2 Clandestine Lab Hazards

Clandestine lab investigation is one of the most dangerous tasks undertaken by law enforcement. The dangers go beyond the violence of the suspects involved in the illegal operation. There are seen and unseen hazards with these toxic operations that must always be kept in the forefront of the minds of the personnel involved in investigation and seizure. The effects of some of these hazards on a human being may not be seen until long after they were encountered.

In this chapter, the different hazards associated with the seizure of clandestine labs are presented. A general overview of the different types of clandestine lab hazards will be presented. While some sections may be a simplified refresher for experienced investigators, the goal is for everyone involved in clandestine lab investigations and prosecutions to understand the scope of the hazards involved.

2.1 General Hazards

The three things clandestine labs have in common, regardless of their location or sophistication, are the simple facts that the operators usually have little chemical training, the operations are makeshift, and no two operations are alike. These three principle hazards exist, whether the final product is methamphetamine or PCP, flash powder or nitroglycerine.

2.1.1 Little Training

With the exception of the educated operator mentioned in Chapter 1, clandestine lab operators have little chemical background or training. Their formal education is limited either in years or content. The so-called "Mexican National" labs, operating in the western United States, are a good example. Illegal aliens are hired to tend methamphetamine production operations. They have little education and do only as they are told. They do not understand the physical and chemical principles of the reaction that they are tending, much less the hazards involved.

The lack of chemical training can lead to hazards within the clandestine lab that endanger more than just the operators and the enforcement personnel tasked with seizing the operation. Unsuspecting people in the area adjacent to the clandestine operation are exposed to many of the same hazards, often with disastrous consequences. There are numerous examples of lab operators, enforcement personnel, and innocent bystanders being hurt as a result of actions taken by clandestine lab operators who do not understand the principles of chemistry and physics that govern the chemical reactions that occur within the operation. Houses and apartments have been destroyed by fire. Explosions were caused by operator error. Emergency responders and neighbors were exposed to toxic fumes generated by the reaction of incompatible chemicals.

Clandestine lab operators neither understand nor practice common laboratory safety procedures (Figure 2.1). They are notorious for storing incompatible chemicals together; strong acids and strong bases are commonly found stored adjacent to each other. Organic acids are stored with oxidizing acids. Flammable liquids are stored near a source of ignition. Chemicals are routinely unlabeled or mislabeled to avoid detection. Waste material from reaction mixtures is often combined without regard to content or pH.

The improper storage and handling of chemicals may lead to violent chemical reactions between incompatible chemicals, or the chemicals may react and create substances that are more toxic than the original chemicals. Emergency medical service personnel often encounter operators at clandestine lab sites who exposed themselves to the toxic waste or by-products of the combination of incompatible chemicals in reaction mixtures or waste material. Improper handling of the chemicals leads to human exposure of unknown chemical hazards, which makes it difficult to treat the exposed operator.

An example of mixing chemicals to create a toxic atmosphere occurred when an operator mixed a waste solution containing acid with a solution containing sodium cyanide. The resulting hydrogen cyanide placed the operator, one police officer, and two EMS responders in the hospital. Fortunately, no deaths occurred in this scenario.

The concepts of vapor pressure, flash point, flammability, and explosive limits are not usually in the operator's knowledge base. Nationally, approximately 20% of clandestine labs are detected as a result of fire or explosion. Flammable vapors build up inside the lab space, reaching the flammable or

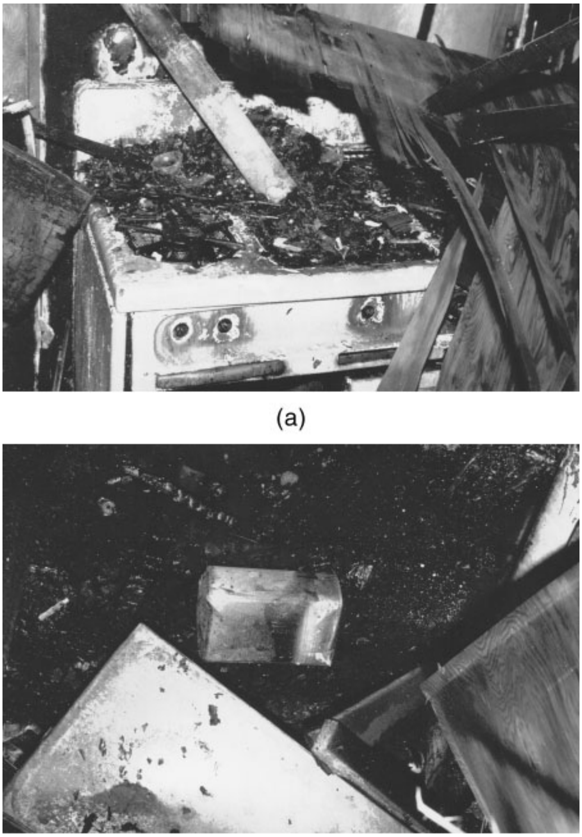
(a)

(b)

Figure 2.1 (a) Ether in trunk. (b) Abandoned explosive chemicals.

explosive limit of the chemical involved. The operator lights a match, turns on a gas stove, or turns on a light switch, thus igniting the fumes in the lab and resulting in a fire or explosion.

Figure 2.2 shows the results of an attempt to evaporate methanol from an extraction solution containing pseudoephedrine. The operator used methanol to extract the pseudoephedrine from an over-the-counter cold preparation. He placed the methanol solution on a gas stove to speed the evaporation process. The combination of the methanol vapors and the gas flame resulted in a fire that caused extensive damage to the two-bedroom bungalow. The operator was caught a week later, when he again caused a vapor explosion under similar circumstances in a motel room less than 2 miles from the location of the bungalow.



(a)

(b)

Figure 2.2 Fire from methanol evaporating on a gas stove. (a) Gas stove fire point of origin. (b) Burned methanol container.

2.1.2 Makeshift Operations

The creativity of clandestine lab operators is amazing. Using a basic understanding of how scientific equipment operates, they design equipment alternatives that allow them to avoid detection by not using scientific supply houses as equipment sources. Also, the cost of the homemade alternatives can be significantly less than the actual items.

The problem with this situation is that even if the operator has taken the physics and mechanics of the equipment into account, he probably has not taken into consideration the interaction between the chemicals involved and the materials with which the makeshift equipment is constructed. Common glass kitchen utensils cannot be substituted for Pyrex™ glassware that is designed to operate at high temperatures. Rubber or cork stoppers cannot be substituted for ground glass connections in reflux and distillation apparatuses when using organic solvents or strong acids. Reaction vessels made of steel are not designed to contain solutions of hydrochloric acid.

