

Chemical Exposures Associated with Clandestine Methamphetamine Laboratories

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- How do the symptoms observed in children present at clandestine drug laboratories relate to the chemical exposures within the laboratory?
- Based on the potential exposures at clandestine drug laboratory seizures, what personal protective equipment should be worn and during what phases should it be worn?
- Based upon the potential exposures at the laboratory sites, what components should the medical screening program for responding personnel contain?

Although not all of these questions have been completely answered by this report, we do have a significant start on answering many of the questions. We have obtained valuable information on the types and magnitude of chemical exposures associated with cooks involving the red phosphorous method of methamphetamine manufacturing. We have also begun to determine how widespread the contamination during these cooks can become and how it may effect the persons conducting the cook, bystanders (including children and spouses) in the same building, and law enforcement personnel responding to the clandestine laboratory. Based on the information that has been gained from this project, we can shed light on a number of areas such as chemical exposures, expected symptoms, suggested personal protective equipment, and concerns regarding children exposed to these environments.

Chemical Exposures Associated with Clandestine Methamphetamine Laboratories:

Based on our sampling results, the chemical exposures of greatest concern produced during the manufacture of methamphetamine (especially using the red phosphorous method) consist of phosphine, iodine, hydrogen chloride, solvents, and the drug or its precursors. During the cooking phase, exposure levels of all of these compounds may meet or exceed current occupational exposure guidelines. This is especially true of exposures to phosphine, iodine, and hydrogen chloride. Each of these compounds may exceed the occupational exposure guidelines as set by the Occupational Safety and Health Administration (OSHA) and by the American Conference of Governmental Industrial Hygienists (ACGIH).

Phosphine:

During our sampling efforts at the Colorado Springs Police Department and at our own controlled cook, phosphine was generated during the red phosphorous methamphetamine cooks. Phosphine was produced at levels ranging from less than 0.17 mg/m^3 to 4.84 mg/m^3 during the cooking phase of the process. It was produced on all occasions during the cook and not just during an overheating event, as has been suggested in the past. No detectable levels ($<0.17 \text{ mg/m}^3$) of phosphine were produced during the hotel cook suggesting that phosphine may be contained by sealing the cooking vessel and providing more water in the cook. The current ACGIH TLV for phosphine is 0.42 mg/m^3 on an

eight-hour time weighted basis with a STEL of 1.4 mg/m³. The highest level observed was four times the STEL, suggesting that overexposure to phosphine is highly likely.

Phosphine is a severe pulmonary irritant that may cause dyspnea, headache, paresthesia, diplopia, tremor, jaundice, and pulmonary edema. Death from exposure to phosphine has occurred to persons exposed as it was being used as an insecticide.⁽⁴⁾ Fatalities thought to be due to phosphine exposure were also linked to a methamphetamine laboratory in Los Angeles, CA where three persons were found dead in a motel room.⁽⁵⁾ A laboratory investigator was also reported by Burgess⁽⁶⁾ to have developed dizziness, dry cough, headache, and diarrhea, with a delayed onset of cough and dyspnea, after investigating a clandestine laboratory. The exposure was measured at 2.7 ppm phosphine and the duration of exposure was approximately 20 – 30 minutes. These levels are in the same range as the levels measured during our investigation. In workers, phosphine exposure has been shown to cause gastrointestinal, respiratory, and central nervous symptoms at concentrations that are less than 10 ppm.⁽⁷⁾

There are a number of reasons why phosphine intoxication may be more common than reported. Phosphine does have a detectable odor but it may be less readily identified with the presence of the more odorous hydrocarbons present during the cook. In addition, the pulmonary toxicity of phosphine may occur shortly after exposure or it may be delayed for 18 hours or more. These factors may result in fewer reported symptoms, although pulmonary irritation is a common complaint after a clandestine laboratory investigation.

Children and adults that are especially susceptible to pulmonary problems, such as asthmatics, individuals with chronic obstructive pulmonary disease, emphysema, etc, may show significantly greater effects to exposure levels of phosphine that are well below the concentrations allowed in the occupational environment. Unfortunately, at this time, there are no published data regarding acceptable levels of exposure for the general population to phosphine. The effects to these sensitive individuals are, therefore, not known at this time.

Iodine:

Airborne iodine concentrations during the Colorado Springs Police Department cooks were found to be very high, ranging from 2.3 to 37 mg/m³. The levels produced during the controlled cooks ranged from 0.07 mg/m³ to 1.6 mg/m³. These levels are close to or exceeding the current ACGIH Ceiling TLV of 1.0 mg/m³. The release of iodine during the red phosphorous cook becomes very obvious when the dark brown effluent is observed. In addition, the walls in many of the cook areas appear to have a brownish yellow stain that is reactive with spray starch forming a dark blue color indicating the presence of iodine.

