g)

AlCu

TCu 24.09

ASCu AlCu

ASCu AlCu

CUMULATIVE RECOVERY

68.1839

TCu 24.09

CUMULATIVE GRADE ASCu

AICu

0.19 0.28

GRADE(%)

AVEARGE

0.2603

60 9.882 1.304

25MIN GRIND TIME 4MINUTES ROUGHER-8MINUTES SCAVENGER

30MINUTES GRIND TIME 4MINUTES ROUGHER-8MINUTES SCAVENGER

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-			7	0.05 0.21335 3.0111 0.0003 82.70048	2 20 70	1 23 0.58476 0.9033 0.5669 92.57314		1 7442 91 98838	1	3 90 173	7 7.40450 7.0001	88.46		86.058		10 40 66 0661 6 4328 70 363 66 96608		TCL	t	CUMULA	<u> </u>	
-			100				Т		Т		t		3	_				_	1			
		1	8	1000	41065	39900	3	49624		41215		0/2/0	32.00	10.26507	22.7	32//5	3	ASCU	3	こくに スロつつくにスト		
			100	0.00	OF 79227	90.73394	73504	90. 10900		4.42489		92.7100	2196	00.0110	31 170	6.432//5 /0.30333	2000	2	\$	תא מ	1	
			2.0/58/		9 090784	10 120	10 1001	10.00900	10 5000	12.1100/	100	14. 14207	1/1/087	10.02010	16 97219	18.08	ı	2	7.	COMO	2	
			100 2.0/58/3 0.110312		21 41065 96 79227 9 090784 0 111473 8 97931	0.10007.0	10 00000 00 70004 10 10044 0 106076 10 00146	17.49624 96.16906 10.36806 0.106623 10.40220	20000	14.41215 94.42489 12.11537 0.102699 12.01240	0.00000	0.101270	10 00075 00 7186 14 14087 0 107048 14 03560	0.10000	00 34470 16 83318 0 108835 18 71854		2	7000	700	COMOLY LANGE	ATIVE CB	
			1.900001	207504	8.979311	10.01	10 00148	10.40220	30,78228	047.0.7	1001018	1.0000	14 03560	10.1.00	16 71654	0.40	10 40	2	>5	701	ב ח	

35MINUTES GRIND TIME 4MINUTES ROUGHER-8MINUTES SCAVENGER

I CIA	1014	l all 4		C7	Co	S	C5	1	2	CS	3	2	3	C				FRACTION				
				12		8.5	σ	,	4.5		4	1	3	0.0	2.0	(MZ)			-	COMOLATIVE	SI 114 11 A TILVE	
1000	1000 23	1017	1577 1 577	311 0.43		29 0.589	45 0.51		52 1.071		43 0.9		75 5 33		122	WI	4		5			
	23 25 1 0205 22 227	0.1000	77 0 7885 0 7885	0.496 0.0133 0.4003	20155	39 0.0174 0.5/13	0.0207	1	/1 0.026 1.0432	١	0.95 0.0258 0.9245		75 5 325 0.0375 5.2875	0.00	134 12 33 0 0804 12 248	7000	200		WEIGHT(a)			
	22.227	0.1.00	0 7885	0.400	1		0.00	0 880	1.0452	١		١		1			AIC: TO: T				AVEARGE	
	_		0.1	ļ	18 0.05	2.03	ı	186 006	2.00		2.21		1.1	١	9.21 0.06	١.	ASCu	ı	GEAUT(%)	١	m	
		١		ì			1							1		1	AICu	1	T(%)			-
			0.00 0.7000 77.200 0.07.0	2 7025 77 76	1.55 2.13355 1.5189 2.1618	7.0020	1 07 2 5323 1 705 2 5703 91 08295	1.8 3.9204 2.8809 3.8001 00.00000		2 01 4 60779 2 5478 4 7024 84 63024	2.10 4.00770 2.0202	087731 2 528	1.00 22.3000 0.01-1	20056 3 674	0.0231 1.010	2 4 52 0201 7 9785 55 102 53 02913	ICU ASCI	750	スロググイント	0000		
	-	_	0.01.0	3 5475	9 2.1618	1	5 2 5703	3.9001	3 200	8 4.7024		2 4 1593		7 23 789	00.101	75 100	ACCU AICU	_	-	_		
			100	100	93.21651 2				- 1				Т				ı		1.	CIMILI ATIV		
		_		<u>6</u>	2/3383 80.	30 3000	1.21509 94.	2.01001	51004 91	0.02911 0/.	2007	1.00133 03.	3	.55316 /0.		7 878491 55.10211	200	ASCI A		TIVE RECOVERY	 	
				100 1.16	40200	45053 5 3/	29075 5.54		72047	10204 0.41	75004 6 47	0499/ /.30	22 7 2001	0.44	0000			AICU I	1			
				100 1.168221 0.051281 1.11694	0.000	22 7220E DE 4E2E3 E 247110 0 056174 5 19094	21.21509 94.29075 5.543089 0.056675 5.48641		10 51004 91 72047 5 8317 0 056402 5 77529	0.000	10 0004 07 7E004 6 471875 0 055800 6 41605	2202 0.0010	7782 0 0570	11,55316 /8.89063 0.446411 0.000411	2444 0 0564	9.2	1	AVCU	100	COMOLATIVE GRADE		
				81 1.11694	000	74 5 190944	75 5.466414	2 100	02 5.775297	0.1.0000	22 6 416053	1.0000	35030 7 3607 7 3607 7 100 7 100 7 100 100 100 100 100 100		8 30	9.14	2		20.	KAUT	הלים הלים הלים	

40MINUTES GRIND TIME 4MINUTES ROUGHER-8MINUTES SCAVENGER

25	TOTAL	181	1	IC7	8	CB	C5		C4	5	3	2	3	<u>.</u>	2		10,010	FRACTION			
-				2	3	8.5	c	9	4.5		4	1	2		٦. م 0	(<u>MIZ</u>)		TIME		CUMULATIVE	
	1946 17.13 0.8321 16.294	1001	1601 1 761 0 64	0.210 0.0	37 0 315 0 0148 0 1998	14 0.347 0.0056 0.3416	10 0.000	43 0 003 0 0129 0 9804	54 0.918 0.0		35 1.173 0.0	Ł	61 3 538 0.03	0.101	101 8 181 0 0808 8 1002	WI TOUR	1	WEIGHT(g)			
	321 16.294		1 761 0 6404 1 1207	10 0.1000	148 0 1998)56 0.3416	١		١	0 001	0.014 1.1585		0.03661 3.50141		08 8 1002	Т	۸D.			AVEARGE	
		1	0.11 0.04	ļ	0.58 0.04	2.40	١	2.311 0.03			3.33 0.04	1	5.8	١	8.1 0.08		TCII ASCII	0.550	CDADE(%)	GE	
				ļ		1	1				0.0	1	i	1		I.	AICu	1	1(%)		
	-		0.2004 10.002	0.07 10.0834 76.060 6.8780	0.54 1.25309 1.7700 1.2202 03.71002	00000	2 44 2 02736 0 673 2 0965 88.46354	2.28 5.80005 1.3303 0.0171 00.73017	SOSOE & FEON	1 65 5 36036 3 2448 5 4684 80 636 2	0.01	8/6/4/ 1 6825	1.0000	6 74 20 659 4 3985 21 489 68 42932	1/03 8./104	200 47 7703 0 7404 40 744 47 77031	TCu ASCu /		RECOVERY		
			10.01	8782	1.202 05.1	200 00 7	2 0965 88.4	0.01	20171 86 /	0.4684 80.6		7 11021 75.2		71 4891 68 4	10.11	10 714 47 7	AICU	?			
				100 100	1000	22 0281			20 58647	19,03017	10000		ı		1	7031 9 710371	l	ASC I	COMOLA LAG ALCOALIA		
				2	3	93 12184 4 453507 0.055565 4.39794	21 25946 91 89559 4.9 8631 0.03/433 4.001330	2	89.79906 5.034966 0.058265 4.97670	00.70100	92 79108 5 501703 0 063108 5 438685	15.79137 76.31337 0.343303 0.000701 0.777200	70 34357	14.10888 /1.20342 /.233831 0.072408 7.10140	2000	49.7141	100	AIC	7	7/150/	
				0.880046		4 453507	4.918831	2000	5.034966	0.00	5 501703	0.040000	6 5/3000	1.23331	1 2000 1	8.1	_	Į L	0011101	CIMIL	
				100 0.880046 0.04276 0.637267	25.05	0.055565	0.00/400	2017435	0.058265 4	0.000	0.083108	0.00070	0 066701	0.072403	0.020,00	0.08	+	ASCu	0.0	CHMLII ATIVE GRADE	
				0.00/20/	707707	1.397942	1.00	061306	1.976701	10000	1 438685	1.4.	3 477208	-	161/81	8.02	3	AICu		ń	

