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Methamphetamine is easily synthesized in makeshift laboratories. These laboratories pose a serious health risk US Drug Enforcement Agency (DEA) reported a 590% increase in methamphetamine laboratories seized by law enforcement officials from 1994-2000.

The USA's Centers for Disease Controls' (CDC) Agency for Toxic Substances and Disease Registry (ATDSR) maintains a Hazardous Emergency Events Surveillance (HSEES) database. From January 2000 through June 2004 sixteen state health departments reported 40,369 events. Of these events 4% of them (1791) were associated with methamphetamine production. Thirty one percent of the reported methamphetamine events resulted in injuries. Of these injures 531 were police officers and 314 were private citizens. There were 9 fatalities. Twenty percent of the injuries involved children.[1]

Illicit methamphetamine laboratories pose numerous hazards including chemical burns, fire and explosions, compressed gases, toxic chemical exposures and exposure to the drug itself. Solvents used to dissolve tablets, reactive metals such as lithium or sodium, and caustic chemicals such as ammonia and hydrochloric acid are usually present in very large quantities. Booby traps designed to destroy evidence and prevent or discourage entry are also a common hazard.

Martyny et.al. [2-3] measured airborne chemical concentrations during controlled methamphetamine synthesis (cook) using both the Birch reduction and red phosphorous methods. Measured values during the 'cooking phase' of the experiments exceeded NIOSH (USA National Institute for Occupational Safety & Health) immediately dangerous to life and health (IDLH) concentrations for anhydrous ammonia and hydrogen chloride. Occupational exposure limits for phosphine and iodine were also exceeded. It should be noted that the various instruments used for 'real time' analysis were quickly over loaded during these experiments. The authors are very clear in pointing out the concentrations could actually be much higher than recorded depending on the techniques and stage of the cook, location, and quantities of chemicals used.

Chemical Hazards during Synthesis

There are many recipes used to synthesize methamphetamine. Most techniques are dependent on availability of bulk chemicals. Since the structures of ephedrine and methamphetamine are very similar, many recipes are designed to remove a bound oxygen and hydrogen

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atom from the ephedrine and replace it with hydrogen. The three most common methods of methamphetamine synthesis techniques encountered by law enforcement are ‘red P’, P2P and the ‘Birch Reduction’ methods. The Birch Reduction method combines anhydrous ammonia and lithium or sodium metal with ephedrine or pseudoephedrine. The red-P method produces methamphetamine by combining ephedrine or pseudoephedrine with red phosphorous, iodine crystals, and water. The P2P method involves phenyl-2-propanone reacted with methylamine, mercuric chloride, alcohol, and aluminium foil. Solvent extractions and precipitation techniques are generally used in all of these techniques.

Anhydrous Ammonia

Anhydrous ammonia is used in the ‘Birch Reduction’ method in combination with a reactive metal such as lithium. Because of the prevalence of anhydrous ammonia in agriculture this method is commonly found in rural areas. Usually pseudoephedrine tablets are dissolved in a solvent and the ammonia and reactive metal are added to the mixture. The remaining solids are then dissolved and precipitated (salted out) with hydrochloric acid. Concentrations of anhydrous ammonia can easily exceed IDLH limits during this process. The substance is corrosive to the eyes, the skin and the respiratory tract. Inhalation of high concentrations may cause fluid in the lungs. Rapid evaporation of the liquid may cause frostbite.

Hydrochloric Acid

Used by all three processes. It can also be a bi-product from the reaction of ephedrine chloride being converted to methamphetamine. Concentrations of HCl should be assumed to exceed IDLH limits during synthesis of methamphetamine. The substance is corrosive to the eyes, the skin and the respiratory tract. Inhalation of the vapour may cause fluid in the lungs.

Phosphine

Bi-product of the red phosphorous method and may be produced by other recipes that use phosphorous compounds. Phosphine exposures from meth labs have resulted in fatalities and injuries. Concentrations should be assumed to exceed IDLH during methamphetamine synthesis using phosphorous. Short term exposure to phosphine is severely irritating to the respiratory tract. Inhalation of the gas may cause fluid in the lungs. Rapid evaporation of the liquid may cause frostbite. Phosphine can affect the central nervous system, cardiovascular system, heart, gastrointestinal tract, liver and kidneys, resulting in impaired functions. Symptoms may be delayed and medical observation is recommended. Long term exposures can lead to toothache, swelling of the jaw, phossy jaw, spontaneous fractures of bones and anaemia. Effects are cumulative.

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Iodine

Iodine is used in the red phosphorous method and is also used in other recipes. Iodine gas is more irritating than chlorine and bromine. Concentrations will exceed Occupational Exposure Limits during methamphetamine synthesis and may exceed IDLH levels. Iodine is severely irritating to the eyes and the respiratory tract, and is irritating to the skin. Inhalation of the vapour may cause asthma-like reactions (RADS). Inhalation of the vapour may cause fluid in the lungs. The effects may be delayed. Medical observation is indicated. Repeated or prolonged contact may cause skin sensitization in rare cases. Repeated or prolonged inhalation exposure may cause asthma-like syndrome (RADS). Iodine may have effects on the thyroid.