In Figure 2.3, three examples of the ingenuity of clandestine lab operators are shown. Shown in Figure 2.3(a) is a countertop deep fryer being utilized as an oil bath heat source for a reflux operation. Shown in Figure 2.3(b) is a hydrogenator that was constructed out of a beer keg and heat tape. In Figure 2.3(c), a homemade condenser made from different diameters of copper tubing is shown. Yet, each of these alternatives efficiently accomplished the task for which it was designed.

2.1.3 No Two Labs Are Alike

There are hundreds of different methods of manufacturing controlled substances. However, only a small number of methods are actually encountered. Even when the same method is repeatedly encountered, there are still enough differences within each clandestine lab to make each unique.

It cannot be repeated emphatically enough that the personnel responding to the scene of a clandestine lab must be constantly vigilant for potential hazards. Even though the particular type of operation may have been encountered numerous times before, it should always be treated as an unknown scenario. Complacency is the biggest danger to personnel investigating or processing the scene. A less-than-aware attitude may lead to not recognizing booby traps, disregarding the presence of odd or unique chemicals, exposing oneself to toxic environments, or improperly handling unsafe makeshift equipment setups. It can further lead to severe injury for the investigators.

2.2 Hazard Priority

There are numerous hazards associated with clandestine labs. These hazards were grouped into priority categories according to the immediate harm they can present the personnel responding to the scene of a suspected clandestine lab. The hazard groups are, in order of priority, explosion, fire, firearms, and exposure.

2.2.1 Explosion

An explosion is a rapid chemical change that produces a large amount of heat and gas. It is the highest hazard priority, because it can potentially do the greatest amount of damage to the responding personnel in the shortest amount of time. The source can be intentionally placed (i.e., a booby trap) or an unintentional result of the improper handling of chemicals.

(a) (b)

(c)

Figure 2.3 (a) Oil bath reflux. (b) Beer keg reaction vessel. (c) Copper tube condenser.

Explosions have two effects on the body. First, the resulting pressure wave can cause internal and external damage to the body by the blast directly or by the secondary effects resulting from being struck by items thrown as a result of the explosion. The second effect is a result of the high temperatures created by the explosion. Both of these effects are reduced for the exposed person as the distance away from the center of the explosion increases.

The three types of explosions are detonations, deflagrations, and mechanical explosions. The only significant difference between the first two is the rate of the reaction. All have pressure waves and intense heat associated with them. The pressure wave of the explosion is proportional to the amount of energy released, which determines the effect on the body that is exposed to the explosion.

Detonations are chemical reactions that produce extraordinary amounts of heat and gas, resulting in a pressure wave that causes the damage. They are the result of known explosive materials or chemical mixtures that have a reaction rate of greater than 1000 miles per second. They can also be the result of the reaction between a mixture of incompatible chemicals or the undesirable outcome of the mishandling of unstable chemicals, such as peroxides, white phosphorus, or picric acid.

Deflagrations have a reaction rate of less than 1000 miles per second. They are explosions that result from the pressure created by a chemical reaction, usually combustion, that compromises the structural integrity of the container. They can result from the spontaneous ignition of an atmosphere that contains ignitable liquid vapors in an explosive concentration, if the ignition takes place in a contained environment (i.e., a room). Confined deflagrations of combustible solids, such as smokeless powder, can also produce explosive results.

Mechanical explosions result from a pressure buildup in a container to the point at which it loses its structural integrity. A boiling liquid expanding vapor explosion, or BLEVE, is an example. The expanding vapors of a boiling liquid in a closed container create so much pressure that the container explodes. In practical examples presented in Chapter 9, the effects of explosion in an actual setting are demonstrated.

The lack of chemical knowledge of the clandestine lab operator can create a situation that is prone to explosive results. Ethers are exposed to the atmosphere, creating unstable peroxide compounds. Picric acid stored in containers with metal lids and allowed to dry will form metal picrates on the treads of the lid that can explode when the lid is twisted. Metallic sodium or lithium stored improperly can explode when exposed to air or water. Flammable vapors may be allowed to collect in a confined space, and when ignited, they will deflagrate, producing explosive results.

Figure 2.4 shows examples of improperly stored chemicals that pose an explosive hazard. The jar without a label, shown in Figure 2.4, contains dry picric acid. The operator placed the label inside the jar so he would know what the contents were.

Other causes for explosions are intentional on the part of the operator. According to DEA statistics, approximately 10% of clandestine labs are booby-trapped. These booby traps may or may not be directed at law enforcement.

Figure 2.4 Explosive chemicals.

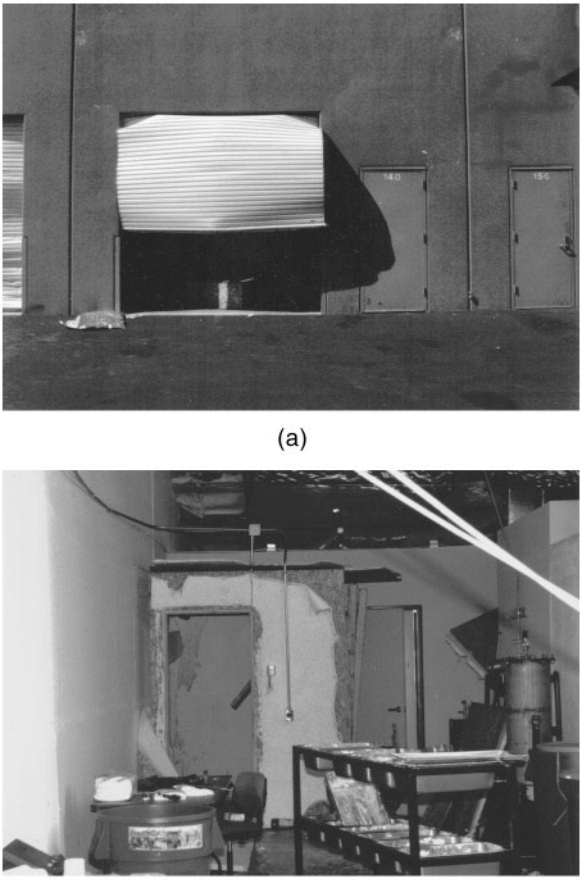
No matter whom the target, personnel processing clandestine lab scenes must be constantly aware of the potential existence of explosive devices.

