CYANIDE SPILLS
PREVENTION AND RESPONSE

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INTRODUCTION

This document provides an introductory discussion of a preferred approach for preventing, and if needed, responding to releases into the environment of cyanide containing solutions at gold mining operations. The gold mining industry should demonstrate that it understands the health, safety, and environment risks of using cyanide, and has taken all the necessary precautions to reduce those risks to the extent practicable. It should also demonstrate that it could effectively respond to an accident to mitigate any short and long-term environmental impacts. By definition an accident is neither routine or planned, therefore it is essential to develop and emergency preparedness plans and procedures with the objective of effectively respond to unforeseen accidents. The emergency preparedness plans and procedures must be updated and tested periodically to maintain the level of preparedness at its optimum readiness.

This document deals specifically with cyanide spills that can potentially affect the environment. Issues related to worker health and safety arising out of the use of cyanide in metallurgical processing is covered in other documents. The gold mining industry has had a good record with respect to worker health and safety globally over the last century of cyanide use. Beyond worker health and safety during operations, the major onsite environmental issue relates to controlling the cyanide concentration in uncovered ponds to protect wildlife. The new UNEP International Code for Management of Cyanide at gold mining operations puts forth recommendations as to the appropriate cyanide level that should be maintained in these ponds. A review of cyanide related spills over the last quarter century has shown the causes to include:

- The lack of a dynamic site water balance and comprehensive water management plan
- The lack of or implementation of improper water treatment capabilities
- The lack of integrity and secondary containment within the solution conveyance system

The environmental impacts of these spills have nearly all been related to the toxic effects on aquatic life resulting from cyanide entering surface water, such as a river. In some instances, the impacts were more severe than anticipated due to the type of response taken by the gold mining operation.

More specifically, the severe cyanide spills have resulted overwhelmingly from the breaching or overtopping of tailings dams during high precipitation or runoff events, or the rupture of pipelines without adequate secondary containment and collections systems. In conjunction with the spills, improper emergency treatment exasperated the impacts on aquatic life and the environment due to toxicity of the cyanide destruction chemicals employed, such as chlorine or sodium or calcium hypochlorite. In order to minimize the number and severity of these spills, there is a need for development and implementation of both spill prevention and emergency response plans and procedures.

PREVENTION

Of course preventing a cyanide spill is preferable to responding to one. There are three components to be considered in the development and implementation of a spill prevention plan including:

- Water management
- Water treatment
- Water quality

With respect to **water management**, a proper water balance must be generated that accurately reflects the annual variations in precipitation patterns with particular emphasis on high intensity events. These variations must be anticipated to the extent possible due to limitations in forecasting and adequate free board made available to accommodate the additional solution volumes. The use of average annual precipitation data is not appropriate for establishment of a site water balance.

In the case of **water treatment**, a permanent onsite facility is preferred to treat either excess process solutions or tailings slurries on a continuous or an as needed basis. There are several proven technologies available for the recovery, removal, or recycling of cyanide at gold mining operations. These include biological treatment, physical treatment with granular activated carbon, and chemical treatment using alkaline chlorination, copper catalyzed hydrogen peroxide, and the INCO sulfur dioxide/air process.

Although these treatment technologies are suitable when permanent onsite cyanide destruction is required or desired, each of them has distinct disadvantages and advantages. A careful decision must be made when selecting a specific treatment process or combination to ensure it is suitable for the specific application under consideration.

In conjunction with proper storage of cyanide solutions, it is the issue of proper conveyance of these solutions throughout the mine site and secondary containment of these solutions in the event a rupture in a pipeline results due to either natural and/or human causes.

In considering **water quality**, there are two important aspects to be considered. The first is the establishment of an appropriate program for the monitoring of water quality both on and off site. The second is the implementation of an appropriate system for minimizing on and off site environmental impacts through lowering of cyanide levels commensurate with the level of protection needed. For example, controlled discharges of excess process solutions into surface waters must be treated to the degree necessary to lower cyanide to levels protective of human health and other wildlife. In the case of direct discharges to surface water, the most vulnerable component of the ecosystem is aquatic life.

On site storage of uncovered solutions like those contained in tailings impoundments must involve lowering of residual cyanide levels that protect wildlife that comes in direct contact with the solution. The lowering of cyanide levels to protect wildlife also provides the additional benefit of reducing the severity of environmental impacts in the event there is an inadvertent release or spill of solution into the environment.

