Mining Environmental Management

DRAFT CODES OF PRACTICE

FOR USE OF CYANIDE IN GUYANA'S GOLD MINING INDUSTRY

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1.0 Introduction

This Code of Practice for **Use of Cyanide** in ALL gold mining (that intend to use cyanide) proposes to provide environmental management guidance and promote the related best management practices. It is not a design manual[1].

1.1 Regulatory Authority/Mandate

The Mining (Amendment) Regulations 2005[2] were promulgated in 2004. Regulation 237 of the Mining (Amendment) Regulations 2005 stipulated that the Guyana Geology and Mines Commission (GGMC) prepare Codes of Practice for Mercury use, Cyanide use and disposal of effluents prior to their incorporation into the Regulations.

The Codes of Practice were intended to provide critical guidance (with respect to environmental management) to the Mining Industry, particularly small and medium-scale gold mines.

1.2 Justification for the Use of Cyanide Code of Practice

The Mining (Amendment) Regulations (2005) Articles 237 stipulates that GGMC prepare a Code of Practice to provide further guidance for the Use of Cyanide in small and medium scale mines.

1.2 Administration of Codes and Responsibilities of Owners and Workers

A useful strategy for sustainable environmental management in the small and medium-scale gold and diamond mining is co-regulation by the various stakeholders including the GGMC, and the Miners, and Mining Industry.

GGMC's mandate or role as defined by the Mining Act 1989 and the Mining (Amendment) Regulations 2005 is to develop, administer and enforce the mining regulations. Specific responsibilities include:

- Development and upgrading of the codes of practice
- Consultations with the stakeholders in the mining industry including mining organizations and miners on the development, and utility of the Codes 0f Practice.
- Public education, orientation and training
- Enforcement of, and monitoring compliance with, the Mining (Amendment) Regulations 2005

[1] This document is **NOT** a design manual. Users of this document shall assume full responsibility for the design of facilities and for any action taken as a result of the information contained in this document.

[2] The Mining Regulations, made under the Mining Act (1989), was amended by the Mining (Amendment) Regulations 2005: Collectively they address all the important aspects of mining environmental management.

The prime responsibility for the implementation of, and compliance with, the Mining (Amendment) Regulations 2005, and the application of sound environmental management practices rests with the Mine Owners and operators. Specifically, with the respect to the Use of Cyanide, the Mine Owners and operators must:

- Manage their operations in compliance with the Mining (Amendment) Regulations 2005, the related Codes of Practices and Guidelines
- Provide their employees with required training and orientation on the Use of Cyanide, and the related the regulations, best management OHS practices, codes and guidelines

2.0 Glossary of Terms

Best practice	The best way of doing things. The objective of best practices is to prevent or (when that is not possible) minimize risks to human health, as well as adverse environmental, social and economic impacts.
Co-Regulation	The mechanism whereby a Community legislative act entrusts the attainment of the objectives defined by the legislative authority to parties which are recognized in the field (such as economic operators, the social partners, non-governmental organizations, or related industry associations).
Code of practice	Means the Environmental Code of Practice for the operation of mines that is published by the Commission and which shall be read as part of the Mining (Amendment) Regulations 2005. (A collection of rules and ethical principles related to a specific field of activity. A code of practice describes procedures and sets out standards considered to be best practices in the said field of activity. The code may be voluntary or mandatory)
Guidelines	A non-binding document, usually designed to provide users with information, explanations, guidance and help with respect to a specific topic. Guidelines are a tool frequently used to enforce new regulations. Users can be either the Regulator itself or the industry.
Medium-scale mine	A mine for which a mining permit has been issued and from which a volume in excess of 200m^3, but less than 1000m^3 of material, inclusive of any overburden, is excavated or processed as an aggregate in any continuous period of twenty-four hours.
Mine	Includes any excavation, processing facility and/or related facilities for the recovery of metal, mineral or quarriable material and excludes any excavation, processing facility or related facilities that excavate or process less than 20m^3 in any continuous period of twenty-four hours
Regulations	A type of “delegated legislation” enacted by a state, or local government agency given authority to do so by the appropriate legislature

	Regulations are generally very specific and are also referred to as rules or simply administrative law. Regulations are official rules and must be followed.
Small-scale mine	A mine for which a claim license has been issued and from which a volume in excess of $20m^3$, but less than $200m^3$, of material, including any overburden, is excavated or processed as an aggregate in any continuous Twenty-four hour period.
STEL	**S**hort-**T**erm **E**xposure **L**imit
Sustainable Development (SD)	Development that meets present-day needs without compromising the ability of future generations to meet their needs.
TWA	**T**ime **W**eighted **A**verage
WAD	**W**eak **A**cids **D**issociable

3.0 Mission and Objectives

3.1 Mission Statement

The following is the Code's mission statement:

Promote sound cyanide management practices in Guyana's small and medium scale gold mining industry so as to minimize impacts on workers, communities and the environment.

3.2 Objectives

1) Protect workers, indigenous and non-indigenous communities and the environment from the misuse and mismanagement cyanide in mining.
2) Ensure and promote proper cyanide management in the Guyana gold mining industry.
3) Promote the Code's use by gold mining operations.
4) Raise the awareness of and educate all parties with respect to the effects of cyanide.
5) Ensure that cyanide management practices are credible and verifiable.

4.0 Scope

This Code of Practice is a mandatory code that applies to ALL gold mining operations that use cyanide. It addresses all issues related to cyanide management in the Guyana gold mining industry, namely:

- Occupational health and safety (OH&S);
- Health hazards for communities;
- The environment.

This Code is subject to the Mining (Amendment) Regulations 2005. The Code is intended to complement the regulatory requirements, not to replace them. Compliance with the rules, regulations and statutes is therefore required.

The application of the Code is intended to prevent hazards, accidents, incidents or injury to workers and/or members of the public at any specific site where cyanide is used for gold beneficiation.

5.0 Principles and Codes of Practice

NOTE: THESE CODES ARE PRESENTED IN SUCH FORMAT SO AS TO PROVIDE OWNERS, HANDLERS, AUDITORS AND REGULATORY INSPECTORS AND OTHER STAKEHOLDERS WITH A DETAILED CHECKLIST OF THE REQUIREMENTS FOR COMPLIANCE. COMPLIANCE REQUIRES A POSITIVE RESPONSE TO THE QUESTIONS THAT FOLLOW THE STATED CODE/STANDARD AT 5.1 to 5.9.

5.1. PRODUCTION: Encourage responsible cyanide manufacturing by purchasing from manufacturers that operate in a safe and environmentally protective manner.

Code of Practice 5.1.1: Purchase cyanide from manufacturers employing appropriate practices and procedures to limit exposure of their workforce to cyanide, and to prevent releases of cyanide to the environment. (PTCCB)

1. Does the operation's contract with all cyanide manufacturer(s) or distributor(s) require that the cyanide be produced at a facility that has been certified as being in compliance with the Code?

2. Is the cyanide purchased by the gold mine manufactured at a facility or facilities certified as being in compliance with the Code?
3. If cyanide is purchased from an independent distributor(s), has the distributor(s) provided evidence that the cyanide shipped to the gold mining operation is from a manufacturer(s) that is certified in compliance with the Code?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.1.1?

5.2. TRANSPORTATION: Protect communities and the environment during cyanide transport.

<u>Code of Practice 5.2.1</u>: Establish clear lines of responsibility for safety, security, release prevention, training and emergency response in written agreements with producers, distributors and transporters. (PTCCB/GGMC)

1. Is there a written agreement between the operation, the cyanide producer, distributor, and transporter(s) designating responsibility for the following, as applicable?
   a) Packaging as required by the United Nations for international shipments and by the political jurisdiction(s) the shipment will pass through
   b) Labeling in languages necessary to identify the material in the political jurisdiction(s) the shipment will pass through, and as required by these jurisdiction(s) and by the United Nations (for international shipments)
   c) Storage prior to shipment
   d) Evaluation and selection of routes, including community involvement
   e) Storage and security at ports of entry
   f) Interim loading, storage and unloading during shipment
   g) Transport to the operation
   h) Unloading at the operation
   i) Safety and maintenance of the means of transportation (e.g., aircraft, vessels, vehicles, trains, etc.) throughout transport
   j) Task and safety training for transporters and handlers throughout transport
   k) Security throughout transport
   l) Emergency response throughout transport

2. Does the written agreement specify that the designated responsibilities extend to any subcontractors used by the producer, distributor, transporter or the operation for transportation-related activities?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.2.1?

