Isocyanates, Aliphatic Thiocyanates, and Related Compounds

SUBSTANCE IDENTIFICATION
Found in oil bases, powder, liquids, and gases in diluted and concentrated forms. Used as contact insecticides; as two-part automobile, boat, and bus paints; in the manufacture of rigid polyurethane foams, adhesives, varnishes, wire enamels, protective coatings, and foundry core binders; and as mediators in chemical reactions. Certain products may have a synergistic effect when combined with organophosphates or other insecticides. Toxicity may result from the hydrocarbon vehicle, which is often kerosene (refer to appropriate guideline).

ROUTES OF EXPOSURE
Skin and eye contact
Inhalation
Ingestion
Skin absorption

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

LIFE THREAT
Respiratory arrest caused by CNS depression, paralysis of the respiratory center, and pulmonary edema. Certain thiocyanates (see Other below) may cause cyanide toxicity.

SIGNS AND SYMPTOMS BY SYSTEM
Cardiovascular: Arrhythmias, cardiovascular collapse.
Respiratory: Respiratory tract irritation, rhinitis, sinusitis, pharyngitis, cough, chest pain, dyspnea, increased secretions, wheezing, hyperpnea, and respiratory arrest. Pulmonary edema, bronchitis, hypersensitivity pneumonitis or asthma/reactive airways disease.
CNS: Restlessness, irritability, ataxia, seizures, decreased level of consciousness or coma.
Gastrointestinal: Mucous membrane irritation, nausea, vomiting, and abdominal pain.
Eye: Lacrimation, chemical conjunctivitis, severe ocular burns, and corneal damage.
Skin: Irritation, irritant or allergic dermatitis with erythema, edema, or blistering.
Renal: Kidney damage.
Isocyanates, Aliphatic Thiocyanates, and Related Compounds

**Hepatic:** Liver damage.

**Other:**

**Thiocyanates (cyanide-producing):** Certain aliphatic thiocyanates such as methyl, ethyl, and isopropyl thiocyanates, Lethane 60, Lethane 384, and Thanite. These thiocyanate compounds may release cyanide ions when metabolized and therefore produce acute cyanide poisoning.

**Thiocyanates (noncyanide-producing):** Ammonium thiocyanate, laurel thiocyanate, methyl isothiocyanate, potassium thiocyanate, and sodium thiocyanate. The thiocyanate ion is slowly excreted in the urine intact and does not generally produce cyanide toxicity.

**Isocyanates:** Methyl isocyanate, ethyl isocyanate, and toluene diisocyanate (TDI). These chemicals act as primary pulmonary irritants and do not release cyanide on exposure. Acute, life-threatening pulmonary edema can develop. Acute exposure may precipitate asthma/reactive airways disease, bronchitis, chest tightness, and dyspnea. These conditions may persist from months to years and may be permanent after a single exposure.

**SYMPTOM ONSET FOR ACUTE EXPOSURE**
Symptoms possibly immediate or delayed
Reactive airway symptoms may appear after acute exposure

**CO-EXPOSURE CONCERNS**
Other isocyanates
Organophosphates
Other insecticides

**THERMAL DECOMPOSITION PRODUCTS INCLUDE**
Carbon dioxide
Carbon monoxide
Hydrocarbons
Hydrogen cyanide
Nitrogen oxides

**MEDICAL CONDITIONS POSSIBLY AGGRAVATED BY EXPOSURE**
Respiratory system disorders
Asthma/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.
- 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
Isocyanates, Aliphatic Thiocyanates, and Related Compounds

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).
- Monitor for 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 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 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).
- Consider vasopressors if patient is hypotensive with a normal fluid volume. If signs of hypovolemia are present, administer fluid cautiously. Watch for signs of pulmonary edema (refer to shock protocol in Section Three).
- Treat seizures with diazepam (Valium) (refer to diazepam protocol in Section Four).
- Treat exposure to Lethane 60, Lethane 384, Thanite, methyl, ethyl, or isopropyl thiocyanates; with the cyanide antidote kit (DIRECT PHYSICIAN ORDER ONLY; refer to cyanide guideline and cyanide 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,
Isocyanates, Aliphatic Thiocyanates, and Related Compounds

and magnesium. Arterial blood gases (ABGs), chest radiograph, and electrocardiogram may be required.

