A technical and operational audit of the First ten years of the Teniente converter operations at Nkana smelter

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Synopsis

In 1994, Nkana smelter commissioned a multimillion US Dollar Chilean Teniente converter (CT) in its operations in order to improve its smelting technological base. The main objective was to reduce the overall smelting energy costs and increase the sulphur capture for sulphuric acid production to support the company's leaching operations at Nchanga tailings leach plant. A decade of CT operations have since ensued following its installation and start-up. This paper provides a technical and operational audit of the performance of the CT in the first 10 years of its operations at Nkana smelter.

The installation of the Teniente converter at Nkana smelter

Background

Faced with a declining copper and acid production, arising from using an ageing smelting technology which was becoming increasingly difficult to operate and maintain, involving mainly conventional reverbs for primary smelting and converters fitted with waste heat boilers, Nkana smelter decided to modernize its operating technology to secure its future copper and acid production. The Teniente technology was chosen as the one that best suited the criteria and the conditions existing at the time.

The total package of the Teniente technology transfer for Nkana smelter was originally meant to be implemented in 3 phases:

Phase 1—1 or 2 roof fired reverbs with evaporative gas coolers to replace WHBs —1990

Phase 2—1 Teniente converter (CT)—1994

Phase 3—Hot patching technology for the CT and PS converters—1995.

The 3-phase refurbishing programme was completed in 6 years spanning 1990 to 1995.

The main drivers in the criteria for Nkana smelter modernization was the increasing smelting costs associated with end wall fired reverbs and waste heat boilers and the overall industry acid requirements to support hydrometallurgical operations at Nchanga leach plant.

CT and auxiliary equipment at startup

At CT start-up, the major equipment in the smelter comprised 3 reverbs (3 x 11 x 30 m — 450 tpd concentrate treatment capacity), 4 standard Pierce Smith converters, 4 anode furnaces, 3 x 50 ton cranes, 2 x 1200 tpd low pressure air blowers, 4 high pressure (14 psi) compressors and an oxygen plant with a capacity of 500 tpd oxygen. Plant steam requirements were and are still being supplied by conventional reverb waste heat boilers, managed by the power plant engineering crew. Current steam demand for the Nkana complex is 15 t/h for refinery and 5 t/h for HFO heating. (See Table I)

Current equipment list and commissioning dates

1932	—2 conventional reverbs
1960	—4 anodes
1990	—1 oxy fuel reverb
1970	—1 oxygen plant
2003	—1 new CT water-cooled hood
2003	—Upgrading of the process control system—IA to PLC SCADA
2004	—1 flash dryer
2004	—1 unit for CT bone dry injection

Design features of the CT

Length:	18.5 metres
Diameter:	4.5 metres
Panels:	4
Tuyere pipes:	36 installed (20–30) operating
Tuyere diameter:	50 mm
Brick type:	magnesite-chrome

Purpose of the Teniente converter

The Teniente converter technology was partic-

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ularly attractive for Nkana because of the continuous nature of its operations to produce a steady gas for acid production and to use the resultant exothermic energy for free smelting of concentrates. The purpose of the CT was therefore to secure future copper and acid production and to reduce smelting costs by treating concentrates using free energy from converting reactions. In particular, the Nchanga high silica medium grade concentrates produced in large quantities at the time, were not considered good smelter concentrates.

The overall plant operating philosophy

The following process steps represented the overall Nkana smelter process philosophy at the time:

Concentrate smelting in reverbs to produce matte
Converting of matte with simultaneous smelting of concentrates in the CT to produce white metal
Finishing off white metal to blister copper in PS converters
Refining of blister copper to anode copper in anode furnaces.

Table I

Power plant air outputs at CT start-up

Description	Capacity: Installed	Capacity: Actual
Oxygen plant tpd	540	500
Compressed air Nm³/h	96000	90000
Mine air m³/h	48000	43000
Steam (one furnace) tpd	40	30

The CT was commissioned in August 1994 and operated for 9 years according to philosophy described above. The major emphasis over the period was matte supply, which was required in large quantities (above 40 ladles per day) to provide the heat energy to satisfy the heat balance for the targeted amount of concentrate throughput. In the tenth year, the flow sheet was modified upon the successful commissioning of the bone dry concentrate injection technology.

The smelter flow sheet has been modified over the years and the current flow sheet is presented in Figure 1, which incorporates the flash dryer and the bone dry concentrate injection system.

Important CT operations (design vs. actual data)

Table II gives the current CT performance data compared to the design, performance test data and the best performances in green charge operation and with bone dry concentrate injection mode.

CT concentrate blends—% 1994–2004

Table III presents the various concentrate blends that have been treated through the CT in the last 10 years. Originally, only copper concentrates and matte were expected to be treated in the CT. But with dwindling matte supply, poor quality concentrates, and increasing slag quality control problems arising from the high silica content of KCM concentrates, pyrite found itself playing a major role in slag chemistry and slag viscosity control. These pyrite additions were in small quantities averaging not more than 5% of total charge input, but in 2003 pyrite treatment increased to 50%

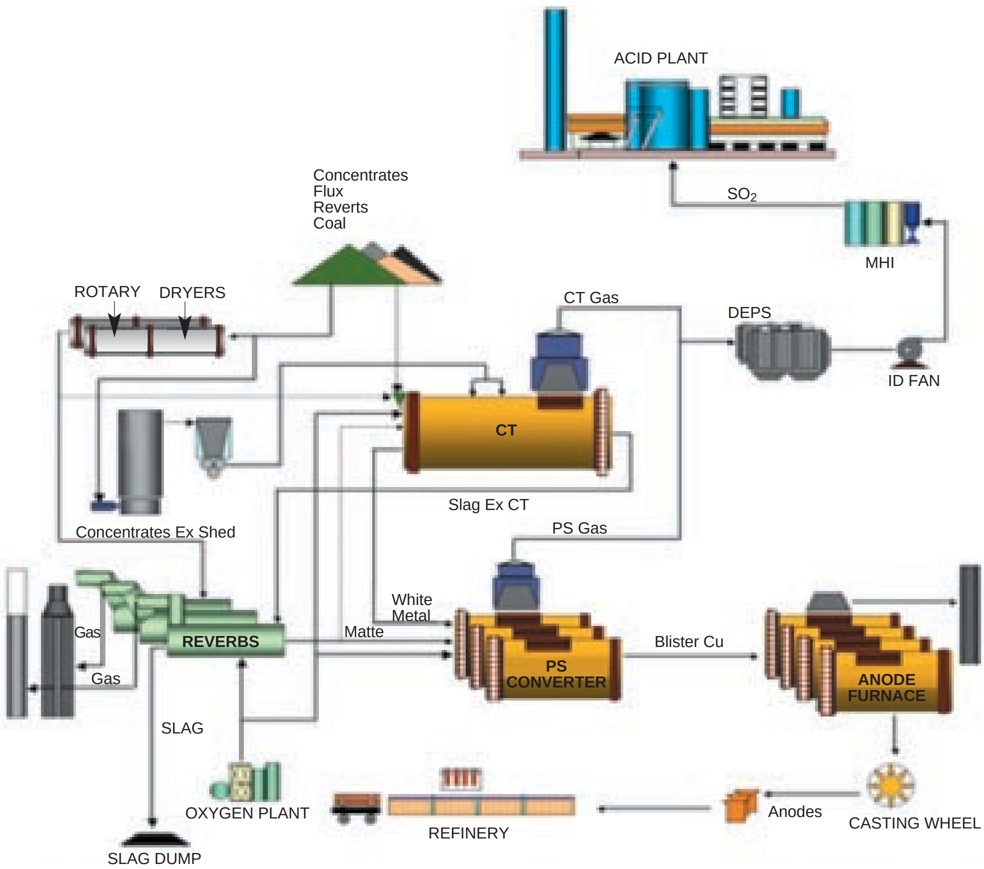


Figure 1—Current Nkana smelter process flow sheet

Table II

The current CT performance data compared to the design and performance test results