<u>Code of Practice 5.2.2</u>: Cyanide transporters are required to implement appropriate emergency response plans and capabilities and employ adequate measures for cyanide management. (GGMC)

1. Does the operation's contract with the cyanide transporter(s) require that the transporter(s) be certified under the Code?
2. Is the cyanide transporter(s) certified under the Code?
3. Does the operation have chain of custody records identifying all elements of the supply chain (producer, transporter(s), interim storage facilities) that handle the cyanide brought to its site? Are all identified transporters certified in compliance with the Code?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.2.2?

5.3. HANDLING AND STORAGE: Protect workers and the environment during cyanide handling and storage.

<u>Code of Practice 5.3.1</u>: Design and construct unloading, storage and mixing facilities consistent with sound, accepted engineering practices, quality control/quality assurance procedures, spill prevention and spill containment measures. (GGMC)

1. Have facilities for unloading, storing and mixing cyanide been designed and constructed in accordance with cyanide producers' guidelines, applicable jurisdictional rules and/or other sound and accepted engineering practices for these facilities?
2. Are unloading and storage areas for liquid and solid cyanide located away from people and surface waters? If not, has the operation evaluated the potential for releases to surface water and/or human exposure, and implemented precautions to minimize these potentials?

3. Is liquid cyanide unloaded on a concrete or other surface that can minimize seepage to the subsurface?
4. Is the cyanide unloading area designed and constructed to contain, recover or allow remediation of any leakage from the tanker truck?
5. Is there a method to prevent the overfilling of cyanide storage tanks, such as a level indicator and high-level alarm?
6. Are cyanide mixing and storage tanks located on a concrete or other surface that can prevent seepage to the subsurface?
7. Are secondary containments for cyanide storage and mixing tanks constructed of materials that provide a competent barrier to leakage?
8. Is cyanide stored:
   a) With adequate ventilation to prevent the build-up of hydrogen cyanide gas?
   b) Under a roof, off the ground or with other measures to minimize the potential for contact of solid cyanide with water?
   c) In a secure area where public access is prohibited, such as within the fenced boundary of the plant or within a separate fenced and locked area?
   d) Separately from incompatible materials such as acids, strong oxidizers and explosives and apart from foods, animal feeds and tobacco products with berms, bunds, walls or other appropriate barriers that will prevent mixing?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.3.1?

<u>Code of Practice 5.3.2</u>: Operate unloading, storage and mixing facilities using inspections, preventive maintenance and contingency plans to prevent or contain releases and control and respond to worker exposures. (GGMC)

1. With respect to empty cyanide containers, are procedures in place and implemented to:
   a) Prevent empty cyanide containers from being used for any purpose other than holding cyanide?

b) Rinse empty cyanide drums, plastic bags and liners with water three times and add the rinse water to the Cyanidation process or otherwise dispose of it in an environmentally sound manner?

c) Crush empty cyanide drums prior to disposal in a landfill and burn or otherwise dispose of empty wooden crates in an environmentally sound manner?

d) Clean any cyanide residue from the outside of cyanide containers that are returned to the vendor and securely close them for shipment?

2. Has the operation developed and implemented plans or procedures to prevent exposures and releases during cyanide unloading and mixing activities such as:

a) Operation of all valves and couplings for unloading liquid cyanide and mixing solid or liquid cyanide;

b) Handling cyanide containers without rupturing or puncturing;

c) Limiting the height of stacking of cyanide containers;

d) Timely clean up of any spills of cyanide during mixing;

e) Providing for safe unloading of liquid cyanide and manual mixing of solid cyanide by requiring appropriate personal protective equipment and having a second individual observe from a safe area, or remote observation by video?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.3.2?

5.4. OPERATIONS: Manage cyanide process solutions and waste streams to protect human health and the environment.

<u>Code of Practice 5.4.1</u>: Implement management and operating systems designed to protect human health and the environment including contingency planning and inspection and preventive maintenance procedures. (GGMC)

1. Have written management and operating plans or procedures been developed for cyanide facilities including unloading, mixing and storage facilities, leach plants, heap leach operations, tailings impoundments, and cyanide treatment, regeneration and disposal systems?
2. Does the operation have plans or procedures that identify the assumptions and parameters on which the facility design was based and any applicable regulatory requirements (e.g., freeboard required for safe pond and impoundment operation; the cyanide concentrations in tailings on which the facility's wildlife protection measures were based) as necessary to prevent or control cyanide releases and exposures consistent with applicable requirements?
3. Does the operation have plans or procedures that describe the standard practices necessary for the safe and environmentally sound operation of the facility including the specific measures needed for compliance with the Code, such as inspections and preventive maintenance activities?
4. Does the operation have a procedure to identify when changes in a site's processes or operating practices may increase the potential for the release of cyanide and to incorporate the necessary release prevention measures?
5. Does the operation have cyanide management contingency procedures for situations when there is an upset in a facility's water balance, when inspections and monitoring identify a deviation from design or standard operating procedures, and/or when a temporary closure or cessation of operations may be necessary?
6. Does the operation inspect cyanide facilities on an established frequency sufficient to assure and document that they are functioning within design parameters?
7. Does the operation inspect the following at unloading, storage, mixing and process areas, as applicable to the site?
   a) Tanks holding cyanide solutions for structural integrity and signs of corrosion and leakage
   b) Secondary containments for their integrity, the presence of fluids and their available capacity, and to ensure that any drains are closed and, if necessary, locked, to prevent accidental releases to the environment
   c) Leak detection and collection systems at leach pads and ponds, as required in the design documents
   d) Pipelines, pumps and valves for deterioration and leakage

e) Ponds and impoundments for the parameters identified in their design documents as critical to their containment of cyanide and solutions and maintenance of the water balance, such as available freeboard and integrity of surface water diversions

8. Are inspections documented, including the date of the inspection, the name of the inspector, and any observed deficiencies? Are the nature and date of corrective actions documented? Are records retained?
9. Are preventive maintenance programs implemented and activities documented to ensure that equipment and devices function as necessary for safe cyanide management?
10. Does the operation have necessary emergency power resources to operate pumps and other equipment to prevent unintentional releases and exposures in the event its primary source of power is interrupted? Is the back-up power generating equipment maintained and tested? If the back-up power generating equipment is not present on site, has sufficient draindown time been incorporated into the water balance to allow acquisition, installation, and activation of such equipment?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.4.1?

<u>Standard of Practice 5.4.2</u>: Introduce management and operating systems to minimize cyanide use, thereby limiting concentrations of cyanide in mill tailings. (GGMC)

1. Does the operation conduct a program to determine appropriate cyanide addition rates in the mill and evaluate and adjust addition rates as necessary when ore types or processing practices change cyanide requirements?
2. Has the operation evaluated various control strategies for cyanide additions?
3. Has the operation implemented a strategy to control its cyanide addition?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.4.2?

<u>Code of Practice 5.4.3</u>: Implement a comprehensive water management program to protect against unintentional releases. (EPA/GGMC)

1. Has the operation developed a comprehensive, probabilistic water balance?
2. Does the water balance consider the following in a reasonable manner and as appropriate for the facilities and environment?
   a) The rates at which solutions are applied to leach pads and tailings that are deposited into tailings storage facilities
   b) A design storm duration and storm return interval that provides a sufficient degree of probability that overtopping of the pond or impoundment can be prevented during the operational life of the facility
   c) The quality of existing precipitation and evaporation data in representing actual site conditions
   d) The amount of precipitation entering a pond or impoundment resulting from surface run-on from the up-gradient watershed, including adjustments as necessary to account for differences in elevation and for infiltration of the runoff into the ground
   e) Effects of potential freezing and thawing conditions on the accumulation of precipitation within the facility and the up-gradient watershed
   f) Solution losses in addition to evaporation, such as the capacity of decant, drainage and recycling systems, allowable seepage to the subsurface, and allowable discharges to surface water
   g) The effects of potential power outages or pump and other equipment failures on the drain-down from a leach pad or the emergency removal of water from a facility
   h) Where solution is discharged to surface waters, the capacity and on-line availability of necessary treatment, destruction or regeneration systems
   i) Other aspects of facility design that can affect the water balance, such as the assumed phreatic surface in a tailings storage facility
3. Do the operating procedures incorporate inspection and monitoring activities to implement the water balance and prevent overtopping of ponds and impoundments and unplanned discharge of cyanide solutions to the environment?
4. Are ponds and impoundments designed and operated with adequate freeboard above the maximum design storage capacity determined to be necessary from water balance calculations?
5. Does the operation measure precipitation, compare the results to design assumptions and revise operating practices as necessary?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.4.3?

