

THE FACTS ABOUT CYANIDES

TECHNICAL INFORMATION

Note to reader: This fact sheet is intended to provide general awareness and education on a specific chemical agent. For information on preparedness and response (e.g., for first responders and emergency medical personnel), please refer to the following Department resources:

Chemical Terrorism Preparedness and Response Card

(http://www.health.state.ny.us/nysdoh/bt/chemical_terrorism/pdf/chemical.pdf)

Chemical Terrorism Wall Chart

(http://www.health.state.ny.us/nysdoh/bt/chemical_terrorism/pdf/poster.pdf)

What are cyanides?

Cyanides are fast-acting poisons that can be lethal. They were used as chemical weapons for the first time in World War I. Cyanides and cyanide-containing compounds are also used in industry and manufacturing. The estimated 2004 annual U.S. production capacities of sodium cyanide and hydrogen cyanide were 286 million pounds and more than 1.8 billion pounds, respectively. Low levels of cyanides are found in living organisms and are present in cigarette smoke, vehicle exhaust, and in foods such as spinach, bamboo shoots, almonds, lima beans, fruit pits and tapioca.

Some chemical and physical properties of the cyanides likely to be involved in an industrial accident or terrorist attack include:

- Hydrogen cyanide (AC) is a pale blue or colorless liquid below 78° F and a colorless gas at higher temperatures. It has a bitter almond odor and is highly volatile and flammable at room temperature.
- Sodium cyanide and potassium cyanide are white powders which may have a bitter almond-like odor. In the presence of moisture, either can form hydrogen cyanide.
- Cyanogen compounds can generate cyanides. Cyanogen chloride (CK) is a colorless liquefied gas that is heavier than air and has a pungent, highly irritating odor. It is soluble in water and organic solvents.

The odors associated with cyanide-containing compounds can not be relied on as an adequate warning of hazardous concentrations. Between 20 and 40% percent of the population does not carry the gene needed to detect the odor of cyanide. Even among those who possess the necessary gene, olfactory fatigue can prevent cyanide detection.

How are cyanides used?

Cyanide and cyanide-containing compounds are used in pesticides and fumigants, plastics, electroplating, photographic developing and mining. Dye, textile and pharmaceutical industries also use cyanides. Cyanogen can be used as a rocket propellant. Historically, hydrogen cyanide has been used as a warfare agent. Iron and steel production, chemical manufacturing and wastewater treatment create cyanides. During water chlorination, cyanogen chloride may be produced at low levels.

How can people be exposed to cyanides?

People may be exposed to low levels of cyanides in their daily lives from foods, smoking and other sources. However, lethal exposures to cyanides result only from accidents, suicides or homicides. Inhalation of cyanide gas, especially within an enclosed space, poses a significant health risk. Ingestion of food and beverages containing cyanide can also cause health effects. The limited information available on dermal exposure to cyanides suggests that large enough doses cause health effects similar to inhalation and ingestion.

What is cyanide's mechanism of action?

Cyanide has a high affinity for metals like cobalt and trivalent iron, and for sulfane compounds such as sodium thiosulfate which contains a sulfur-to-sulfur bond. In large doses, cyanide quickly binds with iron in cytochrome a_3 , preventing electron transport in the cytochrome. This stops oxidative phosphorylation and adenosine triphosphate (ATP) production. As a result, intracellular oxygen utilization ceases. Cells are then forced into anaerobic metabolism, creating lactic acid and leading to acid-base imbalances and metabolic acidosis.

In small doses, cyanide can be metabolized into thiocyanate with the assistance of the hepatic enzyme, rhodanese. Thiocyanate is then excreted in urine. A small amount of cyanide can also be converted to carbon dioxide which leaves the body through exhalation. Some cyanide can react with hydroxycobalamin to form vitamin B₁₂. Most cyanide leaves the body within one day.

What are the specific signs and symptoms of cyanide exposure?

The health effects from high levels of cyanide exposure can begin in seconds to minutes. Some signs and symptoms of cyanide poisoning are:

- Weakness and confusion
- Headache
- Nausea
- Metabolic acidosis
- Gasping for air in a manner similar to asphyxiation, but with a more abrupt onset
- Difficulty breathing, respiratory arrest
- Loss of consciousness
- Seizures prior to death
- Cardiac arrest

The central nervous system and the myocardium are especially sensitive to cyanide exposure due to their high demand for oxygen. The severity of health effects experienced depend upon the route and duration of exposure, the dose, and the form of cyanide.

How is cyanide exposure treated?

Often the most important first step in treating cyanide exposure is to move the patient from the point of exposure to fresh air and to begin decontamination. To decontaminate, remove the patient's contaminated clothing and thoroughly wash the patient's body and hair with soap and

Cyanide poisoning can be treated with rapid oxygen administration and the antidotes sodium nitrite and sodium thiosulfate. Sodium nitrite, administered intravenously, forms methemoglobin and then attracts bound and unbound cyanide away from cytochrome a_3 . This allows cytochrome a_3 to return to assisting in the production of ATP. If sodium nitrite is unavailable, amyl nitrite ampules can be administered by inhalation. The availability of a sulfur source is

normally the limiting factor in the metabolism of cyanide catalyzed by the hepatic enzyme rhodanese. Administration of sodium thiosulfate provides the sulfur source necessary for rhodanese to accelerate the conversion of cyanide into the less toxic thiocyanate.

