CSI's MODULAR PLANT for the ON-SITE MANUFACTURE OF CYANIDE

for presentation at

RANDOL GOLD CONFERENCE
SACRAMENTO, CALIFORNIA
NOVEMBER, 1989

by

Daniel W. Kappes
Kappes, Cassiday & Associates
1845 Glendale Avenue
Sparks, Nevada 89431
ph (702) 356 7107
FAX (702) 356 5609

CSI's MODULAR PLANT
for the
ON-SITE MANUFACTURE OF CYANIDE

Cyanide accounts for 5% to 15% of the total production cost (10 to 30% of metallurgical process cost) at typical precious metal heap leach and milling operations. For some ores (such as high-copper low grade gold ores), the cost of cyanide can be the deciding economic factor in project development.

The 1980's have seen a surge in gold production coupled with a higher gold price. This has resulted in a several-fold increase in the tonnage of gold ores treated. Cyanide consumption is related more to tonnage than gold content, so the demand for cyanide has correspondingly increased.

Until this recent surge, cyanide was produced in established central plants which had been completely amortized, and which functioned in a relatively problem-free regulatory environment. The new plants now being built must cope with a complex set of regulatory and environmental operating restrictions. To achieve an acceptable return on investment, manufacturers have had to dramatically increase the price of sodium cyanide.

The cost spiral is not expected to stop. "Protecting the Environment" seems to be the war-cry of a modern-day Inquisition, and its victim is often the Chemical Industry. While the public reaction may be excessive, the problem is real: as cyanide use and transportation increase, the number of accidents also increases.

Cyano Systems, Inc. (CSI), was formed because the production of cyanide on-site, on-demand, eliminates many of the costs and problems associated with these central plants. A mine operator using CSI equipment can produce sodium cyanide for less than $0.35 per pound ($0.50 per pound including amortization), as compared with projected costs of US$0.75 to $1.25 for cyanide delivered from manufacturers.

MANUFACTURE OF CYANIDE

Sodium cyanide is manufactured commercially using one of three available processes: Andrussow, DeGussa or Shawinigan. These processes are all similar, and they all involve the manufacture of hydrogen cyanide which is then reacted with sodium hydroxide to form sodium cyanide.

In the Andrussow process, a hydrocarbon (typically methane) is mixed with air and ammonia and passed over a platinum catalyst at 1200C. A portion of the air and hydrocarbon combine to produce the heat of reaction, and the balance of the hydrocarbon and ammonia react to form hydrogen and hydrogen cyanide. The resulting gas stream contains hydrogen, hydrogen cyanide, some unreacted feed materials, and combustion products.

In the Degussa process, ammonia and the hydrocarbon are passed through platinum lined ceramic tubes which are externally heated in a furnace chamber. The product stream is purer than in the Andrussow process since combustion residues are separated from the product gases.

The Shawinigan process works much the same way as Degussa, except the reaction takes place at a higher temperature (1650C) without a catalyst. This permits the use of impure and high-sulfur feedstocks, which is an important consideration if cyanide is to be made at remote mine sites. The Shawinigan reaction proceeds in an electrically heated non-pressurized fluidized bed (usually this is a bed of coke, but any other conductive granular solid can be used).

Regardless of the process used, the hydrogen cyanide gas stream from the reactor is reacted with sodium hydroxide to produce sodium cyanide. Sometimes other cyanides are produced, or the gas is liquefied and sold as liquid hydrogen cyanide for chemical industry uses.

The sodium cyanide solution can be used directly, or it can be crystallized. Since sodium cyanide breaks down easily to sodium formate and other undesirable chemicals, the processes for crystallizing the cyanide are somewhat expensive and proprietary. For this reason, several recently-built commercial cyanide manufacturing plants have chosen to sell the dissolved product without crystallization.

INTENSE PROCESS ENGINEERING

CSI has selected the Shawinigan Process for use in its modular plants. It has obtained an exclusive license to use this technology from Gulf Canada Resources (formerly Gulf Oil Corporation). Besides exclusive use rights, the license gives CSI access to extensive Shawinigan plant operating experience.

Since the process is simple, it is relatively easy to build an inexpensive labor-intensive plant to make cyanide (or, conversely, an expensive reliable plant). However, such "one-off" custom-engineered units would be difficult to sell into the mining industry: they would be expensive, and would require continued operator attention and servicing.