<u>Code of Practice 5.4.4</u>: Implement measures to protect birds, other wildlife and livestock from adverse effects of cyanide process solutions. (EPA/GGMC)

1. Has the operation implemented measures (i.e., fencing, filling in collection ditches with gravel, and covering or netting solution in ponds and impoundments) to restrict access by wildlife and livestock to all open waters where WAD cyanide exceeds 50 mg/l?
2. Can the operation demonstrate that the cyanide concentration in open water in TSFs, leach facilities and solution ponds does not exceed 50 mg/l WAD cyanide?
3. Is maintaining a WAD cyanide concentration of 50 mg/l or less in open water effective in preventing significant wildlife mortality?
4. Does the operation apply leach solutions in a manner designed to avoid significant ponding on the heap surface and limit overspray of solution off the heap liner?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.4.4?

<u>Code of Practice 5.4.5</u>: Implement measures to protect fish and wildlife from direct and indirect discharges of cyanide process solutions to surface water. (EPA/GGMC)

1. Does the operation have a direct discharge to surface water and if so, is it no greater than 0.5 mg/l WAD cyanide?
2. Is the concentration of free cyanide 0.022 mg/l or lower downstream of any established mixing zone? How has this been determined?

3. Does the operation have an indirect discharge to surface water? If so, does it result in a concentration of free cyanide in excess of 0.022 mg/l downstream of any established mixing zone?
4. If indirect discharges from the operation have caused cyanide concentrations in surface water to rise above levels protective of a designated beneficial use for aquatic life, is the operation engaged in remedial activity to prevent further degradation and restore beneficial use?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.4.5?

Code of Practice 5.4.6: Implement measures designed to manage seepage from cyanide facilities to protect the beneficial uses of ground water. (EPA/GGMC)

1. Does the operation implement specific water management or other measures to manage seepage to protect the beneficial use(s) of ground water beneath and/or immediately down gradient of the operation?
2. Are WAD cyanide concentrations (or other species of cyanide for which there is a numerical standard established by the applicable jurisdiction) in groundwater at compliance points below or down gradient of the facility at or below levels that are protective of identified beneficial uses of the groundwater?
3. If the operation uses mill tailings as underground backfill, have the potential impacts to worker health and the beneficial uses of ground water been evaluated and have measures been implemented as necessary to address them?
4. If seepage from the operation has caused cyanide concentrations of ground water to rise above levels protective of beneficial use, is the operation engaged in remedial activity to prevent further degradation and restore beneficial use?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.4.6?

Code of Practice 5.4.7: Provide spill prevention or containment measures for process tanks and pipelines. (EPA/GGMC)

1. Are spill prevention or containment measures provided for all cyanide unloading, storage, mixing and process solution tanks?
2. Are secondary containments for cyanide unloading, storage, mixing and process tanks sized to hold a volume greater than that of the largest tank within the containment and any piping draining back to the tank, and with additional capacity for the design storm event?
3. Are procedures in place and being implemented to prevent discharge to the environment of any cyanide solution or cyanide-contaminated water that is collected in a secondary containment area?
4. For cyanide process tanks without secondary containment, are there procedures for remediation of any contaminated soil such that adverse impacts on surface or ground water are prevented?
5. Are spill prevention or containment measures provided for all cyanide process solution pipelines to collect leaks and prevent releases to the environment?
6. Have areas where cyanide pipelines present a risk to surface water been evaluated for special protection needs?
7. Are cyanide tanks and pipelines constructed of materials compatible with cyanide and high pH conditions?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.4.7?

<u>Code of Practice 5.4.8</u>: Implement quality control/quality assurance procedures to confirm that cyanide facilities are constructed according to accepted engineering standards and specifications. (GGMC)

1. Have quality control and quality assurance programs been implemented during construction of all new cyanide facilities and modifications to existing facilities, including cyanide unloading, storage, mixing facilities and other cyanide facilities?
2. Have quality control and quality assurance programs addressed the suitability of materials and adequacy of soil compaction for earthworks such as tank foundations and earthen liners, the installation of synthetic membrane liners used in ponds and leach pads, and for construction of cyanide storage and process tanks?

3. Have quality control and quality assurance records been retained for cyanide facilities?
4. Have appropriately qualified personnel reviewed cyanide facility construction and provided documentation that the facility has been built as proposed and approved?
5. Where there is no available quality control and quality assurance documentation or as-built certification for cyanide facility construction, has an appropriately qualified person inspected those elements of the facility involving cyanide and issued a report concluding that its continued operation within established parameters will protect against cyanide exposures and releases?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.4.8?

Code of Practice 5.4.9: Implement monitoring programs to evaluate the effects of cyanide use on wildlife, surface and ground water quality. (EPA/GGMC)

1. Has the operation developed written standard procedures for monitoring activities?
2. Have sampling and analytical protocols been developed by appropriately qualified personnel?
3. Do procedures specify how and where samples should be taken, sample preservation techniques, chain of custody procedures, shipping instructions, and cyanide species to be analyzed?
4. Are sampling conditions (e.g., weather, livestock/wildlife activity, anthropogenic influences, etc.) and procedures documented in writing?
5. Does the operation monitor for cyanide in discharges of process water to surface water and in surface and ground water down gradient of the site?
6. Does the operation inspect for and record wildlife mortalities related to contact with and ingestion of cyanide solutions?
7. Is monitoring conducted at frequencies adequate to characterize the medium being monitored and to identify changes in a timely manner?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.4.9?

5.5. DECOMMISSIONING: Protect communities and the environment from cyanide through development and implementation of decommissioning plans for cyanide facilities.

<u>Code of Practice 5.5.1</u>: Plan and implement procedures for effective decommissioning of cyanide facilities to protect human health, wildlife and livestock. (EPA/GGMC)

1. Has the operation developed written procedures to decommission cyanide facilities at the cessation of operations?
2. Does the plan include an implementation schedule for decommissioning activities?
3. Does the operation review its decommissioning procedures for cyanide facilities during the life of the operation and revise them as needed?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.5.1?

<u>Code of Practice</u> 5.5.2: Establish an assurance mechanism capable of fully funding cyanide related decommissioning activities. (GGMC)

1. Has the operation developed an estimate of the cost to fully fund third party implementation of the cyanide-related decommissioning measures as identified in its site decommissioning or closure plan?
2. Does the operation review and update the cost estimate at least every five years and when revisions to the plan are made that effect cyanide-related decommissioning activities?
3. Has the operation established a financial mechanism approved by the applicable jurisdiction to cover the estimated costs for cyanide-related decommissioning activities as identified in its decommissioning and closure strategy? If so, no further demonstration is required to comply with this Standard of Practice.
4. If the applicable jurisdiction does not require financial guarantees, has the operation established a mechanism other than self-insurance or self-guarantee to cover estimated costs for the cyanide-

related decommissioning activities as identified in its decommissioning and closure strategy? If so, no further demonstration is required to comply with this Standard of Practice.

5. If the operation has established self-insurance or self-guarantee as a financial assurance mechanism, has the operation provided a statement by a qualified financial auditor that it has sufficient financial strength to fulfill this obligation as demonstrated by an accepted financial evaluation methodology?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.5.2?

5.6. WORKER SAFETY: Protect workers' health and safety from exposure to cyanide.

<u>Code of Practice 5.6.1</u>: Identify potential cyanide exposure scenarios and take measures as necessary to eliminate, reduce and control them. (EPA/GGMC)

1. Has the operation developed procedures describing how cyanide-related tasks such as unloading, mixing, plant operations, entry into confined spaces, and equipment decontamination prior to maintenance should be conducted to minimize worker exposure?
2. Do the procedures require, where necessary, the use of personal protective equipment and address pre-work inspections?
3. Does the operation implement procedures to review proposed process and operational changes and modifications for their potential impacts on worker health and safety, and incorporate the necessary worker protection measures?
4. Does the operation solicit and actively consider worker input in developing and evaluating health and safety procedures?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.6.1?

