Technical Support Document: Toxicology Clandestine Drug Labs: Methamphetamine

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HYDROGEN CHLORIDE

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Introduction

The clandestine synthesis of methamphetamine (meth) and other illegal drugs is a growing public health and environmental concern. For every pound of meth synthesized there are six or more pounds of hazardous materials or chemicals produced. These are often left on the premises, dumped down local septic systems, or illegally dumped in backyards, open spaces, in ditches along roadways or down municipal sewer systems. In addition to concerns for peace officer safety and health, there is increasing concern about potential health impacts on the public and on unknowing inhabitants, including children and the elderly, who subsequently occupy dwellings where illegal drug labs have been located.

The Office of Environmental Health Hazard Assessment (OEHHA), in cooperation with the Department of Toxic Substances Control (DTSC), has been charged with assisting in identifying and characterizing chemicals used or produced in the illegal manufacturing of methamphetamine, which pose the greatest potential human health concerns. To address in part this growing environmental problem and the need for public health and safety professionals to make appropriate risk management decisions for the remediation of former methamphetamine laboratory sites, OEHHA has developed two types of chemical-specific information documents.

The first set, technical support documents (TSDs), are referenced, multi-page publications, which contain important health and safety data, exposure limits, and key information for recognizing chemicals used or produced during the manufacturing of methamphetamine. These documents will likely be most helpful to health and safety officers, industrial hygienists, or others interested in more detailed toxicological information. The second set, two-page fact sheets, contain much of the same information as the corresponding TSDs; however, the details are presented in a more succinct, graphical format. The fact sheets will be helpful to individuals, including the public, who want to be able to quickly recognize potential chemicals of concern found in illegal methamphetamine labs in order to avoid inadvertent exposures and resulting health impacts.

For more information or to obtain copies of these and other documents, contact:

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I. Chemical Name

A. HYDROGEN CHLORIDE (HCl)

B. Synonyms

An aqueous solution of hydrogen chloride is called hydrochloric acid, HCl, hydrochloride, muriatic acid, and spirits of salt (HSDB, 2001).

II. Role in Clandestine Drug Synthesis: Methamphetamine

Hydrogen chloride is used to produce the hydrochloride salt of methamphetamine. Both aqueous and gaseous forms can be used, although gaseous hydrogen chloride is more effective (Turkington, 2000). Operators of clandestine laboratories often generate hydrogen chloride gas by combining sulfuric acid with sodium chloride (rock salt) (Turkington, 2000; ATSDR, 2000).

III. Chemical Description

A. Appearance

Anhydrous hydrogen chloride is a colorless to slightly yellow gas at room temperature. When exposed to air, it condenses with atmospheric moisture and produces dense white vapors, which are corrosive (ATSDR, 2000). Hydrogen chloride is typically stored as an anhydrous liquid in pressurized tanks. Hydrochloric acid (aqueous) is a colorless or slightly yellow fuming liquid. Yellowing is caused by trace amounts of iron, chlorine, or organic matter (HSDB, 2001).

B. Taste

In general, acids have a sour taste.

C. Odor

Pungent and irritating (HSDB, 2001).

D. Odor Threshold

Odor threshold estimates for HCl range from 0.26 to 0.77 ppm (Amoore & Hautala, 1983).

E. Irritancy Threshold

Five ppm is reported to cause immediate irritation when inhaled (HSDB, 2001). In a study of ten asthmatics aged 18-25, no significant effects on pulmonary function were observed after forty-five minutes of exposure to 1.8 ppm hydrogen chloride. No symptoms of upper respiratory tract irritation (sore throat, nasal discharge) were reported. Therefore, even in a sensitive population, the irritancy threshold for short-term exposure was greater than 1.8 ppm (OEHHA, 1999).

F. Odor Safety Class

C (Amoore & Hautala, 1983); less than 50% of distracted individuals perceive warning of threshold limit value (TLV) concentration (Amoore & Hautala, 1983). *Therefore, odor is not an adequate indicator of the presence of hydrogen chloride and does not provide reliable warning of hazardous concentrations.*

G. Vapor Density

The vapor density of hydrogen chloride gas is 1.3 (air = 1) (ATSDR, 2000); therefore, hydrogen chloride gas is heavier than air and may tend to accumulate close to the ground or in depressions (AIHA, 2002).

H. Vapor Pressure

35,000 mmHg at 25° C (HSDB, 2001).