15MINUTES GRIND TIME 5MINUTES ROUGHER-9MINUTESSCAVENGER

TOTAL	Tail 5	(21	င္တ	3	2	22	2	C3		C.		C	2			FRACTION			
		-1	11	10		7.5	o	0	ď	-	N.0	2	_		<u>≩</u>		TIME -		CUMULATIVE	
1984	1671	-	17	11		19	Q.	2	5	3	_	2	Ido	100	2					
38.6505	4.3446		9671 0	0.2893	2000	0.5472	2.7000	8002 C	0.7000	3037 0	2.0102	20102	21.00.12	27 0212	2	3	WEIGHI (g			
0.7455	0.5013		0.0136	0.00//	7 7 7 7	0.0114	0.000	00384	0.0	0 0156	0.000	0000	0. 10	0 1344	AUCU		(g)		ΑVI	
37.905	3.8433		0.136	0.2010	0 2916	0.5358	1.001	2 8624	9	0.754	1.100	2 7951	10.000	26 8068	2	2			AVEARGE	
	0.20	3	0.88	2.00	2 62	2.88		4 2	5	200	i	13.42	. 0.00	16.09	2	5				
	0.00	3	0.08	0.0	70.07	0.06		006		213		011		0.08	200	200	GRADE /a/			
	0.2.0	33	0.8	1:55	2.56	28.2	2	4.16		57		33		16.01	ı	<u>^</u>				
	1.240.0	11 2/072	0.8 0.38/058	0.0000	0 748503	1.410/04	10537	6.98//49		1.9911//		13.31 7.29149/		69.93752 18.02817		건 -		70		
	2.2.0	0 72 11 24073 67 24346	1.8242/9	00000	2 56 0 748503 1.032864	2.82 1.413/04 1.3231/3 1.413334	1200175	4.16 6.98//49 5.150905 /		5.81 1.9911//1 2.0925551		3.098592			1	ASCL		RECOVERY		
	-	10 1393	0.356792		0.74291	1.4	1 112521	0.023075	3700075	1.909100	. 1	1.3/3901	10005	70.95845	20.00	A C				
	į	100	17501.00		88.37221		27 6327	00.20/34	10707	R1077'R1	70 0040	10877.11	10000	20106.60	27750	2	5	CUMULA	2	
		100	32./303 4	22 75651	30.93226	20.000	1008 OC	20.3/022	2000	20.2 20.2	3	21.120/0	25301 10	09.93/32 10.02017 70.93043	40 00047	AVC			! i	
		100	08.0007	2030 00	89.50191	00.700	927 88	07.04047	07 34547	80170700	00 00460	21.120/0 /0.33241 13./3333 0.003333	1000011	70.90040	30 050 45	Ž	\$	ベロスイ		
		1.94811	0.80000	10 06035	11.53929	1.000	11 88316	12.02024	10 50501	10.10/02	15 15700	10.79000	15 70333	10.08	10.00	2	5		2	
		0.037576	0.070010	90 9607 10 96036 0 078019 10 88233	30.93226 89.50191 11.53929 0.077905 11.46139	0.07.02	88 750 11 88316 0 078211 11 80495	00.20/94 20.3/022 0/.3434/ 12.32024 0.0/83/1/ 12:440/3	0.070511	19.22.00.00.00.00.00.00.00.00.00.00.00.00.	2022202	0.0000	0.083333	0.00	200	AUCE	\SS.	COMOLA I VE GRADE		
		1.910534	0.00200	10 88333	11.46139		11 80495	1010	10 44673	10.01220	15 07333	ć.:	15 71	0.0	16.01	2	2	Ć	7	

20MINUTES GRIND TIME 5MINUTES ROUGHER-9MINUTESSCAVENGER

TOTAL	Tail 5	C7	8	3	C _N	C4		C3		- C2		2			TXACTOX	-	0
		14	10		7.5	ō	,	<u>o</u>		2.5			(101114)		- 186	1	CUMULATIVE
1987	1644	25	12		18	26	3	3	2	25	2	140		٤			
18.2339	2.9592	0.045	0.06		0.2322	0.002	מאקט	0.403	3	.0020	3	12.32		TC:	VYCIGITI(9)	WEIGHT/	
0.9209	0.6576	0.0125	0.0072	,	0.0126	0.000	0 0550	0.0240	0.0340	0.020	200	0.126		ASCu	9	2	AVI
17.313	2.3016	0.0325	0.0020	2	0.2196	0.1000	0.4068	20702	2722	1.0070	1 0375	12,194		A C L			AVEARGE
	0.18	0.18	0.0		1.29		0 6	-	٠,	0.00	ממ	8.8		ĮĊ,	1		
	0.04	0.05	0.00	200	0.07		000	0.00	200		2	0.09	2	ASCu		GRADE(%)	
	0.14	0.13		0 //	1.22		0.54	i	3	0.00	27.0	0.71	ľ	AICI			
	0.14 16.22911	0.13 0.246793	0.000	0.44 0.329057	1.22 1.2/3452	22.45	3.02/328		2210169		6 55 9 117633	0/.00040	C7 ECC 40	icu	-1	<u> </u>	!
	/1.4084	1.33/300	4 257260	0.781844	1.300221	200007	0.54 3.02/328 5.994136		2 693018		2.7147361 9.45821	13.00227	13 69337	AOCU	3	スロのくロスト	
	13.29400	12 20 102	0 40773	0.304973	1.4007.1	1 000/11	706907	2000	2.184486		9.456211	20204.0	70 43363	3	2		
	5	100	02 77090	83.5241	00.10004	83 10504	8017610	23450	/α.α94/σ	2000	6.68409	00.000	67 56646	- 52	_	COMOLA	
	100	100	28 5016	27.23423	20.70200	35 75 35	23,00410	200440	70060.6	3000	10.397	10.002	67 56646 13 68227 70 43262	200	200	COMOLATIVE ACCOVED	11/1 0100
	5	100	86 70504	86.51822	00.61020	2027225	04.34404	040404	02.0/032	00 07500	79.89.63	70.702	70 43383	200	210	YENT	in DV
	0.91700	100 0 91766 0 001346 0 87131	92 77080 28 5016 86 70504 4 453265 0 076764 4 37650	83 5241 27 23423 86 51822 4 789214 0 0 / 8868 4 / 10346	1.00	83 10504 26 45238 86 21325 4 957418 0 079608 4 8778	01.92139 23.06416 64.94464 3.166632 0.066266 3.16642	E 196623	/8.89426 19.09002 62.0/032 /.33834 0.08034 /.24864	7 330544	16.397 61616160.0 1242474.6 12808867 1785.81	2 42 42	20	- 02	T T	COMO	2
	0.010	0.046346	0 076764	0.0/8868	0.000	0.079608	0.000	20202	0.00004	0 00004	0.081010	0004646	009	1000	ASC.	CONTOCK OF CITYOUT	ATIVE CD
	0.07	0.871314	4 376501	4./10346		4 87781	0.100727	F 108/3/	1.243041	7 2/08/7	0.302727	0 202727	8.71		<u>A</u>	ļ	Ŕ