<u>Code of Practice 5.6.2</u>: Operate and monitor cyanide facilities to protect worker health and safety and periodically evaluate the effectiveness of health and safety measures. (GGMC)

1. Has the operation determined the appropriate pH for limiting the evolution of hydrogen cyanide gas during mixing and production activities?
2. Where the potential exists for significant cyanide exposure, does the operation use ambient or personal monitoring devices to confirm that controls are adequate to limit worker exposure to hydrogen cyanide gas and sodium, calcium or potassium cyanide dust to 10 parts per million on an instantaneous basis and 4.7 parts per million continuously over an 8-hour period, as cyanide?
3. Has the operation identified areas and activities where workers may be exposed to cyanide in excess of 10 parts per million on an instantaneous basis and 4.7 parts per million continuously over an 8-hour period and require use of personal protective equipment in these areas or when performing these activities?
4. Is hydrogen cyanide monitoring equipment maintained, tested and calibrated as directed by the manufacturer, and are records retained for at least one year?
5. Have warning signs been placed where cyanide is used advising workers that cyanide is present, and that smoking, open flames and eating and drinking are not allowed, and that, if necessary, suitable personal protective equipment must be worn?
6. Are showers, low-pressure eye wash stations and dry powder or non-acidic sodium bi-carbonate fire extinguishers located at strategic locations throughout the operation and are they maintained, inspected and tested on a regular basis?
7. Are unloading, storage, mixing and process tanks and piping containing cyanide identified to alert workers of their contents, and is the direction of cyanide flow in pipes designated?
8. Are MSDS, first aid procedures or other informational materials on cyanide safety in the language of the workforce available in areas where cyanide is managed?
9. Are procedures in place and being implemented to investigate and evaluate cyanide exposure incidents to determine if the operation's programs and procedures to protect worker health and safety, and to respond to cyanide exposures, are adequate or need revising?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.6.2?

<u>Code of Practice 5.6.3</u>: Develop and implement emergency response plans and procedures to respond to worker exposure to cyanide. (EPA/GGMC)

1. Does the operation have water, oxygen, a resuscitator, antidote kits and a radio, telephone, alarm system or other means of communication or emergency notification readily available for use at cyanide unloading, storage and mixing locations and elsewhere in the plant?
2. Does the operation inspect its first aid equipment regularly to ensure that it is available when needed, and are materials such as cyanide antidotes stored and/or tested as directed by their manufacturer and replaced on a schedule to ensure that they will be effective when needed?
3. Has the operation developed specific written emergency response plans or procedures to respond to cyanide exposures?
4. Does the operation have its own on-site capability to provide first aid or medical assistance to workers exposed to cyanide?
5. Has the operation developed procedures to transport workers exposed to cyanide to locally available qualified off site medical facilities?
6. Has the operation made formalized arrangements with local hospitals, clinics, etc., so that these providers are aware of the potential need to treat patients for cyanide exposure? Is the operation confident that the medical facility has adequate, qualified staff, equipment and expertise to respond to cyanide exposures?
7. Are mock emergency drills conducted periodically to test response procedures for various cyanide exposure scenarios, and are lessons learned from the drills incorporated into response planning?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.6.3?

5.7. EMERGENCY RESPONSE: Protect communities and the environment through the development of emergency response strategies and capabilities.

<u>Code of Practice 5.7.1</u>: Prepare detailed emergency response plans for potential cyanide releases. (EPA/GGMC)

1. Has the operation developed an Emergency Response Plan to address potential accidental releases of cyanide?
2. Does the Plan consider the potential cyanide failure scenarios appropriate for its site-specific environmental and operating circumstances, including the following, as applicable?

a) Catastrophic release of hydrogen cyanide from storage or process facilities

b) Transportation accidents

c) Releases during unloading and mixing

d) Releases during fires and explosions

e) Pipe, valve and tank ruptures

f) Overtopping of ponds and impoundments

g) Power outages and pump failures

h) Uncontrolled seepage

i) Failure of cyanide treatment, destruction or recovery systems

j) Failure of tailings impoundments, heap leach facilities and other cyanide facilities

3. Has planning for response to transportation-related emergencies considered transportation route(s), physical and chemical form of the cyanide, method of transport (e.g., rail, truck), the condition of the road or railway, and the design of the transport vehicle (e.g., single or double walled, top or bottom unloading)?
4. Does the Plan describe specific response actions (as appropriate for the anticipated emergency situations) such as clearing site personnel and potentially affected communities from the area of exposure, use of cyanide antidotes and first aid measures for cyanide exposure, control of releases at their source, and containment, assessment, mitigation and future prevention of releases?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.7.1?

<u>Code of Practice 5.7.2</u>: Involve site personnel and stakeholders in the planning process. (GGMC)

1. Has the operation involved its workforce and stakeholders, including potentially affected communities, in the cyanide emergency response planning process?

2. Has the operation made potentially affected communities aware of the nature of their risks associated with accidental cyanide releases, and consulted with them directly or through community representatives regarding appropriate communications and response actions?
3. Has the operation involved local response agencies such as outside responders and medical facilities in the cyanide emergency planning and response process?
4. Does the operation engage in consultation or communication with stakeholders to keep the Emergency Response Plan current?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.7.2?

<u>Code of Practice 5.7.3</u>: Designate appropriate personnel and commit necessary equipment and resources for emergency response. (GGMC)

1. Do the cyanide-related elements of the Emergency Response Plan:
   a) Designate primary and alternate emergency response coordinators who have explicit authority to commit the resources necessary to implement the Plan?
   b) Identify Emergency Response Teams?
   c) Require appropriate training for emergency responders?
   d) Include call-out procedures and 24-hour contact information for the coordinators and response team members?
   e) Specify the duties and responsibilities of the coordinators and team members?
   f) List emergency response equipment, including personal protection gear, available along transportation routes and/or on-site?
   g) Include procedures to inspect emergency response equipment to ensure its availability?
   h) Describe the role of outside responders, medical facilities and communities in the emergency response procedures?

2. Has the operation confirmed that outside entities included in the Emergency Response Plan are aware of their involvement and are included as necessary in mock drills or implementation exercises?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.7.3?

Code of Practice 5.7.4: Develop procedures for internal and external emergency notification and reporting. (GGMC)

1. Does the Plan include procedures and contact information for notifying management, regulatory agencies, outside response providers and medical facilities of the cyanide emergency?
2. Does the Plan include procedures and contact information for notifying potentially affected communities of the cyanide related incident and any necessary response measures, and for communication with the media?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.7.4?

Code of Practice 5.7.5: Incorporate into response plans and remediation measures monitoring elements that account for the additional hazards of using cyanide treatment chemicals. (EPA/PTCCP/GGMC)

1. Does the Plan describe specific, remediation measures as appropriate for the likely cyanide release scenarios, such as:
   a) Recovery or neutralization of solutions or solids?
   b) Decontamination of soils or other contaminated media?
   c) Management and/or disposal of spill clean-up debris?
   d) Provision of an alternate drinking water supply?
2. Does the Plan prohibit the use of chemicals such as sodium hypochlorite, ferrous sulfate and hydrogen peroxide to treat cyanide that has been released into surface water?

3. Does the Plan address the potential need for environmental monitoring to identify the extent and effects of a cyanide release, and include sampling methodologies, parameters and, where practical, possible sampling locations?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.7.5?

Code of Practice 5.7.6: Periodically evaluate response procedures and capabilities and revise them as needed. (EPA/GGMC)

1. Does the operation review and evaluate the cyanide related elements of its Emergency Response Plan for adequacy on a regular basis?
2. Are mock cyanide emergency drills conducted periodically as part of the Emergency Response Plan evaluation process?
3. Are provisions in place to evaluate and revise the Emergency Response Plan after any cyanide related emergency requiring its implementation? Have such reviews been conducted?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.7.6?

5.8. TRAINING: Train workers and emergency response personnel to manage cyanide in a safe and environmentally protective manner.

Code of Practice 5.8.1: Train workers to understand the hazards associated with cyanide use. (GGMC)

1. Does the operation train all personnel who may encounter cyanide in cyanide hazard recognition?
2. Is cyanide hazard recognition refresher training periodically conducted?
3. Are cyanide training records retained?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.8.1?

