Thallium and Related Compounds

SUBSTANCE IDENTIFICATION
Found as a colorless-to-bluish white, odorless solid. Used as fungicides, pesticides, and insecticides. Also used in the manufacture of many products, including semiconductors, dyes, pigments, optical lenses, cement factories, and fireworks. Thallium metal is acid-soluble and very reactive. Home use of thallium was stopped by the U.S. Department of Agriculture in 1965. It is used in medical diagnostic imaging procedures for myocardial scans.

ROUTES OF EXPOSURE
Skin and eye contact
Inhalation
Ingestion
Skin absorption

TARGET ORGANS
Primary
Skin
Eyes
Central nervous system
Respiratory system
Gastrointestinal system
Hepatic
Renal
Secondary
Cardiovascular system

LIFE THREAT
Pulmonary edema, respiratory failure, circulatory collapse, and seizures.

SIGNS AND SYMPTOMS BY SYSTEM
Cardiovascular: Tachycardia, arrhythmias, and hypertension, followed by circulatory collapse and shock.
Respiratory: Pulmonary edema, dyspnea, and respiratory depression. Nasal discharge and tightness of the chest.
CNS: Ptosis, crossed eyes, weakness, ataxia, paralysis, cranial nerve neuropathy, tremor, paresthesia of arms and legs, peripheral neuropathy, lethargy, and jumbled speech. Psychosis, delirium, coma, and seizures.
Gastrointestinal: Nausea, vomiting, and diarrhea. Abdominal pain and GI hemorrhage. Vomitus and stools often contain blood.
Eye: Chemical conjunctivitis
Skin: Irritation and cyanosis.
Renal: Proteinuria and kidney damage.
Hepatic: Liver damage.
Other: Hair loss and muscular atrophy may occur. Some products may present a human teratogenic risk.
Thallium and Related compounds

SYMPTOM ONSET FOR ACUTE EXPOSURE
Immediate
Some symptoms possibly delayed

CO-EXPOSURE CONCERNS
Other metals
Potassium metal

THERMAL DECOMPOSITION PRODUCTS INCLUDE
Metal oxide fumes
Nitrogen oxide fumes

MEDICAL CONDITIONS POSSIBLY AGGRAVATED BY EXPOSURE
Liver disorders
Kidney disorders
Nervous system disorders

DECONTAMINATION
- Wear positive-pressure SCBA and protective equipment specified by references such as the DOT Emergency Response Guidebook or the CANUTEC Initial Emergency Response Guide. If special chemical protective clothing is required, consult the chemical manufacturer or specific protective clothing compatibility charts.
- Delay entry until trained personnel and proper protective equipment are available.
- Remove patient from contaminated area.
- Quickly remove and isolate patient’s clothing, jewelry, and shoes.
- Gently brush away dry particles and blot excess liquids with absorbent material.
- Rinse patient with warm water, 30°C/86°F, if possible.
- Wash patient with Tincture of Green soap or a mild liquid soap and large quantities of water.
- Refer to decontamination protocol in Section Three.

IMMEDIATE FIRST AID
- Ensure that adequate decontamination has been carried out.
- If victim is not breathing, start artificial respiration, preferably with a demand-valve resuscitator, bag-valve-mask device, or pocket mask as trained. Perform CPR if necessary.
- Immediately flush contaminated eyes with gently flowing water.
- Do not induce vomiting. If vomiting occurs, lean patient forward or place on left side (head-down position, if possible) to maintain an open airway and prevent aspiration.
- Keep victim quiet and maintain normal body temperature.
- Obtain medical attention.

BASIC TREATMENT
- Establish a patent airway. Suction if necessary.
- Watch for signs of respiratory insufficiency and assist ventilations if necessary.
- Administer oxygen by nonrebreather mask at 10 to 15 L/min.
- Monitor for pulmonary edema and treat if necessary (refer to pulmonary edema protocol in Section Three).
- Monitor for shock and treat if necessary (refer to shock protocol in Section Three).
- Anticipate seizures and treat if necessary (refer to seizure protocol in Section Three).
- For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport (refer to eye irrigation protocol in Section Three).
- Do not use emetics. For ingestion, rinse mouth and administer 5 ml/kg up to 200 ml.
of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Administer activated charcoal (refer to ingestion protocol in Section Three and activated charcoal protocol in Section Four).

**ADVANCED TREATMENT**

- Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious or in respiratory arrest.
- Positive-pressure ventilation techniques with a bag-valve-mask device may be beneficial.
- Monitor cardiac rhythm and treat arrhythmias if necessary (refer to cardiac protocol in Section Three).
- Start an IV with D5W TKO. Use lactated Ringer’s if signs of hypovolemia are present. Watch for signs of fluid overload.
- Consider drug therapy for pulmonary edema (refer to pulmonary edema protocol in Section Three).
- For hypotension with signs of hypovolemia, administer fluid cautiously. Watch for signs of fluid overload (refer to shock protocol in Section Three).
- Treat seizures with diazepam (Valium) (refer to diazepam protocol in Section Four).
- Use proparacaine hydrochloride to assist eye irrigation (refer to proparacaine hydrochloride protocol in Section Four).