The abatement of explosive hazards is accomplished by explosive ordinance disposal (EOD) experts and chemists trained in the clandestine manufacture of controlled substances. They should jointly process all clandestine lab sites for the presence of explosive devices and dangerous chemical mixtures prior to processing the site for physical evidence. The EOD expert and chemist should have complimentary knowledge of each other's expertise. This team should be able to observe, recognize, and neutralize potentially explosive situations before the rest of the processing team enters the location.

Shown in Figure 2.5 is an example of a vapor explosion that occurred in a gamma hydroxybutaric acid (GHB) lab. Shown in Figure 2.5(a) is a demonstration of the pressure effect of the explosion. The wall at the center of the explosion was blown approximately 3 ft off center. The resulting fire damage is shown in Figure 2.5(b). In this scenario, the operator was drying acetone from his finished product in a heated room (confined space). The acetone fumes reached their explosive limit. When the operator turned on the light in the room, the spark that occurred when the light switch was thrown ignited the vapors, causing the explosion.

2.2.2 Fire

Fire is second in the priority list of hazardous situations the clandestine lab investigator must consider. It has many of the same causes as explosive hazards. Booby traps, ignition of flammable atmospheres, incompatible chemical mixtures, and the operator can contribute to the cause of a fire. A significant difference between fire and explosive hazards is lack of the pressure wave experienced from explosions. However, the heat and resulting combustion damage can be similar.



(a)

(b)

Figure 2.5 Images of a GHB lab. (a) Vapor explosion effect on entrance door. (b) Fire damage on the drying room.

Flash fires and sustained fires are the two types of fire hazards. Flash fires result from the ignition of a flammable atmosphere. They are instantaneous, and usually self-extinguish for lack of fuel. If contained, a flash fire may result in an explosion or produce minor pressure-related effects. A sustained fire, on the other hand, has a continuous source of fuel to feed the fire. The resulting heat and continuous flame allow the fire to spread beyond the area of the original ignition.

Test results from the Phoenix, AZ, Fire Department indicated that exposure to a flash fire may be survivable. If the victim were wearing fire-resistant clothing, significant damage would be limited to the unprotected areas. If the victim was not wearing fire-resistant clothing, the severity of the burns to the protected areas of skin would be determined by the type of clothing he was wearing. The test dummy wearing fire-resistant clothing did not fare as well when exposed to a sustained fire situation, during the same series of tests. The clothing was consumed by fire when exposed to a sustained fire of flammable liquids commonly encountered in clandestine labs.

As with explosions, clandestine labs are commonly detected as a result of a fire. Figure 2.2 showed an example of the results of a fire caused when the lab operator attempted to evaporate a flammable liquid (methanol, in this case) on a gas stove. The fire could have been started just as easily if the flammable liquid had been on an electric stove. Any ignition source would have ignited the flammable vapors. Once the concentration in the room reaches the flammable or explosive limit, a spark from a light switch, a match struck for a cigarette, or a muzzle flash from a discharging weapon could ignite the vapors.

The images in Figure 2.6 show the result of a barricaded clandestine lab operator intentionally burning his lab, in an effort to avoid detection. The operator could just as easily have waited until the investigators were inside the location before he ignited the flammable and combustible substances within the operation, causing incredible injury.

2.2.3 Firearms

As described, the clandestine lab investigator has more things to worry about than just getting shot, but that still ranks up there with dangerous situations potentially encountered.

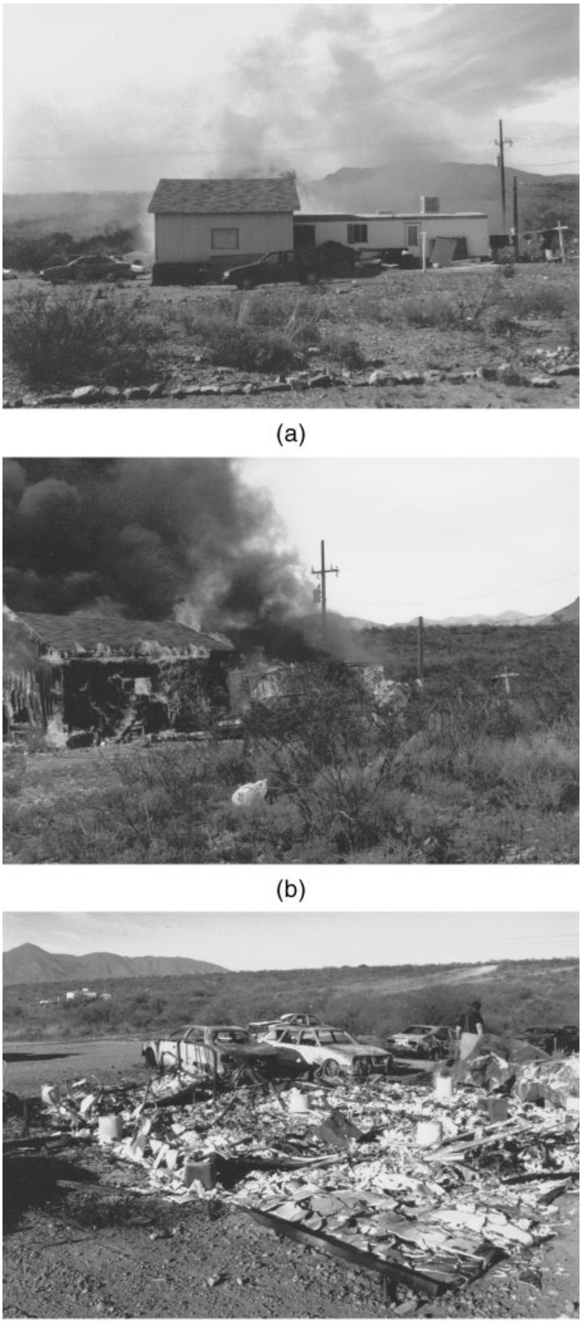
Individuals who abuse methamphetamine develop a paranoid psychosis. These individuals think their personal safety is continuously under attack. As a result, they can be unpredictable, violent, and, in general, are thus likely to be armed with some type of weapon (Figure 2.7). These people are irrational and subject to delusions and hallucinations.

The threat of firearms is not over once the suspects have been arrested and removed from the scene. It is common for armed secondary suspects to appear at the scene once the processing begins. This is a real hazard because many of the people processing the scene are not authorized to carry weapons. Even those who are may not have them in their possession.