- IgE antibodies to certain isocyanates have been detected in individuals sensitive to isocyanates.
- 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.
- Bronchospastic symptoms should be treated with an inhalation medication regime similar to that used for reactive airways disease. Inhaled corticosteroids may be of value in severe bronchospasm.
- 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.
- With products that release cyanide, hyperbaric oxygen therapy may be beneficial as an adjunct to the cyanide antidote kit (nitrite therapy).
- Obtain toxicological consultation as necessary.

SPECIAL CONSIDERATIONS

- Isocyanates produce reversible air flow obstruction by direct irritation of the airways or by sensitizing the airway to isocyanates. Isocyanate-induced asthma may persist for years after the exposure.
- Emergency medical transportation should be rapid. Preferred destination is a facility with a hyperbaric chamber if exposure to cyanide-producing/cyanide-releasing compounds.
- Toxicity may result from the hydrocarbon vehicle (often kerosene). Product should be identified and the appropriate guideline consulted.
- Some products may present a human carcinogenic risk.
Bromine, Methyl Bromide, and Related Compounds

SUBSTANCE IDENTIFICATION
Colorless liquid or gas with no odor at low concentrations and a chloroform-like odor at high concentrations. Used as insecticides and as a fumigant for grain elevators, mills, ships, greenhouses, and food-processing facilities; as a soil fumigant; in fire extinguishers, refrigerants, and solvents; and as a methylating agent in chemical manufacturing processes.

ROUTES OF EXPOSURE
Skin and eye contact
Inhalation
Ingestion
Skin absorption

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

LIFE THREAT
Severe respiratory irritation, progressing to pulmonary edema and respiratory failure. Neurotoxin that may cause coma, convulsions, and death.

SIGNS AND SYMPTOMS BY SYSTEM
Cardiovascular: Arrhythmias and cardiovascular collapse.
Gastrointestinal: Nausea, vomiting, and abdominal pain.
Eye: Chemical conjunctivitis to severe eye injury. Blurred vision
Skin: Cyanosis, chemical burns, and irritant dermatitis (low-level exposures). Allergic dermatitis.
Renal: Kidney damage.
Hepatic: Liver damage.
Blood: Hemolysis and/or decreased white blood cell count (leukocytosis).

Metabolism: Metabolic acidosis.

Other: Human carcinogenic risk of methyl bromide is under review.

SYMPTOM ONSET FOR ACUTE EXPOSURE

Immediate
Pulmonary edema possibly delayed

CO-EXPOSURE CONCERNS

Other halogens
Other neurotoxins
Other respiratory irritants

THERMAL DECOMPOSITION PRODUCTS INCLUDE

Bromide fumes
Carbon dioxide
Carbon monoxide

MEDICAL CONDITIONS POSSIBLY AGGRAVATED BY EXPOSURE

Nervous system disorders
Respiratory system disorders
Skin 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.
- 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).

Cover skin burns with dry 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.

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).

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).

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.

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.

Bronchospastic symptoms should be treated with an inhalation medication regime similar to that used for reactive airways disease. Inhaled corticosteroids may be of value in severe bronchospasm.

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.

Obtain toxicological consultation as necessary.

SPECIAL CONSIDERATIONS

Acute occupational exposure and resultant symptoms may be superimposed over chronic toxicity effects.
SUBSTANCE IDENTIFICATION
White, crystalline powders in solid form may also be found in solutions. Products are used as laboratory reagents and oxidizing agents and in the manufacture of fireworks, matches, weed killers, and dyes.

ROUTES OF EXPOSURE
Skin and eye contact
Inhalation
Ingestion
Skin absorption

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

LIFE THREAT
CNS and respiratory system depression. Renal failure, usually days to weeks after exposure.