Parameter	Units	Design with green charge	Performance test 14/09/94	Best performance with green charge 22/02/04	Best performance with BDC 08/05/04
Concentrate treatment	tpd	500	595	672	774
Concentrate blend ratio Nchanga/Nkana/pyrite	%	100/0	50/50	55/36/9	55/36/9
Matte supply	tpd	1244	874	437	362
Matte grade	%Cu	53	52	57	60
White metal production	tpd	1065	837	400	588
White metal grade	%Cu	75	74	77	76
Slag	tpd	590	576	558	540
Flux	tpd	60	100	35	36
Reverts	tpd	0	0	46	201
LP air blowing rate	tpd	1220	785	695	811
LP air flow rate	Nm^3/min	650	418	370	430
Oxygen	tpd	127	62	87	125
Oxygen enrichment	%	32	27	29	34
Garr gun air	tpd	50	77	75	60
In-stack time	%	85	98.6	95.6	90.2

Table III

CT blend over 10 years

Concentrate	1994–1996	1997–2000	2001–2003	2004 January–April	2004 May–June
Nchanga MD	50–60	70–80	0–10	0	0
Nchanga HG	0	0	40	50	35
Nkana	50–40	30–20	10	30	24
Pyrite	0	0	0–50	7	0
Reverts—crushable	0	0	0	13	18
Copper chunks	0	0	0	0	23
Total	100	10	100	100	100

of charge in a bid to increase the sulphur content of the off-gas for the acid production in the acid plant. The new operating initiatives have included the treatment of reverts comprising matte shells, white metal shells and copper chunks as a normal part of the CT operation, as seen in Table III.

Operating CT slags and the Fe/SiO_2 ratio of CT slag

Table IV shows the chemical analysis of the CT operating slag compared to the PS converter and reverb slags. The CT slag is composed of fayalite and has an operating Fe/SiO_2 ratio of 1.3 to 2.0. CT slags tend to be viscous and difficult to flow when this ratio falls below this operating range.

CT original operating philosophy was a green charge operation

The CT was originally designed to treat 500 tpd of Nchanga concentrates using 1244 tons[3] ladles of matte, (Reference 3). This was later changed to a practical concentrate blend ratio of 60:40 Nchanga to Nkana concentrate for normal operations. However, a blend of 50:50 Nchanga to Nkana concentrates was used on the commissioning day, with 38 ladles of matte and 595 tonnes of the blended concentrates being smelted[3]. The CT design and performance data for specific periods is presented in Table II.

Process control

The CT was commissioned with an intelligence automation (IA) system as the tool for monitoring and controlling the process variables. The critical controlling parameter is the need to produce white metal grade at 75% copper grade. The heat balance is obtained by balancing the feed concentrates, matte input and the blowing rate. Refinements can be obtained by adjusting the oxygen enrichment. Failure to control any of the inputs can lead to a major process upset. Coal can be added in cases of severe matte shortage to satisfy the process heat requirements and reduce magnetite content of the slag.

In September 2003, the IA was replaced by a SCADA and PLC for monitoring and controlling the CT operations. The metallurgical process parameters for mass and heat balance are computed using the METSIM model by the plant metallurgists and the targets and set points are provided to the operators to implement.

Air blowing rate and pressure

The low pressure air supply to the CT is provided by one of two electrically driven turbo blowers rated at 650 Nm^3/min

Table IV

Chemical analysis of current CT slag compared to PS converter and reverb slags

	%Cu	%Fe	%S	$\%SiO_2$	$\%Fe_3O_4$	%CaO	$\%Fe/SiO_2$
CT slag	5.6	40.4	2.8	26.7	22.5	2.4	1.5
PS converter slag	2.5	42.3	4.1	27.5	20.4	1.1	1.5
Reverb slag	1.4	29.2	0.5	38.8	3.1	0.3	0.8

and 110 psi (14 psi) at the tuyeres, driven by a 1420 kw (! 900 hp) motor. When one blower is operating, the other acts as a stand-by. The actual blowing rate varies between 330 and 475 Nm^3/min depending on the production targets.

Management of the CT

The CT and flash dryer are currently managed as one section under the overall control of a unit controller. The total labour force on the CT is 11 per shift and 3 shifts per day, the structure being as follows:

Shift manning structure (8 hours per shift basis)

1 unit controller—CT and flash dryer
1 CT foreman—part time – links with converters and aisle foreman
1 CT outside operator—responsible for hood cooling system
3 white metal tapping attendants
2 slag tapping attendants
2 punchers
1 garr gun attendant also serves as belt attendant.

Engineering and maintenance personnel

The section has a dedicated maintenance crew comprising a full time section engineer, planner, two boilermakers and two fitters. The section engineer reports to the resident engineer who is also responsible for PS converters, anodes and reverbs in addition to the CT.

Further technological changes to CT operations—bone dry concentrate Injection

On 28 March 2004, Nkana smelter commissioned a flash dryer and bone dry concentrate injection into the CT. These are in addition to technologies in line with Nkana smelter's overall plan to reduce smelting costs. With the bone dry injection system, the CT concentrates treatment increased tremendously. The highest throughput that has been achieved so far was on 8 May 2004, when 774 tons of concentrates were treated.

Review of CT operational campaigns in the first ten years 1994–2004

In the period September 1994–2004, which marks its first ten years, the CT has completed a total of 7 campaigns or complete refractory overhauls. The details of these campaigns are presented in Table VII.

In the first 10 years of its operation, the CT was operated with a green concentrate charge fed through the garr gun. The concentrate charge, with 8 per cent moisture and blended to a required Nchanga to Nkana and other concentrate ratios and silica with 4 per cent moisture and 96 per cent free silica, were drawn from bins by feeder belts fitted with weightometers. The main feeder belt discharged the material using a garr gun. The molten matte at 50–60 per cent copper was added intermittently through the mouth to maintain the heat balance. The total amount of concentrates that could be treated depended on several factors such as the following:

The blowing rate, which related to the oxygen enrichment used
Moisture of the concentrate and flux
Matte grade, which relates to the heat content of the matte
In-stack time or blowing time of the CT
Concentrate charging time
Final target white metal grade.

A typical mass balance across the CT with green charge is presented in Table Vb (10 February 2004) where the operating conditions, inputs and outputs are summarized.

Use of pyrite and coal in the CT

For period 1994–2000 or ZCCM era

The use of pyrite and coal in the CT was discouraged as general policy during this period. It was always pointed out and argued that such usage would overlap into the Noranda technology and practice, which was patented in Zambia and would cause problems. Slag quality control and, in particular, the Fe/SiO_2 ratio of the slag was met by carefully blending the available copper concentrates in the industry to make suitable charges.

For period 2001–2003 or prior to concentrate injection period

This coincides with the period the Nkana smelter was directly under Anglo American. There was a general shift in policy and pyrite was considered a concentrate and was heavily budgeted for use in the CT for slag quality control. The use of coal was liberalized and coal was used according to situational requirements and on a case-by-case basis. In mid 2003, with changes in smelter management, pyrite became a major input into the CT. The objective was to attempt to wean the CT of matte as the general vision then was to have a one reverb with Ct operation in the plant trials running July – September 2003, the CT charge carried consisted of up to 50% pyrite and up to 200–250 tpd of pyrite was consumed together with 200–250 tons of concentrates. Coal was used for heat balance and for magnetite control. These trials were not very successful in general as the plant faced unstable process conditions. The slag volume was high and the quality was poor as magnetite was high. Plant control was difficult and CT foaming became common. This resulted in low plant availability and low productivity.

Major operational problems experienced over the years

Process control problems

The initial problems with process control were due to lack of experience by the operators to match the blowing rates and oxygen enrichment with the material inputs and outputs. This was responsible for the inability to operate the CT to the required 75% white metal grade. The normal was 70–73%, which caused problems in the PS converters, mainly:

The build-up of residual slag as magnetite during white metal blows led to tuyere blockages, hard reaming, and excessive tuyere wear rates
Reduction in the treatment of secondary copper bearing materials.

Fast tuyere wear rate

The major mistake committed in the first campaign was to commission the CT without a hot repair system for the PS converters and without mechanical punching machines. This resulted in reduced PS converter life from 200 cycles matte blows to 60 cycles per tuyere line repair in white metal bows. PS converter availability reduced from 90% to 40%, as maintenance personnel could not cope with the rate of wear. It took an average 21 days to repair just the tuyere line.