<u>Code of Practice 5.8.2</u>: Train appropriate personnel to operate the facility according to systems and procedures that protect human health, the community and the environment. (GGMC)

1. Does the operation train workers to perform their normal production tasks, including unloading, mixing, production and maintenance, with minimum risk to worker health and safety and in a manner that prevents unplanned cyanide releases?
2. Are the training elements necessary for each job involving cyanide management identified in training materials?
3. Do appropriately qualified personnel provide task training related to cyanide management activities?
4. Are employees trained prior to working with cyanide?
5. Is refresher training on cyanide management provided to ensure that employees continue to perform their jobs in a safe and environmentally protective manner?
6. Does the operation evaluate the effectiveness of cyanide training by testing, observation or other means?
7. Are records retained throughout an individual's employment documenting the training they receive? Do the records include the names of the employee and the trainer, the date of training, the topics covered, and if the employee demonstrated an understanding of the training materials?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.8.2?

<u>Code of Practice 5.8.3</u>: Train appropriate workers and personnel to respond to worker exposures and environmental releases of cyanide. (GGMC)

1. Are all cyanide unloading, mixing, production and maintenance personnel trained in the procedures to be followed if cyanide is released?
2. Are site cyanide response personnel, including unloading, mixing, production and maintenance workers, trained in decontamination and first aid procedures? Do they take part in routine drills to test and improve their response skills?

3. Are Emergency Response Coordinators and members of the Emergency Response Team trained in the procedures included in the Emergency Response Plan regarding cyanide, including the use of necessary response equipment?
4. Has the operation made off-site Emergency Responders, such as community members, local responders and medical providers, familiar with those elements of the Emergency Response Plan related to cyanide?
5. Is refresher training for response to cyanide exposures and releases regularly conducted?
6. Are simulated cyanide emergency drills periodically conducted for training purposes? Do they cover both worker exposures and environmental releases?
7. Are cyanide emergency drills evaluated from a training perspective to determine if personnel have the knowledge and skills required for effective response? Are training procedures revised if deficiencies are identified?
8. Are records retained documenting the cyanide training, including the names of the employee and the trainer, the date of training, the topics covered, and how the employee demonstrated an understanding of the training materials?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.8.3?

5.9. DIALOGUE: Engage in public consultation and disclosure.

<u>Code of Practice 5.9.1</u>: Provide stakeholders the opportunity to communicate issues of concern. (GGMC/GGDMA/MOAF)

1. Does the operation provide the opportunity for stakeholders to communicate issues of concern regarding the management of cyanide?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.9.1?

Code of Practice 5.9.2: Initiate dialogue describing cyanide management procedures and responsively address identified concerns. (GGMC/MOAF)

1. Are there opportunities for the operation to interact with stakeholders and provide them with information regarding cyanide management practices and procedures?

Finding: Is the operation in full compliance, substantial compliance, or non-compliance with Code of Practice 5.9.2?

Code of Practice 5.9.3: Make appropriate operational and environmental information regarding cyanide available to stakeholders. (EPA/GGMC/GGDMA)

1. Has the operation developed written descriptions of how their activities are conducted and how cyanide is managed? Are these descriptions available to communities and other stakeholders?
2. Has the operation disseminated information on cyanide in verbal form where a significant percentage of the local population is illiterate?
3. Does the operation make information publicly available on the following confirmed cyanide release or exposure incidents?
   a) Cyanide exposure resulting in hospitalization or fatality
   b) Cyanide releases off the mine site requiring response or remediation
   c) Cyanide releases on or off the mine site resulting in significant adverse effects to health or the environment
   d) Cyanide releases on or off the mine site requiring reporting under applicable regulations
   e) Releases that are or that cause applicable limits for cyanide to be exceeded

Finding: Is the operation in full compliance, substantial compliance?

6.0 General Information and Health Issues

Synonyms include formonitrile. Aqueous solutions are referred to as hydrocyanic acid and prussic acid.

- Persons whose clothing or skin is contaminated with cyanide-containing solutions can secondarily contaminate response personnel by direct contact or through off-gassing vapor.
- Hydrogen cyanide is a colorless or pale-blue liquid at room temperature. It is very volatile, readily producing flammable and toxic concentrations at room temperature. Hydrogen cyanide gas mixes well with air, and explosive mixtures are easily formed.
- Hydrogen cyanide has a distinctive bitter almond odor, but some individuals cannot detect it and consequently, it may not provide adequate warning of hazardous concentrations.
- Hydrogen cyanide is absorbed well by inhalation and can produce death within minutes. Substantial absorption can occur through intact skin if vapor concentration is high or with direct contact with solutions, especially at high ambient temperatures and relative humidity. Exposure by any route may cause systemic effects.

Description

At temperatures below 78 °F, hydrogen cyanide is a colorless or pale-blue liquid (hydrocyanic acid); at higher temperatures, it is a colorless gas. Hydrogen cyanide is very volatile, producing potentially lethal concentrations at room temperature. The vapor is flammable and potentially explosive. Hydrogen cyanide has a faint, bitter almond odor and a bitter, burning taste. It is soluble in water and is often used as a 96% aqueous solution (NIOSH 2005).

Routes of Exposure

Inhalation

Hydrogen cyanide is readily absorbed from the lungs; symptoms of poisoning begin within seconds to minutes. The odor of hydrogen cyanide is detectable at 2-10 ppm (OSHA PEL = 10 ppm), but does not provide adequate warning of hazardous concentrations. Perception of the odor is a genetic trait (20-40% of the general population cannot detect hydrogen cyanide); also, rapid olfactory fatigue can occur. Hydrogen cyanide is lighter than air (HSDB 2007).

Children exposed to the same levels of hydrogen cyanide as adults may receive larger doses because they have greater lung surface area:body weight ratios and increased minute volumes:weight ratios.

Skin/Eye Contact

Exposure to hydrogen cyanide can cause skin and eye irritation. More importantly, skin or eye absorption is rapid and contributes to systemic poisoning. After skin exposure, onset of symptoms may be immediate or delayed for 30-60 minutes. Most cases of toxicity from dermal exposure have been from industrial accidents involving partial immersion in liquid cyanide or cyanide solutions or from contact with molten cyanide salts, resulting in large surface-area burns (ATSDR 2006).

Children are more vulnerable to toxicants absorbed through the skin because of their relatively larger surface area:body weight ratio.

Ingestion

Ingestion of hydrogen cyanide solutions or cyanide salts can be rapidly fatal (ATSDR 2006). Treatment of ingested cyanide salts is similar to treatment of oral hydrogen cyanide poisoning because cyanide salts form hydrogen cyanide in acidic conditions.

Sources/Uses

Hydrogen cyanide is manufactured by oxidation of ammonia- methane mixtures under controlled conditions and by the catalytic decomposition of formamide. It may be generated by treating cyanide salts with acid, and it is a combustion by-product of nitrogen-containing materials such as wool, silk, and plastics. It is also produced by enzymatic hydrolysis of nitriles and related chemicals. Hydrogen cyanide gas is a by-product of coke-oven and blast-furnace operations (ATSDR 2006; Hartung 1994).

Hydrogen cyanide is used in fumigating; electroplating; mining; and in producing synthetic fibers, plastics, dyes, and pesticides. It also is used as an intermediate in chemical syntheses (Hartung 1994). Hydrogen cyanide may also be found in cigarette smoke (ATSDR 2006; HSDB 2007).

Standards and Guidelines

OSHA PEL (permissible exposure limit) (ceiling) = 10 ppm (skin) (averaged over 15 minutes) (OSHA 1999)

EPA AEGL-1 (Acute Exposure Guideline Level-1) = 2.5 ppm (10-minute) to 1 ppm (8-hour) (EPA 2007).

Physical Properties

Description: Colorless gas or colorless or pale-blue liquid

Warning properties: Almond odor; inadequate warning because rapid olfactory fatigue can occur and 20â€“40% of the general population cannot smell hydrogen cyanide.