The major focus of CSI has been to apply an intense program of engineering, components selection, and design of fabrication procedures, to create a sophisticated but low-cost equipment package. The acceptance of the CSI plants at operating mines will require that they be safe, reliable, and simple to operate. CSI has budgeted nearly $2 Million for this development process, and is about 70% of the way through a 30-month development program.

CSI completed the construction of an operating engineering prototype (1000 pounds/day NaCN) in late summer 1989. It is currently located in Sparks, Nevada, and it will soon be taken to a minesite near Reno where the first cyanide will be produced.

COMMERCIAL UNITS

The initial commercial plant package which CSI will produce will also have a capacity of 1000 pounds NaCN per 24 hours (or equivalent as pure calcium cyanide). Capital cost of the plant is expected to be US$350,000. The plant will be built on a shipping skid 8 ft wide, 30 ft long and 10 ft high, and will arrive at the user site fully assembled.

The plant has a high turnup/turndown ratio so output can be adjusted to match the needs of the operation. It is expected that this plant can be used economically to produce all the cyanide for heap leaches treating 1500 to 4000 tons ore per day, and for mills treating 600 to 2000 tons per day.

The 1000 pound/day commercial units are expected to be available early in 1990. Larger units - probably 5000 and 10,000 pounds/day - will subsequently be developed. As with the smaller unit, these will require a fairly extensive development program.

OPERATING AND CAPITAL COST

To make 1000 pounds of sodium cyanide equivalent per day, raw materials include ammonia (50 gallons per day), propane or diesel (50 gallons/day), lime (580 pounds/day of CaO) or caustic soda (810 pounds/day), and an 80 kW electric power source. Using typical Western U.S. costs, the total raw materials will cost US$0.24 per pound NaCN. Plant maintenance (performed under contract by CSI) will add $0.08 per pound. If the plant is fully leased from a leasing firm using commercial lease rates (i.e. no on-balance-sheet financing by the mine), capital cost will be $0.16/pound NaCN. Total cost will therefore be $0.48 per pound sodium cyanide NaCN equivalent for calcium cyanide. If sodium rather than calcium cyanide is required, costs will increase to about $0.55 per pound.

The plant will require only occasional checks by the mill or heap leach operator. Labor input is expected to be the same as that now required to mix and feed solid cyanide.

Operator control will consist of a simple pushbutton start-up procedure, and occasional review of operating conditions. The plant will shut itself down in the event of a processing problem, and alert the operator.

SAFETY & ENVIRONMENTAL CONCERNS

Because of the simple nature of the process, it is fairly easy to design an inherently safe plant. Operator errors or equipment malfunctions will cause neither safety nor environmental problems. Hydrogen cyanide is a very dangerous gas, but it exists in a small, easily-contained section of the plant and there is less than 100 grams of this substance present at any time. In fact, the quantity of potential gaseous emissions is less than that present over the mixing tanks now used at most mines to dissolve solid sodium cyanide.

Environmentally, the use of the modular plant eliminates the need to transport and store large quantities of cyanide. The only difficult substance which needs to be transported is ammonia. Ammonia is now widely used agriculturally (5 million tons/yr in the U.S.) and it is not considered hazardous.

Cyanide is present only in dilute form which is made on the day and at the location it is required. There are no waste discharges from the plant.

PROCESS ADVANTAGES

The CSI process offers two unique chemical advantages not now available from cyanide sources:

1. For heap leaches and some mills, the use of calcium cyanide is preferred because it stabilizes clays. However the presently available calcium cyanide is made by an electrolytic process and contains only 50% calcium cyanide mixed with chloride, lime and some carbon black. When this product is dissolved for use, it produces a dirty scale-forming slurry. With the CSI plant, a reasonably pure calcium cyanide can be made by using a lime slurry as the absorbent for the HCN.

2. Heap leaches which use cement agglomeration usually operate at excessively high alkalinity levels, because the cement itself is highly alkaline. In the CSI process, the HCN can be directly absorbed into the barren heap solution. This will not only lower the pH to more acceptable levels, but it will also eliminate the expense of caustic or lime to make cyanide.

CONCLUSION

The principles in CSI are DVR Resources, Vancouver, B.C., and Kappes, Cassiday & Associates, Sparks, Nevada. Both companies have a wide range of experience in the precious metals mining industry, and have organized the goals of CSI to meet the industry needs. We expect a conservative response by mine management and operators to our concept, and have designed the equipment accordingly. We feel confident that these modular plants will begin a new era in the supply of cyanide to the mining industry.