**INITIAL EMERGENCY DEPARTMENT CONSIDERATIONS**

- Useful initial laboratory studies include complete blood count, serum electrolytes, blood urea nitrogen (BUN), creatinine, glucose, urinalysis, and baseline biochemical profile, including serum aminotransferases (AST and ALT), calcium, phosphorus, and magnesium. Arterial blood gases (ABGs), chest radiograph, and electrocardiogram may be required.
- Blood or urine thallium determinations may be done. Urine thallium concentration is probably the most useful. Blood thallium in normal individuals may average 3 µg/L with most individuals less than 5 µg/L. Urine concentration should be less than 2 µg/L.
- Positive end-expiratory pressure (PEEP)-assisted ventilation may be necessary in patients with acute parenchymal injury who develop pulmonary edema or adult respiratory distress syndrome.
- Hemoperfusion and hemodialysis may be beneficial in the symptomatic patient. This therapy is controversial and should be guided by clinical presentation and laboratory findings.
- There is no effective chelator for thallium poisoning.
- Combination oral therapy with potassium chloride and activated charcoal has been successful. ADULT DOSAGE: Oral KCL 20 mEq with 20-30 g activated charcoal and cathartic QID.
- Obtain toxicological consultation as necessary.
Zinc and Related Compounds

SUBSTANCE IDENTIFICATION
Odorless gray dust, lustrous powder, or ingot. May be found in solution form. Used in alloys, galvanizing and electroplating other metals, dry cell batteries, and manufactured metal goods. Compounds are used as paint pigments, coatings, and inks; as an ingredient of cosmetics, driers, quick-setting cements, dental cements; in the manufacture of opaque and transparent glass, enamels, automobile tires, white glue, matches, porcelains, and zinc chromates; as a reagent in analytical chemistry; in electrostatic copying paper; as a flame retardant; in electronics as a semiconductor; and in medicine as an antiseptic, astringent, and topical protectant. Zinc is an essential dietary trace metal.

ROUTES OF EXPOSURE
Skin and eye contact
Inhalation
Ingestion

TARGET ORGANS
Primary
Skin
Eyes
Cardiovascular system
Respiratory system
Secondary
Gastrointestinal system
Renal
Blood

LIFE THREAT
Respiratory irritant that may cause metal fume fever or pulmonary edema.

SIGNS AND SYMPTOMS BY SYSTEM
Cardiovascular: Tachycardia and cardiovascular collapse.
Respiratory: Respiratory tract irritation, metal fume fever (flu-type symptoms), bronchospasm, or pulmonary edema.
CNS: Lethargy, CNS depression, and seizures.
Gastrointestinal: Burning pain in the mouth, throat, and abdomen. Nausea, vomiting, abdominal pain, and bloody diarrhea.
Eye: Metal particles can irritate the eyes. Irritation and severe burns with some compounds. Corneal damage.
Skin: Dryness, irritation, dermatitis, and dermal burns.
Renal: Kidney damage.
Blood: Anemia, low white blood cell count (leukopenia), copper deficiency.

SYMPTOM ONSET FOR ACUTE EXPOSURE
Immediate
Some symptoms possibly delayed for days
CO-EXPOSURE CONCERNS
Other metals

THERMAL DECOMPOSITION PRODUCTS INCLUDE
Zinc oxide
Hydrogen gas when wet
Hydrochloric acid—zinc chloride
Sulfur oxides—zinc sulfate

MEDICAL CONDITIONS POSSIBLY AGGRAVATED BY EXPOSURE
Respiratory system disorders
Anemia

DECONTAMINATION
● Wear positive-pressure SCBA and protective equipment specified by references such as the DOT Emergency Response Guidebook or the CANUTEC Initial Emergency Response Guide. If special chemical protective clothing is required, consult the chemical manufacturer or specific protective clothing compatibility charts.
● Delay entry until trained personnel and proper protective equipment are available.
● Remove patient from contaminated area.
● Quickly remove and isolate patient’s clothing, jewelry, and shoes.
● Gently brush away dry particles and blot excess liquids with absorbent material.
● Rinse patient with warm water, 30°C/86°F, if possible.
● Wash patient with Tincture of Green soap or a mild liquid soap and large quantities of water.
● Refer to decontamination protocol in Section Three.

IMMEDIATE FIRST AID
● Ensure that adequate decontamination has been carried out.
● If victim is not breathing, start artificial respiration, preferably with a demand-valve resuscitator, bag-valve-mask device, or pocket mask as trained. Perform CPR if necessary.
● Immediately flush contaminated eyes with gently flowing water.
● Do not induce vomiting. If vomiting occurs, lean patient forward or place on left side (head-down position, if possible) to maintain an open airway and prevent aspiration.
● Keep victim quiet and maintain normal body temperature.
● Obtain medical attention.

BASIC TREATMENT
● Establish a patent airway. Suction if necessary.
● Watch for signs of respiratory insufficiency and assist ventilations if necessary.
● Administer oxygen by nonrebreather mask at 10 to 15 L/min.
● Monitor for pulmonary edema and treat if necessary (refer to pulmonary edema protocol in Section Three).
● Anticipate seizures and treat if necessary (refer to seizure protocol in Section Three).
● Monitor for shock and treat if necessary (refer to shock protocol in Section Three).
● For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport (refer to eye irrigation protocol in Section Three).
● Do not use emetics. For ingestion, rinse mouth and administer 5 ml/kg up to 200 ml of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Administer activated charcoal (refer to ingestion protocol in Section Three and activated charcoal protocol in Section Four).
ADVANCED TREATMENT

- Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious or has severe pulmonary edema.
- Positive-pressure ventilation techniques with a bag-valve-mask device may be beneficial.
- Monitor cardiac rhythm and treat arrhythmias if necessary (refer to cardiac protocol in Section Three).
- Start an IV with D$_5$W TKO. Use lactated Ringer's if signs of hypovolemia are present. Watch for signs of fluid overload.
- Consider drug therapy for pulmonary edema (refer to pulmonary edema protocol in Section Three).
- For hypotension with signs of hypovolemia, administer fluids cautiously. Consider vasopressors for hypotension with a normal fluid volume. Watch for signs of fluid overload (refer to shock protocol in Section Three).
- Treat seizures with diazepam (Valium) (refer to diazepam protocol in Section Four).
- Use proparacaine hydrochloride to assist eye irrigation (refer to proparacaine hydrochloride protocol in Section Four).