Molecular weight: 27.03 daltons

Boiling point (760 mm Hg): 78 F (25.6 °C)

Freezing point: 8 F (-13.4 °C)

Specific gravity (liquid): 0.69 (water = 1)

Vapor pressure: 630 mm Hg at 68 °F (20 °C)

Gas density: 0.94 (air = 1)

Water solubility: Miscible with water

Flammability: Flammable at temperatures >0 °F (-18 °C)

Flammable range: 5.6-40% (concentration in air) (ATSDR 2006)

Incompatibilities

Hydrogen cyanide reacts with amines, oxidizers, acids, sodium hydroxide, calcium hydroxide, sodium carbonate, caustic substances, and ammonia. Hydrogen cyanide may polymerize at 122-140 °F (NIOSH 2005).

Health Effects

- Hydrogen cyanide is highly toxic by all routes of exposure and may cause abrupt onset of profound CNS, cardiovascular, and respiratory effects, leading to death within minutes.
- Exposure to lower concentrations of hydrogen cyanide may produce eye irritation, headache, confusion, nausea, and vomiting followed in some cases by coma and death.
- Hydrogen cyanide acts as a cellular asphyxiant. By binding to mitochondrial cytochrome oxidase, it prevents the utilization of oxygen in cellular metabolism. The CNS and myocardium are particularly sensitive to the toxic effects of cyanide.

Acute Exposure

In humans, cyanide combines with the ferric ion in mitochondrial cytochrome oxidase, preventing electron transport in the cytochrome system and bringing oxidative phosphorylation and ATP production to a halt. The inhibition of oxidative metabolism puts increased demands on anaerobic glycolysis, which results in lactic acid production and may produce severe acid-base imbalance. The CNS is particularly sensitive to the toxic effects of cyanide, and exposure to hydrogen cyanide generally produces symptoms within a short period of time (ATSDR 2006).

Children do not always respond to chemicals in the same manner as adults. Different protocols for managing their care may be needed.

CNS

CNS signs and symptoms usually develop rapidly. Initial symptoms are nonspecific and include excitement, dizziness, nausea, vomiting, headache, and weakness. As poisoning progresses, drowsiness, tetanic spasm, lockjaw, convulsions, hallucinations, loss of consciousness, and coma may occur (ATSDR 2006).

Cardiovascular

Abnormal heartbeat can occur in cases of severe poisoning. Slow heartbeat, intractable low blood pressure, and death may result. High blood pressure and a rapid heartbeat may be early, transient findings (ATSDR 2006).

Respiratory

After systemic poisoning begins, victims may complain of shortness of breath and chest tightness. Pulmonary findings may include rapid breathing and increased depth of respirations. As poisoning progresses, respirations become slow and gasping; a bluish skin color may or may not be present. Accumulation of fluid in the lungs may develop (ATSDR 2006).

Children may be more vulnerable to gas exposure because of relatively increased minute ventilation per kg and failure to recognize the need to promptly evacuate an area when exposed.

Metabolic

An anion-gap, metabolic acidosis occurs in severe poisoning from increased blood levels of lactic acid (ATSDR 2006).

Because of their higher metabolic rates, children may be more vulnerable to toxicants interfering with basic metabolism.

Dermal

Dermal contact with hydrogen cyanide can cause skin irritation (HSDB 2007).

Dermal absorption can occur, leading to systemic toxicity. Absorption occurs more readily at high ambient temperature and relative humidity (ATSDR 2006).

Because of their relatively larger surface area:body weight ratio, children are more vulnerable to toxicants absorbed through the skin.

Ocular/Ophthalmic

When splashed in the eye, hydrogen cyanide can cause eye irritation and swelling. Eye contact with cyanide salts has produced systemic symptoms in experimental animals (ATSDR 2006).

Potential Sequelae

Survivors of severe exposure may suffer brain damage Cases of neurologic sequelae such as personality changes, memory deficits, disturbances in voluntary muscle movements, and the appearance of involuntary movements (i.e., extrapyramidal syndromes) have been reported (ATSDR 2006).

Chronic Exposure

Chronically exposed workers may complain of headache, eye irritation, easy fatigue, chest discomfort, palpitations, loss of appetite, and nosebleeds (ATSDR 2006).

Chronic exposure may be more serious for children because of their potential longer life span.

Carcinogenicity

Hydrogen cyanide has not been classified for carcinogenic effects (IARC 2007; IRIS 2007; NTP 2005), and no carcinogenic effects have been reported for hydrogen cyanide.

Reproductive and Developmental Effects

No hydrogen cyanide-induced developmental effects have been reported in humans or in animals at exposure levels that were not maternally toxic (ATSDR 2006). Mild reproductive effects of sodium cyanide have been reported in rats and mice administered the substance orally for 13 weeks (ATSDR 2006). Increased levels of thiocyanate in the umbilical cords of fetuses whose mothers smoked compared to those whose mothers were non-smokers suggests that thiocyanate, and possibly also cyanide, can cross the placenta. No data were located pertaining to hydrogen cyanide in breast milk (ATSDR 2006).

Prehospital Management

- A victim exposed to hydrogen cyanide gas could secondarily contaminate a rescuer attempting resuscitation without a respiratory barrier. Victims whose clothing or skin is contaminated with hydrogen

cyanide liquid or solution can secondarily contaminate response personnel by direct contact or through off-gassing vapor. Avoid dermal contact with cyanide-contaminated victims or with gastric contents of victims who may have ingested cyanide-containing materials.

- Hydrogen cyanide poisoning is marked by abrupt onset of profound toxic effects that may include syncope, seizures, coma, gasping respirations, and cardiovascular collapse, causing death within minutes. These effects can occur from all routes of exposure.
- Victims exposed to hydrogen cyanide require supportive care and rapid administration of specific antidotes.

Hot Zone

Rescuers should be trained and appropriately attired before entering the Hot Zone. If the proper equipment is not available, or if rescuers have not been trained in its use, assistance should be obtained from a local or regional HAZMAT team or other properly equipped response organization.

Rescuer Protection

Hydrogen cyanide is a highly toxic systemic poison that is absorbed well by inhalation and through the skin.

Respiratory Protection: Positive-pressure, self-contained breathing apparatus (SCBA) is recommended in response situations that involve exposure to potentially unsafe levels of hydrogen cyanide (HSDB 2007).

Skin Protection: Chemical-protective clothing against hydrogen cyanide is recommended because both hydrogen cyanide vapor and liquid can be absorbed through the skin to produce systemic toxicity.

ABC Reminders

Quickly establish a patent airway, ensure adequate respiration and pulse. If trauma is suspected, maintain cervical immobilization manually and apply a cervical collar and a backboard when feasible.

Victim Removal

If victims can walk, lead them out of the Hot Zone to the Decontamination Zone. Victims who are unable to walk may be removed on backboards or gurneys; if these are not available, carefully carry or drag victims to safety.

Victims with chemically-induced acute disorders may suffer from anxiety, especially children who may be separated from a parent or other adult.

Decontamination Zone

Patients exposed only to hydrogen cyanide gas who have no eye irritation do not need decontamination. They may be transferred immediately to the Support Zone. Other patients will require decontamination as described below.

Rescuer Protection

If exposure levels are determined to be safe, decontamination may be conducted by personnel wearing a lower level of protection than that worn in the Hot Zone (described above). **However, do not attempt resuscitation without a respiratory barrier**.

ABC Reminders

Quickly establish a patent airway, ensure adequate respiration and pulse. Stabilize the cervical spine with a collar and a backboard if trauma is suspected. Administer supplemental oxygen as required. Assist ventilation with a bag-valve-mask device if necessary.

Basic Decontamination

Speed is critical. For symptomatic victims, provide treatment with 100% oxygen and specific antidotes as needed. Treatment should be given simultaneously with decontamination procedures. (For treatment, see *ABC Reminders, Advanced Treatment, and Antidotes* below).

Victims who are able may assist with their own decontamination. Quickly remove and double-bag contaminated clothing and personal belongings.

Flush exposed skin and hair with copious amounts of water for at least 20 minutes. Wash with soap and rinse thoroughly with water. Use caution to avoid hypothermia when decontaminating victims, particularly children or the elderly. Use blankets or warmers as needed.

Flush exposed or irritated eyes with plain water or saline for 5 minutes. Remove contact lenses if easily removable without additional trauma to the eye. Continue eye irrigation during other basic care or transport (HSDB 2007). If pain or injury is evident, continue irrigation while transferring to the Support Zone.

In cases of ingestion, **do not induce emesis. If the victim is symptomatic, immediately institute emergency life support measures including the use of a cyanide antidote (see Antidotes below)**.

