SME Annual Meeting
Feb. 23-25, Denver, Colorado

Preprint 04-97

CYANIDE RECOVERY PRACTICE AT CERRO VANGUARDIA

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ABSTRACT

The Cerro Vanguardia mine is an AngloGold Limited operation in southern Argentina that includes multiple open pits and a hybrid Merrill-Crowe and CIL circuit to recover gold and silver from oxide ore. Operations were commissioned at the site in 1998, which included a plant in the metallurgical circuit to recover cyanide from mill tailings. The cyanide recovery plant was initially configured to process tailings slurry and achieved greater than 90% cyanide recovery from tailings containing about 600 to 800 mg/L WAD cyanide (as CN). The cyanide recovery circuit was operated in this manner for approximately eight months, during which time the consumption of sulphuric acid and sodium hydroxide was relatively high, leading to high rates of scale formation in the acidification tank and stripping towers. In July 1999, several piping changes were made in the cyanide recovery system to permit its operation with clear solution, which reduced the sulphuric acid consumption and eliminated scale formation in process equipment. The cyanide recovery system currently operates with a two-stage counter-current decantation (CCD) circuit which provides clear solution for processing in the cyanide recovery plant. The cyanide recovery efficiency now averages about 90% to 92% from solution containing about 350 mg/L WAD cyanide (as CN). Recovered sodium cyanide now accounts for about two-thirds of the total cyanide added to the leaching circuit. This paper presents a description of the cyanide recovery plant and details regarding its current operating efficiency.

INTRODUCTION

AngloGold Limited operates the Cerro Vanguardia S.A. (CVSA) gold and silver mine which is located about 2,150 kilometres south of Buenos Aires in the Santa Cruz province in southern Argentina, as shown in Figure 1. The mine is located in a remote, semi-arid environment with cold winters and high winds. Multiple open pits are mined to provide approximately 900,000 tonnes per year of oxide ore to the milling and cyanidation circuits. The metallurgical plant was commissioned in September 1998 and quickly reached its design capacity of 683,000 tonnes per year of ore, though since this time the mill throughput has been pushed to 900,000 tonnes per year. The average grade of gold in the ore is approximately 10 g/tonne and the average silver grade is approximately 110 g/tonne. The metallurgical processing system includes a three-stage crushing circuit, ball mill, carbon in leach (CIL) circuit, Merrill Crowe circuit and cyanide recovery system to remove cyanide from tailings prior to disposal in a surface impoundment.

CYANIDE RECOVERY PLANT CONFIGURATION

The CVSA cyanide recovery plant was initially configured to recover cyanide from 120 m^3/hour of tailings pulp containing about 42% solids and 600 to 800 mg/L weak acid dissociable (WAD) cyanide (as CN). During the first eight months of operation, calcium sulphate (gypsum) scale formation was observed in the acidification stage of the process and in the stripping towers. The scale accumulation required occasional manual cleaning of the equipment, and in response options for anti-scalant addition and conversion of the plant to operate with clear solution were investigated. In July 1999, it was decided that with minor piping changes the plant could be converted to clear solution operation. This change required that two existing thickeners be reconfigured to act as a two-stage CCD circuit to wash cyanide solution from the final tailings pulp. The general configuration of the cyanide recovery system following its conversion to operate with clear solution is illustrated in Figure 2. Further details regarding initial operations of the cyanide recovery plant and its conversion to clear solution operation are presented by Rule et al. (2000).

CYANIDE RECOVERY PROCESS DESCRIPTION

The stripping and recovery approach to recovering cyanide, also known as the acidification-volatilization-reneutralization (AVR) and Cyanisorb processes, removes cyanide from solution as hydrogen cyanide gas and recovers it as concentrated sodium cyanide (NaCN). At a pH of less than about 8.0, free cyanide and some WAD cyanide compounds are converted to hydrogen cyanide gas, which can then be air-stripped from solution. Once removed from solution as hydrogen cyanide, the hydrogen cyanide is easily absorbed into an alkaline solution of sodium hydroxide.

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The three main reactions involved with the cyanide recovery process are as follows.