25MINUTES GRIND TIME 5MINUTES ROUGHER-9MINUTESSCAVENGER

TOTAL	2	Tail A	C7		65	S	P _T	74	2	C	3	CZ		<u> </u>				FRACTION			
			14		<u></u>		7.6	ď	0	٥	п	0.7	2			ŝ Z		2		CUMULATIVE	
1978		1685	ā	5	<u> </u>	٤	ມ	ن	תת	42	3	27	2	Ξ		2					
36.67		3.37	0.0704	1020	0.1496	0.0000	0 3663	9.7000	7885	0.07.2	0 5713	0.200	3 265	20.000	2000	2	3	WEIGHT (9)	WEIGHT.		
1.5945		1.348	2110.0	0.0113	0.0077	0.010	0 0084	0.000	0 0385	0.00	0 0378	0.020	200	0.0555	0 0000	AUCU	200	9	-	AVE	
35.0755	2000	2.022	0.00.4	0.0673	0.1419		0 3399		0.748	0.000	0 5334	7.7.7	2 2A	27.3001	27 0821	7100	2			AVEARGE	
		0.2	0.10	0.49	1.36				143		36		13 06	10.0	S N	2	3				
		0.08		0 07	0.07		0.0		0.07		0.091	1	0	0.00	0 00	200	200	010000	GRADE(%)		
		0.12		0.42	57.1	3	1.03		.36		1.27		12.96	-	25 21	1	2				
		0.12 9.190074 04.34001	2 4 2 2 2 4	0.42 0.213799 0.702415 0.19158/	1.28 0.407303	207063	1.03 0.9989091	20000	2.144805		1.55/6//		12.96 8.903736		25 21 76 58304 6 265287		700		20		
		04.0400	04 54004	0.702415	0.40251	0 48201	.00000	000001	2.41455	,	1.55/6// 2.3/0649		1.56/89		6.265287		ASCU		RECOVERY		
		3.704700	E 764709	0.19158/	1000	955000	0.908002	0.000050	2.132343	300	1.52072	١	1.56789 9.237217	7,77	79.7.962		A C C				
		5	100	56608.06		90 59613	90.10010	218816	03.10320	20001	07.04443	27 04 46	85.486//	25,700	/6.583U4	1	2		COMOLA		
		5	100	15.45939	17 17 17 17 17 17 17 17 17 17 17 17 17 1	14 75698	14.7.40	14 37407	12.01000	10 61939	10.20303	10000	1.033111	7 000177	6.58304 6.265287 79.77962	2007	AVC		COMOLATIVE XECOVEX		
		3	100	94.23329	2000	94 04371	0.000	03 63015	32.0701	02 6701	90.007.00	2255	09.01004	00 04004	706/1/6/	2000	2		777		
			1 853893	15.45939 94.23529 11.30313 0.00413 11.20100	11 30510	1 59613 14 75698 94 04371 11 99336 0 084946 11 90841	1.10000	0.0 18816 14 27407 93 63915 12 43308 0 085564 12 34752	1.36 2.144805 2.41455 2.152545 68.16820 12.01656 32.0161 1.76801 2.36822 2.164805	14 03678	10.20303 90.33733 11.33213 0.341401 11.34013	17 02313	/.8331// 08.01004	33.05	20.0	26.20	2		COMOL	2	
			1 853893 0.080612 1.77328	0.00	0 08/13	0 084946		0 085564	0.0000	0 086350	0.00	001/04	0.00	0 001838	0.00	1	200	200	COMOLATIVE GRADE	ATIVE CD.	
			1.773281	1.100	11 28106	11.90841		12 34752	0.00	13 95043		17 84073	27.000.0	22 05818		25.21	2	>		Ź —	_

30MINUTES GRIND TIME 5MINUTES ROUGHER-9MINUTESSCAVENGER

TOTAL	lall 5		C7	C6		C.	4	2	-	1	3		2	(Altial)		TRACTION	_	CUMULATIVE	
	-		14	٥	;	7.5	a	2	<u>o</u>		25	ŀ	_				1	Æ	
1983	1000	1500	29	ō	3	38	ę	28	31	2	48		68	-	7				
42 4356	3.7032	3 7633	0.0725	0.0332	0 0000	0.5434	0.0	2 2	0.0401		3.9984		32.6088	1	7	AACIG!!!(A)	NAC DET		
1.3869	L	SUPO U	0.0203	0.0	0 0113	0.0418		0 0935	0.0400	20100	0.0816		0.1512		ASCu	9	9	A	
41.048/	T	2 8224	0.0522		0.088	0.5016	1	0.4165	Γ		3.9100	1	32.45/6	T	A C			AVEARGE	
		0.24	0.20	T	0 85			0.6		271	0.00	223	19.41	5	C				
		0.06		Ī	0.07			0.11	Ī	0 15		0 17	0.00	200	ASCu	3	GRADE(%		
						Ī			T		Ī				AICu	T	_		
		8.86802		0 17084	0.23376	1.000	1 28052	1.20102	3	1.9/9/0		9 42227	. 0.0	76 8430	2	1	-		_
		0.18 8.868026 67.63474 6.673733	2 0047	0.18 0.170847 1.463696 0.127166	0.55 0.233766 0.607336 0.21436	235000	3.01391	0.74100	0 40 4 001001 6 741654 1 014648	3.35200	0.00	5.88362		10 32 76 84303 10 90201	200	200	スロくくロスト		
		4 0.0/0/0	6 07572	6 0 12716	0.2143	0 3443	6 1.22196	0	1 01464	1.80001	2333	9.54183		11 79.07096	7100	<u>A</u>		`	
		-				00 061	3 90.7273	00.	8 89 4468	00.2400	00 3450	7 80.2000	200000		Т		001	2	-
	•	١	3	17 32 1652	00.101	20 7015	16 29.8940	10.000	36 8800	20.100	30 138	10.7000	16 7056	3 10.9020	1	ASCu		CHMI II ATIVE RECOVERY	
		1	1	36 93.1242	02.00	20 007	11 92.7827		19 91 5607	90.010	200 5461	00.0121	20 6127	76.84303 10.90201 79.07096	2000	AICu	100	COVERY	
			70 2 1390	26 9.3186	1	71 9 9999	(2) 10.405		76 11.4329	10.100	15 1609	9 10.047	0 16 0477	19.41		2	1	CUM	_
			100 2 13997 0 069939 2 0700	51 0.10/48		74 0 11031	39 0.11200	2 4 4 2 2	32 0.11228		88 34501 20 13844 80 54611 15 16085 0 113077 15 0477	0.107	00 00001 46 70001 98 61070 16 04778 0 107778	+1	3	ASCU		CUMULATIVE GRADE	
			19 2.07003	91.13197 32 16526 93.12426 9.318651 0.107494 9.211157		00 06113 30 70156 02 9971 9 999974 0 110311 9.889663	90.72736 29.89401 92.78272 10.40559 0.112054 10.25554	10 0005	89 44683 26 88009 91 56076 11.43292 0.112289 11.32063		7 15.04777	.0.0	16.84	10.04	10 33	ACL	•	RADE	