Adherence to the water management, treatment, and quality principles associated with a sound spill prevention program and the newly created UNEP International Code for Management of Cyanide will dramatically improve the status of environmental protection in the gold mining industry. To aid in the implementation of these principles, there is a need for ongoing training of the workforce to foster a sense of pride and purpose with respect to protecting the environment.

EMERGENCY RESPONSE

Regardless of the level of preparation and training, accidents do occur due to human error, mechanical failure, and nature. The goal of emergency response is to protect human health and the environment to the extent possible through minimization of impacts. It is critically important that emergency response be carried immediately in accordance with a well thought out and administered plan.

There are five basic elements to consider in developing and implementing an emergency response plan or procedure:

- Notification
- Containment
- Treatment
- Monitoring
- Training

Notification of the appropriate site personnel, as well as local, state, and federal agencies must be an immediate priority in the event a cyanide spill occurs at a mining operation, regardless of the time of day. Of critical importance in the event of a cyanide spill reaching surface water, is the notification of all down stream individuals, municipalities, or other industrial users that rely upon it as a primary source of potable water. Other notifications include those required under law or those noted in the operating permit for the mine. The notification process should involve a single call from a worker to an individual of authority, who is on call and on behalf of the company makes the appropriate notifications. A designated chain of command must be established to ensure the notification process proceeds without interruption.

Containment of the cyanide spill on site should be the first physical priority in conjunction with proper notification. If there is any indication that the pH of the solution has been lowered and hydrogen cyanide gas has been released, all personnel accessing the spill area should be equipped with a self-contained breathing apparatus. A decision must be made immediately regarding the evacuation of the other on site and off site personnel to some predetermined distance. Containment could involve diverting the spill to a holding pond, building a temporary dam or collection system, and/or pumping of solution. If the spill is from a tailings impoundment in which the cyanide levels have been lowered for protection of wildlife, then further treatment may not be necessary. However, if the cyanide levels are at full strength and/or the spill could enter surface water, then further treatment could be mandatory.

Treatment of the spill to lower the cyanide concentration may become necessary if it is or could eventually enter surface water and effect the environment or human health down stream of the mine site. Treatment is only effective if it can be accomplished in conjunction with the occurrence of the spill. If the spill has already occurred, then addition of treatment chemicals to surface water, like a stream, is not advised, since the addition of these chemicals could result in additional environmental impacts and are generally not effective in downstream cyanide levels.

Specifically, chlorine or hypochlorite reagents are not recommended for direct treatment of cyanide spills in flowing surface water, since these compounds are quite toxic and form additional toxic intermediates that can cause further undesirable environmental impacts. Furthermore, ferrous iron reagents should not be added directly to surface water to precipitate cyanide as this too will result in secondary adverse environmental impacts if done improperly.

If treatment is deemed necessary and appropriate and a permanent treatment facility is not already available, then selection of either hydrogen peroxide for treatment of solution spills or the INCO sulfur dioxide/air process for treatment of slurry spills is preferred. These chemicals should only be used as a last resort if containment is not achievable and the spill can be treated directly at the point of release.

Although additional chemicals are being added in conjunction with these treatment processes, their impacts are limited in comparison to those arising from the use of chlorine or hypochlorite. Removal of cyanide with ferrous sulfate is not recommended either as this process involves merely precipitation of the cyanide as an insoluble iron salt, which can again dissolve under elevated pH conditions releasing free cyanide. A permanent treatment facility of some type should be mandatory at a mining operation that utilizes cyanide in elevated concentrations.

Monitoring of on site and off site downstream water quality must be incorporated into an emergency response plan. If the cyanide spill reaches an off site surface water source, then extensive monitoring of water quality downstream must be initiated to determine the extent of the spill and potential environmental impacts. As soon as possible, additional monitoring of sensitive ecosystems, such as aquatic life, should be implemented. The more intensive water quality monitoring program should continue until there is no further threat to human health or the environment.

Training of on site personnel and members of the public should be associated with the entire spill prevention and emergency response program. Training should include the various aspects of cyanide chemistry, toxicity, analysis, and treatment. The training should be ongoing with periodic updates and simulated spill events to maintain optimal response performance. With respect to the public there should be ongoing awareness training of the community as a whole but also specific hazardous materials and emergency response training of specific individuals such as firemen, policemen, and other government personnel depending upon local conditions.