2.2.4 Exposure

Exposure to chemical and physical hazards is lowest in the priority of hazards. This does not mean that it is any less dangerous to the clandestine lab investigator. These are silent hazards. Their effects may not become apparent until after the exposure.

Exposures to chemical and physical hazards may have acute and chronic effects. Acute effects are experienced by exposure to hazards of high concen-



(a)

(b)

(c)

Figure 2.6 Images (a), (b), and (c) show the progression of an intentionally set fire.

Figure 2.7 Guns on the wall of a clandestine lab.

trations, even for a short duration. The effects are felt immediately. The exposed generally will recover if the exposure does not exceed lethal limits. Chronic effects are generally experienced by numerous exposures to chemical hazards in low concentrations over long periods of time. The effects are cumulative, creating a toxic effect. These effects are usually different than the acute effects of the same hazard.

The difference between acute and chronic effects can be demonstrated in the example of a person who gets drunk and falls every night for an extended period of time. The acute effects of the alcohol may cause the person to lose control of his motor functions, causing him to fall and hit his head. Hitting his head may have one acute effect — that of a fierce headache — but the effect is short-lived. The person eventually sobers up, and the headache goes away.

A chronic effect of drinking alcohol is different. Long-term exposure to alcohol may lead to cirrhosis of the liver; brain damage can result from repeated blows to the head over an extended period of time. These effects will not go away by simply removing the alcohol from the person after the fact.

2.2.4.1 Chemical Hazards

All chemicals are hazardous. The degree of hazard depends upon the chemical's properties, the proximity to other chemicals, and the other chemicals' properties. While water is considered a benign substance, when exposed to sodium metal, the combination becomes explosive.

Many common household products contain hazardous chemicals that can be used to manufacture controlled substances and explosives. Acids can be found in swimming pool chemicals and battery acid. Bases or caustic compounds are commonly used in drain cleaners. Flammable solvents found in paint thinners and camping fuels are used for extractions. Poisonous chemicals used as automobile antifreeze are the precursor for an explosive. Just because these chemicals are found in the home does not make them any less hazardous.

The hazardous properties a chemical can possess are varied: explosive, flammable/combustible, corrosive, oxidizing, compressed gases, and poisonous. The chemical's reactivity potential should also be taken into account. A single chemical may possess multiple hazardous properties. For example, nitric acid (HNO_3) is a corrosive, oxidizing poison. Listed in Appendix E are the hazards associated with chemicals commonly encountered in clandestine labs.

Explosive chemicals undergo rapid chemical changes that release large amounts of heat and gas. This rapid chemical change may result from encountering a shock or friction, being exposed to a source of ignition, or being subjected to sudden changes in temperature, water, or air. Certain chemical combinations will explode, or a mixture will be created that will explode at the least provocation.

It is rare to encounter explosive chemicals, unless the operation's final product is an explosive. However, there are numerous combinations of chemicals that will explode under the proper conditions. That is why it is imperative that properly trained EOD personnel and chemists evaluate clandestine lab sites prior to evidence collection.

Most organic chemicals will sustain combustion if exposed to an ignition source or to enough heat. The chemicals with the greatest fire hazard are those that ignite easily at low temperatures. Flammable liquids are those that have a flash point below 100˚F. Combustible liquids are defined as those having a flash point above 100˚F. Combustible chemicals, such as phosphorus and magnesium, are solids that can easily sustain combustion (Figure 2.8).

Many of the solvents used for extraction or purification purposes are extremely flammable. Solvents like methanol and acetone have low flash

Figure 2.8 Combustible solid mixture.

points and readily ignite; these chemicals also have the potential to create a flammable or explosive atmosphere. Solvents like xylene or mineral spirits burn, but because of their higher flash points, are less likely to form a flammable or explosive atmosphere.

Corrosive chemicals are those that can cause visible damage to metals, plastics, or other materials (especially your skin). They are composed of acids and caustic or basic compounds. Acids are compounds that readily donate a proton (hydrogen) to a chemical reaction. They have a pH less than seven (with a pH of two or less considered corrosive). They can be subdivided into organic and mineral acids. Organic acids are compounds that contain carbon. Mineral acids do not contain carbon but may (oxidizing) or may not (non-oxidizing) contain oxygen.

Acids are soluble in water (Table 2.1). In concentrated solutions, they will attack minerals and tissues. They can coagulate protein. Contact with oxidizing acids or a reaction with organic material can result in fire. Metals reacting with sulfuric, nitric, or hydrochloric acids can create an explosive environment.

Acids are generally found in synthesis and conversion labs. They are used as reagent chemicals. The acid alters the chemistry of the compounds and provides the physical environment necessary for the reaction to take place. Acids are also used to convert freebase drugs into the water-soluble salt form that is sold to the end user.

Acids generally exist in a water solution of varying concentrations. Pure acids are rarely encountered. However, mineral acids, such as hydrochloric acid and hydriodic acid, produce fumes. These fumes can fill the atmosphere

Table 2.1 Acid Relative Strength

Acid Name	Formula	
Perchloric acid	$HClO_4$	Stronges t
Sulfuric acid	H_2SO_4	
Hydrochloric acid	HCl	
Nitric acid	HNO_3	
Phosphoric acid	H_3PO_4	
Hydrofluoric	HF	
Acetic acid	CH_3COOH	Weakest

in and around the lab area. As a rule of thumb, "hydro-" acids are corrosive and will produce fumes.

For identification purposes, if the label says acid in the chemical name, it should be considered corrosive. The strength and concentration may be unknown, but the compound will react like an acid. Therefore, treat all unknown acids as if they were extremely corrosive.

Caustics or bases are chemicals that readily accept a proton (hydrogen) in a chemical reaction. They have a pH greater than seven with any pH greater than 12 considered corrosive. They can be subdivided into inorganic peroxides and organic amines. Inorganic peroxides are characterized by the presence of a hydroxyl ion (OH^-) group. The organic amines contain a characteristic amine ($-NH_2$) group.

Caustics generate heat when reacting with water, acids, organic material, and some metals. They have a tendency to liquefy protein (i.e., tissue). Caustics are used to neutralize acids in the synthesis and conversion processes. They are used to adjust the pH of water solutions in the preparation of an extraction. In conversion labs, they are used to convert the salt form of a drug into the freebase form. In some instances, they can act as a precursor chemical and become part of the final product.