INITIAL EMERGENCY DEPARTMENT CONSIDERATIONS

- Useful initial laboratory studies include complete blood count, serum electrolytes, blood urea nitrogen (BUN), creatinine, glucose, urinalysis, and baseline biochemical profile, including serum aminotransferases (ALT and AST), calcium, phosphorus, and magnesium. Arterial blood gases (ABGs), chest radiograph, and electrocardiogram may be required.
- Zinc may be measured in blood and urine. Concentrations are not necessarily related to toxicity.
- Positive end-expiratory pressure (PEEP)-assisted ventilation may be necessary in patients with acute parenchymal injury who develop pulmonary edema or adult respiratory distress syndrome.
- Obtain toxicological consultation as necessary.

SPECIAL CONSIDERATIONS

- Metal fume fever, also termed “Monday Morning Fever,” may develop from exposure to zinc oxide. Symptoms include metallic taste, dry cough, shortness of breath, diaphoresis, fever, chills, fatigue, and myalgia. Symptoms usually begin 4 to 12 hours after exposure, are self-limited, remit during the work week, and reappear with exposure after the weekend. This is most likely an immune-mediated problem related to occupational exposures.
SUBSTANCE IDENTIFICATION
Colorless, tasteless, and odorless gas that is formed when organic material undergoes incomplete combustion. Found in exhaust fumes of internal combustion engines and furnace flues. Also used in metallurgy, organic synthesis, and the manufacture of metal carbonyls. Rarely found in liquid form. Metabolite of methylene chloride (example of lethal synthesis).

ROUTES OF EXPOSURE
Skin and eye contact
Inhalation

TARGET ORGANS
Primary
Central nervous system
Cardiovascular system
Respiratory system
Blood
Secondary
Skin
Eyes
Gastrointestinal system
Hepatic
Renal
Metabolism

LIFE THREAT
Hemoglobin has a 200 to 300 times greater affinity for carbon monoxide (CO) than oxygen. The oxygen transport function of hemoglobin in the blood is reduced when it binds with carbon monoxide, forming carboxyhemoglobin. Carboxyhemoglobin cannot bind with oxygen. This cellular poison causes death via hypoxia.

SIGNS AND SYMPTOMS BY SYSTEM
Cardiovascular: Cardiovascular collapse, arrhythmias, and angina. Exposure may precipitate an acute myocardial infarction.
Respiratory: Tachypnea, followed by slow irregular respirations and respiratory arrest.
Signs of pulmonary edema
CNS: CNS depression and coma. Dizziness, headache, tinnitus, weakness, hallucinations, and seizures. Confusion, visual disturbances, irritability, impaired judgment, loss of memory, and fatigue. Increased intracranial pressure from cerebral edema.
Gastrointestinal: Nausea and vomiting.
Eye: Chemical conjunctivitis.
Skin: Cyanosis, pallor, and rare cherry red color.
Renal: Kidney damage and myoglobinuria.
Hepatic: Liver damage.
Metabolism: Lactic acidosis.
Blood: Carboxyhemoglobin formation.
Other: The period between exposure and toxic signs and symptoms is shortened by any factor that speeds circulation or respiration, such as exercise, exertion, or trauma.

SYMPTOM ONSET FOR ACUTE EXPOSURES
Immediate
Neurological and neurobehavioral effects possibly delayed

CO-EXPOSURE CONCERNS
Simple asphyxiants
Other chemical asphyxiants
Trauma

THERMAL DECOMPOSITION PRODUCTS INCLUDE
Carbon
Carbon dioxide

MEDICAL CONDITIONS POSSIBLY AGGRAVATED BY EXPOSURE
Respiratory disorders
Cardiovascular disorders

DECONTAMINATION
- Wear positive-pressure SCBA and protective equipment specified by references such as the DOT Emergency Response Guidebook or the CANUTEC Initial Emergency Response Guide. If special chemical protective clothing is required, consult the chemical manufacturer or specific protective clothing compatibility charts.
- Delay entry until trained personnel and proper protective equipment are available.
- Remove patient from contaminated area.
- Quickly remove and isolate patient’s clothing, jewelry, and shoes.
- If any concurrent liquid or solid contamination exists:
  - Gently brush away dry particles and blot excess liquids with absorbent material.
  - Rinse patient with warm water, 30° C/86° F, if possible.
  - Wash patient with Tincture of Green soap or a mild liquid soap and large quantities of water.

Refer to decontamination protocol in Section Three.

IMMEDIATE FIRST AID
- Ensure that adequate decontamination has been carried out.
- If victim is not breathing, start artificial respiration, preferably with a demand-valve resuscitator, bag-valve-mask device, or pocket mask as trained. Perform CPR if necessary.
- Immediately flush contaminated eyes with gently flowing water.
- Do not induce vomiting. If vomiting occurs, lean patient forward or place on left side (head-down position, if possible) to maintain an open airway and prevent aspiration.
- Keep victim quiet and maintain normal body temperature.
- Obtain medical attention.