35MINUTES GRIND TIME 5MINUTES ROUGHER-9MINUTESSCAVENGER

TOTAL		Tail 5	S	3	င္တ	5	3	ţ	2	C	3	7	S	-	21			300	TED ACTION			
			14		10		7.5		מ		'n	2.2	<u>بر</u>		_	(IVIIIV)	MINI	-	TIME		CLIMILI ATIVE	
1583	3	1477	ŧ	À	ဌဌ		မ္တ		2	į	140		43		165		ş					
33./390		1.3293	0.230	0.0204	0.3003		0.4464		0 729		308		0.4644		29.16	1	<u></u>		WEIGHT/a			
1.1442	1 1//2	0.8862	0.01	0 024	0.0165		0.018		0.027		0.07		0.0215		0.081		ASCu	3	9		A۷	
07.000	2202	0.4431		0 2064	0.2000	2020	0.4284		0.70.2		3.01		0.4429	,	29.0/9		ACC				AVEARGE	
		0.08	3	0.48	0.9	001	1.24	2	3	3	2.2	2	1.00	200	ō	١Ł	5	4	c	,		
		0.00	200	0.05	0.00	3	0.00	200	0.00	2	0.00	200	0.00	2	0.00	200	ACCU	• 000	GRAUE(%)	2000		
		0.00	202	0.43		286		2	-	۵	2.10	2 17	- 2	2	7.00	17 05	7100	2				
		0.7	2 710383	0.644659		0.84024	10000	1 249028	1.000	1 3 2 039743 2 359727	2.10 0.01.010 0.11.01=	8 617843	1.00001	1 29239		81 58071	- 6	5		D.T.	!	
			0 03 3 719383 77 45149 1	0.43 0.644659 2.097535 0.590000	303535	0.86 0.84024 1.442056 0.820336	1.10	1 573152	1.000	2359727		6 1178121		1 03 1 299392 1 879042 1 28022	0.01	17 05 81 58071 7 079182 84 05404	2000	A N N	1		i	
	L		1 280799	1	_1		7	238308		2.02916	т	8 700528		22082		84 05404		AC:	+			
			6	20.2002	06 28062 22 54851	95.63596 20.45097 30.12239 7.30377	25.00	04-001.1 0220C.18 18000.81 7/66/146		93,54669 17.43576 96.06385 6.378286		97.50695	2002	82.889	2002	81 58971		<u>.</u>		この こうしょう こうしょうしょ	2 = 1	
			100	_	_	20.40097	7007	1800081	3	7/.435/6	25.75	97.50695	15070	0.90024 00.00420 In. HU000	0.000	7.079182 84.03404		ASCU		マロ スロくくく		
	-		100		98 7192 6 668702	90.12233	08 13350	02200.18	3000	CECOOO	2000	94.004/9	07/20	02.33420	30406	34.03404		200		7) 	
			100 1./93266 0.05/411 1./33033	10000	6 668702		7 30344	/ / 00+0	2700/6	0.3/8/20	90000	9.4/9000	323071 0	14.40000	1 15003	ō	٥	2	5	COMOL		
			0.05/411	2	0.05	6	200	0.00	20.0	0.00	200	0.00	2	0.00	20.5	0.00	200	7000	200	11000	CLIMI II ATIVE GRADE	
			1./30000	10000	0.05 6.618702	100	7 25344		0.05 7.73846	0.020200	800008	0.72000	0.05 9.429536	1.1000	0.05 14.40093	11.00	17 05)	2		퓌 _	

40MINUTES GRIND TIME 5MINUTES ROUGHER-9MINUTESSCAVENGER

101	lall o	1	C.		င္တ	5	,	\$	2	S	3	2	3	_	3]			TRACTOR				
			14		10		7.5	ď	D		7	2.0	Э		1	(MIIN)		INIT	-	000000	CHAN II ATIVE	
1883	100	1557	20	3	7		34	2	33	2.0	20	1	41	-	1	**	Ä					
22 222	1.0000	1 0800	0.1012	0 1613	0.2363	2	0.5202	1.0200	1000	1.100	1 2205	9:1:1	3 773	10.01	5 83	2	7	44 []	WEIGHT(a)			
0 98371	τ	0.4671	0.000	0.030	0.0400	2000	0.051	0.1.00	0 1 188	1	0 0638		0.0902		0 113	1000	ASC:	4	3		AVE	
22 × 2/5		0.6228		2 1 2 2 2	0.1900	25010	0.4692		0.9108		1.1658		3.6818		15.707		AICL				AVEARGE	
		0.0/		0.62	- 5	1 30	1.53	3			4.24		2	3	4		5	1	G)		
		0.03	3	0.15	١	0 24	0.10	2 1 2	0.18	2	77.0	200	22.0	2	<u></u>	2	ACCU		GKAUE(%)	3		
		0.04		0.4/	i	15		1 28		200	4.02	3	0.50	0	10.0	300	2	5				
		4.000120	4 569136	0.6/5642		0.99041	1.0000	2 180228	4.01000	215380	0.10000	72007	0.0000	83008	00.000	20677	2	1	2	200		
		1,1000	004 4 569106 47 48399 2 722611	3.904023	20000	4.14/606	0.10	5 184507	12.07	10 07885	0.400	6 485717	0.100	9 169462	1.70	11 48724	200	200	2011			
			2 722611	0.4/ 0.6/5642 3.964623 0.334203 33.	20072	1 15 0.99041 4.14/606 0.85464 34		1 38 2 180328 5 184507 2 051139 93.	1.30 4.313000 12.07000 0.001022 0	3 98 1622	4.02 3.133034 0.4037 17 0.00007	5 096371	0.30 10.00000 0.100101 10.0000	16 095231	3	42 0 66 30677 11 48724 68 66418 66 3	100	A				
			100	3	13187	120C3	2003	76582		91.58549		8/2/011		82 11645		66.30677		2		CUMULA		
			8	01.00	53 51601	40.33138 30.74310	10 55130	44.403/8		39.21927		21.14242		/000/		306771 11.487241 68.66418		ASCU		COVER THE COVER	i	
			200		97 27739	30.74010	06 7/318	95.88854		93.83/4	2	αΨ.αυυ/α	25.220	04./594	2	68.664.0		P C	;	くけスプー	Ì	
			1.26/063		6.984325	1.0000	7 5350	1900000	2000	0.77002	003322	11.3/192	27700	2.1.2.00	20000	14		2	5	COMOÇ	2	
			100 1.26/063 0.052241 1.214624		52 51601 97 27739 6 984325 0 158466 6 825858	0.1001	0 1592	44,403/8 95,88854 /.905088 0.154548 /./50/4.	2 42 42	58549 39.21927 93.8374 8.775562 0.15494 0.020045	2 45.0	2/0111 2/.142421 89.855761 11.377921 0.1459021 1	245000	11645 20.6567 84.759411 12.722001 0.1319401	131010	<u>-</u>	2	AUCL	3	COMOLY INC. GIZZON	TIVE CON	
			1.214622	2	6.825859		7 3767	1.100142	7 750743	0.020040	0 600643	11.20202	11 33303	2.00010	13 50013	0.0	300	2	5	_	ń —	