Methylamine

Methylamine is a gas at normal room temperature and is a primary component in the P2P method of synthesizing methamphetamine. Concentrations can easily exceed IDLH levels when the gas is released into enclosed areas. Methylamine is corrosive to the eyes and the respiratory tract. Inhalation at high concentrations may cause fluid in the lungs. The effects may be delayed. Medical observation is indicated. Rapid evaporation of the liquid may cause frostbite

Mercuric chloride

Mercury is a highly toxic heavy metal. Mercuric chloride is used in the pesticide industry and is a component of the P2P method of methamphetamine synthesis. It poses short and long term health effects to people exposed to it. Mercuric chloride irritates the eyes and is corrosive to the skin and the respiratory tract. Inhalation of vapour or aerosol may cause fluid in the lungs. The substance may cause effects on the cardiovascular system. The effects may be delayed. Medical observation is indicated. Repeated or prolonged contact with skin may cause dermatitis. Lungs may be affected by repeated or prolonged exposure.

Methamphetamine

Surface contamination in illicit labs and the surrounding area can be substantial. The entire area of an illicit methamphetamine laboratory should be considered significantly contaminated with the drug itself. Martyny et. al. reported wipe sample concentrations as high as 16,000 micrograms per 100 square centimetres ($\mu g/100cm^2$). Significant concentrations were also found in areas away from the primary synthesis area such as refrigerators, microwaves, and kitchen appliances.

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Investigation and Cleaning Up Methamphetamine Laboratories

Cleaning up illicit laboratories generally falls under local, state and federal environmental agencies. Although concentrations of chemicals should generally be lower in an inactive laboratory it should be assumed that concentrations are greater than IDLH until proven otherwise. Cleanup involves removing, neutralizing and cleaning up spills of chemicals used in synthesis. It also involves cleaning up methamphetamine residue itself. Regulatory activity in this area is heavy and several studies have been performed to assess current cleanliness standards. An important point is that most of the surrounding area of an illicit laboratory will be heavily contaminated with the drug.

Health Effects to First Responders

Several studies performed on law enforcement personnel responding to and investigating clandestine laboratories have showed significant evidence of short and long term health effects. Primary effects are to the respiratory system. A study published in 2001 in Clinical Toxicology is the first published case of symptomatic occupational phosphine exposure in a law enforcement official. This case report involves a 28 year old forensic scientist exposed to phosphine during an investigation of a methamphetamine lab while not wearing respiratory protection. Estimated exposure concentration was 2.7 ppm for 20-30 minutes. The subject developed initial symptoms of dizziness, dry cough, headache, and diarrhoea. She was examined within 90 minutes of exposure and released. One week later she developed a chronic cough that increased during exertion, did not respond to treatment, and lasted 9 months. [5-7]

Burgess et. al. conducted a study designed to determine the extent of chronic health effects in 40 drug lab investigators over a seven year period. The study demonstrated decreased lung capacity in many of the investigators exposed to toxic chemicals which was more pronounced in investigators that tended not to wear respiratory protection.[8]

Personal Protection

The USA’s Occupational Safety and Health Administration's (OSHA) "Hazardous Waste Operations and Emergency response" (HAZWOPER) regulation, 29 CFR 1910.120 requires a minimum of level B personal protection when entering an unknown atmosphere. Level B protection is generally deemed appropriate when conditions require a high level of respiratory protection due to inhalation hazard but require less skin protection, because chemicals harmful to the skin or capable of absorption through the skin are not present as a splash or immersion hazard or in high concentrations in atmospheric contaminants. It consists of a Self Contained

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Breathing Apparatus (SCBA), splash resistant chemical suit, chemical resistant gloves and boots. Level C protection is generally deemed appropriate when the respiratory protection can be decreased to air purifying respiratory protection such as full face negative pressure respirators or powered air purifying respirators.

Australian Standard AS/NZS1715 states that all employees required to wear a respirator be included in a respiratory protection program that details workplace-specific procedures. Key procedures which must be addressed in the program are the proper selection of respirators, medical evaluation of employees required to wear the respirators, fit testing, proper use and maintenance of respirators, training, and an annual evaluation of the program. The standard requires that only Australian Standard AS/NZS1716 compliant or equivalent respirators be used.

Self Contained Breathing Apparatus (SCBA)

Self-contained breathing apparatus (SCBA) is an atmosphere-supplying respirator where the breathing air source is designed to be carried by the user. There are a wide variety of SCBA's ranging from 15 minute escape models, industrial models and SCBA's designed for fire fighting. The primary limitation is duration of the air bottle.