1995—Implementing the converter hot repair technology

Due to the reduced PS converter availability brought about by processing white metal, the converter hot repair technology (also from Codelco) was introduced in 1995 to enable the replacement of a complete tuyere line and surrounding refractory brick work within 72 hours instead of the 21days previously.

Excessive revert generation

The difficult problem for Nkana smelter associated with the CT was excessive revert generation and accumulation of huge process stocks whenever the CT was operational. The reverts arise from white metal ladle skulls and dirty converter mouths. This is worsened by periodic dumping of converters, which creates a large proportion of high-grade reverts.

This problem, however, has been resolved finally (May 2004) as the smelter has arrested the revert generation using better skills in heat balance management and they have found a way of dealing with excess revert stocks by treating them in the CT.

CT burn-throughs in 2002

In 2002, the CT suffered 2 burn-throughs. The first burn-through, which was particularly severe, took place in May 2002. The poor furnace and operating conditions in place in the first burn-through were probably the cause as illustrated below:

- High pyrite and coal addition
- Low magnetite in slag (down to 3–5% Fe_3O_4)
- Operating the submerged burner
- Short brick work below 6 inches in some places.

The second burn-through took place within one month of CT major overhaul. This was attributed to poor refractory bricks.

Concentrate and matte feeding system

Figure 2 shows a general layout of the CT and the material inputs and outputs. In normal operations, currently 80% of the concentrates input are injected into the vessel, the remainder is wet concentrates with 8% moisture, which is fed from the bins and used for temperature control. Silica flux with 96% free silica is drawn from an independent bin onto a feeder belt with a weightometer. The wet concentrates, flux, crushable reverts and coal are discharged into the CT through the garr gun.

White metal tapping and slag skimming

White metal at 74–79% copper and at 1220°C is tapped manually by lancing with oxygen, from a 75 mm diameter water cooled tap hole located 1.95 metres from the centre of the converter. The tap hole is closed manually with a dolly bar when a ladle (23 tons) is filled. Normally 8 ladles of white metal are tapped per shift. Slag is skimmed through a water-cooled tap hole positioned at a higher level in relation to the white metal tap plate. Normally 10 ladles of slag (18 tons) are skimmed per shift. For matte and slag analysis, refer to Tables IV and Va and Vb.

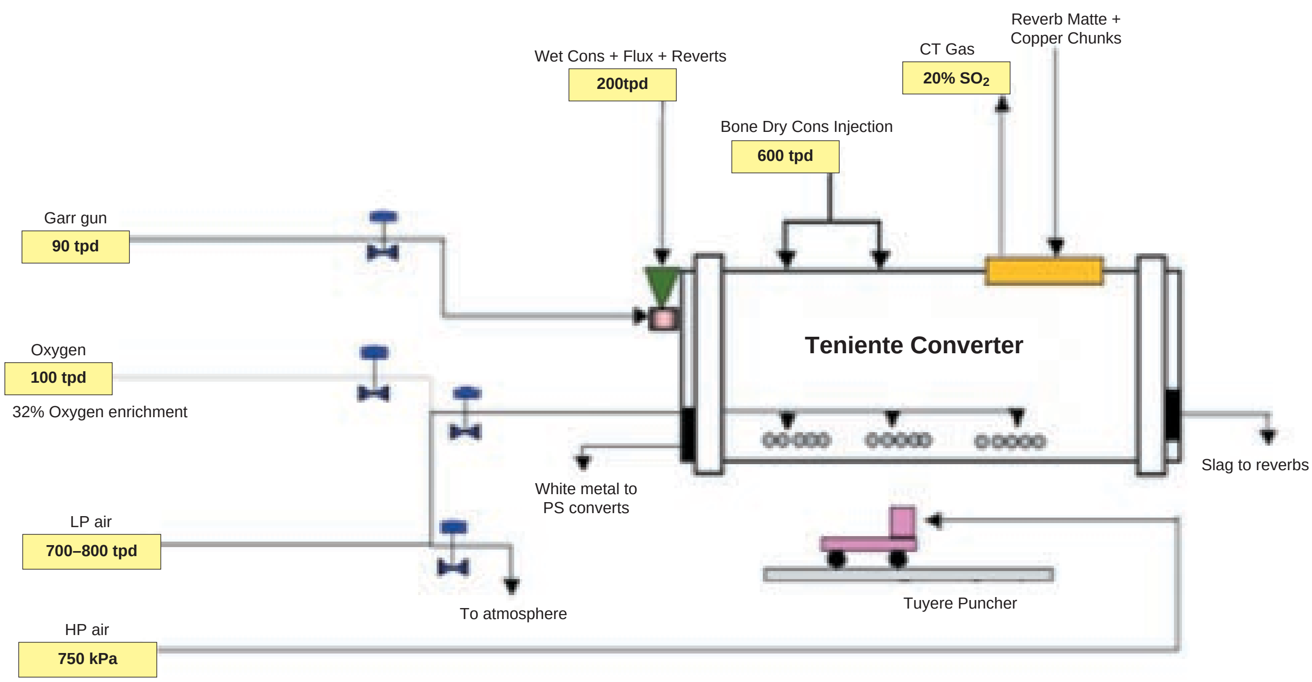


Figure 2—CT mass balance with bone dry concentrates injection

Table Va

CT mass balance–with bone dry concentrate

	tpd	%Cu	%Fe	%S	$\%SiO_2$	$\%Fe_3O_4$
Inputs						
Concentrate	774	37.2	17.1	23.0	15.6	-
Matte	362	56.4	23.1	22.8	-	3
Reverts	201	36.1	20.1	13	8.8	5.2
Flux	36	-	-	-	95.2	-
Total inputs	1373	-	-	-	-	-
Outputs						
White metal	588.0	75.2	9.1	18.4	-	0.9
Slag	540.0	5.6	40.4	2.8	26.7	22.5
Dust	6	24	-	-	-	-
Total outputs	1134	-	-	-	-	-

Table Vb

CT mass balance–with green charge concentrate

	tpd	%Cu	%Fe	%S	$\%SiO_2$	$\%Fe_3O_4$
Inputs						
Concentrate	589	37.24	17.1	23	15.6	-
Matte	713	56.4	23.1	22.8	-	3
Reverts	131	36.1	20.1	13	8.8	5.2
Flux	39	-	-	-	95.2	-
Total inputs	1472	-	-	-	-	-
Outputs						
White metal	675	75.2	9.1	18.4	-	0.9
Slag	630	5.6	40.4	2.8	26.71	22.5
Dust	73.6	24	-	-	-	-
Total outputs	1378.6	-	-	-	-	-

Table VI

CT charge blend with reverts and copper chunks achieved on 6 June 2004

Wet concentrates (after drying)	166 tons
Bone dry concentrates	456 tons
Crushable reverts	193 tons
Copper chunks	242 tons
Total treatment	1052 tons

The treatment of high-grade reverts and copper chunks in the CT

On 14 May 2004, an innovative idea struck the smelter management to treat in the CT the high-grade reverts and copper chunks, which accumulated to about 10000 tons of crushable materials and 4000 tons of copper chunks over a period 6 of months following a period of poor aisle operation.

The idea was tried on the night shift when five boats weighing approximately 4 tons each were treated successfully. The following morning, copper chunks in the form of anode slag buttons and heavy spoon scrap were tied on ropes and dropped in the CT one by one. Over a period of two weeks, a total of 2000 tons of copper chunks and 4 000 tons of crushable reverts were treated in the CT. The remainder of the reverts were treated in the following month of June 2004.

The operating conditions that existed on that day were such that with bone dry concentrates being injected at a rate of 40 tph, the furnace temperature rose to 1250°C while the white metal grade lowered to 72–73% copper. The challenge was to control the furnace temperature and normalize the white metal grade and other operating parameters. In May and June 2004, a typical CT through-put would comprise a charge blend such as the one given in Table VI, treated on 6 June 2004.

Treatment of matte shells and white metal shells in the CT

The latest handling method for matte and white metal shells in the converter aisle is to treat them in the CT directly after shelling. This has eliminated double handling of reverts and is expected to improve copper recovery. It has also helped with the house-keeping because any new arisings are easily identified and handled expeditiously. This practice was started in July 2004 and it was done as an extension of the copper chunks treatment programme.