BASIC TREATMENT
- Establish a patent airway. Suction if necessary.
- Watch for signs of respiratory insufficiency and assist ventilations if necessary.
- Administer 100% oxygen by nonrebreather mask at 10 to 15 L/min.
- Monitor for shock and treat if necessary (refer to shock protocol in Section Three).
- Monitor for signs of an acute myocardial infarction and treat if necessary.
- Monitor for pulmonary edema and treat if necessary (refer to pulmonary edema protocol in Section Three).
- Anticipate seizures and treat if necessary (refer to seizure protocol in Section Three).
For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport (refer to eye irrigation protocol in Section Three).

**ADVANCED TREATMENT**
- Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious.
- Positive-pressure ventilation techniques with a bag-valve-mask device may be beneficial.
- Hyperventilation may be beneficial for increased intracranial pressure.
- Monitor cardiac rhythm and treat arrhythmias if necessary (refer to cardiac protocol in Section Three).
- Start an IV with D$_5$W TKO. Use lactated Ringer's if signs of hypovolemia are present. Watch for signs of fluid overload.
- Consider vasopressors to treat hypotension without signs of hypovolemia (refer to shock protocol in Section Three).
- Consider drug therapy for pulmonary edema (refer to pulmonary edema protocol in Section Three).
- Treat seizures with diazepam (Valium) (refer to diazepam protocol in Section Four).
- Proparacaine hydrochloride should be used to assist eye irrigation (refer to proparacaine hydrochloride protocol in Section Four).

**INITIAL EMERGENCY DEPARTMENT CONSIDERATIONS**
- Useful initial laboratory studies include: carboxyhemoglobin, complete blood count, serum electrolytes, blood urea nitrogen (BUN), creatinine, glucose, urinalysis, and baseline biochemical profile, including serum aminotransferases (AST and ALT), calcium, phosphorus, and magnesium. Determination of anion and osmolar gaps may be helpful. Arterial blood gases (ABGs) with measured (not calculated) oxygen saturation, chest radiograph, and electrocardiogram may be required.
- Use caution with interpretation of pulse oximetry as readings may be inaccurate.
- Hyperbaric oxygen (HBO) may be required for optimal treatment. Absolute indications for HBO therapy are neurological dysfunction such as seizures, decreased level of consciousness, and/or cardiac arrhythmias. Also, because of delayed neurotoxic effects of CO, carboxyhemoglobin blood concentrations of 25% to 30% may require HBO therapy.
- Fetal hemoglobin binds CO more tightly (half-life 15 hours) than adult hemoglobin. Pregnant women therefore require longer administration of 100% oxygen and in case of severe poisoning, probably should be considered for HBO therapy. Severe maternal exposures have caused fetal morbidity and mortality.
- Hyperventilation and osmotic therapy may be beneficial in treating increased intracranial pressure.
- Positive end-expiratory pressure (PEEP)-assisted ventilation may be necessary in patients with acute parenchymal injury who develop pulmonary edema or adult respiratory distress syndrome.
- Obtain toxicological consultation as necessary.
Cyanide and Related Compounds

SUBSTANCE IDENTIFICATION
May be found in liquid, solid, or gaseous form. In solid form it is white, with a faint almond odor (an estimated 20% of the population is genetically unable to detect this odor). Used as a fumigant, in metal treatment, and in the welding/cutting of heat-resistant metals. Also used in paper manufacturing, photography, electroplating, blueprinting, and engraving. By-product liberated during ore extraction and metal purification. Thermal decomposition product of many plastics and other combustible products. Present in most smoke inhalation cases.

ROUTES OF EXPOSURE
Skin and eye contact
Inhalation
Ingestion
Skin absorption

TARGET ORGANS
Primary
Skin
Eyes
Central nervous system
Cardiovascular system
Secondary
Respiratory system
Gastrointestinal system
Hepatic
Renal
Metabolism

LIFE THREAT
Death caused by an inhibitory action on the cytochrome oxidase system, preventing mitochondrial use of oxygen to make adenosine triphosphate (ATP). Cyanide brings cellular respiration to a halt.

SIGNS AND SYMPTOMS BY SYSTEM
Cardiovascular: At first, pulse rate decreases and blood pressure rises. As poisoning continues, bradycardia, heart blocks, ventricular arrhythmias, hypotension, and cardiovascular collapse may occur. Palpitations and tightness of the chest.
Respiratory: May cause immediate respiratory arrest. Initially, respiratory rate and depth are increased; as poisoning progresses, respirations become slow, gasping, and finally apneic. Respiratory tract irritation and pulmonary edema.
CNS: Immediate coma. Early symptoms include anxiety, agitation, vertigo, weakness, paralysis, headache, confusion, and lethargy. Seizures.
Gastrointestinal: Nausea, vomiting, excessive salivation, and hemorrhage.
Eye: Chemical conjunctivitis. Dilated pupils.
Skin: Dermatitis and, in some cases, ulcers. Pale or reddish skin color with diaphoresis. Cyanosis is not always present.
**Renal:** Kidney damage.

**Hepatic:** Hepatic damage.

**Metabolism:** Anion gap metabolic acidosis and rhabdomyolysis.

**Other:** May be rapidly fatal without early symptoms.

**SYMPTOM ONSET FOR ACUTE EXPOSURE**

Immediate

Symptoms possibly delayed

**CO-EXPOSURE CONCERNS**

Other oxygen excluders

Simple asphyxiants

**THERMAL DECOMPOSITION PRODUCTS INCLUDE**

- Ammonia gases
- Carbon monoxide
- Hydrogen cyanide
- Nitrogen oxides

**MEDICAL CONDITIONS POSSIBLY AGGRAVATED BY EXPOSURE**

- Central nervous system disorders
- Liver disorders
- Kidney disorders
- Lung disorders
- Thyroid gland dysfunction

**DECONTAMINATION**

- Wear positive-pressure SCBA and protective equipment specified by references such as the *DOT Emergency Response Guidebook* or the *CANUTEC Initial Emergency Response Guide*. If special chemical protective clothing is required, consult the chemical manufacturer or specific protective clothing compatibility charts.