1. In the acidification stage, the solution or slurry pH is lowered through the addition of sulphuric acid, which converts free and WAD cyanides into molecular hydrogen cyanide (HCN). The HCN at this point remains in dissolved in solution.

$$2CN^- + H_2SO_4 \rightarrow 2HCN_{(aq)} + 2SO_4^{-2} \quad (1)$$

2. Following acidification, the solution or slurry is directed to a stripping tower where it is counter-currently contacted with large volumes of air to strip HCN as a gas. The stripping tower provides the environment for rapid transfer of HCN from dissolved form to gas form, which includes high surface area packing for turbulent gas-liquid contact.

$$HCN_{(aq)} \rightarrow HCN_{(g)} \quad (2)$$

3. Stripped HCN gas is absorbed into a high pH solution of sodium hydroxide (NaOH) to generate a concentrated solution of recovered sodium cyanide (NaCN).

$$HCN_{(g)} + NaOH \rightarrow NaCN + H_2O \quad (3)$$

Figure 1. Location of the Cerro Vanguardia Site.

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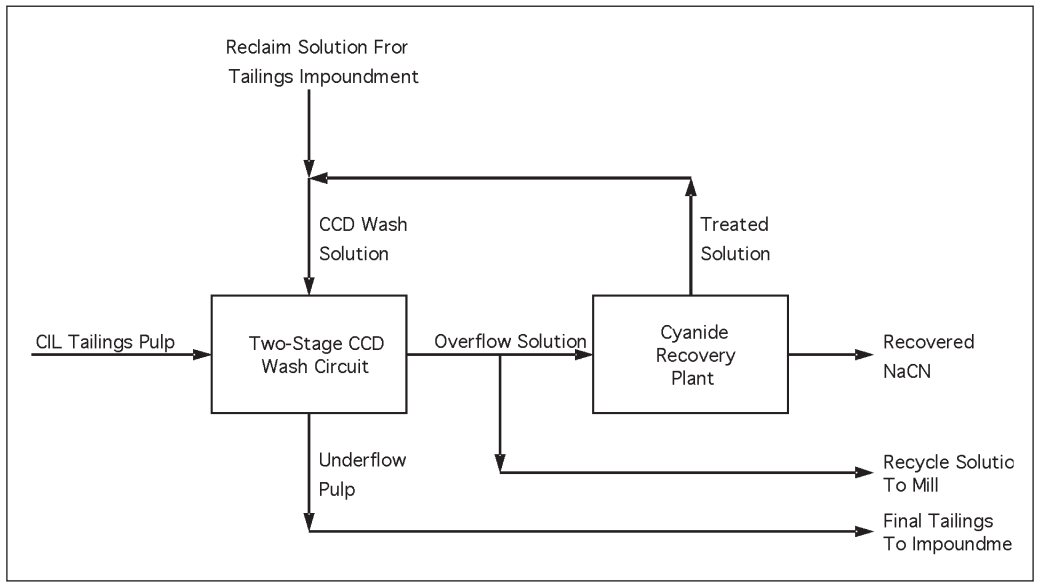

Figure 2. Configuration of the CVSA Cyanide Recovery Plant and Two-Stage CCD Circuit.

Further details regarding the chemistry of cyanide recovery and case studies from other operations are presented by Mudder et al. (2001) and Botz and Mudder (2002).

CYANIDE RECOVERY PLANT DESCRIPTION

The CVSA cyanide recovery plant includes the following major equipment:

1. One acidification tank where sulphuric acid is added to lower the pH of the solution to about 4.0. The rate of concentrated sulphuric acid addition is adjusted using a variable speed metering pump and pH controller.

2. Acidified solution is pumped from the acidification tank to two stripping towers. The volumetric ratio of air to solution in the stripping towers is approximately 520:1, which affects an HCN stripping efficiency of about 90%.

3. Stripped solution is collected in a neutralization tank where slaked lime slurry can be added to raise the pH. Currently, the solution is not neutralized but is directly pumped to the CCD circuit as wash solution where it is neutralized by dilution with the incoming slurry and other wash solution.

4. Stripped HCN gas is recovered in two absorption towers using 25% sodium hydroxide solution. The absorption towers function analogously to the stripping towers, where the gas and liquid are counter-currently contacted. Recovered sodium cyanide solution from the two absorption towers is collected in a single tank and transferred in batches to a central reagents storage area.

A general process flow diagram for the CVSA cyanide recovery plant is presented on Figure 3. On this figure, one stripping-absorption tower system is shown, but as indicated two stripping-absorption towers are operated in parallel.