Caustics can be found in solid, liquid, and gas forms. They are found in pure forms more often than their acidic counterparts. However, they can be just as easily found in a water solution of varying concentrations. Words like caustic, hydroxide, and amine in the chemical name indicate a compound with caustic or basic properties.

Oxidizers are compounds that provide oxygen to a reaction. These compounds may cause a fire if they come in contact with combustible material, and they can react violently when exposed to water or in a fire. Oxidizers contribute oxygen to chemical reactions, which increases the fire and explosion hazard, because they provide a source of oxygen to sustain combustion in a normally oxygen-deficient atmosphere. An excess amount of available oxygen can also increase the reaction rate, making the combustion hotter and faster.

Oxidizers are used as reagent chemicals in the manufacture of drugs and explosives. More significantly, they are a major component of inorganic explosive mixtures. Oxidizers are generally found in solid forms. Some strong acids, such as nitric acid and sulfuric acid, act as oxidizers. Compounds with names ending in "-ate" (i.e., chlorate, nitrate, permanganate) are compounds with strong oxidizing potential.

As acids have bases as a conjugate, oxidizers have reducers. A reducer is a compound that can remove oxygen from or add hydrogen to a compound. Reducers are used as reagent chemicals in conversion labs. Strong reducing agents react rapidly and violently. They are found in solid and liquid forms, and their labels contain the word hydride or acetylide in the chemical name.

Compressed gases pose a dual hazard. Not only does the chemical inside the container have unique chemical hazards associated with it, but also, the container can pose a threat. The incompatibility of the contents with its container may cause the container to explode or discharge its contents unexpectedly. This often happens in situations in which the operator refilled a container with something other than what the container was designed for.

There is no accepted color code for compressed gas cylinders. The color of a compressed gas cylinder containing helium may vary depending upon the distributor. The only clue as to the contents of a legitimate gas cylinder is the connection on the top. For example, compressed gas cylinders to be used for compressed air have unique fittings, so a flammable gas cannot be accidentally connected to the line.

In the world of clandestine labs, it is a given that the outside label of a container may not reflect the contents. Operators routinely replace the contents of compressed gas containers with chemicals other than those the container was designed to hold. These replacement chemicals will often corrode the brass fittings used to regulate the release of the compressed gases. This creates a hazard for anyone handling the container. Even the minor act of opening the valve may cause it to break, releasing the pressurized contents in a single violent rush. When the contents are unknown and may be under high pressure, and there is generally no safe way to sample the contents in the field, the field investigator may consider not to even sample the contents of the compressed gas cylinders and to simply allow the chemical waste disposal company to dispose of them properly.

Another compressed gas hazard is the homemade hydrogenator (Figure 2.9). This apparatus is made of materials that were not designed to withstand the pressures or temperatures generated by the reaction. The minor act of touching the container may be enough to compromise the structural integrity of the container if it is under pressure, causing a BLEVE-like explosion that sprays the contents of the container over the surrounding area.

(a)

(b)

Figure 2.9 (a) Compressed gas container. (b) Clandestine HCl generators.

A poison is a substance that in low concentrations will cause death or injury upon ingestion. Poisons act on the internal systems of the body. Highly toxic poisons are usually gases or highly volatile liquids that have an oral LD50 of <5 mg/kg. Moderately toxic poisons may be solids or liquids, with an LD50 of >5 mg/kg.

Chemical reactivity is the final hazard. How chemicals interact with each other can potentially pose a significant threat to clandestine lab responders. How the responders handle the chemicals at the scene is just as important as what lab operators did with them prior to their arrival.

Chemicals are either compatible or incompatible. Compatible chemicals can remain in close or permanent contact without a reaction. Incompatible chemicals react with undesirable results.

Incompatible chemical reactions generate heat that can cause a fire or explosion, form a toxic gas or vapor, or form a substance that is more toxic than the original compounds. The reaction can disperse a toxic mist or dust, produce a violent chemical reaction, or any combination thereof.

Water-reactive and pyrophoric chemicals are examples of chemical groups that pose extreme reactivity problems. Water-reactive chemicals hydrolyze with water, forming flammable, corrosive, or toxic products. Pyrophoric chemicals react with the air and may spontaneously ignite.

Metallic sodium used in the Birch reduction is an example of a water-reactive chemical. It reacts violently with water, producing sodium hydroxide and hydrogen gas. Sodium hydroxide is extremely caustic. Hydrogen is extremely flammable and, under the right conditions, explosive. Under the right conditions, the water reacting with metallic sodium can produce an explosive hydrogen environment. If the hydrogen explodes, a caustic aerosol of sodium hydroxide would be dispersed. For this reason, metallic sodium is stored in mineral spirits of other nonaqueous solvent.

2.2.4.2 Physical Hazards

The final group of hazards associated with a clandestine lab is the physical hazards. These hazards include accidents, thermal exposure, electrical dangers, and the dangers of confined spaces.

An accident is an unforeseen happening resulting in damage to people or property. Accidents are not the result of an unsafe act. For example, if a person opens a door without realizing there is someone on the other side, and the door hits the other person, causing them to spill red wine on their shirt, the person opening the door did not know there was anyone on the other side and could not foresee the collision; therefore, it was an accident.

On the other hand, if an investigator opens an unknown chemical container without the appropriate training or personal protective equipment, spilling acid on his shirt, damaging it and burning his skin, this was not an accident. The actions and damages were avoidable. The investigator should not have been handling the container without the proper training, or minimally, without the proper personal protective equipment.

Processing the scene of a clandestine lab is the proverbial "accident waiting to happen." However, knowing the causes of accidents can help prevent and eliminate them. The major causes of accidents are lack of preparedness, inattention, carelessness, and fatigue.