Provide reassurance to chemically-contaminated victims during decontamination, particularly children who may suffer separation anxiety if separation from a parent occurs.

Transfer to Support Zone

As soon as basic decontamination is complete, move the victim to the Support Zone.

Support Zone

Be certain that victims have been decontaminated properly (see *Decontamination Zone* above). Victims who have undergone decontamination pose no serious risks of secondary contamination to rescuers. In such cases, Support Zone personnel require no specialized protective gear.

ABC Reminders

Quickly establish a patent airway, ensure adequate respiration and pulse. If trauma is suspected, maintain cervical immobilization manually and apply a cervical collar and a backboard when feasible. Administer supplemental oxygen as required and establish intravenous access if necessary. Place on a cardiac monitor.

Patients who rapidly regain consciousness and who have no other signs or symptoms may not require antidotal treatment. Those who remain comatose or develop shock should be treated promptly with the antidotes in the cyanide antidote kit (see Antidotes below).

Additional Decontamination

Continue irrigating exposed skin and eyes, as appropriate.

In cases of ingestion, **do not induce emesis. If the patient is symptomatic, immediately institute emergency life support measures, including the use of a cyanide antidote (see *Antidotes* below)**.

Advanced Treatment

In cases of respiratory compromise, secure airway and support respiration according to advanced life support (ALS) protocols.

Patients who are in shock or have seizures should be treated according to ALS protocols. These patients or those who have arrhythmias may be seriously acidotic; consider giving, under medical supervision, 1 mEq/kg intravenous sodium bicarbonate (HSDB 2007).

Antidotes

When possible, treatment with cyanide antidotes should be given under medical supervision to unconscious victims who have known or strongly suspected cyanide poisoning. There are currently two cyanide antidotal kits approved by the U.S. Food and Drug Administration (FDA). Use either the standard cyanide antidotal kit that includes amyl nitrite perles and intravenous infusions of sodium nitrite and sodium thiosulfate or the recently approved cyanokit that employs intravenous infusion of hydroxocobalamin (FDA 2006; HSDB 2007).

Use of the standard cyanide antidotal kit includes the following: Amyl nitrite perles should be broken onto a gauze pad and held under the nose, over the Ambu-valve intake, or placed under the lip of the face mask. Inhale for 30 seconds every minute and use a new perle every 3 minutes if sodium nitrite infusions will be delayed (HSDB 2007). If the patient has not responded to oxygen and amyl nitrite treatment, infuse sodium nitrite intravenously as soon as possible. The usual adult dose is 10 mL of a 3% solution (300 mg) infused over **absolutely no less than 5 minutes**; the average pediatric dose is 0.12-0.33 mL/kg body weight up to 10 mL infused as above. Monitor blood pressure during sodium nitrite administration, and slow the rate of infusion if hypotension develops (HSDB 2007). Next, infuse sodium thiosulfate intravenously. The usual adult dose is 50 mL of a 25% solution (12.5 g) infused over 10-20 minutes; the average pediatric dose is 1.65 mL/kg of a 25% solution. Repeat one-half of the initial dose 30 minutes later if there is an inadequate clinical response (HSDB 2007).

Use of the Cyanokit includes the following: Infuse hydroxocobalamin (5 g) intravenously over 15 minutes. Depending on the severity of poisoning and the clinical response, a second dose of 5 g may be administered over 15 minutes to 2 hours (based on patient condition). The recommended

diluent is 0.9% sodium chloride. Some drugs are incompatible with hydroxocobalamin, in which case, a separate intravenous line may be necessary (Drugs.com 2007).

Transport to Medical Facility

Only decontaminated patients or patients not requiring decontamination should be transported to a medical facility. Body bags are not recommended.

Report to the base station and the receiving medical facility the condition of the patient, treatment given, and estimated time of arrival at the medical facility.

If a cyanide-containing solution has been ingested, prepare the ambulance in case the victim vomits. Have ready several towels and open plastic bags to quickly clean up and isolate vomitus.

Multi-Casualty Triage

Consult with the base station physician or the regional poison control center for advice regarding triage of multiple victims.

Patients with evidence of significant hydrogen cyanide exposure, and all patients with oral exposure to hydrogen cyanide and those with potentially hazardous dermal exposure, should be transported to a medical facility for evaluation.

Patients who have only brief inhalation exposure and mild or transient symptoms may be discharged from the scene after their names, addresses, and telephone numbers are recorded. They should be advised to seek medical care promptly if symptoms develop or recur (see *Patient Information Sheet* below).

Emergency Department Management

- Hospital/Health Centre personnel in an enclosed area can be secondarily contaminated by vapor off-gassing from heavily soaked clothing or skin, or from vomitus. Avoid dermal contact with cyanide-contaminated patients or with gastric contents of patients who may have ingested cyanide-containing materials. Patients do not pose secondary contamination risks after contaminated clothing is removed and the skin is washed.
- Hydrogen cyanide poisoning is marked by abrupt onset of profound health effects that may include syncope, seizures, coma, gasping

respirations, and cardiovascular collapse, causing death within minutes.

- Patients exposed to hydrogen cyanide can survive with supportive care and rapid administration of specific antidotes.

Decontamination Area

Previously decontaminated patients and patients exposed only to hydrogen cyanide gas and have no skin or eye irritation may be transferred immediately to the Critical Care Area. Other patients require decontamination as described below.

ED personnel should don butyl rubber gloves and aprons before treating patients who have been exposed to hydrogen cyanide liquid or solutions. Hydrogen cyanide readily penetrates most rubbers and barrier fabrics or creams, but butyl rubber provides good skin protection for a short period of time.

Be aware that use of protective equipment by the provider may cause anxiety, particularly in children, resulting in decreased compliance with further management efforts.

Because of their relatively larger surface area:body weight ratio, children are more vulnerable to toxicants absorbed through the skin.

ABC Reminders

Evaluate and support airway, breathing, and circulation according to ALS protocols.

Patients who are comatose, hypotensive, or have seizures or cardiac dysrhythmias should be treated in the conventional manner. If not previously administered, give sodium bicarbonate intravenously to these patients (HSDB 2007). Further bicarbonate therapy should be guided by ABG measurements.

Basic Decontamination

Patients who are able may assist with their own decontamination. Remove and double-bag contaminated clothing and personal belongings.

Speed is critical. If the patient is symptomatic, immediately institute emergency life support measures, including the use of a cyanide antidote kit (see Antidotes in the Prehospital Management section above).

If the patient's clothing is wet with hydrogen cyanide solution, quickly remove contaminated clothing while flushing exposed skin and hair with plain water for 2-3 minutes (preferably under a shower), then wash twice with mild soap (HSDB 2007). Use caution to avoid hypothermia when decontaminating victims, particularly children or the elderly. Use blankets or warmers as needed.

Irrigate exposed eyes for at least 5 minutes. Remove contact lenses if easily removable without additional trauma to the eye. Continue irrigation while transporting the patient to the Critical Care Area.

In cases of ingestion, **do not induce emesis**. If the victim is alert, asymptomatic, and has a gag reflex, consider administering a slurry of activated charcoal at a dose of 1 g/kg (infant, child, and adult dose) (HSDB 2007). Because cyanide absorption from the gut is rapid, the effectiveness of activated charcoal will depend on how quickly after ingestion it can be administered. Consider gastric lavage if the patient is conscious and it can be performed shortly after ingestion. Isolate gastric washings and vomitus; they may off-gas hydrogen cyanide (HSDB 2007).

Critical Care Area

Be certain that appropriate decontamination has been carried out (see *Decontamination Area* above).

ABC Reminders

Evaluate and support airway, breathing, and circulation as in *ABC Reminders* above under *Decontamination Zone*. Establish intravenous access in seriously ill patients if this has not been done previously. Continuously monitor cardiac rhythm.

Patients who are in shock or have seizures should be treated according to ALS protocols. These patients or those who have dysrhythmias may be seriously acidotic; consider giving 1 mEq/kg intravenous sodium bicarbonate (HSDB 2007).

Inhalation Exposure

Inhalation is the primary route of exposure to hydrogen cyanide. Refer to *Antidotes and Other Treatments* below for appropriate clinical treatment of systemic effects.