Other considerations exist in the administration of cyanide antidotes. If the patient is a victim of recent smoke inhalation and may have high carboxyhemoglobin levels, administer only sodium thiosulfate. Sodium nitrite may overproduce methemoglobin and further compromise oxygen-carrying capacity in such patients. It is also essential that antidote administrations be slow and titrated to effect to prevent overdosing of the patient. Vigorous supportive care may aid in the recovery of patients who have not received antidotes.

Normal saline infusions and a supine position are recommended for sodium nitrite-induced orthostatic hypotension. Intravenous sodium bicarbonate administration may be necessary to correct for metabolic acidosis.

CYANIDE ANTIDOTE RECOMMENDATIONS

| Patient | Mild (conscious) | Severe (unconscious) | Other Treatment |
|--------------|---|---|--|
| Child | If patient is conscious and has no other signs or symptoms, antidotes may not be necessary. | Sodium nitrite ¹ : 0.12 - 0.33 ml/kg, not to exceed 10 ml of 3% solution ² slow IV over no less than 5 minutes, or slower if hypotension develops and Sodium thiosulfate: 1.65 ml/kg of 25% solution IV over 10 - 20 minutes | For sodium nitrite-induced orthostatic hypotension, normal saline infusion and supine position are recommended. If still apneic after antidote administration, consider sodium bicarbonate for severe acidosis. |
| Adult | If patient is conscious and has no other signs or symptoms, antidotes may not be necessary. | Sodium nitrite ¹ : 10 - 20 ml of 3% solution ² slow IV over no less than 5 minutes, or slower if hypotension develops and Sodium thiosulfate: 50 ml of 25% solution IV over 10 - 20 minutes | |

1. If sodium nitrite is unavailable, administer amyl nitrite by inhalation from crushable ampules. If neither is available, use sodium thiosulfate alone.

2. Available from Taylor Pharmaceuticals in cyanide antidote kit, formerly known as the Pasadena or Lilly Kit.

Anyone treating a contaminated person should wear appropriate personal protective equipment to avoid exposure. Responders can be secondarily contaminated through dermal contact or off-gassing vapors, from a victim's clothing or skin contaminated by cyanide-containing solution or from the vomitus of those exposed to cyanide through ingestion. Victims exposed **only** to hydrogen cyanide gas do **not** pose contamination risks to rescuers.

Will laboratory tests assist in making treatment decisions if someone has been exposed to cyanide?

Laboratory testing for cyanide exposure will not be useful in making emergency treatment decisions. Medical tests are available, but any delay in administering antidotes to draw blood or collect urine could endanger patient welfare. Treatment should not be delayed if signs and symptoms are present and exposure is believed to have occurred. The diagnosis of cyanide poisoning is primarily clinical. Laboratory tests may be helpful in monitoring the patient, handling complications, and confirming exposure. Elevated blood cyanide concentration and urinary presence of thiocyanate can confirm exposure to cyanide. Acidosis and elevated venous blood oxygen are likely laboratory findings.

How can I get more information about cyanide?

Call the following numbers, or visit the websites listed among the “Sources.”

- Centers for Disease Control and Prevention Public Response Hotline (1-888-246-2675)
- Agency for Toxic Substances and Disease Registry (1-888-422-8737)
- Regional Poison Control Center (1-800-222-1222)

Sources:

Agency for Toxic Substances and Disease Registry. 1997. Toxicological Profile for Cyanide. Division of Toxicology, U.S. Department of Health and Human Services. Public Health Service: Atlanta, GA.

<http://www.atsdr.cdc.gov/toxprofiles/tp8.html>

Agency for Toxic Substances and Disease Registry. 2004. Medical Management Guidelines for Hydrogen Cyanide. Division of Toxicology, U.S. Department of Health and Human Services. Public Health Service: Atlanta, GA.

<http://www.atsdr.cdc.gov/MHMI/mmg8.html>

Centers for Disease Control and Prevention. 2004. Cyanide. Emergency Preparedness and Response. U.S. Department of Health and Human Services. Public Health Service: Atlanta, GA.

<http://www.bt.cdc.gov/agent/cyanide/index.asp>

U.S. Army Medical Research Institute of Chemical Defense (USAMRICD). 2000. Medical Management of Chemical Casualties Handbook, Third Edition. Chemical Casualty Care Division. Aberdeen Proving Grounds: Aberdeen, MD.

<https://ccc.apgea.army.mil/sarea/products/handbooks/MMCC/mmccthirdeditionjul2000.pdf>

This fact sheet is based on the most current information. It may be updated as new information becomes available.

September 2004