There is no excuse for lack of preparedness. Investigators should have an idea of what manufacturing method the operator is utilizing prior to entry. With this knowledge, investigators should assemble the proper personnel and equipment to process the scene in a safe manner. The lab is not going anywhere; time is on the investigator's side. Therefore, the scene should not

Table 2.2 Hazardous Materials Handling Guidelines

Hazard Type	Abatement
Explosive chemicals	**Do not handle chemicals** unless trained or absolutely necessary. The handling of chemicals should be left to trained personnel. Trained personnel can recognize chemical names that have explosive potential. They can also recognize chemical combinations or other situations with explosive potential. Untrained personnel should seal the area of the clandestine lab and wait for trained personnel to effect the abatement procedures. **Separate incompatible chemicals.** Trained personnel should separate chemicals with known incompatibilities. This will reduce the potential for these chemicals to accidentally combine and create an explosive situation. **Remove heat** from reaction mixtures. This will slow or stop the reaction taking place. This will reduce the amount of potentially explosive and toxic fumes that are being produced. Allowing the reaction mixture to reduce to room temperature naturally eliminates the effect of drastic changes in temperature. **Ventilate** confined spaces. This will reduce the concentration of explosive fumes in the area to below the explosive limit.
Flammable/ combustible	**Do not handle chemicals** unless trained or absolutely necessary. **Separate incompatible chemicals.** **Remove heat** from reaction mixtures. **Ventilate** confined spaces. **Isolate from ignition source.** All fires need fuel, oxygen, and a source of ignition. Removing the source of ignition removes the capacity to burn. (The muzzle flash from a discharged weapon is sufficient to ignite a flammable atmosphere.)
Acids and caustics	**Do not handle chemicals** unless trained or absolutely necessary. **Identify the pH** and acid type of all unknown liquids. Knowing the basic characteristics of the liquids will provide insight into how they should be segregated. (See Table 2.3 for bottle cap identification guide.) **Seal all containers.** This reduces the likelihood of the mixing of liquids if the containers are spilled. Also, some mineral acids produce fumes that can contaminate the air or mix with uncovered solutions containing incompatible mixtures. **Separate acids and caustics.** Segregating liquids by pH will prevent violent reactions if a chemical spill occurs. **Separate acids by type.** All acids are not created equal. Oxidizing mineral acids react violently when they come in contact with nonoxidizing mineral acids and organic acids. Segregating acids by type will prevent violent reactions if a chemical spill occurs.

Table 2.2 Hazardous Materials Handling Guidelines (Continued)

Hazard Type	Abatement
Oxidizers and reducers	**Do not handle chemicals** unless trained or absolutely necessary. **Identify** known chemicals from container label. Unfortunately, there is no screening test for the rapid identification of oxidizers or reducers commonly used in the field by chemists investigating clandestine labs in the field. Unlabeled containers should be treated as unknowns, leaving the field identification to the chemical waste disposal company. **Seal all containers.** This reduces the likelihood of the mixing of incompatible chemicals if the containers are spilled. (*Cont.*)
Oxidizers and reducers (*Continued*)	**Separate oxidizers and reducers**. Segregating chemicals by class will prevent violent reactions if a chemical spill occurs. Segregate oxidizers from organic material and other combustible materials to prevent fire in case of a spill.
Compressed gas containers	**Do not handle containers** unless trained or absolutely necessary. **Do not handle containers unless absolutely necessary.** Safety outweighs the need to identify the contents of the container. **Do not open valves unless trained to do so.** **Close valves** of containers connected to reaction apparatuses. **Secure container** for chemical disposal company disposal.

Table 2.3 Acid Cap Color Code

Cap Color	Acid
Blue	Hydrochloric (HCl)
Yellow	Sulfuric (H_2SO_4)
Brown	Acetic (CH_3COOH)
Red	Nitric (HNO_3)
Clear/white	Phosphoric (H_3PO_4)
Black	Perchloric ($HClO_4$)
Black	Hydriodic (HI)

be entered or processed if the proper personnel and equipment are not present, unless exigent circumstances exist.

Inattention and carelessness go hand in hand. Many seasoned clandestine lab investigators routinely see the same manufacturing process and become lax in their handling of the situation. They begin to ignore common safety practices or fail to see obvious hazardous situations.

Fatigue can lead to such carelessness and inattention. Many clandestine labs are processed late at night, after a long protracted investigation or surveillance. Lack of sleep leads people to be not only tired but also frustrated. The lengthy procedure of safely processing a clandestine lab scene adds to the fatigue. Sleep deprivation also leads to many poor or hasty decisions, which in turn, can lead to undesirable consequences.

Thermal hazards are another type of physical hazard. In this context, they relate to the environmental temperature rather than to the heat of the reaction equipment in the lab, encompassing both extremes of hot and cold.

Heat stress occurs when the body is exposed to excess heat for an extended period of time. Such stress can affect the body's ability to regulate its temperature as well as other functions. Heat exhaustion can be debilitating but leaves no permanent effects. However, heat stroke can be fatal, and medical attention is required as soon as possible.

Figure 2.10 Group in Level B protection.

Heat effects can be minimized by acclimatizing the body to the temperature in the lab area prior to beginning work. It is not wise to go from an air-conditioned building or car to immediately working in an outdoor lab with an ambient temperature of 110°C. Allowing the body to get used to the temperature in the work area reduces shock to the body.

Hydrating your body with fluids containing electrolytes is a good preventative measure. Avoid drinks containing diuretics, such as caffeine (coffee, tea, soda). These cause the body to lose fluid faster than normal. These fluids could be used to cool the body, in the form of perspiration, if they are not eliminated through the urinary tract so quickly.

The personal protective equipment (PPE) used by investigators to process clandestine labs accentuates the problems related to heat (Figure 2.10). The characteristics of the equipment that protect the body from environmental hazards in the lab area work against the body's natural ability to cool. Such clothing does not "breathe" or allow the body's perspiration to evaporate, and thus cool itself naturally.

Two common signs of heat stress are the loss of rational thought and the slowing of bodily functions. Inattention and carelessness lead to accidents. The reaction times of people suffering from heat stress slow noticeably. And, those with heat stress are easily recognizable (by someone else) by changes in body language, speech patterns, and perceptions of time.

It is imperative that the buddy system be used when working in situations involving elevated ambient temperatures. The buddy needs to be constantly aware of the condition of his partner. As soon as he sees signs of heat stress in his partner, they should both leave the area for a period of rehydration and cooling off.

The effects of heat can be minimized. Establishing a work–rest pattern will help reduce heat effects. Consistent breaks to cool the body and replenish fluid levels are good preventative measures in this battle. It is recommended that cotton underclothing be worn to wick the perspiration away from the skin. Also, during rest breaks, the PPE should be opened, allowing the body to breathe and cool.

Cold is the other side of the thermal hazard coin. As with heat, excess cold tends to distract a person's attention from the task at hand and lead to accidents. Cold stress occurs in cold, wet, and windy environments, with frostbite the most common injury. Hypothermia is the extreme case, which can result in unconsciousness or death if not addressed immediately.