15MINUTES GRIND TIME 6MINUTES ROUGHER-10MINUTES SCAVENGER

TOTAL	Tail 6	C7	6	S	C5	2	2	ဌ	22	3	Ω			FRACTION		
		16	21	13	9		7	6		ı,		1	MN)	T ME		CUMULATIVE
1978	1587	19	2	12	21	111	117	36	1	21	164		LM			
37.2245	3.6501	0.1368	0.1000	0 1859	0.5439	0.0	2 51	0.9864	*	2 7258	25.4856		TCu	WEIGHT		
0.7524	0.4761	0.0133	0.000	0 0091	0.0105	0.0700	8970 0	0.036	0.010	0 0294	0.1312		ASCu	(g)		Ą
36.4721	3.174	0.1235		0 1768	0.5334	0.1001	3 4632	0.9504		2 6964	25.3544	2	AICu			AVEARGE
	0.23	0.72	,	1.43	2.59		ω	2.74		12.98	15.54	15.51	TCL			
	0.03	0.07	3	0.07	0.05		0.04	0.1	,	0.14	0.00	000	ASCu	GIVADE(70)		
	0.2	0.00	200	1.36	2.54		2.96	2.64		12.84	0.40	15 40	AlCu			
	9.800242	0.00 0.307290	0007000	1.36 0.499127	1.46033		9.424084	2.648409		7.318566	00.4200	20 4250	TCu		0	
	0.2 9.800242 63.27/51 8.702542	1.707077	1 757577	1.209463	2.54 1.46033 1.395534		2.96 9.424084 6.220096 9.495477	2.64 2.648409 4.784689 2.603627	2000	3.907496	17.407.00	17 /2752	ASCu	ארטטערוזי		
	8.702542	0.330013 30.1	0 220615	1.209463 0.484754 89.7	1.462488 89.2			7.00007	20202	12.84 7.318566 3.907496 7.393048 /5.6	00.4200 17.40700 00.01720 00.	60 51725	AlCu			
	100		775	89.77/42	62.27.69	2000	87.81/96	10.39300	70 20200	/5./454/	00.1200	68 4360	100			
	50	200	26 72240	34.95481	33.74333	20214	31796] 32.34981]	20.12972	26 42072	21.34503	24.500	17 43753	ASCU	1	VIII AT VE RECOVERY	
	5	100	01 20746	90.95884	90.47409	00 47400	89.0116	19.01012	70 51613	76.9103	20.01.00	17 43753 69 51705	AICU	A .	VFRY	
	02610011	4 884006	8 586803	2.988602	9.202312	0 161343	9.676864	10.21107	12 21167	15,24941	1000	15 54	1	100)
	100 1.00 1920 0.030030	0.03000	36 72240 01 20746 8 586803 0 070665 8 516138	77/42 34.95481 90.95884 8.988602 0.070699 8.917903	7029 33.74333 BU47408 B.202312 U.U/U/24 B.181300	0.070704	89.0116 9.676864 0.072012 9.604852	22000 20.129/2 /9.010/2 10.2110/ 0.000909 10.122/	0.088880	7454/ 21.345U3 /6.91U3 15.24941 U.U86611 15.16259	20001	008	AUCU	1	COME A VT GRADT	
	1.040000	1 0 1 0 0 0	8516138	8.91/903	9.191000	0 101500	9.604852	0.127	13 13371	10. 10238	10050	15 46	AiCu		7	1

20MINUTES GRIND TIME 6MINUTES ROUGHER-10MINUTES SCAVENGER

TOTAL	Tail	C7		S	C5	2	3	3	Š	3	C1			FRACTION			
		16		12	9	7		Я	ć	2	_	(1000.4)	(NIN)		!	CUMULATIVE	
1994	1663	20	3	11	26	69	3	11	2.2	33	172		×				
17.6054	3.1597	0.034	2	0.0528	0.1248	77.16.0		0.2992	1.0120	1 3778	11.6444		TCII	WEIGHT (g)	14150117		
1.9575	1.663	0.010	0010	0.0099	0.0156	0.0621		0.0099	0.0272	0 0242	0.1548		ASCu	9)		AVE	
15.6479	1.4967	0.010	0.016	0.0429	0.1092	0.0000	20250	0.2893		3486	11.4896		AICu			AVEARGE	
	0.19		0 17	0.48	0.48	1.00	3	2.72		624	6.77	1	던		ה		
	0.7	200	0 09	0.09	0.06	Т		0.09		0.11	0.09	4	ASCu /	10/04/			
L	90.09		0 08	0.39	0.42	, ;	1 24	2.63		6.13	0.00	3	AlCu				
	0.09 17.94733	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	0.08 0.193123	0.299908	0.708873	0.5000	5 212605	1.699479		6.13 7.797608 1	0.00 00.1410/ /.900040 /3.42303 00.1410/	20777	TCu	1.	200		
	04.9000		0.91954	0.505747	0.790933	20002	3 172414	0.505/4/		1.236271	1.900040	2 000010	ASCu		RECOVERY		
	2.004002	0 60 400	0.10225	0.2/4158	0.097007	23052	5 467826	1.84881	101001	8.618409	10.42000	73 43503	AlCu				
	5	100	82.05267	81.85954	01.03904	DA EEODA	80 85076	15.53610	25000	73.93868	00.	66 14107	2		CUMULA)	
	100	100	15.0447	14.12310	13.0134	13 64044	12.82248	9.00004	0.000	9.14431/		7 008046 73 42583	ASCU	3			
	- 00	100	90.43514	90.33209	2000	00 05073	89.36087	00.09000	20000	82.04424	2000	73 42583	AICU	2	VEZ.	i	
	0.002010	0 882010	4.36426	4.033907	1.1007	4 7963	5.194927	0.483003	CARROLE	6.709897	20002	6 77	- 52	1	COMOL		
	0.000	100 0 882010 0 00817 0 784740	4.36426 0.088973 4.27528	0.00007	0.42 0.708673 0.70873 0.70873 0.70873 0.70873 0.70873 0.70873 0.70873 0.70873 0.70873 0.70873 0.70873 0.70873	738887	0.091606	2.63 1.699479 0.505747 1.84881 /5.63616 9.650004 63.69303 6.493603 0.092146 6.403633	000116	1.236271 8.618409 73.93868 9.14431/ 82.04424 6.70989/ 0.092268 6.617629	2000	000	AUCU	3	COMOLATIVE GRADE		
	0.10	0 784749	4.275287	4.04000	1.001100	4 607/33	5.103321	0.40000	6 403650	6.61/629	2000	88.8	Ä	2		7	