CT constraints under bone concentrate injection operation (See Figure 3)

CT-related activities

Gas capture and cleaning

Figure 4 presents the gas collection and cleaning plant. At a blowing rate of 700–800 tpd low pressure air (LP-Air), the gas flow rate off the CT mouth is of the order of 25 000 Nm^3/h and a temperature of about 1220–1240 degrees centigrade. The gas is captured in a water-cooled hood and cooled in a gas chamber where sonic water sprays are introduced. This process is continued in the evaporative cooling chamber (ECC) where additional water sprays are located. The hood is designed to give the gas a maximum 100% dilution with infiltration air around the mouth. It is provided with a sliding door in front and a moveable flap in the back to assist in controlling the air infiltration. The cooling water flow to the hood is 1200 Nm^3/hs, which help to maintain its structural integrity and reduce the off-gas temperature. A draft of 0.05 kpa is maintained at the hood so that the hot gas leaving the CT is chilled to 675°C by the hood and dilution air as it leaves the hood into the CT

Codelco, of Santiago Chile, designed the original CT hood, but Zambia Engineering Services based in London and installed by ZCCM under a separate arrangement designed the rest of the gas-handling system. The hood cooling water system was lost within the first two years of its operation. This was caused by corrosion of the water pipes and panels on the hood, as there was no system for monitoring the water quality.

The ECC operations

In the next seven years that followed, the CT operated without water-cooling on the hood. During this period, the hood and the ECC experienced severe pressurization and high gas temperatures that ranged from 750–800°C against the design of 615–675°C. The increase in the ECC temperatures meant that more water had to be released by the sonic system to maintain the ECC temperature below the design 390°C. The excess water input upset the water balance in the gas cooling section and disturbed the operation of the acid plant.

Constraint	Hours	% Distribution
Working and repairs on the concentrate injection tuyere pipes	64.1	48
Power plant blower failures	5.5	4
Power plant compressor trip-outs	14.5	11
Mechanical repairs	16.4	12
Repairs on the CT charge feeder conveyor	16.0	12
ID' fan trip-outs.	10.5	8
Plant power failure	6.25	5
Total	**133.3**	**100**

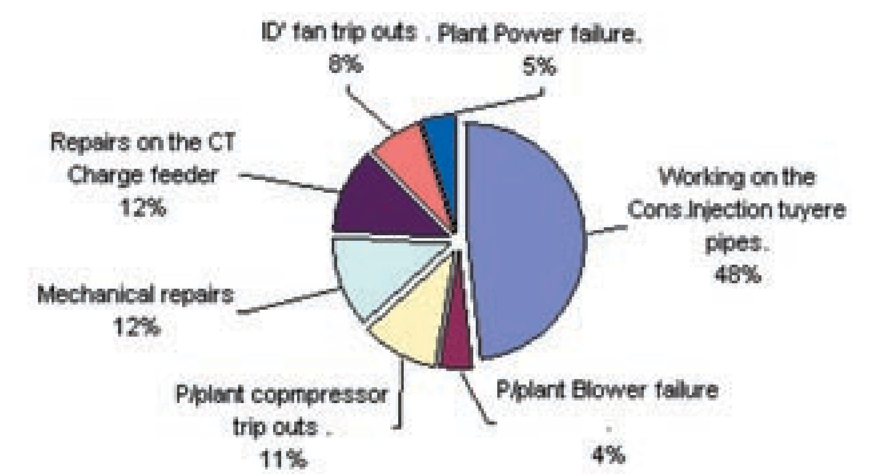
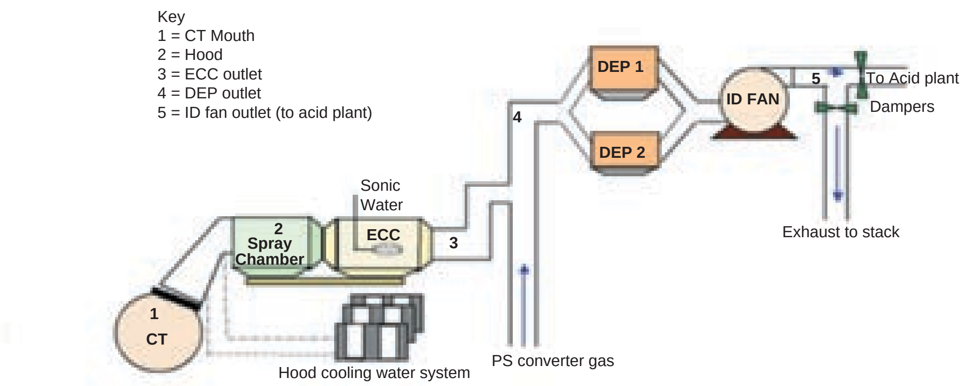


Figure 3—CT lost-time hours and down time in June 2004



PARAMETER	1	2	3	4	5
Flow (Nm^3/h)	25 000	50 .000	50 000	90 000	117 000
Temperature (°C)	1220	675	390	280–350	280–350
Pressure (KPa)	0	-0.01	-0.05	-0.45	+4–6
Gas strength (% SO_2)	20	10	10	7–8	5–6

Figure 4—The modified CT gas collection and cleaning system

The ECC modifications

In September 2003, a new water-cooled CT hood was commissioned, complete with a water treatment chemicals programme to monitor the pH and TSS, biocide content and to monitor the nitride levels.

The ECC was extended to include a spray chamber and the gas ducts were modified such that the CT gas and the PS converter gas join before entry to the dry electrostatic precipitator. The PS converters have a facility to vent the gas directly to the atmosphere using exhaust fans. This facility was removed for the CT gas system and instead a return leg to the PS exhaust fans was provided immediately after the DEPs. From the ECC, the gas enters the high velocity duct at a speed of 15–20 m/s under the action of the induced draft fan (ID fan), to two DEPs where it can be diverted to stack or the acid plant.

Dust collection and efficiency

The CT off-gas is treated in two DEPs where the inlet dust loading is reduced from 8–20 g/Nm^3 to 0.2 g/Nm^3. The dust carry-over is about 2% of the total dry solids charge. The dust is collected in the hoppers at the bottom of the units and is recycled to the concentrate storage shed. The dust collection efficiency at the DEPs is 95–98%. With the commissioning of the concentrate injection system, the dust carry-over from the furnace to DEPs has reduced tremendously from 15 tpd with green charge to 3–4 tpd with bone-dry concentrate operation.

Acid production

One of the major attraction of the installation of the CT was its great potential for gas capture, which was at 70% by design across the CT and the PS converters. The gas is used to manufacture sulphuric acid required to support KCM's copper production in the tailings leach plant at Nchanga Mine in Chingola.

From the data presented in Tables VIIa, VIIb and in Appendix II, the great contribution of the CT to acid production can be seen. The acid production with CT operating most of the time has increase to above 550 tpd from about 350 without the CT. The acid to copper ratio is 1.0 with the CT operating compared to 0.6–0.7 without the CT (see Appendix II).

Generally, the acid production process is greatly improve by the steady and continuous supply of sulpher dioxide from the CT. Nkana smelter will benefit from this potential as the CT takes a more central role of treating the majority of concentrates with bone dry injection than in the past.

Review of acid production vs. CT in-stack time over the last ten years

The overall performance of the CT with regard to acid production is presented in Appendix II and in Tables VIIa and VIIb. The best scenario for maximizing acid production is to run the CT and a copper blow on the converters and most of the time if possible. This gives the highest probability, the highest gas strength and a good gas flow for good acid production.

By inference, this means that acid production is promoted by more copper blows that take place in the smelter. Attempting to treat more pyrite in the CT for acid production should always be carefully done such that it does not displace the copper concentrates or the net copper input required for more copper blows. To a large extent, massive pyrite treatment in the CT will produce neither the copper nor the acid and should be avoided.

Engineering performance and maintenance

The 8 CT campaigns

Table VIII presents the relevant engineering data for the 8 campaigns for the life of the CT at Nkana to date. The longest campaign was the third campaign, which lasted 2 years.