SIGNS AND SYMPTOMS BY SYSTEM
Cardiovascular: Tachycardia and hypotension.
Gastrointestinal: Mucous membranes irritation. Nausea, vomiting, diarrhea, and abdominal pain.
Skin: Cyanosis followed by pallor. Irritation and burns.
Renal: Kidney damage and renal failure.
Metabolism: Metabolic acidosis.
Blood: Methemoglobinemia may be present but not apparent until hours after exposure. Decreased platelet count (thrombocytopenia) and hemolysis.
Other: The patient may present with lumbar pain.

SYMPTOM ONSET FOR ACUTE EXPOSURE
Immediate
Renal symptoms possibly delayed
CO-EXPOSURE CONCERNS

Chlorates

THERMAL DECOMPOSITION PRODUCTS INCLUDE

Bromine

MEDICAL CONDITIONS POSSIBLY AGGRAVATED BY EXPOSURE

Respiratory system disorders

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 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).

· 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).

· 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.
Bromates and Related Compounds

- Positive-pressure ventilation techniques with a bag-valve-mask device may be beneficial.
- Start an IV with D$_3$W TKO. Use lactated Ringer’s if signs of hypovolemia are present. Watch for signs of fluid overload.
- 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, platelet count, coagulation profile, methemoglobin, 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.
- **Sodium thiosulfate** may reduce bromate to bromide ion, which may be less toxic.
  
  ADULT DOSAGE: 10 to 50 ml (0.2 to 1 ml/kg; maximum 50 ml) of 10% sodium thiosulfate solution slow IV over 30 minutes.
- Hemodialysis may be required for renal failure. Therapy should be guided by patient presentation and laboratory values.
- Titrate hydration status to maintain adequate urine output.
- Obtain toxicological consultation as necessary.

**SPECIAL CONSIDERATIONS**

- Methylene blue has little or no effect on this form of methemoglobinemia and may intensify the bromate-catalyzed oxidative hemolysis; therefore it should not be used.
- Exchange transfusion has been advocated for severe poisoning.
Chlorates and Related Compounds

SUBSTANCE IDENTIFICATION
White or colorless crystals. Also found in solutions. Products are used in the production of chlorine dioxide; as analytical agents, herbicides, and oxidizing agents; and in the manufacture of fireworks, matches, throat gargles, and dyes.

ROUTES OF EXPOSURE
Skin and eye contact
Inhalation
Ingestion

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

LIFE THREAT
Hemolysis and methemoglobinemia causing chlorate catalyzed hypoperfusion and CNS depression. Renal failure, usually 2 to 14 days after exposure.

SIGNS AND SYMPTOMS BY SYSTEM
Cardiovascular: Tachycardia. Myocardial injury.
Respiratory: Irritation of the respiratory tract, tachypnea, and dyspnea.
CNS: Restlessness followed by apathy. Seizures are rare, usually in the later stages of renal failure or from hypoxia. Coma.
Gastrointestinal: Nausea, vomiting, irritation of the GI tract, hemorrhage, diarrhea, and abdominal pain.
Eye: Chemical conjunctivitis.
Skin: Cyanosis, pallor, and dermatitis.
Renal: Hemoglobinuria, proteinuria, kidney damage, and renal failure.
Hepatic: Liver damage.
Metabolism: Hyperkalemia.
Blood: Hemolysis. Methemoglobinemia and decreased platelet count (thrombocytopenia) are prominent features but may not be apparent until several hours after exposure.
Other: Lumbar pain.

SYMPTOM ONSET FOR ACUTE EXPOSURE
Immediate
Some symptoms possibly delayed
CO-EXPOSURE CONCERNS
Bromates
Arsine

THERMAL DECOMPOSITION PRODUCTS INCLUDE
Chlorine dioxide
Hydrogen chloride
Oxygen
Sodium perchlorate

MEDICAL CONDITIONS POSSIBLY AGGRAVATED BY EXPOSURE
Respiratory system disorders
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 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).
• 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.
• Start an IV with D5W TKO. Use lactated Ringer’s if signs of hypovolemia are present. Watch for signs of fluid overload.
• 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, platelet count, coagulation profile, methemoglobin, 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.
• Sodium thiosulfate may reduce chlorate to chloride ion, which may be less toxic.
  ADULT DOSAGE: 10 to 50 ml (0.2 to 1 ml/kg; maximum 50 ml) of 10% sodium thiosulfate solution slow IV over 30 minutes.
• Hemodialysis may be required for renal failure. Therapy should be guided by patient presentation and laboratory values.
• Titrate hydration status to maintain adequate urine output.
• Obtain toxicological consultation as necessary.