Airborne iodine is a very heavy halogen vapor that is considered to be more irritating and corrosive than bromine or chlorine gases. In animal studies, iodine vapor has been found to be intensely irritating to mucous membranes, causing damage in both the upper and lower portions of the respiratory tract. Iodine vapors can be an intense irritant to the

eyes, mucous membranes and skin. It has a steep effects curve in that concentrations of 1 mg/m³ may cause very little effect while levels of 3 mg/m³ cause severe irritation.⁽⁸⁾

Although there have been no documented cases of over-exposure to iodine vapor in clandestine methamphetamine laboratories reported in the literature, iodine would be a plausible cause of mucous membrane and eye irritation reported at many of these investigations. Iodine may persist for some time in the walls, carpeting, draperies, etc. present in many of these clandestine laboratories. The fact that it is commonly observed on the walls, even after months of no cooking, suggests that it can be very persistent.

The fact that the iodine is persistent in the environment of the cook is very important to the children that are present in the clandestine laboratories as well as children who inadvertently become residents in a building previously used as a methamphetamine laboratory. Children crawling on contaminated carpeting may pick up high levels of iodine. In addition, based on an evaluation by the Colorado Department of Public Health and Environment, the population-based exposure concentration should be less than 0.001 mg/m³, three orders of magnitude below the occupational exposure level.⁽⁹⁾

Hydrogen Chloride:

Hydrogen chloride levels were measured during all methamphetamine cooks, including periods where hydrogen chloride was not expected. The levels ranged from less than detectable to a time-weighted average of 14.6 mg/m³. Peak levels measured during the controlled cook ranged as high as 56.2 mg/m³. The most recent change to the current ACGIH TLV for hydrogen chloride was proposed in 2003 and is a ceiling value of 3.0 mg/m³, much lower than the levels that have been found during the controlled cooks that we have conducted. In fact, the Immediately Dangerous to Life and Health (IDLH) level for hydrogen chloride is 74.5 mg/m³ which is being approached by the levels generated during the salting-out phase conducted during the controlled cooks.⁽¹⁰⁾

Exposure to high levels of hydrogen chloride have been known to cause both acute and chronic effects. One individual exposed during a swimming pool cleaning effort developed severe bronchospasm and asthma. Workers exposed to as little as 15 mg/m³ of hydrogen chloride experienced work impairment. Hydrogen chloride is a strong irritant of the eyes, mucous membranes, and skin at levels that are well below the levels that we have measured during our controlled cooks. It would seem likely that individuals exposed to the measured concentrations that we have found would have acute symptoms from the exposure.⁽¹⁰⁾

Young persons and individuals with pulmonary problems may show much greater effects from a hydrogen chloride exposure than would an individual with an occupational exposure. The reference level proposed by the Colorado Department of Public Health and Environment for hydrogen chloride was set at 0.02 mg/m³, a level that is one hundred times lower than the proposed ACGIH TLV.⁽⁹⁾ It is important to realize that this level is likely exceeded during production at all clandestine methamphetamine laboratories.

Methamphetamine Exposures:

Methamphetamine contamination of buildings used to cook methamphetamine was a common finding in all of the labs tested. Even labs that had been busted several months prior to testing still had high contamination levels of methamphetamine present on many surfaces within the building. Samples as high as 16,000 ug/sample were found with most samples over 25 ug/100 cm².

Although the effects of methamphetamine are well known on individuals using the drug, the effects of low level exposures to emergency personnel or other associated individuals are not as well known. It is known that methamphetamine may cause some teratogenic effects and may change behavior in exposed infants. Prenatal exposure to methamphetamine has been shown to cause an increase in pre-term labor, placental abruption, fetal distress, and postpartum hemorrhage. Infants exposed to methamphetamine are generally smaller, have feeding difficulties, and are described as "very slow". Infants born to mothers that have used methamphetamine during pregnancy may have abnormal sleep patterns, poor feeding, tremors, and hypertension. In some reports, subtle neurological abnormalities have also been found.⁽¹¹⁾

Currently, allowable levels for a residence that has been used as a clandestine laboratory to be re-occupied range from 0.1 ug/ft² to 5 ug/ft². Most states and local jurisdictions have adopted 0.5 ug/ft² or 0.5 ug/100 cm². These levels have been set primarily at the limit of detection for the compound since, at this time, no safe level has been established. Since the drug appears to settle out on all porous surfaces in the area in which the cook is conducted, it is difficult to determine the actual dose of individuals working within that atmosphere. It is logical to assume that hand contamination will result in oral ingestion, especially in the case of children, but it may also be possible for the drug to penetrate the skin of adults involved in the investigation. The State of California has recently begun to study the possibility of skin absorption and its role in methamphetamine exposure.

We have also found that police officers handling suspects or children at the scene, for very short periods of time, can become contaminated with methamphetamine. It is possible, therefore, for these individuals to carry this material off of the scene and to their own families. Since there has not been a no-effect level established for this drug at this time, it would seem prudent to minimize exposure to as low as possible.

Suggested Personal Protective Equipment Requirements:

Our study has shown that exposures to a variety of chemical compounds may occur during the investigation of clandestine methamphetamine laboratories. During a cook, the exposures at the lab may approach IDLH levels, which by definition may be extremely dangerous to the lives and health of investigating officers. Recent studies have shown that individuals responding to clandestine methamphetamine laboratory investigations have a good chance of being injured. Of 112 methamphetamine-associated hazardous materials events reported to the Centers for Disease Control, 53% resulted in