



Grassy Mountain Gold Project

Cyanide Briefing

Adam Bonin

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Topics

01 Cyanide in Gold Mining

02 Management & Sourcing

03 Transportation

04 Safety and Response

05 Fate and Risk



Cyanide in Gold Mining

Ore is crushed and ground, and any free gold is gravity-separated. Gold must then be separated from other minerals in ore through chemical means.

Cyanide is a negatively-charged ion (CN^-) with triple bond
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Cyanidation/leaching:

- Dilute sodium cyanide solution (approx. 25%) used to dissolve and separate gold from ore:



Cyanide Management - ICMC

International Cyanide Management Code (ICMC)

- Voluntary initiative for gold and silver mining industries, and producers and transporters of cyanide
- Focuses exclusively on the safe management of cyanide and cyanidation mill tailings and leach solutions.
- Certified companies must be audited by an independent third party
- Objective - improve the management of cyanide to protect human health and reduce environmental impacts.

Cyanide Management - ICMC

ICMC Principles and Standards of Practice:

1. **Production** – encourage responsible manufacturing
2. **Transportation** – protect communities and environment
3. **Handling & Storage** – protect workers and environment
4. **Operations** – properly manage cyanide solutions/waste streams
5. **Decommissioning** - protective decommissioning plans
6. **Worker Safety** – protect workers' health and safety from exposures
7. **Emergency Response** – protective response strategies & capabilities
8. **Training** – cyanide management safety training
9. **Dialogue** – engage in public consultation and disclosure

Cyanide Sourcing

Approximately 1.1 million metric tons produced annually

- Asia-Pacific lead producer followed by North America and Europe (China, US, South Korea)
- Approximately 6% used to for gold and silver processing

Sodium cyanide (NaCN) supplied as either briquettes or liquid

- Liquid moved by tanker truck or rail car – offloaded into mine facility storage tanks
- Briquettes delivered in drums, plastic bags, boxes or other containers
 - Safely dissolved in high pH solution and stored

Cyanide Sourcing – Western US Supplier

One of the largest US sodium cyanide manufacturers based in Winnemucca, Nevada (since 1990)

Driver training modules provided on their website, for example:

- Shipping containers – proper actions for emergencies
- Liquid offloading

Applied Technology Laboratory in Reno

- Evaluate customers' samples for most effective cyanide detoxification method(s) to comply with permit standards

ICMC-certified

Cyanide Sourcing - Delivery

Solid-to-liquid systems (SLS) in ISO container units:

- Transportation of solid sodium cyanide
- Liquid sodium cyanide prepared in containers on site
- Minimal handling by mine personnel and higher safety standard

Liquid tanker:

- Quickly offloaded directly to storage tank; minimal handling
- Tankers equipped with unique internal valves and safety features designed to prevent releases during accidents

Bag/Box:

- One-metric ton boxes, lined and sealed to protect contents from exposure to the environment

Cyanide – Safety & Response

Sodium Cyanide Hazards:

- Water-reactive
- Decomposes on contact with acids, acid salts, water, moisture, and carbon dioxide, producing highly toxic, flammable hydrogen cyanide gas
- Containers can explode when heated or contaminated with water
- Non-combustible but hydrogen cyanide by-product is highly-flammable

Cyanide – Safety & Response

Emergency Response:

- Spill - First responders use SCBA with Level A protective suit when entering area with unknown contaminant concentration
 - Maintain Level A protection until monitoring results indicate concentration and necessary protection
- Fire:
 - Small fires - use dry chemical, dry sand
 - Large fires - use water spray, fog, or alcohol-resistant foam
 - Tank, rail car, or tank truck involved in fire - isolate for 0.5 miles in all directions and consider evacuation
 - Run-off from fire control may be corrosive – control and dispose of effluent, if possible
- Decontamination – individual and/or equipment safety
 - Decon corridor upwind and uphill of hot zone
 - Decon workers must also wear proper personal protective equipment (PPE)