IV. Containers and Packaging

A. Commercial Products

Hydrogen chloride is typically distributed and stored for commercial use as an anhydrous liquid in pressurized tanks. Aqueous hydrogen chloride as a solution can be found in toilet bowl cleaners, such as 4-D Bowl Sanitizer and Quest Bowl Cleaner Super Concentrated (~30% Hydrogen chloride) (HSDB, 2001). It can also be purchased at pool supply and hardware stores as swimming pool cleaner and disinfectant (ATSDR, 2000).

B. Pharmaceutical Use

No pharmaceutical uses for hydrogen chloride were identified (USP, 1998). Hydrochloric acid is used in veterinary medicine as a gastric acidifier (HSDB, 2001).

V. Chemical Hazards

A. Reactivity

Hydrogen chloride and hydrochloric acid are highly corrosive (HSDB, 2001). Both react with oxidizers releasing chlorine gas. When hydrogen chloride is mixed with water, a large amount of heat is given off (Meditext, 2003). Hydrochloric acid attacks nearly all metals with the evolution of hydrogen gas, which is flammable (HSDB, 2001).

B. Flammability

Hydrogen chloride is not flammable, but upon contact with strong bases such as ammonium hydroxide or sodium hydroxide, an explosive reaction can occur (Meditext, 2003). Flammable hydrogen gas can be produced when hydrogen chloride contacts metals. Containers holding hydrogen chloride or hydrochloric acid may explode when heated. In the event of a fire, corrosive hydrogen chloride fumes may result. The water used to control a fire may become corrosive or toxic due to hydrochloric acid contamination (HSDB, 2001).

C. Chemical Incompatibilities

Hydrogen chloride is incompatible with alkalis (hydroxides and carbonates of lithium, sodium, or potassium), ammonia, amines, copper, copper alloys, zinc, sulfuric acid, and organic materials (Meditext, 2003).

VI. Health Hazards

A. General

Inhalation of hydrogen chloride vapor or hydrochloric acid fumes can result in irritation, edema, and corrosive burns in the nose, throat, and upper respiratory tract. High concentrations may cause airway constriction with laryngeal and glottal edema, ultimately leading to cessation of breathing, asphyxia, and death. Dermal contact can produce irritation, pain, corrosive burns, and ulceration. Exposure to vapor or fumes is extremely irritating to the eyes. Eye contract with hydrochloric acid causes pain, swelling, conjunctivitis, and corneal erosion; permanent eye damage may result (Meditext, 2003). Ingestion of hydrochloric acid may cause irritation, nausea, vomiting, salivation, chills, fever, and shock. Corrosive burns, ulceration, and perforation of the gastrointestinal tract may also result.

B. Acute Effects

Inhalation of hydrogen chloride vapor or hydrochloric acid fumes may cause irritation and burning of the eyes, nose, throat and larynx, sneezing, coughing, choking, hoarseness, shortness of breath, labored breathing, bronchitis, chest pain, and upper respiratory tract edema (Meditext, 2003). Ulceration of the nose and nosebleeds may also occur.

Mild exposure may produce symptoms resembling those of acute viral upper respiratory infection. Changes in the depth and rate of respiration may occur at concentrations as low as approximately 0.1 ppm (Meditext, 2003).

Inhalation of anhydrous hydrogen chloride gas at a concentration of 1,000 ppm for a few minutes is potentially lethal (Hisham & Bommaraju, 1995). Circulatory collapse, accompanied by clammy skin, weak and rapid pulse, and shallow respiration, is one of the most common immediate causes of death from overexposure (Meditext, 2003).

Ingestion of hydrochloric acid may cause severe corrosive burns of the esophagus and stomach with pain, vomiting, and nausea. Survivors of an acute episode of strong acid ingestion may develop esophageal strictures after a delay of several weeks to several years (Meditext, 2003).

Hydrogen chloride is corrosive to the skin and is capable of producing severe burns, ulceration, and scarring (Meditext, 2003).

C. Chronic Effects

Prolonged or chronic exposure to hydrogen chloride may cause changes in pulmonary function, chronic bronchitis, skin inflammation, decay and erosion of dental enamel, bleeding from the nose and gums, ulceration of the mucous membranes of the nose and mouth, and conjunctivitis. Symptoms may be delayed 1-2 days (Meditext, 2003).

D. Skin Contact

Dermal contact with hydrogen chloride vapor or hydrochloric acid mist can cause irritation, pain, dermatitis, corrosive burns and ulceration (Meditext, 2003). Contact with liquefied anhydrous hydrogen chloride can produce frostbite (HSDB, 2001).

E. Eye Contact

Fumes of hydrogen chloride and hydrochloric acid mist are extremely irritating to the eyes. Eye contact with hydrochloric acid produces pain, swelling, conjunctivitis, and erosion and necrosis of the cornea with perforation and scarring. Ocular damage may be permanent (Meditext, 2003).