25MINUTES GRIND TIME 6MINUTES ROUGHER-10MINUTES SCAVENGER

TOTAL	10110	Tail 6	C/		CG	C		2	S	3	22	3	Cl			7200	EDACTION		
			ī	10	12	ď		7		9		3	_	,	(MZ)		TIME	CUMULATIVE	2
1966		1604	20	35	16	30	30	84	-	16	1.2	27	10/	457	ş				
50.6329		4.01	0.000	330.0	0.0976	0.000	2 2007	2.1924	0.000	0.5808	7.1007	4 1004	01/10/80	20 0773	TCu		WEIGHT(n)		
828.2	2000	2.406	0.0016	0 0243	0.0176	0.0402	0.0422	0.1008	0.0	0.016	0.0100	0.0405	0.1121		ASCu	(8)	<u>@</u>	Ž	^
47.8049	il	1 604	0.000	8550 0	0.08	4101.0	0 4570	2.0916		0.5648	1.000	4 0689	00,000	3000	AlCu			AVEANGE	200
		0.25	1	0 25	0.61		30	2.61		3.63		15.22	67.00	24 80	TCu		_		
		0.15		0 12	0.11		0 13	0.12	2	0.1		0.15	9	0 11	ASCu		GRADE(%)		
		0.1	2	0.13	0.5		1.27	2.49	,	3.53		15.07		24 78	AICu	:			
		75/6167 1.0	10150	0.13 0.128375 1.103253 0.070704	0.19276		7 0.98829 1	4.329991	22000	1.14/08		8.116067		77 17768	2	3	2	!	
		67.770.00	05550	1.103253	0.022340	2000	1.527581	3.304330	3 504350	0.565771	2027	1.432107		6.106789	ASCU	_	XECOVEXY		
		0.00000	300300	0.070704	0.10/04/	7 2 2 2 2 2	1.527581 0.956387 91.75911	4.3/320*	1 375301	1.181469		8.5114/1		81.38203	AICE	200			
			130	92.08025 14.92221	91.90107	04 05107	91./5913	30.11.002	27722	00.44000	000	85.293/5	2	77.1768	- 62	5	COMOLA		
		5	100	14.92221	10.01000	12 21 205	13.19661	1.0000	11 66000	0.104000	0 404660	1.535591	7 - 7 - 7	6.106/89	2000	200			
			100	90.0447	00.07	06 57300	90.40604	1000	95 45008	31.07437	04 07407	69.6935	300	81.38203	2000	5	VEZ.		
		2.010721	100 2 575427 0 143845 2 43158	96.6447 12.87925 U.116575 12.76266	U.192/6 U.622346 U.10/34/ 91.9316/ 13.01093 90.37399 13.03092 0.10991	12 85552	13.19661 96.40664 14.51884 0.116625 14.4022	0.000	18 18308	21.00073	27522 10	23.4/ 103	2747	24.69		7	COMICE		
		0.100	0 143845	0.1100/0	0.1100	0 11631	0.110020	2 2 2 2 2	0 116197	9	01116	0.1100/	7 1 2 2	<u>.</u>	200	200	CONICE ALVE GIVEN	ATIVE COA	
		1.10	2 431582	12.70200	10.7000	13 74001	4.40222	2.49 4.32991 3.304330 4.373204 30.77002 0.770020 0.770020 0.77000	16 06687	4:10010	24 76015	23.33310	22 25 50	24.70	200	A 0		Ź —	

30MINUTES GRIND TIME 6MINUTES ROUGHER-10MINUTES SCAVENGER

		Tall 6		C7	8	3	G G	4	2	3	3	3	-	3		_	FRACTION	•		
				16	7.	13	9		7	٥	6	ω		_	(141114)	(NIN)	IME		CUMULATIVE	
1900	1005	6201	100	22	11	22	35	1	72	4	٨	3	3	132		۲				
	2023	1.3060	7 0635	0.1056		0 2134	0.5495		1 5257	7.002	4 802	2000.0	20050	33.2244		TCL	ANCION (A)	NEIOCET,		
	6349	0.00	0 075	0.0418		0.0572	0.07	707	0.0949	0.000	960 0	0.0700	0.0750	0.2244	+	ASCu		-	AVE	
	47 6734	0.00	6 9875	0.0030	0000	0.1562	0.4/30	307.4	1 4308		4 796	0.7000	7506	J.	3	ACu			AVEARGE	
		١	0 49	040	2 40	0.97	ز	1 57	2.09		12.23	10.7	ა ა	23.17	75 47	L Cu	1	<u> </u>		
			0.06	0.10	2 10	0.26	, , , , , , , , , , , , , , , , , , ,	3	0.13	,	0.24	,	21	9.1.	0 17	ASCu /	r	GRADE(%)		
			0.43	0.10	0000	0.71	2	1 37 1 114417	1.90 3.0	3	11.99 9.921251	!	211 16	5	25 67	AlCu	_			
	Ĺ		16.1484 39.63666 14.63702		14163 2	32/0/ 3.4	2070	14417 4.2	94200 0.0	2000	21251 5.0		2 11 1 693832 4 624136 1 59334		251 67 380951 13 725611 69 220991 67 38	2	\ \	REC.) 	
			03000 14	20000	56731 0	190000	20300	81607 1.0	0.000	25370	19191 10	1	24136 1.:		725611 69	Adda	┨	KECOVEKY		
			20100	2700	133827 8	040	37646 87	05802 83	201231	31354 8	71000	27	293341 08		22099 67	2		_		
			č	ŝ	33.8516 40	0.007	63744 3	3.20465 34	12000	146000	2 00000	20000	1.0/4/0	07470	.38095	2	TC	OMOLATIV	i i i i i i i i i i i i i i i i i i i	
	-		ē	3).36332 8	.0000	7 80650 B	1.30791 8	0.000	0083	*.22 100 0	22166	0.04970	24075	8095 13.72561 69.22099		A S C =	COMODATIVE RECOVERS		
			100	3	5.34298 1	0.100	2 200505 0 327646 83 63744 37 80650 85 20015 12 20124 0 18287 12 01837	4.281607 1.005802 83.20465 34.30791 84.88151 12.98316 0.1775 12.80588	1.96 3.094203 3.004030 3.001237 32.00227 33.0020	83 8757 1	1 5.87.19 10.00012 70.33003 23.243 10.12073 0.13000 13.0000	0 07445 4	0.01433 2	201423	66027.6	2000	AIC.	֓֓֓֓֓֓֓֓֓֓֓֓֜֜֜֜֡֓֓֓֓֜֜֜֡֜֜֜֡֓֓֡֡֜֜֜֡֡		
	-		101010	100 2 484045 0 082363 2 40168	1.48494		2 20124	2.98316		4 40473	0.12010	8 73673 C	0.61001	0 22257 0	25.17		7	CONTO	CIMIL A	
	-			1 PS2383 :	183306		0 18287	0.1775		174698	, 10000	190385		178571	0.17		ASCu	2	CHMI II ATIVE GRADE	
			1000	7 401683	11.30164		12 01837	2.80500		14.23004	0.00	18 53635	1000	20 005	23	26	A C	Ì	Ħ	

35MINUTES GRIND TIME 6MINUTES ROUGHER-10MINUTES SCAVENGER

	Tail 6	ζ,	3	S	C	2	2		<u></u>	-	3		2			FRACTION		
		-	16	12		0	- '	-	σ		ú		_	(MILIA)	(MIN)	- 1	1	CUMULATIVE
1994	1637		15	21		47	١٥/	0,7	67	2	3/		125		TW			
42.8449	2.1281		0 201	0.3171		0.5875	0.900	0 0657	0.0020	2020	3.293	3	35		TC.	/R/ I I I DI JAA	WEIGHT	
1.0244	0.8185		0.0075	0.0103	200	0.0235	0.000	0 0500	0.0	200	0.0222	2000	0.075	4	ASCu		2	ΑVI
1.0244 41.8205	1.3096	2000	0.1935	0.0000	2000	0.564	0.0	0 0135	0.00	0 2275	0.77.00	3 3708	34.925	2	AICu			AVEARGE
	c.	3	1.34		1 21	1.25		<u>_</u>		1 41	5	20	28	3	TCu	1	_	
	0.00	20.02	0.05	0.00	20.0	0.05	2	0.06		000	9.00	3	0.00	200	ASCu		GRADE(%)	
_	0.00	20.08	1.29		1 46	1.2	2	1.05		υ U		200	46.17	27.04	AlCu	+		
	1.00000	4 966986	0.469134	2	1 46 0 740111	1.3/1223	271775	2 253944		0.822/35		7 685862	0.00	22	Cu	3	곭)
	0.000	n na 4 966986 79 90043 3 131479	0.732130	2010	1 02499	0204020	304036	5.095000	202000	1.4042/2	2	2.16/122	1.000	81 60 7 331350 83 51167	Aocu	2	KECOVEX*	ì
		3.131479	0.402032	0 460600	0.733133	1.000	1 248621	2. 04333	30000	0.00702	20700	8.84 7.685862 2.16/122 /.821045 89.3/	100.01	83 51167	300	١٥.		
		6	90.000	05 03301	94.56388	00.02.01	93 82377	92.43234	02 45254	90.1900	2000	09.3/30/	200	81.69	2	5	COMOLY	
		100	20.0000	20 00057	19.36/43		18 34244	0.04042	16 04840	10.30210	10 05375	756/ 9.400401 91.332/2 23.03/03	2	81 69 7 321359 83 51167	200	200	NOTALIVE VECTORES	
		200	00.000	98 8852	96.40583	207-00	95 6727	07.02700	80ACF A0	02.10017	02 12074	91.33272	2777	83.5116/	100	<u>A</u>	77	YEDV
		100 2.148691 0.051374 2.09731		05 03301 0 163603 05 03301 20 00057 06 86852 11 40527 0 057675 11 34759	1 02499 0.733133 94.56388 19.36743 96.40583 11.84673 0.056012 11.7667	1.2 1.3/1223 2.234020 1.34021 00.02071 10.021 00.02071 00.02071 44 70074	12.52296	1.7000	14 45664	10000	20 66604	20.00700	33765	22	4	5	CONTO	
		0.0513/4	2000	0.057675	0.00012	0.00040	0.058536	6.60	200	5.50	38	0.00	200	6	1	ASCU	10.0	CLIMI III ATIVE GRADE
		2.09/31/	7	11.34759	11.70071	44 70074	12.46442	1	14 39664	10.000	20 60604	0.00	22 57765	27.94	27.2	A Cu	Í	ב ב