To reduce the effects of cold, clandestine lab responders should dress appropriately for the weather conditions. Layers of warm clothing are a wise choice, because layers can be added or removed as needed. Avoiding windy and wet conditions, when possible, also reduces the effects of the cold. Staying physically active generates heat and keeps the body warm. However, excessive sweating should be avoided. When the activity stops, the excess perspiration evaporates, increasing the effects of the cold.

As with hot conditions, an established work–rest pattern reduces the effects of cold. Frequent rest breaks remove personnel from the cold environment and allow them to warm up. This also keeps them from generating an excess of perspiration that will lead to excessive cooling and gives them the ability to adjust the number of warming layers to the current environmental conditions.

Electricity is taken for granted in modern America. We plug something into an outlet, turn the switch, and it works. Electricity in the world of the clandestine lab operator is not that simple. The wiring of some of the equipment is makeshift, or the original design was unsafely altered (Figure 2.11). Electrical boxes that were originally wired to the local building code were altered to clandestinely divert current. A single outlet designed to draw 15 amps of current may have multiple extension cords attached to it, leading to equipment drawing 50 amps of current. Bare wires present a constant threat of electric shock or source of spark that can ignite a flammable atmosphere.

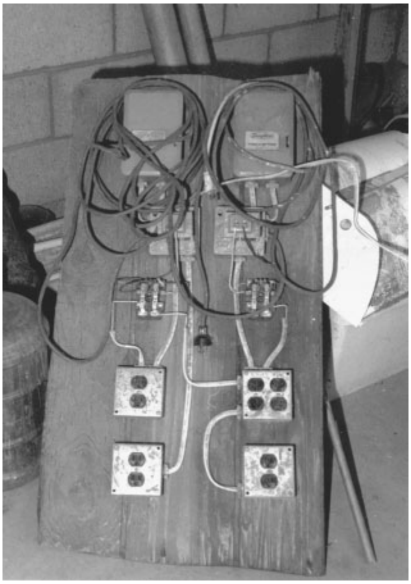


Figure 2.11 Clandestine lab wiring panel and wires.

To eliminate all electrical hazards prior to processing, turning off the electrical power to the site is simple but effective. However, prior to turning off the power, the assessment team needs to determine if there is some portion of the operation that would be adversely affected if the power were off. For example, it would not be wise to turn off the power if there was a cooling operation being powered by electricity. If the power were turned off, the cooling operation would stop, and potentially, the reaction could overheat, leading to an explosion or the like.

Confined spaces have limited entry and exit openings, unfavorable ventilation, and are not intended for continuous occupancy. Almost by definition, a clandestine lab is a confined space. To avoid detection, they are squirreled away in bathrooms, attics, closets, a workroom off a garage, or in small outbuildings. Ventilation is usually minimal or nonexistent. Even though it does not appear to be suitable for continuous occupation, some operators will spend hours or days at a time in the lab, while the manufacturing process is under way. It is common for the lab area to contain so much stuff that there is hardly any room to move. This increases slip, trip, and fall hazards.

When processing clandestine labs in confined spaces, the number of people in the area at one time should be kept to a minimum. Increasing the number of people in the area increases the potential for accidents and exposure to chemical hazards.

Personnel must be constantly aware of the limitations placed on them by their PPE. A person who normally has the agility of a rabbit is converted to a turtle when the PPE is worn. The PPE also reduces the person's dexterity and limits mobility. The use of a self-contained breathing apparatus (SCBA) increases the operating size of a person by placing an air tank (adding 12 additional inches) behind them. Air-purifying respirators (APRs) and SCBAs narrow peripheral vision and reduce the ability to verbally communicate. Unfortunately, these are necessary evils when working in an environment containing numerous unknown and potentially lethal hazards.

2.3 Hazard Abatement

A clandestine lab has a mixture of physical hazards and chemicals with varying hazard levels and chemical compatibilities. The hazards associated with some of the reaction by-products may be greater than those of any known chemicals. The following generic rules can be used when dealing with the hazards at a clandestine lab site:

Do not process a clandestine lab without the proper training. Training provides the knowledge with which to recognize the potential hazards involved in any scenario. It also provides the knowledge of how to abate the hazards when encountered. Processing a clandestine lab without the proper training can lead to serious injury of the individual and the surrounding personnel.

Do not process unless all personnel are present. The processing of a clandestine lab scene involves a team of people and incorporates many specialized tasks. This includes support personnel, such as the fire department and emergency medical services. Safety may be compromised if the processing commences without an individual with a specific expertise. The operation is not going anywhere. Unless there are exigent circumstances, safety concerns overrule expedience.

Do not process without the appropriate safety equipment. The chemical and physical hazards involved in clandestine labs pose a variety of health hazards to the personnel processing the operation. Chemicals can enter the body many ways, and specialized equipment is required to minimize such hazards. The use of the proper safety equipment will provide the responders with the protection necessary to minimize such effects of exposure. The operation should not be processed unless the proper safety equipment is present. As with the need for the proper personnel, the operation is not going anywhere. Therefore, for safety reasons, the operation should not be processed until the proper PPE is present.

Ventilate confined spaces. This reduces the concentration of explosive, flammable, or toxic fumes in the area to below the hazardous limit. Proper ventilation also provides an atmosphere in which the need for respiratory protection is reduced or eliminated. This, in turn, reduces the potential for accidents that result from the use of bulky PPE.

Isolate from the ignition source. All fires need fuel, oxygen, and a source of ignition. Removing the source of ignition removes the capacity to burn. Turning on a light or lighting a cigarette at an inappropriate time can serve as ignition sources. Enforcement personnel should be reminded that the muzzle flash from a discharged weapon is sufficient to ignite a flammable atmosphere.

Remove heat from reaction mixtures. This will slow or stop the reaction taking place, reducing the amount of potentially explosive, flammable, and toxic fumes being produced. Allowing the temperature of the reaction mixture to reduce to room temperature naturally eliminates the effect of drastic changes in temperature. This task should only be done by a trained chemist who is able to identify the type of reaction being utilized.

Identify known chemicals from container labels. Untrained personnel who encounter chemicals should relay any label information to trained personnel. Label information may provide trained personnel insight as to what chemicals are potentially at the location. The information could help establish potential manufacturing methods and additional chemicals that may be at the location. It is important to remember that not all labels accurately indicate the contents of their containers; however, it is a start in the flow of information.