CT overhauls

The CT major overhauls are planned and conducted in such a manner that two minor overhauls are conducted from major overhaul to major overhaul. In between minor overhauls, 3 hot repairs are conducted between the minor overhauls. Nowadays, only two hot repairs or tuyere line replacements are allowed per annum. A major overhaul involves a total replacement of all the brickwork, replacement of the mouth parts and replacement of the hood panels. There would also be a general maintenance and clean-up of the mechanical, electrical, instrumentation and lubrication system of the unit.

Table VIIa

Acid production without CT

Converter	Duration h/day	Probability %	Gas strength %SO_2	%O_2	Gas flowrate Nm^3/hr
PS slag only	6.5	27.1	2.5	18.5	55 000
PS Cu only	6.5	27.1	5.5	15.5	70 000
2PS slags only	0.5	2.1	3.0	18	90 000
PS Cu and PS slag	0.5	2.1	8.4	12.6	117 000
PS Cu and PS slag	9.0	37.5	6.5	14.5	110 000
Nothing blowing	1.0	4.2	-	-	-
Total	**24.0**	**100.0**	**-**	**-**	**-**
Total acid production per day			**321**	**tons**	

Table VIIb

Acid production with CT

Converter	Duration h/day	Probability %	Gas strength %SO_2	%O_2	Gas flowrate Nm^3/hr
CT only	6.1	25.4	4.2	16.8	62 000
CT + 1 PS Cu	12.4	51.7	7.3	13.7	114 000
CT + 1 PS Slag	1.8	7.5	5.0	16	72 000
CT + 2 PS Slag	0.1	0.4	4.7	16.3	113 000
CT + 2 PS Cu	0.1	0.4	8.7	12.3	117 000
CT + 1 PS Slag + 1PS Cu	0.3	1.3	7.5	13.5	117 000
Nothing blowing	3.2	13.3	-	-	-
Total	**24.0**	**100.0**	**-**	**-**	**-**
Total acid production per day			**557**	**tons**	

Table VIII

CT Campaigns for 1994 to 2004

Campaign No. Parameter	1 September 1994– November 1995	2 November 1995– September 1996	3 September 1996– August 1998	4 August 1998– June 2001	5 June 2001– May 2002	6 May 2002– August 2002	7 August 2002– July 2003	8 July 2003– Todate
Operating days	261	287	479	37	146	18	263	182
Major repairs/year	1	0	0	0	0	1	0	0
Minor repairs/year	0	1	1	1	1	0	1	1
Unscheduled maintenance	69	43	52					
Tuyere line replacement	2	3	4	3	3	2	2	1
Operational availability	80	87	90	44	64	74	70	
Refractory consumption Kg/Co	5.6	4.7	2.6	5.5	0.52	8.44	0.68	

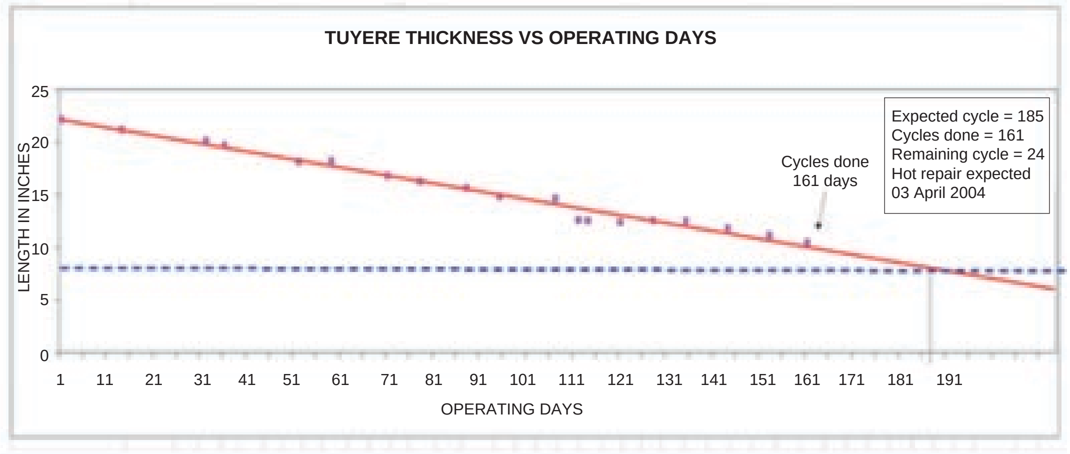


Figure 5—CT Tuyere line measurements and refractory performance

Minor repairs

The CT minor overhauls are planned for 330 operating days per annum. The CT is shut down once a year for a minor overhaul, depending on the extent of the wear, but usually the following repairs are performed:

- Replacement of the mouth-parts
- Replacement of worn out panels
- Replacement of the tuyere line and worn out parts
- Conduct a general maintenance around the systems units.

Tuyere line measurements and thermogrames

These measurements are conducted on a weekly basis. The best tuyere performance was achieved in the first tuyere line operation of the 7th campaign installed on 19 September 2003 that lasted 161 operating days or 5.4 months before replacement.

Safety factor and refractory performance

The safety factor is the minimum refractory brick length that must be retained to protect the steel shell of the converter and reduce the heat loss. According to experience at Nkana smelter, the CT safety factor is 15.24 cm (6 inches). This performance was achieved with CT on green charge operation. Our observation with bone-dry concentrates injection operations are that a tuyere line lasts only 3 months.

General smelting results over ten years

The CT performance data and results are presented in Appendices II and I. From these results, it is observed that the furnace performed well in the first three years after commissioning. Thereafter, a period of poor operations was experienced, resulting from reduced matte supply and inputs such that the CT operated outside its normal design parameters.

1998—The CT submerged burner (not used currently)

The submerged burner in the CT was an innovative idea developed by Nkana smelter metallurgists in May 1998, specifically to meet the shortfall in the CT energy requirements. Operating with HFO and HP air, the burner increased the smelting rate and the in-stack time considerably for the same matte supply. The submerged burner also served to reduce the magnetite in the CT slag from 28% to 20%.

Central role of the CT

However, in 2004, with modifications to the process following the successful commissioning of the flash dryer and bone dry concentrate injection system, the role of the CT at Nkana smelter took a critical and central position. The throughput increased tremendously to two-thirds of the total concentrate treatment, leaving the reverbs only on slag cleaning duty.

Achievements

The impact of the Teniente converter on the Nkana smelter performance

The following benefits have been realized from the CT:

Reduction in overall smelting energy

With the commissioning of the bone dry concentrate injection into the CT, the whole operating philosophy has changed such that now two-thirds of the total concentrate input is smelted in the CT and only one-third in the reverbs. The overall smelter energy utilization has progressively improved since commissioning. The energy requirement is now 150 tons of coal equivalent per 1 000 tons of concentrates smelted compared to 300 tons without CT, an improvement of 100%.

Provision of increased capacity and flexibility in smelting concentrates

The CT now has capacity to smelt 20 000 tons of concentrates per month compared to 6 000–7 000 tons in the past, and a clean-up capacity for 9 000 tons of reverts per month. The CT operation is easy and flexible. The furnace can be brought up to full stable operation within four hours from zero operation. The treatment rates can be varied over a wide margin and the inputs can be very diverse from green charge to 100 % bone-dry concentrates and reverts.

Acid production from smelter gas

Acid production without the CT is 300 tpd and 500 tpd with the CT during a stable operation. Acid production is improved by steady supply of sulpher dioxide from the CT.

Short converter cycles with white metal operation

The white metal operation from the CT has eliminated the slag blow stage in the PS converters and has increased the PS converter availability by 50%. Consequently, the number of PS converter requirement at 2, is one converter fewer at the current level of production.

Clean environment

The CT smelting technology is cleaner compared to the reverbs and it provides a higher sulphur dioxide concentration and capture. Presently the sulphur recovery has improved from 35–40% to 60–70% with normal CT operation.

Conclusions

- The CT has been a successful project and its operation after the introduction of the flash dryer and bone dry concentrate injection into the CT has demonstrated a great potential. The increased smelting capacity will enable Nkana smelter to phase out two operating reverbs and remain with one reverb that will be saved as a slag-cleaning vessel. This will effectively reduce smelting energy requirements and the overall cost of copper production
- The CT technology has a high sulphur recovery and has resulted in an increase in acid production to support copper production at KCM's TLP
- From the environmental point of view, the CT is a clean technology; the increased sulphur recovery has reduced sulphur emissions to satisfy Nkana smelter's environmental legal requirements
- The CT is flexible in the options of the quality of the feed materials and operating parameters. It ability to operate on both green charge and bone-dry concentrates has surpassed the imagination of the Nkana smelter metallurgists.