- Delay entry until trained personnel and proper protective equipment are available.

- Remove patient from contaminated area.

- Quickly remove and isolate patient’s clothing, jewelry, and shoes.

- Gently brush away dry particles and blot excess liquids with absorbent material.

- Rinse patient with warm water, 30°C/86°F if possible.

- Wash patient with Tincture of Green soap or a mild liquid soap and large quantities of water.

- Refer to decontamination protocol in Section Three.

**IMMEDIATE FIRST AID**

- Ensure that adequate decontamination has been carried out.

- If victim is not breathing, start artificial respiration, preferably with a demand-valve resuscitator, bag-valve-mask device, or pocket mask as trained. Perform CPR if necessary.

- Immediately flush contaminated eyes with gently flowing water.

- Do not induce vomiting. If vomiting occurs, lean patient forward or place on left side (head-down position, if possible) to maintain an open airway and prevent aspiration.

- Keep victim quiet and maintain normal body temperature.

- Obtain medical attention.

**BASIC TREATMENT**

- Establish a patent airway. Suction if necessary.

- Watch for signs of respiratory insufficiency and assist ventilations if necessary.
Cyanide and Related Compounds

- Administer oxygen by nonrebreather mask at 10 to 15 L/min.
- Administer amyl nitrite ampules as per protocol and physician order (refer to cyanide kit protocol in Section Four).
- Monitor for shock and treat if necessary (refer to shock protocol in Section Three).
- Monitor for pulmonary edema and treat if necessary (refer to pulmonary edema protocol in Section Three).
- Anticipate seizures and treat if necessary (refer to seizure protocol in Section Three).
- For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport (refer to eye irrigation protocol in Section Three).
- Do not use emetics. For ingestion, rinse mouth and administer 5 ml/kg up to 200 ml of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool (refer to ingestion protocol in Section Three).

**ADVANCED TREATMENT**

- Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious or in respiratory arrest.
- Positive-pressure ventilation techniques with a bag-valve-mask device may be beneficial.
- Start an IV with D5W TKO. Use lactated Ringer’s if signs of hypovolemia are present. Watch for signs of fluid overload.
- Administer cyanide antidote kit as per protocol and physician order (refer to cyanide antidote kit protocol in Section Four).
- Monitor and treat cardiac arrhythmias if necessary (refer to cardiac protocol in Section Three).
- Consider vasopressors to treat hypotension without signs of hypovolemia (refer to shock protocol in Section Three).
- Consider drug therapy for pulmonary edema (refer to pulmonary edema protocol in Section Three).
- Treat seizures with diazepam (Valium) (refer to diazepam protocol in Section Four).
- Use proparacaine hydrochloride to assist eye irrigation (refer to proparacaine hydrochloride protocol in Section Four).

**INITIAL EMERGENCY DEPARTMENT CONSIDERATIONS**

- Useful initial laboratory studies include complete blood count, serum electrolytes, blood urea nitrogen (BUN), creatinine, glucose, urinalysis, and baseline biochemical profile, including serum aminotransferases (ALT and AST), calcium, phosphorus, and magnesium. Determination of anion and osmolar gaps may be helpful. Arterial blood gases (ABGs), chest radiograph, and electrocardiogram may be required.
- Whole blood cyanide concentrations may be drawn. Background and postexposure values are extremely variable. Smokers demonstrate higher background concentrations than non-smokers.
- Treatment should not be withheld pending laboratory cyanide determinations. Treatment must be based on exposure history and clinical presentation.
- Positive end-expiratory pressure (PEEP)–assisted ventilation may be necessary in patients with acute parenchymal injury who develop pulmonary edema or adult respiratory distress syndrome.
- Hyperbaric oxygen therapy as an adjunct to the cyanide antidote kit administration may be beneficial in severe poisonings.
- Obtain toxicological consultation as necessary.
SPECIAL CONSIDERATIONS

- Administration of sodium nitrite may cause hypotension.
- Hyperbaric oxygen therapy has been used as an adjunct to nitrite administration in severe cyanide poisoning. Emergency medical transport should be rapid. Preferred destination is a facility with a hyperbaric oxygen chamber.
- Asymptomatic individuals who may have transiently inhaled cyanide vapors are not at risk for delayed systemic symptoms once removed from the contaminated environment, unless they have ingested the product or continue to have skin exposure to liquids or solids.
Hydrogen Sulfide and Related Compounds

SUBSTANCE IDENTIFICATION
Colorless gases with strong offensive odors. Colorless liquid at low temperature or under high pressure. Used as an agricultural disinfectant and fumigant, a laboratory reagent, an additive in cutting oils and lubricants and in the preparation of heavy water for nuclear reactions. By-products of numerous manufacturing processes and petroleum refining. Naturally occurs when organic matter decays; may be found in sewers, sewage treatment facilities, natural gas/crude oil operations, and manure tanks. Products may have an odor of “rotten eggs,” but may prove to have an inadequate warning property. Olfactory nerve fatigue develops after a relatively brief exposure time.