CYANIDE RECOVERY PLANT PERFORMANCE

The CVSA cyanide recovery plant treats approximately 230 m^3/hour of solution containing about 350 mg/L WAD cyanide (as CN) and affects a cyanide recovery of about 90%. Effluent from the cyanide recovery plant contains about 35 mg/L WAD cyanide (as CN) and is used as wash solution in the two-stage CCD circuit along with decant water reclaimed from the tailings impoundment. A summary of representative performance data for the plant is provided in Table 1.

Table 1. Performance Summary for the CVSA Cyanide Recovery Plant.

Feed Solution pH	11.0
Acidification pH	4.0
Solution Flow Rate (total), m^3/hour	230
Stripping Tower Air Flow Rate (each), m^3/hour	60,000
Feed Solution Cyanide Concentration, mg/L	350
Feed Solution Zinc Concentration, mg/L	200
Effluent Solution Cyanide Concentration, mg/L	35
Cyanide Recovery Efficiency, %	90%
H2SO4 Consumption, kg/tonne solution	2.0
CaO Consumption, kg/tonne solution	0.0
NaOH Consumption, kg/kg recovered NaCN	01.0

The CVSA cyanide recovery plant recovers approximately 1,200 tonnes per year of NaCN, which is returned to the leaching circuit. The value of this recovered NaCN is about $1.3 million per year. Overall, recovered NaCN accounts for about two-thirds of the total NaCN added to the CVSA cyanidation circuit. Operating costs for reagents (sulphuric acid and sodium hydroxide) and electrical power equate to approximately $0.90 to $0.95 per kilogram of recovered NaCN, which is less than the cost for newly purchased NaCN.

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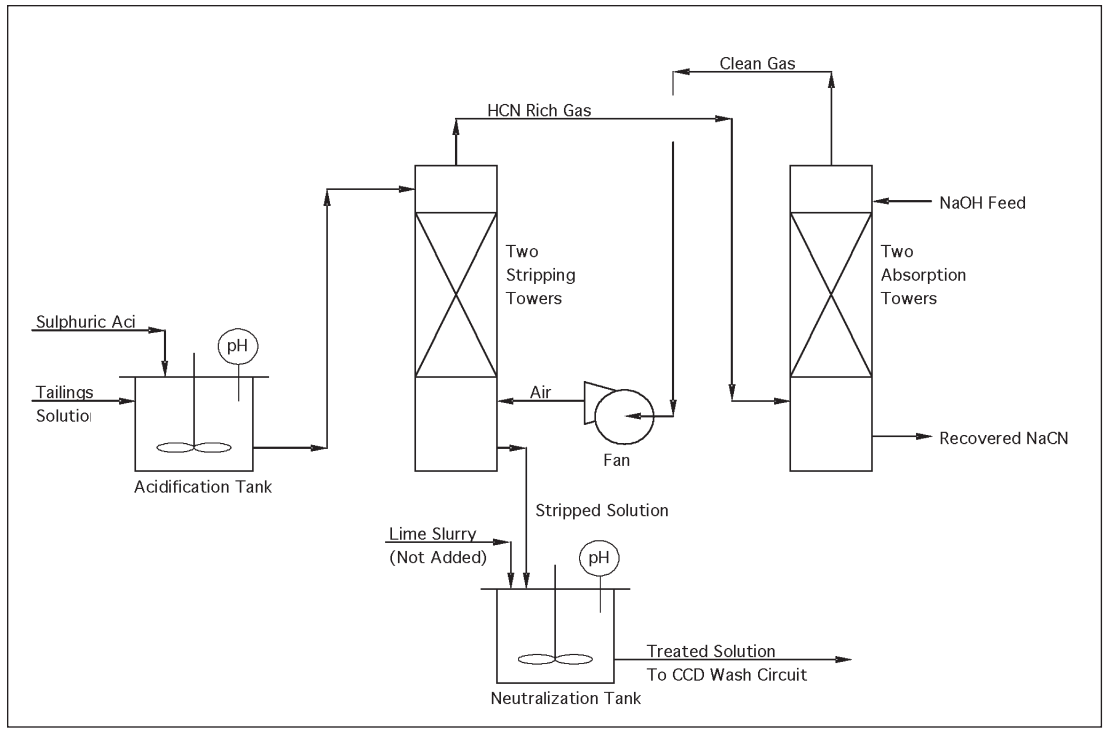

Figure 3. General Process Flow Diagram for the CVSA Cyanide Recovery Plant.

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