Future plans

The smelter stability theory for copper and acid production

A review of the smelter performance in the last two years shows a pattern of consistent failure to meet production targets in both copper and acid production. Specifically, the smelter converter aisle needs 2 extra copper blows to achieve the required output expected of Nkana smelter. As for acid production, it is generally observed that 25% of the time the plant is idling due to no smelter gas, which is the main reason for the high fuel cost at the preheater. An additional 2 copper blows in the smelter could produce an additional 250 tpd of acid in a plant rated at 1 000 tpd but producing nominally 450 tpd on average.

Bone dry concentrate injection in PS5

Considering the above, it is proposed that the 2 elusive copper blows in the converter aisle should be obtained from a PS converter modified to have bone dry concentrate injection during slag blow stage. Such a process would involve blowing the converter on 3 matte ladles and then injecting the bone dry concentrate to bring up the white metal level to a cleaning-off stage, where the charge would be finished off in a normal manner. The process can then be repeated in the day as required.

An ideal vessel would be the PS5, which has the provision for proper fluxing facilities from the hood. Such a converter would also take in grisly reverts as cold dope. My view would be to assess urgently the possibility of commissioning the PS5 with BDC injection system. The existing capacity of the flash dryer and the concentrate pneumatic transfer and injection systems would still be able to satisfy the new converter requirements.

Improvements in gas capture and recovery

It is be expected that at least 200 tpd of concentrates would be treated in this vessel. This will undoubtedly increase the sulphur capture and recovery, more so than by treating the concentrates in the reverbs, a matter that would be environmentally friendly and go a long way to help KCM meet its Environmental regulations.

Electric furnace slag cleaning facility

Nkana smelter will benefit and operate better with a better slag-handling facility. Presently, one reverb is not able to handle all the CT slag, forcing the smelter to operate two reverbs at a time when the smelter is striving to reduce smelting energy and save costs. In this regard, it is recommended Nkana installs a single vessel, such as an electric furnace, close enough to the CT for slag cleaning.

It is also recommended they introduce a slag granulation facility alongside the slag-cleaning furnace to reduce difficulties in slag handling and reduce slag-handling costs that are currently in the order of 3–4 c/lb.

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APPENDIX Ia

CT CAMPAIGN DETAILS FROM 1994 - 2003

C . T. YEAR 1994 CAMPAIGN DETAILS.

	Jan-94	Feb-94	Mar-94	Apr-94	May-94	Jun-94	Jul-94	Aug-94	Sep-94	Oct-94	Nov-94	Dec-94	TOTAL
CONCETRATES TREATD (DRY).							2054.43	4633.97	6001.40	7837.19	2719.32	5778.75	29025.06
MATTE LADLES.							163.00	389.00	435.25	692.25	254.50	457.25	2391.25
Cons/Matte Ladle							12.60	11.91	13.79	11.32	10.68	12.64	12.14
WHITE METAL LADLES							116.00	303.75	319.00	497.75	160.75	358.50	1755.75
OXYGEN USED.(T)							297.40	537.59	710.70	1181.02	379.70	856.40	3962.81
FLUX TREATED.(T)							492.20	905.46	438.00	270.83.	478.30	951.89	3265.85
INSTACK TIME.(%)							12.76	28.14	42.09	55.13	19.27	26.58	30.66
NEW COPPER	13608	7925	9897	9814.00	11817	10433							
TOTAL ACID PRODUCTION	15274	10226	11081	9412.00	16068	17145	14860.00						
ACID TO COPPER RATIO	1.12	1.29	1.12	0.96	1.36	1.64	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ACID PRODUCTION (NO. 4 A/PLANT)	7498	5976	7460	6805.00	7892	7800	8075.00						
C.T OPERATED DAYS													

C . T. YEAR 1995 CAMPAIGN DETAILS.

	Jan-95	Feb-95	Mar-95	Apr-95	May-95	Jun-95	Jul-95	Aug-95	Sep-95	Oct-95	Nov-95	Dec-95	TOTAL
CONCETRATES TREATD (DRY).	8126.13	9053.07	5721.87	7797.84	8352.88	4919.96	7101.78	940.26			3095.52	11140.37	66249.68
MATTE LADLES.	699.5	787.5	420	653.50	799	573.75	698.25	216.50			262.25	684.50	5794.75
Cons/Matte Ladle	11.62	11.50	13.62	11.93	10.45	8.58	10.17	4.34	#DIV/0!	#DIV/0!	11.80	16.28	11.43
WHITE METAL LADLES	548.25	567	296.75	460.75	502.5	348.5	457.50	132.00			177.50	540.25	4031.00
OXYGEN USED.(T)	1545.73	1807.1	881.9	1514.50	1463.38	894.1	1023.45	246.76			309.00	712.80	10398.72
FLUX TREATED.(T)	822.3	766	147	718.30	1036.3	418	727.50	420.60			340.10	1985.90	7382.00
INSTACK TIME.(%)	55.76	72.84	40.26	67.67	63.64	52.12	68.68	18.44			24.66	70.68	53.48
NEW COPPER				11346.00	10723	11302	11593.00	9042.00	7422.00	7748.00	5247.00	12076.00	86499.00
ACID PRODUCTION													
ACID TO COPPER RATIO	#DIV/0!	#DIV/0!	#DIV/0!	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C.T OPERATED DAYS								11.00	0.00				
Cons dry Tons per day													

C . T. YEAR 1996 CAMPAIGN DETAILS.

	Jan-96	Feb-96	Mar-96	Apr-96	May-96	Jun-96	Jul-96	Aug-96	Sep-96	Oct-96	Nov-96	Dec-96	TOTAL
CONCETRATES TREATD (DRY).	8354.57	6601.11	11501.8	8175.96	9346.1	8444.5	9810.42	10083.20	9058.04	74.40	9544.35	6838.35	97832.84
MATTE LADLES.	519.75	443	713	508.00	825.75	898.75	998.00	1081.25	1073.75	14.00	680.50	717.75	8473.50
Cons/Matte Ladle	16.1	14.9	16.1	16.1	11.3	9.4	9.8	9.3	8.4	5.3	14.0	9.5	11.5
WHITE METAL LADLES	372	340	553.5	370.75	562	602	660.75	727.50	717.50	9.00	417.00	395.50	5727.50
OXYGEN USED.(T)	2003	1548	2690	1382	1674	2077	1428	1596	2113	15	1149	842	18518
FLUX TREATED.(T)	767	1161	1862	1021	1389	1935	1363	1437	1054	25	1624	1196	14833
INSTACK TIME.(%)	60	55	82	50	69	73	71	75	82	1	64	59	62
NEW COPPER	9451	10599	10423	11297	12753	12414	13907	13248	12102	5430	7736	8154	127514
ACID PRODUCTION	9515	9513	9291	10941	12223	11219	13125	10790	11006	236	8226	8074	114159
ACID TO COPPER RATIO	1.0	0.9	0.9	1.0	1.0	0.9	0.9	0.8	0.9	0.0	1.1	1.0	0.9
C.T OPERATED DAYS	30	24							30.00	1.00	30.00	31.00	146.00
Cons dry Tons per day	278.486	275.046	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	301.93	74.40	318.15	220.59	670.087945

APPENDIX Ib

C . T. YEAR 1997 CAMPAIGN DETAILS.