F. Inhalation

Inhalation of hydrogen chloride produces irritation, pain and burning of the nose, throat and larynx, coughing, choking, hoarseness, laryngeal spasms, sneezing, and edema of the upper respiratory tract. Headache and palpitations may also result. High concentrations produce corrosive burns of the nasal passages, nasoseptal perforation, constriction of the larynx and bronchi, and necrosis of the bronchial epithelium (Meditext, 2003). Respiratory tract irritation, if severe, can progress to pulmonary edema, which in some cases may be delayed in onset 24-72 hours after exposure.

G. Ingestion

Ingestion of hydrochloric acid produces pain, irritation, nausea, vomiting (with “coffee ground” emesis), thirst, difficulty swallowing, salivation, chills, fever, and shock. In cases of severe exposure, corrosive burns, ulceration, and perforation of the gastrointestinal tract may result.

H. Predisposing Conditions

Persons with skin, eye, respiratory, or digestive diseases (including ulcers) may be more sensitive to the toxic effects of hydrogen chloride (HSDB, 2001).

I. Special Concerns for Children

Children may inhale relatively larger does of hydrogen chloride due to their greater lung surface area to body weight ratio and increased minute volumes to weight ratio. Children may also receive higher doses due to their short stature and the higher levels of hydrogen chloride vapor that may be present near the ground when a container of the chemical is opened (ATSDR, 2000).

VII. First Aid

A. Eyes

Flush exposed eyes with water or saline for fifteen minutes. Remove contact lenses if easily removable. Seek medical attention immediately.

B. Skin

Remove contaminated clothing. Flush skin and hair with water for five minutes, then thoroughly wash with soap and water. Seek medical attention if needed.

C. Ingestion

In case of ingestion, do not induce vomiting, give activated charcoal, or attempt to neutralize. Give 4-8 ounces of water or milk (ATSDR, 2000). Seek medical attention immediately.

D. Inhalation

Remove affected person to fresh air and monitor for respiratory distress. Administer oxygen and assist ventilation as required. Seek medical attention immediately. Respiratory tract irritation, if severe, can progress to pulmonary edema, which may be delayed in onset up to 24-72 hours after exposure in some cases (Meditext, 2003).

VIII. Standards for Inhalation Exposure

A. Occupational Exposure Limits (NIOSH, 1997; ACGIH, 1994)

1. Ceiling Limit (C) (not to be exceeded at any time): 2 ppm
2. Short-Term Exposure Limit (STEL or ST): Not established.
3. 8-Hour Time Weighted Average (TWA): Not established.
4. 10-Hour Time Weighted Average (TWA): Not established.
5. Immediately Dangerous to Life & Health (IDLH): 50 ppm (75 mg/m^3)

Important Definitions Follow:

Ceiling Limit (C) is a concentration that must not be exceeded during any part of the workday.

Short-Term Exposure Limit (STEL or ST) is a 15-minute time-weighted average concentration that should not be exceeded during any part of the workday.

8-Hour Time Weighted Average (8-hour TWA) concentration is an exposure standard that must not be exceeded during any 8-hour work shift of a 40-hour workweek. 8-Hour TWA exposure standards established by the Occupational Safety and Health Administration (OSHA) are called Permissible Exposure Limits (PELs). 8-Hour TWA exposure standards established by the American Conference of Governmental Industrial Hygienists (ACGIH) are called Threshold Limit Values (TLVs).

10-Hour Time Weighted Average (10-hour TWA) concentration is an exposure standard that must not be exceeded during a 10-hour workday of a 40-hour workweek. 10-Hour TWA exposure standards developed by the National Institute for Occupational Safety and Health (NIOSH) are called Recommended Exposure Limits (RELs).

Immediately Dangerous to Life & Health (IDLH) defines a concentration which poses a threat of death or immediate or delayed permanent health effects, or is likely to prevent escape from such an environment in the event of failure of respiratory protection equipment. IDLH values are developed by the National Institute for Occupational Safety and Health (NIOSH).

“Skin” notation (NIOSH): significant uptake may occur as a result of skin contact. Therefore, appropriate personal protective clothing should be worn to prevent dermal exposure.

B. Emergency Response Planning Guidelines (1 hour or less) (AIHA, 2002)

1. ERPG-1 (protective against mild, transient effects): 3 ppm
2. ERPG-2 (protective against serious adverse effects): 20 ppm
3. ERPG-3 (protective against life-threatening effects): 150 ppm

NOTE: There is a significant discrepancy between the IDLH concentration (50 ppm) and the ERPG-3 concentration (150 ppm). Both values are intended to provide an estimate of a life-threatening concentration. Given the lack of human toxicity data for lethality of airborne hydrogen chloride, OEHHA recommends using the IDLH value as an estimate of a potential lethal concentration.