SPECIAL CONSIDERATIONS

• Methylene blue has little or no effect on this form of methemoglobinemia and may intensify the chlorate catalyzed oxidative hemolysis; therefore it should not be used.
• Exchange transfusion has been advocated for severe poisoning.
CHLORINE AND RELATED COMPOUNDS

SUBSTANCE IDENTIFICATION
Found in liquid and gaseous forms. Colorless-to amber-colored liquid and greenish-yellow gas with a characteristic odor. Some solid compounds may generate chlorine when in contact with water. Used in the production of chlorinated inorganic and organic chemicals and in the manufacture of solvents, automotive compounds, and plastics. Also used in metallurgy and disinfectants and as a bacteriostat in water treatment and a bleaching/cleaning agent. Some are used as fumigants, rodenticides, and insecticides.

ROUTES OF EXPOSURE
Skin and eye contact
Inhalation
Ingestion

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

LIFE THREAT
Severe respiratory tract irritant that may cause pulmonary edema. Skin, eye, and mucous membranes irritant.

SIGNS AND SYMPTOMS BY SYSTEM
Cardiovascular: Cardiovascular collapse and possible ventricular arrhythmias.
Respiratory: Acute or delayed noncardiogenic pulmonary edema, dyspnea, and tachypnea. Upper airway irritation and burns to the mucous membranes and lungs. Cough, choking sensation, rhinitis, sinusitis, rhinorrhea, pneumonitis, and pneumonia.
CNS: Decreased level of consciousness to coma. Headache and dizziness.
Gastrointestinal: Nausea and vomiting.
Eye: Chemical conjunctivitis with lacrimation. Severe and painful irritation and burns.
Skin: Irritation and chemical burns. Cyanosis. Possible frostbite secondary to exposure to expanding gas.
Renal: Kidney damage.
Hepatic: Liver damage.
Other: Metabolic acidosis.
SYMPTOM ONSET FOR ACUTE EXPOSURE
Immediate
Respiratory symptoms may be delayed for hours

CO-EXPOSURE CONCERNS
Caustics/corrosives
Phosgene
Other respiratory irritants

THERMAL DECOMPOSITION PRODUCTS INCLUDE
Reacts with water to form hydrochloric and hypochlorous acid
Reacts with carbon monoxide to form phosgene
Toxic substances are formed when combustibles burn in chlorine

MEDICAL CONDITIONS POSSIBLY AGGRAVATED BY EXPOSURE
Respiratory disorders
Chronic skin 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).
• 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).
Chlorine and Related Compounds

- 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).
- Cover skin burns with dry 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, has severe pulmonary edema, or is 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).
- Consider vasopressors to treat hypotension without signs of hypovolemia (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 (AST and ALT), 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.
- Obtain toxicological consultation as necessary.

SPECIAL CONSIDERATIONS
- Chlorine’s relatively high water solubility accounts for the early upper airway symptoms.
- Mixing chlorine and ammonia cleaners may result in the release of hydrochloric acid, nitrogen oxides, and chlorine active compounds.
Fluorine and Related Compounds

SUBSTANCE IDENTIFICATION
Found in liquid, yellowish gas and in solid forms with various colors. Most have an irritating odor. Used in the manufacture of fluorinated organic and inorganic chemicals, pesticides, refrigerants, fertilizer, microelectronic circuits, and rocket fuel. Also used for etching, electroplating, and water treatment.

ROUTES OF EXPOSURE
- Skin and eye contact
- Inhalation
- Ingestion
- Skin absorption

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

LIFE THREAT
CNS depression and respiratory arrest. Cardiovascular collapse, shock, and arrhythmias may be found.

