The Safe and Effective Use of Cyanide in the Mining Industry

August 2014

The purpose of this briefing is to provide a general overview about the use of cyanide and its application to recover gold from ore. While the use of cyanide is essential to the modern gold mining industry, SME acknowledges the public's concern regarding the use of this reagent and through this discussion presents information to inform and engage in meaningful dialogue about safety and best practices utilized by the mining industry for the extraction of gold from ore. Technical references regarding the use of cyanide in the processing of gold ore are noted at the end of this briefing.

Issue

The family of chemicals containing "cyanide," which is a combination of carbon and nitrogen ("CN"), has been used safely and effectively for over 125 years around the world for the efficient extraction and recovery of gold and silver. Cyanide is also used for a variety of other applications both within and outside the mining industry. However, while cyanide is an acutely toxic chemical in certain high concentrations, with proper management and control of its use, cyanide can continue to be used safely and without harming humans or the environment. (Frasier Institute, 2012)

Background

Cyanide is used to make a number of things we use every day; over one million tons of it is used annually in electroplating, metal processing, the production of organic chemicals and plastics, insecticides, and in photographic applications. It is also used as a stabilizer in table salt and road salt and is found in significant amounts in smoke from forest and structural fires as well as in cigarette smoke [2].

Low concentrations of cyanide are also present in the everyday environment including in over 1000 plants including leaves (laurel and yew), roots (cassava and potato), vegetables (cabbage and broccoli), nuts (almonds and cashews), beans (lima), seeds (apple and cherry), grain (corn and sorghum), pits of stone fruits (plums and apricots), and extracts (quince and vegetable oil) [1, 2]. It is also a natural decomposition product of dead plant matter, mostly after the natural chemical "amygdalin," reacts with water.

The mining industry has used cyanide to process ore for about 125 years, and typically uses less than 15% of the global production of industrial cyanide [2, 3]. Production of reagents for mineral processing to recover gold, copper, zinc and silver represents approximately 15% of cyanide consumption globally, with the remaining 85% of cyanide used in other industrial processes named above [2].

Role of Cyanide in Ore Processing

A process called "Cyanide Leaching" or Cyanidation has been the dominant gold extraction technology since the 1970s. Cyanide, in the form of a dilute sodium cyanide solution, is used to dissolve and separate gold from ore [4]. This process was first used in large scale commercial mining in 1889 [3, 4]. Cyanide leaching is safer and more efficient than mercury amalgamation, which was previously the main method of recovering gold from ore [5]. As part of their best practices, mines use as little cyanide as possible for environmental, safety, and economic reasons [2].

The concentration of cyanide used in this process averages approximately 0.025% sodium cyanide (250 parts per million) [2]. The cyanide leaching process is often carried out following physical processes like crushing, grinding and gravity separation. The gold is then further processed before being smelted into gold bullion.

Although considerable research has been conducted over many years, no other chemical reagent has been found to come close to exhibiting the superior economic and environmental qualities of cyanide in recovering precious metals.

Cyanide Toxicity and Management

Cyanide is strictly regulated worldwide to protect people, animals, and the aquatic environment. Cyanide is highly toxic and can be fatal to humans and animals if ingested in sufficient quantity. However, people and animals can rapidly detoxify non-lethal amounts of cyanide without negative effects, and repeated small doses can be tolerated by many species [4]. Some long-term health effects have been observed in people who have a diet high in cyanide-containing plants such as cassava, and include goiter and depressed thyroid function [7]. Cyanide does not cause cancer, is not mutagenic and does not accumulate or "biomagnify" in the food chain [9]. It does not persist in the environment, and is quickly broken down into less toxic chemicals by sunlight and air [2].

The greatest environmental threat from cyanide is to aquatic life from intentional or unintentional discharges into surface waters. Water monitoring and water management on mine sites are very important [8] and regulations frequently limit the amount of cyanide which may be discharged into the environment. There are a number of water treatment technologies available to remove cyanide from mine water [2] and following discharge, the residual cyanide is rapidly diluted and destroyed through natural processes, such as oxidation and ultra-violet-catalysis (by sunlight). The effects on aquatic life, while significant, are not long-term [4]. Regarding protection of human health, "despite its high toxicity, there have been no documented accidental human deaths definitively related to cyanide poisoning in the Australian and North American mining industries over the past 100 years which indicates that the hazard of cyanide to humans has been controlled by minimizing the risk of its handling and of industrial exposure" [6, p.4].