Air Purifying Respirators (APR)

Air purifying respirators consist of negative pressure half and full face models and powered air purifying respirators. APRs purify the breathing air by passing it over a filter designed to remove the contaminant either by filtration or absorption. Tables one and two list several NIOSH approved canisters/cartridges that have been challenged with three of the suspect chemicals. Laboratory testing should never be assumed to represent respiratory protection performance in the work place. However, it does provide data that can be used to estimate service life for cartridges/canisters.

Table 1. 3M™ Canister FR-40 and FR-15CBRN

	Challenge Concentration (mg/m3)	Testing Relative Humidity (%)	Maximum Allowed Breakthrough (mg/m3)	Minimum Service Time (min)	TLV/IDLH (mg/m3)	Allowable Maximum Use Concentration (MUC) (mg/m3)
Phosphine	2086	50	0.42	12	0.42/278	20.9
Hydrogen chloride	7460	50	7.5	25	7.5C/149	149
Ammonia	3480	50	34.8	25	17.4/348	348

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Table 2. 3M^{TM} Cartridge FR-64

	Challenge Concentration (mg/m3)	Testing Relative Humidity (%)	Maximum Allowed Breakthrough (mg/m3)	Minimum Service Time (min)	TLV/IDLH (mg/m3)	Allowable Maximum Use Concentration (MUC) (mg/m3)
Phosphine	2086	50	0.42	12	0.42/278	20.9
Hydrogen chloride	746	50	7.5	25	7.5C/149	149
Ammonia	697	50	34.8	25	17.4/348	348

Table 3. 3M^{TM} Cartridge FR-57

	Challenge Concentration (mg/m3)	Testing Relative Humidity (%)	Maximum Allowed Breakthrough (mg/m3)	Minimum Service Time (min)	TLV/IDLH (mg/m3)	Allowable Maximum Use Concentration (MUC) (mg/m3)
Phosphine	N/A	N/A	N/A	N/A	N/A	N/A
Hydrogen Chloride	746	50	7.5	25	7.5C8 / 149	149
Ammonia	697	50	34.8	25	17.4 / 348	348

Service Life

Service life is generally inversely proportionate to flow rate. According to Nelson and Correia, the breathing rate is roughly 20 litres/min, 40 litres/min and 60 litres/min for light, medium and heavy work respectively (Nelson, G.O. and Correia, A.N., Respirator Cartridge Efficiency Studies VIII. Summary and Conclusions. Am. Ind. Hyg. Assoc. J. 36:514-525 (1976)). Powered air purifying respirators can range from approximately 160 litres/min for tight fitting facepieces and 220 litres/min for loose fitting facepieces, helmets and hoods.

Service life information is often modified by a safety factor before determining a change schedule. This is done because of factors such as uncertainty in the method used to estimate service life, lot to lot variation in the cartridges, variability and uncertainty of the environmental conditions, mixtures, and high relative humidity. The warning properties and the acute toxicity of the contaminant may also be considered. It should be noted that the breakthrough concentration in these experiments is often at or above the exposure limit. Users may want to estimate service life at a breakthrough concentration that is less than these levels.

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For example, service life for the FR-64 at a moderate work breathing rate of 60 litres/min against 350 ppm phosphine to 0.30 ppm breakthrough, at 25C, 50% RH would be:

12min*(1500ppm÷350ppm)*(64l/min÷60l/min)*1÷safety factor = 55min÷safety factor

Regulatory Activity

USA Regulatory activity regarding methamphetamines is very high on the Federal and State level. Many states have implemented or are in the process of implementing cleanliness standards. Almost all standards currently range from 0.05 – 0.1 µg/100cm^2. Much of the legislation at the State levels also contains language for medical surveillance of first responders that have entered illicit laboratories.

At the federal level in the USA, both the house and senate have introduced numerous bills addressing illegal methamphetamine laboratories. In December 2005 the Methamphetamine Remediation Research Act of 2005 was passed by the House and sent to the Senate. This act directs the Environmental Protection Agency (EPA) to establish: (1) voluntary guidelines, based on the best currently available scientific knowledge, for the remediation of former methamphetamine laboratories, including guidelines regarding preliminary site assessment and the remediation of residual contaminants; and (2) a program of research to support the development and revision of such guidelines. It also requires the Director of the National Institute of Standards and Technology (NIST) to support a research program to develop: (1) new methamphetamine detection technologies, with an emphasis on field test kits and site detection; and (2) appropriate standard reference materials and validation procedures for methamphetamine detection testing.

Conclusion

Appropriate respiratory protection along with other personal protective equipment is key components in reducing the risk of adverse health affects for personnel entering and cleaning up methamphetamine laboratories. For assistance in selection of respiratory protection please call 3M Australia Technical Service at 1800 024 464.

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