SIGNS AND SYMPTOMS BY SYSTEM
- Cardiovascular: Cardiovascular collapse with a weak, rapid pulse and arrhythmias.
- Respiratory: Shallow respirations and respiratory arrest caused by laryngospasm and CNS depression. Respiratory tract irritation, rhinitis, sinusitis, pneumonitis, pneumonia, and pulmonary edema.
- CNS: CNS depression, coma, and seizures. Headache, dizziness, muscle weakness, and tremors. Hyperactive reflexes, painful muscle spasms, and carpopedal spasm.
- Gastrointestinal: Nausea, vomiting, diarrhea, and abdominal pain.
- Eye: Chemical conjunctivitis and corneal damage.
- Skin: Local or generalized rash, deep, painful skin burns. Cyanotic, cold, and wet skin.
- Renal: Kidney damage.
- Metabolism: Systemic exposure may result in life-threatening reduction in serum calcium (hypocalcemia) and serum magnesium (hypomagnesemia) and increased serum potassium (hyperkalemia).

SYMPTOM ONSET FOR ACUTE EXPOSURE
- Immediate
  - Some symptoms such as pulmonary edema may be delayed for hours
Fluorine and Related Compounds

CO-EXPOSURE CONCERNS
Chlorine
Other halogens

THERMAL DECOMPOSITION PRODUCTS INCLUDE
Hydrogen fluoride
Nitrogen oxides

MEDICAL CONDITIONS POSSIBLY AGGRAVATED BY EXPOSURE
Cardiovascular disorders
Respiratory 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 (refer to ingestion protocol in Section Three).
- Cover skin burns with dry 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 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. Use lactated Ringer's to support vital signs 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. 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. 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.
- IV calcium gluconate may be needed for severe systemic hypocalcemia. Therapy should be guided by patient presentation and laboratory values. See calcium gluconate protocol in Section Four.
- Massive hypocalcemia/hypomagnesemia from concentrated HF exposure demonstrates high morbidity/mortality. Rapid, aggressive treatment is required, with close monitoring of electrocardiogram, serum electrolytes, calcium and magnesium.
- Monitor and treat if necessary for hyperkalemia.
- Obtain toxicological consultation as necessary.

SPECIAL CONSIDERATIONS

- See also hydrogen fluoride guideline 16.
SUBSTANCE IDENTIFICATION
Powders, purple crystalline solids, or colorless liquids that may darken on exposure to light. Used in the separation of mixtures of minerals; in the manufacture of germicides, antiseptics, pharmaceuticals, and medical imaging contrast media; and in water treatment, laboratory tests, and the photographic industry.

ROUTES OF EXPOSURE
Skin and eye contact
Inhalation
Ingestion
Skin absorption

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

LIFE THREAT
Hypotension, circulatory collapse, and pulmonary edema.

SIGNS AND SYMPTOMS BY SYSTEM
Cardiovascular: Cardiovascular collapse. Weak, rapid pulse and arrhythmias.
Respiratory: Respiratory tract irritation, rhinitis, bronchitis, pneumonitis, pneumonia, and pulmonary edema.
CNS: Headache, delirium, dizziness, decreased consciousness, and coma.
Gastrointestinal: Severe corrosive gastroenteritis and parotid gland inflammation (parotitis). Nausea, vomiting, diarrhea, and abdominal pain. A metallic taste in the mouth.
Eye: Pain, chemical conjunctivitis, blepharitis, burns, and corneal damage.
Skin: Erythema, irritant dermatitis, burns, and/or hypersensitivity reaction.
Renal: Kidney damage.
Hepatic: Liver damage.
Metabolism: Metabolism acidosis.
Other: Severe allergic reactions have been reported.

SYMPTOM ONSET FOR ACUTE EXPOSURE
Immediate
Some symptoms may be delayed for hours

CO-EXPOSURE CONCERNS
Other halogens and halogenated compounds
THERMAL DECOMPOSITION PRODUCTS INCLUDE
Carbon dioxide
Carbon monoxide
Iodine
Iodine compounds

MEDICAL CONDITIONS POSSIBLY AGGRAVATED BY EXPOSURE
Thyroid disorders
Respiratory disorders
Kidney disorders
Skin 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).
- 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).
Iodine and Related Compounds

- Cover skin burns with dry 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 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. Use lactated Ringer’s to support vital signs 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).
- 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.
- 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.
- Obtain toxicological consultation if necessary.