Do not handle chemicals unless trained. The handling of chemicals should be left to trained personnel. They can recognize chemical names that have hazardous potential. They can also recognize chemical combinations or other situations with hazardous potential. Untrained personnel should seal the area of the clandestine lab and wait for trained personnel to begin the abatement procedures.

Do not handle containers unless absolutely necessary. Safety outweighs the need to identify the contents of the container. When practical, law enforcement personnel should take evidentiary samples of containers where they are located and allow hazardous waste disposal specialists to move such containers at the time of disposal. Every time a container is handled, there is potential for an accident. Therefore, reducing the number of times hazardous materials are handled reduces the potential for an accident.

Only trained personnel should do field testing. Field testing involves conducting chemical reactions with unknown chemicals. Trained chemists and hazardous materials responders have the training and experience to determine what field tests are appropriate for a given unknown. Applying an inappropriate field test may lead to an incompatible chemical reaction that creates a more hazardous situation than existed prior to the field test.

Powdered sodium cyanide can easily be mistaken for a controlled substance. Administering controlled substance field tests that are commonly available to law enforcement officers can prove to be a lethal decision. Many of these tests contain an acid that, when reacted with sodium cyanide, produces hydrogen cyanide. Exposure to hydrogen cyanide is extremely hazardous, if not deadly.

Beyond establishing the pH of a liquid and whether it is organic or aqueous, there are few field tests that will establish probative information for the clandestine lab investigator. Evidentiary testing should be restricted to laboratory conditions. However, field tests to establish potentially hazardous characteristics of chemicals may be done by trained personnel for the purpose of separating and segregating chemicals before the chemical disposal company arrives.

Separate and segregate incompatible chemicals. Trained personnel should separate and segregate chemicals with known incompatibilities. This reduces the potential for these chemicals to accidentally combine and create a more hazardous situation. Trained personnel use known label information and their training and experience to approximate the contents of unlabeled containers and separate them accordingly. They then segregate chemicals by placing those with similar properties in distinct groups. Placing a physical barrier between chemicals with known incompatibilities reduces the likelihood of chemical interaction if a spill should occur. Acids and caustics are differentiated by pH and are segregated. Acids are also separated by type, because all acids are not created equal. Oxidizers are separated from organic material and reducers. Listed in Appendix E are groups of incompatible chemicals that can be used to assist in the segregation process.

Seal containers. Sealing containers reduces the likelihood of incompatible chemicals combining. Some mineral acids produce fumes that can contaminate the air or mix with uncovered solutions containing incompatible mixtures. However, hot reaction vessels should not be sealed until they reach room temperature. If they are sealed prior to cooling, the act of cooling will create a vacuum seal, making the removal of the lid difficult and hazardous.

Do not handle compressed gas containers unless absolutely necessary. The contents of compressed gas containers are unknown. There is no way to safely determine such contents or the structural integrity of the container. The valves of compressed gas containers should not be manipulated unless absolutely necessary, because they could break off from corrosion. They may release an unknown toxic gas into the atmosphere. Close valves of containers only if they are connected to reaction apparatus. Compressed gas containers should be secured and left for the chemical disposal company to handle.

There are a number of subsequent steps clandestine lab responders can take to minimize the effects of physical hazards:

Be in good physical shape. The human body has the remarkable ability to compensate for a wide variety of physical stresses that are placed upon it. Proper exercise and diet maximize the body's defenses against physical stress. It is recommended that clandestine lab responders exercise regularly and eat properly. It is also wise to have yearly physicals to help determine any medical conditions that may have an adverse effect upon the body when placed under the physical stress involved in clandestine lab response.

Be rested. Being well rested also reduces the effects of mental and physical fatigue that lead to inattention and carelessness. This may not be realistic under the circumstances involved in the seizure of a clandestine lab. However, every effort should be made to minimize the effects of fatigue. Frequent rest breaks are necessary to reduce the effects of heat and cold stress on the body. These breaks also provide a mental break to reduce the effects of mental fatigue.

Drink liquids. Proper hydration is necessary to allow the body to regulate its internal temperature. It is wise for a responder to hydrate his body with liquids high in electrolytes prior to arrival at a clandestine lab scene. Replacing fluids during regularly scheduled rest breaks is essential to maintain the fluid levels the body requires for optimum efficiency. This suggestion cannot be emphasized too often, especially in hot climates. Avoid caffeinated drinks because of their diuretic effects.

Minimize number of people exposed. Keeping the number of people to a minimum in the lab area at any given time helps to reduce the potential for accident. A clandestine lab has a limited amount of space in which to operate. Increasing the number of people in this small space coupled with the reduction in agility and dexterity brought on by the limitations inflicted by the PPEs increases the potential for an accident. Also, by limiting the number of people in the lab area, it is possible to limit the number of people exposed to the maximum amount of hazard. Bottom line: if you do not need to be in the lab area, do not go in.

Utilize a buddy system. The buddy system is an essential safety consideration. The effects of heat and cold stress and chemical exposure may not be apparent to the person exposed. Exposure may lead to clouded thinking, irrational responses, distortion of time, and compromised motor skills. A buddy is needed to monitor the physical well-being of his partner and determine if he is functioning normally. At the first sign of abnormal behavior, it is the responsibility of the buddy to decide to leave the area as a pair for rehabilitation. Also, if one of the partners is involved in an accident, the buddy is there to render aid.

2.4 Summary

There are numerous hazards associated with clandestine laboratories, all of which can be minimized with proper training and education. The key is for the responders to use knowledge, skills, and abilities provided in the training to recognize potential hazards and to take the preventative measures necessary to minimize the potential for undesirable effects.

All clandestine labs have three things in common. The operators have little training, they are generally makeshift operations, and no two operations are exactly alike. Keeping these three principles in mind allows the scene investigator to have a greater appreciation for the number of things that can potentially go wrong while processing the scene of the operation.

While on location, all personnel should continually be evaluating the scene for potential hazards. What can explode? Is there anything or a situation that could cause a fire? Are firearms available to undesirable people? Are there unseen things or situations that could present a hazardous situation, either now or in the future? Finally, what can be done to reduce or eliminate these hazardous situations?

There are numerous things that can go and do go wrong at clandestine lab scenes. The post-scene debriefings of incidents in which something went wrong revealed a common thread. The undesirable effect was a direct result of someone not following the established safety procedures. The lesson being, using the established safety procedures and equipment reduces the effects of the hazards involved with clandestine labs to the degree that will allow anyone processing the scene to leave as healthy as they arrived.