Skin Exposure

If the skin contacted hydrogen cyanide liquid or cyanide solutions, chemical burns may occur; treat as thermal burns. Watch for signs or symptoms of systemic toxicity, which may be delayed in onset for up to 1 hour.

Eye Exposure

Continue irrigation for at least 15 minutes. Test visual acuity. Examine the eyes for corneal damage and treat appropriately. Immediately consult an ophthalmologist for patients who have corneal injuries.

Ingestion Exposure

Do not induce emesis. If the victim is symptomatic, immediately institute emergency life support measures including the use of a cyanide antidote kit (see *Antidotes* in the Prehospital Management section above). If the victim is alert, asymptomatic, has a gag reflex, and it has not been done previously, consider performing gastric lavage.

Vomitus or gastric washings should be isolated (e.g., by attaching the lavage tube to isolated wall suction or another closed container).

Antidotes and Other Treatments

Patients who have signs or symptoms of significant systemic toxicity should be evaluated for antidotal treatment. There are currently two cyanide antidotal kits approved by the U.S. FDA. Use either the cyanide antidotal kit that includes amyl nitrite perles and intravenous infusions of sodium nitrite and sodium thiosulfate or the recently approved cyanokit that employs intravenous infusion of hydroxocobalamin (FDA 2006; HSDB 2007). For instructions on use of cyanide antidotal kits, see *Antidotes* in the Prehospital Management section above.

The efficacy of hyperbaric oxygen in cyanide poisoning is unproven. It has been reported to be useful in severe cases of smoke inhalation combined with exposure to hydrogen cyanide and carbon monoxide (HSDB 2007).

Laboratory Tests

The diagnosis of acute cyanide toxicity is primarily a clinical one (based on rapid onset of CNS toxicity and cardiorespiratory collapse). Specific tests for the presence of cyanide in blood and urine may be useful in confirming exposure, but have limited usefulness in acute treatment decisions. Routine laboratory studies for all exposed patients include CBC, blood glucose, and electrolyte determinations. Additional studies for patients exposed to hydrogen cyanide include ECG monitoring, determinations of serum lactate and urinary thiocyanate, chest radiography, and pulse oximetry (or ABG measurements) (Hall and Rumack 1998). Some pulse oximeters may give spurious results in the presence of hemoglobin species other than oxyhemoglobin and deoxyhemoglobin.

In severe poisonings, venous blood is oxygenated and has a bright red color. Elevated venous PO2 and venous percent O2 saturation occurs, narrowing the gap between arterial and central venous PO2 or percent O2 saturation (Hall and Rumack 1998).

After treatment with nitrites, serum methemoglobin levels may be monitored. Whole blood cyanide tests generally require several hours and cannot be used to guide emergency treatment. However, blood cyanide levels may be useful in documenting exposure (Hall and Rumack 1998; Kruszyna et al. 1993).

MRI studies may be useful in identifying the location and extent of brain injury in patients with cyanide-induced Parkinsonian syndrome.

Disposition and Follow-up

Consider hospitalizing patients who have histories of significant exposure and are symptomatic. Whenever infusions from a cyanide antidote kit are used, the patient should be admitted to the intensive care unit (Hall and Rumack 1998).

Delayed Effects

Patients who have ingested hydrogen cyanide solutions or patients who have direct skin or eye contact should be observed in the Emergency Department for at least 4 to 6 hours (Hall and Rumack 1998).

Patient Release

Patients who remain asymptomatic 4 to 6 hours after exposure may be discharged with instructions to seek medical care promptly if symptoms develop (see the *Hydrogen Cyanideâ€"Patient Information Sheet* below).

Follow-up

Obtain the name of the patient's primary care physician so that the hospital can send a copy of the ED visit to the patient's doctor.

Survivors of a serious exposure should be evaluated for ischemic damage to the brain and heart. Patients who have serious systemic cyanide poisoning may be at risk for CNS sequelae including Parkinsonian-like syndromes; they should be monitored for several weeks to months (Hall and Rumack 1998).

Patients who have corneal injuries should be reexamined within 24 hours.

Reporting

If a work-related incident has occurred, you may be legally required to file a report; contact your state or local health department.

Other persons may still be at risk in the setting where this incident occurred. If the incident occurred in the workplace, discussing it with company personnel may prevent future incidents. If a public health risk exists, notify your state or local health department or other public agency. When appropriate, inform patients that they may request an evaluation of their workplace from OSHA or NIOSH. See Appendices III and IV for a list of agencies that may be of assistance.

Patient Information Sheet

This handout provides information and follow-up instructions for persons who have been exposed to hydrogen cyanide.

What is hydrogen cyanide?

At room temperature, hydrogen cyanide is a volatile, colorless-to-blue liquid (also called hydrocyanic acid). It rapidly becomes a gas that can produce death in minutes if breathed. Hydrogen cyanide is used in making fibers, plastics, dyes, pesticides, and other chemicals, and as

a fumigant to kill rats. It is also used in electroplating metals and in developing photographic film. Low cyanide levels can be measured in cigarette smoke.

What immediate health effects can be caused by exposure to hydrogen cyanide?
Breathing small amounts of hydrogen cyanide may cause headache, dizziness, weakness, nausea, and vomiting. Larger amounts may cause gasping, irregular heartbeats, seizures, fainting, and even rapid death. Generally, the more serious the exposure, the more severe the symptoms. Similar symptoms may be produced when solutions of hydrogen cyanide are ingested or come in contact with the skin.

Can hydrogen cyanide poisoning be treated?
The treatment for cyanide poisoning includes breathing pure oxygen, and in the case of serious symptoms, treatment with specific cyanide antidotes. Persons with serious symptoms will need to be hospitalized.

Are any future health effects likely to occur?
A single small exposure from which a person recovers quickly is not likely to cause delayed or long-term effects. After a serious exposure, a patient may have brain or heart damage.

What tests can be done if a person has been exposed to hydrogen cyanide?
Specific tests for the presence of cyanide in blood and urine may be useful in confirming exposure, but have limited usefulness in acute treatment decisions. If a severe exposure has occurred, blood and urine analyses and other tests may show whether the brain or heart has been injured. Testing is not needed in every case.

Where can more information about hydrogen cyanide be found?
More information about hydrogen cyanide can be obtained from your regional poison control center; your state, county, or local health department; the Agency for Toxic Substances and Disease Registry (ATSDR); your doctor; or a clinic in your area that specializes in occupational and environmental health. If the exposure happened at work, you may wish to discuss it with your employer, the Occupational Safety and Health Administration (OSHA), or the National Institute for Occupational Safety and Health (NIOSH). Ask the person who gave you this form for help in locating these telephone numbers.

Follow-up Instructions

Keep this page and take it with you to your next appointment. Follow only the instructions checked below.

[ ] Call your doctor or the Emergency Department if you develop any unusual signs or symptoms within the next 24 hours, especially:

- difficulty breathing, shortness of breath, or chest pain
- confusion or fainting
- increased pain or a discharge from your eyes
- increased redness, pain, or a pus-like discharge in the area of a skin burn

[ ] No follow-up appointment is necessary unless you develop any of the symptoms listed above.

[ ] Call for an appointment with Dr. ____ in the practice of _____.

When you call for your appointment, please say that you were treated in the Emergency Department at _____ Hospital/Heal Centre by_____and were advised to be seen again in ____days.

[ ] Return to the Emergency Department/Clinic on ____ (date) at _____ AM/PM for a follow-up examination.

[ ] Do not perform vigorous physical activities for 1 to 2 days.

[ ] You may resume everyday activities including driving and operating machinery.

[ ] Do not return to work for _____days.

[ ] You may return to work on a limited basis. See instructions below.

[ ] Avoid exposure to cigarette smoke for 72 hours; smoke may worsen the condition of your lungs

[ ] Avoid drinking alcoholic beverages for at least 24 hours; alcohol may worsen injury to your stomach or have other effects.

[ ] Avoid taking the following medications: _____

[ ] You may continue taking the following medication(s) that your doctor(s) prescribed for you: _____

[ ] Other instructions: _____
_____

- Provide the Emergency Department/Hospital/Health Centre with the name and the number of your primary care physician so that the ED can send him or her a record of your emergency department visit.
- You or your physician can get more information on the chemical by contacting: _____ or _____, or by checking out the following Internet Web sites: _____;_____.

Signature of patient _____ Date _____

Signature of physician _____ Date _____

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