40MINUTES GRIND TIME 6MINUTES ROUGHER-10MINUTES SCAVENGER

TOTAL	0	Tail 6	()	3	S		CS	7	2	ີ	3	CZ		<u>0</u>				LEB ACTION I			
				16	7.1		9		7	o	6	u	2			ŽŽ		TIME	001100	CHMI II ATIVE	
1994		1510		46	24	2	46		127	0	99	o/	57	5		¥					
40.5/56	١	2.567		0 299	0.040	Ì	0.7958		1.8669	. 1007	1 1937	2000.0	2 0023	0.12	370	5	1	WEIGHT(g)			
2.8028	-1	1.208		0.069	0.1240	2778	0.2392		0.4191	9	0 1518	0.170	0 1767	1	0 414	ASCU		9		₽	
31.113	2777	1.359		0.23	20.22.0	2 222	0.5566	2	1.4478		1.0419	0.1100	5 7285	27.100	27 186	ACC	2			AVEARGE	
		0.17		0.65		1 45	1./0	4 73	1.4/		1.73		10.36		24	2	4				
		0.00	200	0.15	,	0.52	0.52	20.53	0.33	3	0.22		0.31		0.36				70/70/00/		
		0.00	000	0.5		0.93	1.5	3	- 14	1	-0		10.05		23.64	100	A .				
		0.0101	6 336463	0.730090	20000	0.85/658	2011	1 061277	4.00 104	4 601041	2.94 19 10		14.55357		23.64 68.02118		7				
		10.1000	43 10283	704.7	2 162	4.400000	450000	8 534932	17.00001	14 05307	3.410388	E 410000	0.30400	20400	14.//2		ASCu	100	RECOVERY (%)		
			0.00 6.336462 43.10283 3.597808	0.0000	0 608001	0.00000	0.500000	1.473539	0.00400	3 832897	2.100010	2 758210	10.10000	45 40550	/1.9/204	10000	ACL		8		
			100	00.0	03 67354	26.3000	02 03667	92.0/898		90 11771	00.0100	85 51667	02.07470	22 57175	00.02110	20140	2	•	COMOLA	-	
			5	20.00	56 89717	4.1001	54 43517	49.98210		41.44723	10010	26 49326	1.07000	31 07686	14.772	14 770	AVCU	200		1	
			Ę	1	96 40219	00.1	95 79329	85.20238	20000	93,72885	00.000	89 89596	0,0	87 13764	11.01.00	71 07001	200	2	\t\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	1	
			2.034665	0000	7.853017	0.000	8 609498	9.02434	0004544	9.936359		14 39788		19 47977	1	24	2	75	CONT	2	
			1001 2.034665 U. 140324	2 40553	0.329463		1.21 1.22 1.22 1.22 1.22 1.22 1.22 1.22	0.00007	1.14 4.00 04 1 33337 333337 333337 3533337 3533337 3 33357 9 696184	0.315652		0.308091		0.34343	0.00	25	7000	_	COMOLY LIVE GLAVEL	ATIVE COA	
			.094000	4 00 4333	7.523554		8 261187	0,000	0 606107	70/079.6	20070	14.08979		19 13634	10.0	23 64	2	2	Ć	7	

15MINUTES GRIND TIME 7MINUTES ROUGHER-11MINUTES SCAVENGER

IATOTAL		Tail 7	()	27	<u>c</u>	5	2	2	3	3	77	3	C			50101	EBACTION			
			101	1	14	10.0	10.5	8		7	0.0	S Fi	_		(MZ)		TINE.	COMOC	CHMI II ATIVE	
1978		1619	ď		9	2.5	20	107		24	٥	27	144		≦					
40 4617		4.2094	- C-	0 1124	0.2142	0.724	0 7001	3.16/2		0 6864	0.000	2000	20.20	3	Z Z		MEIGHT(a)			
0.8315		0.4857	0.000	0 000	0.0072		0.0203	0.0642	3	0.0168	0.000	0 0555	0.1720	0 1770	ASCu		2		AVE	
39.5302	3	3.7237		0 1044	0.207		0.7018	3.103	3	0.6696		5 0135	20.1012	36 1073	AlCu	;			AVEARGE	
		0.26		1.26	2.30	3	2.49	2.30	3000	2.86		13.7	10.10	18 25	2	1	G			
		0.03	3	0.1	0.00	2	0.07	9.00	200	0.07	2	0.15	9.11	2	ASCU	3	GXAUT(%)			
		0.23	3	1.16	1.0	3	2.42		20	2.13	2 70	13.55		18 13	200	2				
		0.23 10.40342 30.71231	2000	1.16 0.280265	0.0200	2 0 K2039 0 865905	2.42 1.784651 2.441371		7 827649	2.13 1.030.13 6.1020.10	1 606/10	R/7C7L	2	54.95031	2	5	1	מ		
		70.7120	58 /1051	1.082381		0.865905	2.4413/1	1	2 9 7 827649 7 720986 7		200045	13.55 12.52/9 0.0/4004 12.000/	1007	18 13 64 95031 20.76172 03.07703	200	ASC =	ľ			
		0.000	9396117	0.263433	_	0.522329	1-	770075	7.829887		_	F	13 65071	П	Т	AC.	t			i
		١	3	09.09000	00.000	89.31632	00.70000	20202	87.00228	2000	79 17463	17011		10008.40	05034	2	00000	CLIMINI ATIVE RECOVERY		
			100	41.30/45	14 50740	40.50511	00.00021	20 62021	37.19784		29 47685	V. 1001	27 /56/	20.10112	70173	ASCu		VE RECO		
			200	90.00000	00 60399	90.34045	00.01012	80 81813	88.04/25	20.5	80.21736	0.04	78 57774	20.10112 03.01103	25 97703	A Cu		ERY		
			100 2.045586 0.042037 2.003549	10.00010	10 001 10 00000 10 00013 0 0000303 10 0018	40.50511 90.34045 10.3254 0.096229 10.2291	0.000	20 62021 80 81812 10 5351 0 096657 10 43845	87.002281 37.197841 88.047251 11.282881 0.0991331 11.10373	20000	79 17463 29 47685 80 21736 15.62702 0.119561 15.50746	1000	27 ASSA 78 52774 17 31989 0 126133 17 1937	0.10	- 1	5	3	CUMUL		
			0.042037	0.000	0.006333	622960.0	9000	0.096657	0.099133	200135	0.119561		0 126133	9	0 10	A		COMOLA I VE GRADE	1	
			2.003549		10 00181	10.22917	2001	10 43845	1.100/0	11 19275	0.50/46		17 19376		18 13	Ä	5	_	1	