	Jan-97	Feb-97	Mar-97	Apr-97	May-97	Jun-97	Jul-97	Aug-97	Sep-97	Oct-97	Nov-97	Dec-97	TOTAL
CONCETRATES TREATD (DRY).	1.8548	2899.2	5325.37	0.00	6078.35	5266.11	3977.89	5474.02	1897.99	8203.65	5313.22	7017.97	51455.62
MATTE LADLES.	1	326	501.25	0.00	610	585	421.50	497.00	237.25	783.25	629.25	828.00	5419.50
Cons/Matte Ladle	1.85	8.89	10.62	0.00	9.96	9.00	9.44	11.01	8.00	10.47	8.44	8.48	9.49
WHITE METAL LADLES	5.5	209	332.5	0.00	384	368.75	266.00	292.50	147.50	468.50	413.50	515.50	3403.25
OXYGEN USED.(T)	1	547.2	1002.7	0.00	940.8	815.5	579.90	656.90	285.00	1084.00	794.72	1062.50	7770.22
FLUX TREATED.(T)	4	572.8	795.9	0.00	951.5	728.28	636.20	702.00	407.52	1312.50	1240.40	1439.40	8790.50
INSTACK TIME.(%)	7.26	76.17	73.19	0.00	70.71	70.74	69.55	41.90	20.98	69.41	64.69	65.75	57.30
NEW COPPER	9480	7347	9358	4593.00	7899	8167	8816.00	8158.00	7696.00	9641.00	8639.00	10320.00	100114.00
ACID PRODUCTION	7875	6634	9560	1161.00	9236	7256	5946.00	8342.00	4179.00	8233.00	7331.00	8256.00	84009.00
ACID TO COPPER RATIO	0.83	0.90	1.02	0.25	1.17	0.89	0.67	1.02	0.54	0.85	0.85	0.80	0.84
C.T OPERATED DAYS	1	11	21	0.00	26	24	18.00	20.00	12.00	31.00	26.00	31.00	221.00
Cons dry Tons per day	1.8548	263.564	253.589	#DIV/0!	233.7827	219.421	220.99	273.70	158.17	264.63	204.35	226.39	232.830881

C . T. YEAR 1998 CAMPAIGN DETAILS.

	Jan-98	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98	Dec-98	TOTAL
CONCETRATES TREATD (DRY).	5855.07	2352.15	3625.59	3231.96	10594.21	8845.45	6512.71	8395.47	399.67	0.00	0.00	0.00	49812.29
MATTE LADLES.	748.75	311.25	535.37	348.50	848.25	874	837.50	953.00	38.00	0.00	0.00	0.00	5494.62
Cons/Matte Ladle	7.82	7.56	6.77	9.27	12.49	10.12	7.78	8.81	10.52	0.00	0.00	0.00	9.07
WHITE METAL LADLES	436.5	192	337.75	223.25	5595	588.5	560.25	611.50	23.00	0.00	0.00	0.00	8567.75
OXYGEN USED.(T)	1014	402.28	540.5	453.60	1299.4	1179.62	1138.46	1318.22	47.40	0.00	0.00	0.00	7393.48
FLUX TREATED.(T)	1472	512.6	849.6	710.10	1262.9	1376.69	1448.73	1238.64	49.10	0.00	0.00	0.00	8920.36
INSTACK TIME.(%)	60.523	62.69	54.09	52.01	72.3	70.8	65.41	73.91	44.09	0.00	0.00	0.00	61.76
NEW COPPER	8439	8392	9027	7071.00	11035	11213	10691.00	9725.00	8609.00	9383.00	9696.00	9504.00	112785.00
ACID PRODUCTION	2938	6736	5955	2781.00	9265	9600	7312.00	8509.00	5943.00	8001.00	6285.00	5521.00	78846.00
ACID TO COPPER RATIO	0.35	0.80	0.66	0.39	0.84	0.86	0.68	0.87	0.69	0.85	0.65	0.58	0.70
C.T OPERATED DAYS	31	12	24	17.00	31	30	31.00	31.00	2.00				209.00
Cons dry Tons per day	188.873	196.013	151.066	190.12	341.7487	294.848	210.09	270.82	199.84	#DIV/0!	#DIV/0!	#DIV/0!	238.336298

C . T. YEAR 1999 CAMPAIGN DETAILS.

	Jan-99	Feb-99	Mar-99	Apr-99	May-99	Jun-99	Jul-99	Aug-99	Sep-99	Oct-99	Nov-99	Dec-99	TOTAL
CONCETRATES TREATD (DRY).													0.00
MATTE LADLES.													0.00
MATTE TONNAGE..													
Cons/Matte Ladle													
WHITE METAL LADLES													0.00
OXYGEN USED.(T)													0.00
FLUX TREATED.(T)													0.00
INSTACK TIME.(%)													
NEW COPPER	7487	8202	7848	6612.00	9744	9176	8670.00	9659.00	6340.00	9383.00	9498.00	10161.00	102780.00
ACID PRODUCTION	6459	5770	5869	5429.00	5486	3636	3258.00	3456.00	4651.00	6453.00	4698.00	5532.00	60697.00
ACID TO COPPER RATIO	0.86	0.70	0.75	0.82	0.56	0.40	0.38	0.36	0.73	0.69	0.49	0.54	0.59
C.T OPERATED DAYS													
Cons dry Tons per day													

APPENDIX Ic

C . T. YEAR 2000 CAMPAIGN DETAILS.

	Jan-00	Feb-00	Mar-00	Apr-00	May-00	Jun-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00	TOTAL
CONCETRATES TREATD (DRY).													0.00
MATTE LADLES.													0.00
Cons/Matte Ladle													
WHITE METAL LADLES													0.00
OXYGEN USED.(T)													0.00
FLUX TREATED.(T)													0.00
INSTACK TIME.(%)													
NEW COPPER	8466	7169		8748.00	7670	8274	8808.00	5555.00	7997.00	7879.00	5526.00	7906.00	83998.00
ACID PRODUCTION	3780	3211	3404	3751.00	3329	3551	3263.00	2235.00	6318.00	3508.00	2357.00	5641.00	44348.00
ACID TO COPPER RATIO	0.45	0.45	#DIV/0!	0.43	0.43	0.43	0.37	0.40	0.79	0.45	0.43	0.71	0.53
C.T OPERATED DAYS													
Cons dry Tons per day													

C . T. YEAR 2001 CAMPAIGN DETAILS.

	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01	TOTAL
CONCETRATES TREATD (DRY).	756.8	946.71	0	0.00	0	5038	0.00	0.00	5011.24	1403.92	4621.00	1753.61	19531.28
MATTE LADLES.	118.25	117.5				717			726.25	235.25	728.00	368.50	3010.75
Cons/Matte Ladle	6.40	8.06	0.00	0.00	0.00	7.03	0.00	0.00	6.90	5.97	6.35	4.76	6.49
WHITE METAL LADLES	77	96				512			440.22	147.00	432.25	203.50	1907.97
OXYGEN USED.(T)	149.71	179.76				554			705.18	193.91	574.55	341.80	2698.91
FLUX TREATED.(T)	452.19	331.53				1798.44			1757.74	690.06	1818.90	1232.90	8081.76
INSTACK TIME.(%)	42.6613	63.9919	0	0.00	0	87.23	0.00	0.00	73.14	43.35	72.52	69.04	37.66
NEW COPPER	6110	7860	5631	7722.00	7322	11492	7686.00	7686.00	11181.00	8298.00	10516.00	7906.00	99410.00
ACID PRODUCTION	3828	4468	3035	4844.00	3928	7863	0.00	590.00	7567.00	4271.00	8089.00	4540.00	53023.00
ACID TO COPPER RATIO	0.63	0.57	0.54	0.63	0.54	0.68	0.00	0.08	0.68	0.51	0.77	0.57	0.53
C.T OPERATED DAYS	9	6				22			23.00	12.00	24.00	12.00	
Cons dry Tons per day	84.0889	157.785				229			217.88	116.99	192.54	146.13	#DIV/0!

C . T. YEAR 2002 CAMPAIGN DETAILS.