ROUTES OF EXPOSURE
Skin and eye contact
Inhalation
Skin absorption with some compounds

TARGET ORGANS
Primary
Eyes
Respiratory system
Secondary
Skin
Central nervous system
Cardiovascular system
Gastrointestinal system
Metabolism

LIFE THREAT
Severe respiratory irritant that can cause pulmonary edema and respiratory paralysis (especially hydrogen sulfide). Products may inhibit the cytochrome oxidase system and interfere with cellular respiration.

SIGNS AND SYMPTOMS BY SYSTEM
Cardiovascular: Cardiovascular collapse, tachycardia or bradycardia, and arrhythmias.
Respiratory: Respiratory tract irritant, cough, dyspnea, tachypnea, laryngitis, pneumonia or bronchitis. Pulmonary edema and respiratory arrest may occur with severe exposures.
CNS: Headache, confusion, vertigo, dizziness, excitement, tiredness, olfactory fatigue and a garlic taste in mouth. Decreased level of consciousness, delirium, coma, and seizures.
Gastrointestinal: Nausea, vomiting, diarrhea, and profuse salivation.
Eye: Chemical conjunctivitis (sometimes termed “gas eye”), lacrimation, and photophobia. Permanent damage, including corneal ulceration.
Skin: Dermatitis, sweating, and local pain. Cyanosis. Contact with liquid may cause frostbite.
Metabolism: Lactic acidosis.
SYMPTOM ONSET FOR ACUTE EXPOSURE
High concentrations have an immediate effect
Pulmonary edema possibly delayed

CO-EXPOSURE CONCERNS
Alcohol
Other chemical asphyxiants
Simple asphyxiants

THERMAL DECOMPOSITION PRODUCTS INCLUDE
Hydrogen
Sulfur
Sulfur oxides

MEDICAL CONDITIONS POSSIBLY AGGRAVATED BY EXPOSURE
Eye conditions
Asthma and fibrotic pulmonary diseases
Reactive airways disease

DECONTAMINATION
· Wear positive-pressure SCBA and protective equipment specified by references such as the DOT Emergency Response Guidebook or the CANUTEC Initial Emergency Response Guide. If special chemical protective clothing is required, consult the chemical manufacturer or specific protective clothing compatibility charts.
· Delay entry until trained personnel and proper protective equipment are available.
· Remove patient from contaminated area.
· Quickly remove and isolate patient’s clothing, jewelry, and shoes.
· If any concurrent liquid or solid contamination exists:
  · Gently brush away dry particles and blot excess liquids with absorbent material.
  · Rinse patient with warm water, 30° C/86° F, if possible.
  · Wash patient with Tincture of Green soap or a mild liquid soap and large quantities of water.
  · Refer to decontamination protocol in Section Three.

IMMEDIATE FIRST AID
· Ensure that adequate decontamination has been carried out.
· If victim is not breathing, start artificial respiration, preferably with a demand-valve resuscitator, bag-valve-mask device, or pocket mask as trained. Perform CPR if necessary.
· Immediately flush contaminated eyes with gently flowing water.
· Do not induce vomiting. If vomiting occurs, lean patient forward or place on left side (head-down position, if possible) to maintain an open airway and prevent aspiration.
· Keep victim quiet and maintain normal body temperature.
· Obtain medical attention.

BASIC TREATMENT
· Establish a patent airway. Suction if necessary.
· Watch for signs of respiratory insufficiency and assist ventilations if necessary.
· Administer oxygen by nonrebreather mask at 10 to 15 L/min.
· Monitor for pulmonary edema and treat if necessary (refer to pulmonary edema protocol in Section Three).
· Monitor for shock and treat if necessary (refer to shock protocol in Section Three).
· Anticipate seizures and treat if necessary (refer to seizure protocol in Section Three).
Hydrogen Sulfide and Related Compounds

- For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport (refer to eye irrigation protocol in Section Three).
- Treat with rapid rewarming techniques (refer to frostbite protocol in Section Three) if frostbite occurs.

**ADVANCED TREATMENT**

- Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious or in respiratory arrest.
- Positive-pressure ventilation techniques with a bag-valve-mask device may be beneficial.
- Monitor cardiac rhythm and treat arrhythmias if necessary (refer to cardiac protocol in Section Three).
- Start an IV with D<sub>5</sub>W TKO. Use lactated Ringer’s if signs of hypovolemia are present. Watch for signs of fluid overload.
- Consider drug therapy for pulmonary edema (refer to pulmonary edema protocol in Section Three).
- For hypotension with signs of hypovolemia, administer fluid cautiously. Watch for signs of pulmonary edema. Consider vasopressors to treat hypotension without signs of hypovolemia (refer to shock protocol in Section Three).
- Treat seizures with diazepam (Valium) (refer to diazepam protocol in Section Four).
- In severe cases use amyl nitrite and sodium nitrite (from the cyanide antidote kit) as described for cyanide poisoning; omit the sodium thiosulfate injection. Early administration will be the most effective. DIRECT PHYSICIAN ORDER ONLY (refer to cyanide kit protocol in Section Four).
- Use proparacaine hydrochloride to assist eye irrigation (refer to proparacaine hydrochloride protocol in Section Four).