20MINUTES GRIND TIME 7MINUTES ROUGHER-11MINUTES SCAVENGER

TOTAL	Tail 7	9	C7	Co		<u>G</u>		<u>0</u>	3	3	ç	3	2	21			TRACTOR	_		
		i	18	14		10.5		00		7	0.0	מני		1	(<u>MEZ</u>)	````		i	CUMULATIVE	
1971	1551		14	13	2	27		6		28	3	ယ္ဟ	5	2D2	I VV					
18.1956	2.9469		0.0644	0.020	200	0.135		0.45		1 0752		0.161		13 3371	100	7	WEIGHT (g)			
0.9541	0.6204	3	0.0322	0.01	00117	0.0243	,	0.08		0.0224		0.021		0 1421	7000	200	g	-		
17.2415	2.3203	3300	0.0322	0.0140	001/3	0.1107	2	0.37	2	1.0528		0.14		13.195	2	2				
	0.10	0 10	0.46	ľ	2	0.0	200	0.45	2	ر. 40.0	2	0.40	2	6.57		5		_		
	0.01	200	0.23		000	0.00	200	0.00	000	0.00	200	0.00	3	0.07		ASC	0.00			
	9.10	0 15	0.23		0.11	1	0 41	0.07	0.37	0.70	378	4.5	2	6.0	2	ACu				
	0.100	0 15 16 19567	0.303932	20000	0.142892	0.1	0.741938	11.0	2 473125	0.00011	5 000131	0.0000	0 884830	13.29049	2000	5	- 1	<u>.</u>	!	
		65.02463 13.49361	0.23 0.333332 3.374300	800726 6	107077	700007	0.411 0.7419381 2.5469031 0.6420561	0.00	0.37 2.473125 8.384865 2.145985	0.70 0.000 14 1.0	227762	4.10.01.1	0.4 0.884829 2.201027 0.811994	6.5 /3.29049 14.03002 /0.33040	44 90363	AGCI		スケワント	i	
		13.49361		0 186750	0.002908	00000	0.642056		2 145985		6 106197		0.811994	10.000	31053 37	7100	2			
		100	0.00	22 80423	00.40000	93 AE030	83.30/5	20.20	82.5655/		80.09244		74 18332	10.20070	73 20849	-	_	COMOLA		
		100	0.00	74 97537	0.00040	24 60046	30.3/41/	777477	12/28/12		19.44241		17.09464	1.00001	73 20940 14 80362 76 53046	200		COMOLATIVE ARCOVEY		
		100	100	86 50639	00.01007	21064	00.2307	7307	80.59464 40464		83.44866		77.34246	0.00	76 53046	200	2	VENT	ì	
		0.923100	200400	3 630643	0.7000	3 730075	0.007074	2 057074	4.104/2/	2027	0.4/0004	170004	5.6/14/1		6 57	۰	7	CONTO		
		100 0.923166 0.046407 0.074733	2040407	83 80433 34 97537 86 50639 3 630643 0.079452 3.5511	0.01	93 JED20 24 EDDAE 86 31964 3 739975 0 074261 3 66571	0.07074	20025 20147 86 2367 2 2002 7 2002 2	82.5655/1 2/.82/2/1 85.594641 4.104/2/1 0.0/23411 4.032100	0 070511	80.09244 19.44241 83.44866 5.478684 0.008737 5.40084	70707	74 183321 17.094641 77.342461 5.6714711 0.0665291 5.60294		0.07	+	- SA	1 2 2	CHAIR ATIVE CRADE	
		0.0/4/03	0 074750	3,55119	0.00	3 665714	0.70000	2 782222	4.032100	20100	7.400947	5 JOSO 7	0.00294	200	6.5		<u>A</u> C	ľ	7	

25MINUTES GRIND TIME 7MINUTES ROUGHER-11MINUTES SCAVENGER

TOTAL		Tail 7	07	27	S		G.	+	2	3	3	CZ	3	<u>Ω</u>			777	ED ACTION	
			ā	10	14		10.5	c	8	1	7	٥.٥	2			MIN)	-141	T MA	CUMULATIVE
1994		1532	Ç	22	30		48	٩	87	17	37	4	5	197		Ş			
48.6833	ı	3.064	0.000	980 0	0.06		0.2352	0.000	0 230V	0 + 100	0 4158	2.88.2	3	41.3109		TCL	44.0	WEIGHT(a)	
1 3416	+	0.9192	0.010	0 0064	0.024	2	0.0384	0.000	0 0696	0.05	0 007	0.01	2	0.19/	2	ASCu		2	AVE
47.3417	1	2.1448		0 0396	0.030	2025	0.1968		0 4698	0.000	0.3888	4.004	2 052	41.1139		AICu			AVEARGE
		2.0		0.2	0.6	2	0.49		0.62		- 5		7 48	20.37	30 07	C	4	_	
		0.00	3	0.08	2	80.0	0.08	3	0.08		0.1		01	ç	2	ASCU		GRADE(%)	
		1	2	0.12		0 13	0.41	, <u>:</u>	C.04		1.44		7.38	10.01	20.87	AlCu	;		
		0.2007.00	0 44 6 203730 68 51521	0.13557		0 12 0 123246	0.400120	0 44 0 482123 2 882254	1.10/9//	70707	1.44 0.854092		6.145845	1000	20 87 84 85641	2	3	쥬) 1
				1.96/0 0.00004/	0770	. 788909	2.002207	3 863354	3.10/033	207025	7707107	2000	7.38 6.145845 2.981515 6.235310		14 68396	2000	2	XECOVEX 1	
		1.00	4 530467	+	_	0.0/6043	+	0.415701	۲		0.021200			т	86.845	2	2		
			<u>6</u>	30.10020	30307 50	93.5/069	2000	93 44745	04.00.00	2000	91.000		91.00221 17.00047 30.0002 10.0002	2000	84 85641	_		COMOC	CHAIN ATIVE BECOVERY
			6	0	21 48470	R601C.67	2	27 72809	1.0000	24 86583	0.070	10.678 93.90178 16.9389	7.00047	4.7 CCE 4.7	14.68396		200	VE VECO	
			100	0000	95 46953	80.00008	20500	95 30984		94 894 14	00.00	93 90178	30.00002	2 02052	86.845		AC)
			2.441469		9 874307	0.010	10 61949	11.40183		02 06/32 24 86583 94 89414 12 89405 0.095043	0.000	16 9389	10.0002	18 60331	76.07		CL	001110	CIMIL
			100 2.441489 0.067262 2.37420	2007	02 70626 31 48470 95 46953 9 874307 0.091429 9.782879	93.57069 29.51699 95.56569 10.61646 0.652566 15.525	0.000308	93 44745 27 728091 95 30984 11.40183 0.093233 11.3000	2	0.095043		0		01	9	2	ASCU		CHMI II ATIVE GRADE
			7.3/4200	374300	9.782879	0.01	10 52618	.0000	2000	12.799		16.8389	0.00	18 59321	20.07	20 27	<u>A</u>		ਜ