Emergency Response Planning Guidelines (ERPGs) are developed by the American Industrial Hygiene Association (AIHA) to assist in planning and preparation for catastrophic accidental chemical releases. ERPGs allow emergency response planners to estimate the consequences of large-scale chemical releases on human health, and evaluate the effectiveness of prevention strategies and response capabilities. ERPGs assume that the duration of exposure is one hour or less. They are not intended to be used as limits for routine operations and are not legally enforceable.

Definitions for the three ERPG levels are:

ERPG-1: an estimate of the maximum airborne concentration below which nearly all individuals could be exposed for up to one hour without experiencing more than mild, transient adverse health effects or without perceiving a clearly defined objectionable odor.

ERPG-2: an estimate of the maximum airborne concentration below which nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action.

ERPG-3: an estimate of the maximum airborne concentration below which nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.

C. Acute Reference Exposure Level (1-hour exposure) (OEHHA, 1999)

1. Level protective against mild adverse effects: 1.4 ppm (2.1 mg/m^3)
2. Level protective against severe adverse effects: 20 ppm (30 mg/m^3)
3. Level protective against life-threatening effects: 42 ppm (63 mg/m^3)

D. Chronic Reference Exposure Level (multiple years) (OEHHA, 2002)

Level protective of adverse health effects: 6 ppb (9 μg/m^3)

Reference Exposure Levels (RELs) are developed by the California EPA's Office of Environmental Health Hazard Assessment (OEHHA). A REL is a concentration at or below which no adverse health effects are anticipated, even in the most sensitive members of the general population (for example, persons with pre-existing respiratory disease). RELs incorporate uncertainty factors to account for information gaps and uncertainties in the toxicological data. Therefore, exceeding a REL does not necessarily indicate an adverse health impact will occur in an exposed population. Acute RELs are based on an assumption that the duration of exposure is one hour or less. Chronic RELs are intended to be protective for individuals exposed continuously over at least a significant fraction of a lifetime (defined as 12 years).

E. Chronic Reference Concentration (lifetime exposure) (IRIS, 1995)

Level protective of adverse health effects: 13 ppb (20 $\mu g/m^3$)

IX. Environmental Contamination Concerns

A. Surface Water

In water, hydrogen chloride dissociates almost completely, with the hydrogen ion associating with the water molecule, forming a hydronium ion. The contaminated water can be neutralized with agricultural lime (CaO), crushed limestone ($CaCO_3$), or sodium bicarbonate ($NaHCO_3$) (HSDB, 2001).

B. Groundwater

If hydrochloric acid is spilled, it will be neutralized by organic and inorganic constituents in the soil. Except in cases of massive spills, groundwater contamination should not be a concern.

C. Drinking Water

No information available.

Suggested No Adverse Response Level (NAS, 1980): Not established.

Preliminary Remediation Goal for Tap Water (U.S. EPA, 2002 Region IX): Not established.

D. Soil

Anhydrous hydrogen chloride will readily combine with soil moisture. Aqueous hydrogen chloride will infiltrate the soil, dissolving some of the soil material, especially carbonates. Neutralization of the acid will occur (HSDB, 2001).

Preliminary Remediation Goal for Residential Soil (U.S. EPA, 2002 Region IX): Not established.

E. Air

Hydrogen chloride readily combines with water vapor in the air to form hydrochloric acid and is subject to wet deposition (washout by rainfall) and dry deposition (ARB, 1997).

Preliminary Remediation Goal for Ambient Air (U.S. EPA, 2002 Region IX): 14 ppb (21$\mu g/m^3$)

F. Indoor Surface Contamination

Anhydrous hydrogen chloride is a gas at room temperature. It can combine with airborne water vapor to form hydrochloric acid, which may condense on surfaces. Spills of hydrochloric acid should be diked to prevent runoff. In both cases, appropriate precautions should be taken to prevent inhalation of vapors and contact with contaminated surfaces. Neutralization with a weak base (such as sodium bicarbonate) is effective, but may cause the acid to spatter (HSDB, 2001).

X. Personal Protective Equipment

When exposure levels are unknown, wear a full face-piece, positive-pressure, air-supplied respirator. Wear rubber or neoprene gloves, as well as impervious boots, and apron or coveralls to prevent skin contact. Chemical safety goggles and/or a full-face shield should be worn when splashing is possible (Mallinckrodt, 2001).

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