**INITIAL EMERGENCY DEPARTMENT CONSIDERATIONS**

- Usefull initial laboratory studies include complete blood count, serum electrolytes, blood urea nitrogen (BUN), creatinine, glucose, urinalysis, and baseline biochemical profile, including serum aminotransferases (ALT and AST), calcium, phosphorus, and magnesium. Determination of anion and osmolar gaps may be helpful. Arterial blood gases (ABGs), chest radiograph, and electrocardiogram may be required.
- Positive end-expiratory pressure (PEEP)–assisted ventilation may be necessary in patients with acute parenchymal injury who develop pulmonary edema or adult respiratory distress syndrome.
- Products may cause acidosis; hyperventilation and sodium bicarbonate may be beneficial. Bicarbonate therapy should be guided by patient presentation, ABG determination, and serum electrolyte considerations.
- Hyperbaric oxygen therapy as an adjunct to nitrite administration may be beneficial in severe poisonings.
- Obtain toxicological consultation as necessary.

**SPECIAL CONSIDERATIONS**

- Hydrogen sulfide inhibits the cytochrome oxidase P<sub>450</sub> system.
- Emergency medical transport should be rapid. Preferred destination is a facility with a hyperbaric chamber.
Simple Asphyxiants and Related Compounds

SUBSTANCE IDENTIFICATION
Found as colorless and usually odorless gases. Some compounds may have odorants added. These gases are used in a variety of manufacturing processes. Simple asphyxiants usually have no or very little inherent toxicity. Their primary hazard is the displacement of atmospheric oxygen below normal. The hazard is increased in confined areas. Use caution in scene operations, since many of these products have inadequate warning properties. They are shipped as a compressed or liquefied gas or in a cryogenic state. Liquefied gases present a frostbite hazard when released. Cryogenics are gases compressed into liquids with a temperature below −150°F. Cryogenic and liquefied gases have a large expansion ratio; a small amount of liquid vaporizes to a large amount of gas.

ROUTES OF EXPOSURE
Inhalation
Skin contact

TARGET ORGANS
Primary
Respiratory system
Central nervous system
Skin
Secondary
Cardiovascular system
Gastrointestinal system

LIFE THREAT
Asphyxia caused by atmospheric oxygen deficiency.

SIGNS AND SYMPTOMS BY SYSTEM
Cardiovascular: Tachycardia, arrhythmias, hypotension, and cardiovascular collapse caused by hypoxia.
Respiratory: Increased respiratory rate and dyspnea followed by apnea and death.
CNS: Headache, dizziness, and confusion. Decreased level of consciousness, coma, and seizures.
Gastrointestinal: Nausea and vomiting.
Eye: Vision deficits.
Skin: Frostbite or frozen tissue from product at low temperatures. Cyanosis
Other: At low atmospheric oxygen concentrations, coordination and judgment may be lost without warning, making self-rescue impossible.

SYMPTOM ONSET FOR ACUTE EXPOSURE
Immediate

CO-EXPOSURE CONCERNS
Carbon monoxide
Hydrogen sulfide
Methemoglobin formers
Trauma
THERMAL DECOMPOSITION PRODUCTS INCLUDE
Numerous: Varies with compound

MEDICAL CONDITIONS POSSIBLY AGGRAVATED BY EXPOSURE
Respiratory disorders
Cardiovascular disorders

DECONTAMINATION
- Wear positive-pressure SCBA and protective equipment specified by references such as the DOT Emergency Response Guidebook or the CANUTEC Initial Emergency Response Guide. If special chemical protective clothing is required, consult the chemical manufacturer or specific protective clothing compatibility charts.
- Delay entry until trained personnel and proper protective equipment are available.
- Remove patient from contaminated area.
- If any concurrent liquid or solid contamination exists:
  - Quickly remove and isolate patient’s clothing, jewelry, and shoes.
  - Gently brush away dry particles and blot excess liquids with absorbent material.
  - Rinse patient with warm water, 30°C/86°F, if possible.
  - Wash patient with Tincture of Green soap or a mild liquid soap and large quantities of water.
- Refer to decontamination protocol in Section Three.

IMMEDIATE FIRST AID
- Ensure that adequate decontamination has been carried out.
- If victim is not breathing, start artificial respiration, preferably with a demand-valve resuscitator, bag-valve-mask device, or pocket mask as trained. Perform CPR if necessary.
- Immediately flush contaminated eyes with gently flowing water.
- Do not induce vomiting. If vomiting occurs, lean patient forward or place on left side (head-down position, if possible) to maintain an open airway and prevent aspiration.
- Keep victim quiet and maintain normal body temperature.
- Obtain medical attention.

BASIC TREATMENT
- Establish a patent airway. Suction if necessary.
- Watch for signs of respiratory insufficiency and assist ventilations if necessary.
- Administer oxygen by nonrebreather mask at 10 to 15 L/min.
- Anticipate seizures and treat if necessary (refer to seizure protocol in Section Three).
- Use rapid rewarming techniques if frostbite occurs (refer to frostbite protocol in Section Three).

ADVANCED TREATMENT
- Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious or in respiratory arrest.
- Monitor cardiac rhythm and treat arrhythmias if necessary (refer to cardiac protocol in Section Three).
- Start an IV with D5W TKO.
- Treat seizures with diazepam (Valium) (refer to diazepam protocol in Section Four).

INITIAL EMERGENCY DEPARTMENT CONSIDERATIONS
- Useful initial laboratory studies include complete blood count, serum electrolytes, blood urea nitrogen (BUN), creatinine, glucose, urinalysis, and baseline biochemical profile, including serum aminotransferases (ALT and AST), calcium, phosphorus,
and magnesium. Determination of anion and osmolar gaps may be helpful. Arterial blood gases (ABGs), chest radiograph, and electrocardiogram may be required.  
* Obtain toxicological consultation if necessary.  
**SPECIAL CONSIDERATIONS**  
* Assess the scene and exposure history carefully to rule out other toxic or physical mechanisms of injury.
Carbon Disulfide and Related Compounds

SUBSTANCE IDENTIFICATION
Clear, colorless-to-faintly yellow liquids with a strong, sweet odor; in commercial grades an offensive odor like decaying cabbage. Used in the manufacture of viscose rayon, carbon tetrachloride, cellophane, dyes, and rubber. Also found in solvents, waxes, and cleaners. Used in vapor form as a disinfectant, insecticide, and fumigant. Products may be extremely flammable.