Cyanide – Safety & Response

Federal Motor Carrier Safety Administration (FMCSA)

- Routine random inspections at truck stops and weigh-ins
- Compile and report compliance/non-compliance and accidents

Cyanide Accidents – A Recent Reportable:

- Sodium cyanide released on major highway in West Memphis, Tennessee in January 2017
- “...*always want to treat it as a worse case scenario and then you can digress from there,*” - West Memphis Fire Department.
- Carrier servicing 49 states for 30+ years with satisfactory safety record
- Granular form of sodium cyanide was well-packaged and protected so no release or exposures

Cyanide – Safety & Response

Emergency Monitoring and Emergency Contingencies:

- Including facility workers and local responders and law enforcement individuals
- Hydrogen cyanide gas monitoring instruments with alarms (elevated concentrations and evacuation level alarms at facility and local fire department)
- Cyanide site-specific objectives and action plan

Residual Cyanide Fate

Detoxification:

- For example, sulfur dioxide and air (WAD cyanide → cyanate)
- Thiosulfate – emerging technology
- Remaining cyanide in tailings storage facility (TSF)

Weak-acid dissociable cyanide (WAD):

- Weak or moderately stable metal complexes (copper, iron, nickel, and zinc)
- ICMC standard = **50 mg/L** WAD cyanide; Oregon's standard = **30 mg/L** WAD

Hydrogen cyanide, HCN:

- Toxic but not persistent (volatilization, photodegradation [e.g., iron complexed cyanides], biodegradation, oxidation, hydrolysis)

Residual Cyanide Fate

Soil:

- Primarily lost via volatilization and biodegradation (bacteria can be inhibited at elevated concentrations)
- Less mobile when absorbed by clays, biological solids, and sediments

Air:

- HCN is a gas with slow degradation rate in the atmosphere (Half-life 1-3 yrs)

Surface Water:

- Volatilization primary process for cyanide loss (especially at lower pH)

Groundwater:

- May persist in groundwater
- Biodegradation limited

Toxicity and Risk – Human Health

Human Health Risk:

- Facility workers, inspectors, agency personnel, trespassers
- Free cyanides most toxic
- Potential exposure routes:
 - Ingestion, inhalation, absorption (eyes, skin)
- Acute toxicity due to hypoxia

EPA MCL 0.2 mg/L:

- Level in drinking water below which there is no known expected health risk

Toxicity and Risk - Wildlife

Ecological Risk:

- Free cyanide most toxic
 - Aquatic organisms most sensitive (diet):
 - Chronic (sublethal [reproduction, growth]): **0.005 – 0.007 mg/L**
 - Acute (lethal): **0.02 – 0.076 mg/L**
 - Birds:
 - Sensitive receptor category; primarily ingestion via drinking
 - Sensitivity – physiological or access issue? Waterfowl attracted to open water such as in TSF supernatant pond
 - Mammals:
 - Sensitive to acute exposures
 - Chronic exposures to sublethal concentrations not shown to cause adverse effects; rapidly detoxified and excreted

Risk Reduction

- Primary protective mechanism - **minimize WAD cyanide concentration**
 - Detoxification
 - Natural processes (metal-cyanide dissociation, volatilization)

- Proper PPE and robust handler training and safety compliance

- Monitoring and emergency contingencies (including facility workers, local responders, law enforcement individuals)
 - Hydrogen cyanide gas monitoring
 - Cyanide site specific objectives and action plan

Risk Reduction

- Habitat modification
 - Prevent foodweb in supernatant (less ingestion risk but bathing can still occur)
 - Reduce TSF open water area
 - Reduce attractiveness of surrounding landscape
 - Wetland mitigation sites

- Wildlife exclusion
 - Fencing, netting

- Wildlife deterrents
 - Hazing (munitions), bird deterrent balls

- Wildlife monitoring protocols

Thank you

For more information

Adam Bonin
Project Manager
Portland Office: +1 503 575 3317

www.cardno.com