Gold Mining Industry Cyanide Management

The industry has promoted adherence to a voluntary "*Cyanide Management Code*" that aims to assist in the protection of human health and reduce environmental impacts through implementation of best practices for cyanide management and verification through third party audits. The "**International Cyanide Management Code for the Manufacture, Transport, and Use of Cyanide in the Production of Gold**" was developed by a multi-stakeholder Steering Committee under the auspices of the United Nations Environmental Program and the then-International Council on Metals and the Environment. The Cyanide Code is an industry voluntary program for gold mining companies and the companies producing and transporting the cyanide used in gold mining. It focuses exclusively on the safe management of reagent cyanide from manufacturing through transportation and all aspects of use in the mining operation. Companies that adopt the Cyanide Code have their mining operations that use cyanide audited by independent third party professional health, safety and environmental auditors and technical experts to determine compliance with program's requirements. Those operations that meet the Cyanide Code requirements are certified and authorized to display a unique trademarked symbol signifying their certification. Audit results are made public to inform stakeholders of the status of cyanide management practices at the certified operation (see www.cyanidecode.org). ***Over the past decade since the Code came into full effect there have been no major environmental incidents involving cyanide at any certified gold mining operation***. - See more at: http://www.cyanidecode.org/.

SME Statement of Technical Position

- Cyanide has been used effectively and safely for over 125 years for gold and silver recovery.
- Cyanide is used for processing of gold and silver in milling and leaching circuits and in refining of metals.
- Cyanide is highly selective for gold and silver over other metals, and is much more selective and safer than other chemicals (including the new bromide-dextrin [10] chemistry), which means that cyanide has a significant environmental advantage over these alternatives.
- Cyanide is typically not persistent in the environment, and degrades to products existing in nature, including carbon dioxide, ammonia and nitrates.
- The potential alternative reagent schemes to cyanide all have significant disadvantages compared to the recovery capabilities of cyanide and the ability to control potential environmental impacts from its use.

References

[1]Canada, Canadian Food Inspection Agency. *Natural Toxins in Fresh Fruit and Vegetables*. 2012 [cited 2012 June 14]; Available from: http://www.inspection.gc.ca/food/consumer-centre/food-safety-tips/specific-products-and-risks/natural-toxins/eng/1332276569292/1332276685336.

[2]Minerals Council of Australia. *Fact Sheet--Cyanide and its Use by the Minerals Industry*. 2005.

[3]InfoMine. *Summary Fact Sheet on Cyanide*. n.d. [cited 2012 July 30]; Available from: http://www.infomine.com/publications/docs/SummaryFactSheetCyanide.pdf.

[4]Eisler, R. and S.N. Wiemeyer. *Cyanide Hazards to Plants and Animals from Gold Mining and Related Water Issues*. Reviews of Environmental Contamination and Toxicology, 2004. 183: p. 21-54.

[5]Ophardt, C.E. *Conversion of Gold Ore to Gold Metal*. Virtual Chembook: Gold Processing. 2003 [cited 2012 July 30]; Available from: http://www.elmhurst.edu/~chm/vchembook/327gold.html.

[6]Australia Government, Department of Resources, Energy and Tourism. *Cyanide Management*. 2008. Commonwealth of Australia.

[7]International Cyanide Management Institute. *Cyanide Facts*. 2012 [cited 2012 June 21]; Available from: http://cyanidecode.org/cyanidefacts.php.

[8]Mudder, T., M. Botz, and K.A. Hagelstein. *A Global Perspective on Cyanide Use and Management*. [Online course] 2006 Version: 10 July 2006 [cited 2012 February 2]; Available from: http://www.edumine.com/xutility/html/menu.asp?category=xcourse&course=Xcyunara0.

[9]Laberge Environmental Services. *Cyanide -- The Facts*. 2001 [cited 2012 July 25]; Available from: http://www.geology.gov.yk.ca/pdf/MPERG_2001_2.pdf.

[10]Liu, Z. et al., *Selective Isolation of Gold Facilitated by Second-Sphere Coordination with α-Cyclodextrin*, Nature Communications, 4:1855, 2013.

Additional Technical References

Mudder, T *Making Sense of Cyanide*, 1999, The Gold Institute.

Mudder, T., M. Botz *A Global Perspective of Cyanide*, 2001, Proceedings of the SME Annual Meeting and Exhibit, Denver, Colorado, February 26-28, 2001.

Marsden, J.O. and House, C.I., The Chemistry of Gold Extraction, 2nd Edition, Society of Mining, Metallurgy and Exploration (SME), Littleton, CO, 2006.

Young, C.A., Cyanide: Just the Facts, Department of Metallurgical and Materials Engineering, Montana Tech, Butte Montana, 2001.

Young, C.A., Remediation Techniques for the Management of Aqueous Cyanide Species, Department of Metallurgical and Materials Engineering, Montana Tech, Butte Montana, 2001.
Young, C.A., Twidwell, L.G., Anderson, C.G., *Cyanide: Social, Industrial and Economic Aspects*, Minerals, Metals and Materials Society (TMS), Warrendale, PA, 2001.
http://www.miningfacts.org/environment/what-is-the-role-of-cyanide-in-mining/#sthash.klvxhhuO.dpuf.
http://technology.infomine.com/cyanidemine/