ROUTE OF EXPOSURE
Skin and eye contact
Inhalation
Ingestion
Skin absorption

TARGET ORGANS
Primary
Skin
Eyes
Central nervous system
Cardiovascular system
Renal
Hepatic
Secondary
Respiratory system
Gastrointestinal system

LIFE THREAT
Respiratory paralysis and arrest caused by CNS depression.

SIGNS AND SYMPTOMS BY SYSTEM
Cardiovascular: Arrhythmias, cardiovascular collapse, and hypotension.
Respiratory: Irritation to the respiratory tract and respiratory arrest. Garlicky odor on breath.
CNS: Mood and personality disturbances. Dizziness, unsteady gait, fatigue, muscle weakness, headache, and hallucinations. CNS depression, seizures, and coma. Neurobehavioral changes.
Gastrointestinal: Irritation of mucous membranes, nausea, vomiting, diarrhea, and abdominal cramps.
Eye: Chemical conjunctivitis, corneal burns, and optic nerve damage.
Skin: Irritant dermatitis and burns.
Renal: Kidney damage.
Hepatic: Liver damage.

SYMPTOM ONSET FOR ACUTE EXPOSURE
Immediate

CO-EXPOSURE
Alcohol
Disulfiram (Antabuse)
Hydrogen sulfide

**THERMAL DECOMPOSITION PRODUCTS INCLUDE**
- Carbon dioxide
- Carbon monoxide
- Sulfur dioxide

**MEDICAL CONDITIONS POSSIBLY AGGRAVATED BY EXPOSURE**
- Central nervous system disorders
- Cardiovascular disorders
- Gastrointestinal disorders
- Liver or kidney disorders

**DECONTAMINATION**
- Wear positive-pressure SCBA and protective equipment specified by references such as the *DOT Emergency Response Guidebook* or the *CANUTEC Initial Emergency Response Guide*. If special chemical protective clothing is required, consult the chemical manufacturer or specific protective clothing compatibility charts.
- Delay entry until trained personnel and proper protective equipment are available.
- Remove patient from contaminated area.
- Quickly remove and isolate patient’s clothing, jewelry, and shoes.
- Gently blot excess liquids with absorbent material.
- Rinse patient with warm water, 30°C/86°F, if possible.
- Wash patient with Tincture of Green soap or a mild liquid soap and large quantities of water.
- Refer to decontamination protocol in Section Three.

**IMMEDIATE FIRST AID**
- Ensure that adequate decontamination has been carried out.
- If victim is not breathing, start artificial respiration, preferably with a demand-valve resuscitator, bag-valve-mask device, or pocket mask as trained. Perform CPR if necessary.
- Immediately flush contaminated eyes with gently flowing water.
- Do not induce vomiting. If vomiting occurs, lean patient forward or place on left side (head-down position, if possible) to maintain an open airway and prevent aspiration.
- Keep victim quiet and maintain normal body temperature.
- Obtain medical attention.

**BASIC TREATMENT**
- Establish a patent airway. Suction if necessary.
- Watch for signs of respiratory insufficiency and assist ventilations if necessary.
- Administer oxygen by nonrebreather mask at 10 to 15 L/min.
- Anticipate seizures and treat if necessary (refer to seizure protocol in Section Three).
- Monitor for shock and treat if necessary (refer to shock protocol in Section Three).
- For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport (refer to eye irrigation protocol in Section Three).
- Do not use emetics. For ingestion, rinse mouth and administer 5 ml/kg up to 200 ml of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Administer activated charcoal (refer to ingestion protocol in Section Three and activated charcoal protocol in Section Four).
- Cover skin burns with sterile dressings after decontamination (refer to chemical burn protocol in Section Three).
ADVANCED TREATMENT
- Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious.
- Monitor cardiac rhythm and treat arrhythmias if necessary (refer to cardiac protocol in Section Three).
- Start an IV with lactated Ringer's TKO.
- Treat seizures with diazepam (Valium) (refer to diazepam protocol in Section Four).
- For hypotension with signs of hypovolemia, administer fluid cautiously. Watch for signs of fluid overload (refer to shock protocol in Section Three).
- Use proparacaine hydrochloride to assist eye irrigation (refer to proparacaine hydrochloride protocol in Section Four).

INITIAL EMERGENCY DEPARTMENT CONSIDERATIONS
- Useful initial laboratory studies include complete blood count, serum electrolytes, blood urea nitrogen (BUN), creatinine, glucose, urinalysis, and baseline biochemical profile, including serum aminotransferases (ALT and AST), calcium, phosphorus, and magnesium. Determination of anion and osmolar gaps may be helpful. Arterial blood gases (ABGs), chest radiograph, and electrocardiogram may be required.
- Obtain toxicological consultation as necessary.

SPECIAL CONSIDERATIONS
- Avoid epinephrine and related beta agonists (unless patient is in cardiac arrest or has reactive airways disease refractory to other treatment) because of the possible irritable condition of the myocardium. Use of these medications may lead to ventricular fibrillation.