	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	Jul-02	Aug-02	Sep-02	Oct-02	Nov-02	Dec-02	TOTAL
CONCETRATES TREATD (DRY).	2892.65	3508.88	2392.64	2392.64	816.15		1617.42	2948.34	10057.68	6990.60		2607.00	36224.00
MATTE LADLES.	674.25	843.25	383	383.00	89.5	0	213.50	356.00	913.00	827.50	0.00	413.50	6096.50
Cons/Matte Ladle	4.29	4.16	6.25	6.25	9.12	#DIV/0!	7.58	8.28	11.02	8.45	#DIV/0!	6.30	7.11
WHITE METAL LADLES	359	500	219	219.00	61	0	118.50	189.00	563.00	477.75	0.00	229.00	2925.25
OXYGEN USED.(T)	444.9	617.6	555	555.00	135.6	0	279.20	462.00	951.13	921.90	0.00	375.00	5297.33
FLUX TREATED.(T)	1232.9	1202.25	754.1	754.10	165.1	0	271.34	516.00	553.00	377.00	0.00	368.00	6193.79
INSTACK TIME.(%)	64.24	71.7	81.28	81.28	84.72	0	70.32	90.28	89.19	80.64	0.00	54.62	64.02
NEW COPPER	10657	9304	9331	12664.00	10445	7670	9144.00	8828.00	10426.00	11566.00	5034.00	6489.00	
ACID PRODUCTION	5196	6793	7649	9581.00	3286	6048	5910.00	9513.00	12593.00				
ACID TO COPPER RATIO	0.49	0.73	0.82	0.76	0.31	0.79	0.65	1.08	1.21	0.00	0.00	0.00	#DIV/0!
C.T OPERATED DAYS	21	27	12	12.00	3	0	8.00	10.00	29.00	28.00	0.00	23.00	173
Cons dry Tons per day	138	130	199	199	272	#DIV/0!	202	295	347	250	#DIV/0!	113	209

C . T. YEAR 2003 CAMPAIGN DETAILS.

	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03	Jul-03	Aug-03	Sep-03	Oct-03	Nov-03	Dec-03	TOTAL
CONCETRATES TREATD (DRY).	0	5732.92	7577	4283.00	5670	8066	7729.00	3037.00	1521.00	9328.00	7259.00	13135.00	73337.92
MATTE LADLES.	38.5	537.5	689.25	359.75	506	612.5	674.00	208.00	176.00	381.25	571.75	677.50	5432.00
Cons/Matte Ladle	0.00	10.67	10.99	11.91	11.21	13.17	11.47	14.60	8.64	24.47	12.70	19.39	13.50
WHITE METAL LADLES	20	341.5	439	238.00	353	378	471.00	147.00	92.00	311.00	408.00	517.00	3715.50
OXYGEN USED.(T)	3	1136.34	2082	1237.00	1432	1383	1796.00	657.00	330.75	330.75	1576.00	2523.14	14486.98
FLUX TREATED.(T)	29	699.4	1060	707.00	1021	1426	1231.00	442.00	595.00	1543.00	977.00	744.00	10474.40
INSTACK TIME.(%)	25.3704	84.4444	78.98	66.68	73.55	74.94	73.90	80.80	61.26	80.64	79.24	86.90	72.23
ACID PRODUCTION	5424	8453	8687	5731.00	7887	7784	8781.00	2788.00	3173.00	11573.00	10089.00	11132.00	91502.00
NEW COPPER	8147	7633	8481	8233.00	9351	8611	10531.00	4690.00	5362.00	8279.00	9980.00	11226.00	100524.00
ACID TO COPPER RATIO	0.66577	1.10743	1.02429	0.70	0.843439	0.90396	0.83	0.59	0.59	1.40	1.01	0.99	0.89
C.T OPERATED DAYS	3	22	31	23.00	26	29	31.00	10.00	12.00	27.00	25.00	31.00	270.00
Cons dry Tons per day	0	260.587	244.419	186.22	218.0769	278.138	249.32	303.70	126.75	345.48	290.36	423.71	271.621926

Acid Production at No.3 Acid Plant between January 1996 to May 2004

Year	Month	Acid Prodn	New Copper	CT Instack(%)	Acid to Cu ratio	Year	Month	Acid Prodn	New Copper	CT Instack(%)	Acid to Cu ratio
1996	Jan	9515	9451	60.2	1.0	1997	Jan	7875	9480	7.3	0.8
	Feb	9513	10599	54.6	0.9		Feb	6634	7347	76.2	0.9
	Mar	9291	10423	81.7	0.9		Mar	9560	9358	73.2	1.0
	Apr	10941	11297	50.4	1.0		Apr	1161	4593	0.0	0.3
	May	12223	12753	69.0	1.0		May	9236	7899	70.7	1.2
	Jun	11219	12414	73.1	0.9		Jun	7256	8167	70.7	0.9
	Jul	13125	13907	70.8	0.9		Jul	5946	8816	69.6	0.7
	Aug	10790	13248	74.5	0.8		Aug	8342	8158	41.9	1.0
	Sep	11006	12102	82.4	0.9		Sep	4179	7696	21.0	0.5
	Oct	236	5430	1.0	0.0		Oct	8233	9641	69.4	0.9
	Nov	8226	7736	63.7	1.1		Nov	7331	8639	64.7	0.8
	Dec	8074	8154	58.7	1.0		Dec	8256	10320	65.8	0.8
1998	Jan	2938	8439	60.5	0.3	1999	Jan	6459	7487	0.0	0.9
	Feb	6736	8392	62.7	0.8		Feb	5770	8202	0.0	0.7
	Mar	5955	9027	54.1	0.7		Mar	5869	7848	0.0	0.7
	Apr	2781	7071	52.0	0.4		Apr	5429	6612	0.0	0.8
	May	9265	11035	72.3	0.8		May	5486	9744	0.0	0.6
	Jun	9600	11213	70.8	0.9		Jun	3636	9176	0.0	0.4
	Jul	7312	10691	65.4	0.7		Jul	3258	8670	0.0	0.4
	Aug	8509	9725	73.9	0.9		Aug	3456	9659	0.0	0.4
	Sep	5943	8609	44.1	0.7		Sep	4651	6340	0.0	0.7
	Oct	8001	9383	0.0	0.9		Oct	6453	9383	0.0	0.7
	Nov	6285	9696	0.0	0.6		Nov	4698	9498	0.0	0.5
	Dec	5521	9504	0.0	0.6		Dec	5532	10161	0.0	0.5
2000	Jan	3780	8466	0.0	0.4	2001	Jan	3828	6110	42.7	0.6
	Feb	3211	7169	0.0	0.4		Feb	4468	7860	64.0	0.6
	Mar	3404		0.0			Mar	3035	5631	0.0	0.5
	Apr	3751	8748	0.0	0.4		Apr	4844	7722	0.0	0.6
	May	3329	7670	0.0	0.4		May	3928	7322	0.0	0.5
	Jun	3551	8274	0.0	0.4		Jun	7863	11492	87.2	0.7
	Jul	3263	8808	0.0	0.4		Jul	0	7686	0.0	0.0
	Aug	2235	5555	0.0	0.4		Aug	590	7686	0.0	0.1
	Sep	6318	7997	0.0	0.8		Sep	7567	11181	73.1	0.7
	Oct	3508	7879	0.0	0.4		Oct	4271	8298	43.4	0.5
	Nov	2357	5526	0.0	0.4		Nov	8089	10516	72.5	0.8
	Dec	5641	7906	0.0	0.7		Dec	4540	7906	69.0	0.6
2002	Jan	5196	10657	64.2	0.5	2003	Jan	5424	8147	25.4	0.7
	Feb	6793	9304	71.7	0.7		Feb	8453	7633	84.4	1.1
	Mar	7649	9331	81.3	0.8		Mar	8687	8481	79.0	1.0
	Apr	9581	12664	81.3	0.8		Apr	5731	8233	66.7	0.7
	May	3286	10445	84.7	0.3		May	7887	9351	73.5	0.8
	Jun	6048	7670	0.0	0.8		Jun	7784	8611	74.9	0.9
	Jul	5910	9144	70.3	0.6		Jul	8781	10531	73.9	0.8
	Aug	9513	8828	90.3	1.1		Aug	2788	4690	80.8	0.6
	Sep	12593	10426	89.2	1.2		Sep	3173	5362	61.3	0.6
	Oct	9513	11566	80.6	0.0		Oct	11573	8279	80.6	1.4
	Nov	9513	5034	0.0	0.0		Nov	10089	9980	79.2	1.0
	Dec	9513	6489	54.6	0.0		Dec	11132	11226	86.9	1.0
2004	Jan	9923	8525	83.6	1.2						
	Feb	10860	10447	79.0	1.0						
	Mar	8797	9751	74.3	0.9						
	Apr	10683	10750	72.0	1.0						
	May	9290	11021	71.0	0.8						