Indiana University Northwest
Environmental Health & Safety

Title: Laboratory Chemical Safety Plan

Applies to:
Indiana University Northwest

Latest Review/Revision:
March 31, 2005

Purpose

The Indiana University Northwest Laboratory Chemical Safety Plan (LCSP) was developed to:

- Inform IUN's laboratory employees of the hazards associated with chemicals in the workplace;
- Ensure safe use, handling, and disposal of hazardous chemicals in the laboratory environment; and
- Comply with the Occupational Safety and Health Administration's (OSHA) Laboratory Standard (29CFR1910.1450) and Indiana University's health and safety policy.

Regulatory Reference

29CFR1910.1450, OSHA's Occupational Exposure to Hazardous Chemicals in Laboratories (Laboratory Standard)

Emergency Information

Major Emergencies

In the event of an accident in the laboratory which involves an uncontrolled fire, explosion, or a large release of a hazardous chemical:

- Evacuate the building by activating the nearest fire alarm.
- Call **9-911 or 6501** and give the details of the accident including the location, type of hazardous material involved, and whether there are any personal injuries.

If the accident involves serious personal injury or chemical contamination, follow the above steps as appropriate and at the same time:

- Move the victim from the immediate area of the fire, explosion, or spill (if this can be done without further injury to the victim or you).
- Remove any contaminated clothing from the victim and flush all areas of the body contacted by chemicals with copious amounts of water for 15 minutes.
- Administer first aid as appropriate.

Minor Emergencies

In the event of an accident in the laboratory which involves a minor chemical release or spill (with no personal injuries):

- Follow the *Chemical Spill Response Procedures* - SOP 3.13.
- Call DEHS at **981-4230** for advice or assistance. After hours, call the IU Police Department at **980-6501**.

Emergency and Laboratory Safety Contacts

Emergency Phone Numbers	
Police, Fire Department, Ambulance	9911 or 6501 from any campus phone

Department of Environmental Health & Safety (DEHS)				
Name	**Title**	**E-Mail**	**Office**	**Phone**
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APPENDICES

1.0 INTRODUCTION

The *Laboratory Chemical Safety Plan* is a written program for ensuring the safe use of chemicals in laboratories at Indiana University Northwest. It describes policies, procedures, and control measures that must be understood and observed by all individuals involved in the laboratory use of chemicals.

1.1 Regulatory Basis

The development and implementation of a *Laboratory Chemical Safety Plan* (formerly known as the Chemical Hygiene and Safety Plan) is a central requirement of the federal rule entitled "Occupational Exposure to Hazardous Chemicals in Laboratories," more commonly referenced as the Occupational Safety and Health Administration's (OSHA) "Lab Standard." The Lab Standard was published as a "final rule" in the January 31, 1990 issue of the *Federal Register* and was required to be fully implemented by January 31, 1991. Of particular importance in understanding the applicability of this standard are the definitions it contains for "hazardous chemical," "laboratory," "laboratory scale," and "laboratory use of hazardous chemicals." From a review of these definitions, it is clear that the Lab Standard applies to essentially all chemical use in laboratories at Indiana University Northwest. For laboratories that are not covered by the Lab Standard (i.e., those that do not meet the definitions of the terms referenced above) or for non-laboratory uses of chemicals, safety issues are typically governed by other state and federal regulations such as OSHA's "Hazard Communication Standard." Assistance in determining which regulatory requirements apply to specific work environments is provided by the Department of Environmental Health and Safety.

1.2 Responsibility for Implementation

It is the policy of Indiana University to support the use of chemicals and other potentially hazardous materials for the purposes of research and teaching. At the same time, the University is committed to ensuring the safety of its students, employees, and visitors and to complying with all regulatory requirements that impact its facilities and operations. Toward this end, Indiana University has designated the following specific responsibilities for developing and implementing the *Laboratory Chemical Safety Plan.*

1.2.1 Laboratory Chemical Safety Committee

The University Laboratory Chemical Safety Committee (LCSC) is a group of faculty and staff members appointed by the Vice President of Research and the University Graduate School (RUGS) to establish, and guide the interpretation of, University policy for the safe use of chemicals in the laboratory environment. The LCSC, in cooperation with the Department of Environmental Health and Safety, develops the *Laboratory Chemical Safety Plan* and advises on its implementation.

1.2.2 Department of Environmental Health and Safety

The Department of Environmental Health and Safety (DEHS) is an administrative unit that has responsibility for the development and implementation of all university programs concerning safety and environmental quality. This role is accomplished by DEHS staff through the provision of a range of safety services including project reviews and consultations, formal training sessions, and periodic laboratory audits.

1.2.3 Academic Departments

The chair of each academic department (or head of each academic unit) is responsible for the safety of all individuals working in the department's laboratories. The chair fulfills this responsibility, in part, by ensuring that all departmental faculty members understand and take seriously their roles in implementing the *Laboratory Chemical Safety Plan.* To facilitate this process, each chair must appoint a departmental Laboratory Chemical Safety Officer (LCSO) who will coordinate and monitor the implementation of the LCSP within the department.

1.2.4 Faculty Members

Each faculty member (or principal investigator) is responsible for the safety of individuals working within his or her laboratories. Toward this end, faculty members must work with the respective departmental Laboratory Chemical Safety Officer to adapt and implement the provisions of the *Laboratory Chemical Safety Plan*. This includes ensuring that each individual working within the lab is provided with appropriate training on safety and regulatory requirements; that required safety equipment and personal protective devices are provided, maintained, and used; that specific standard operating procedures incorporating safety considerations are developed and observed; and that prompt action is taken to correct any unsafe acts or conditions which have been observed or reported.

1.2.5 Laboratory Workers

Each laboratory worker is responsible for implementing the requirements of the *Laboratory Chemical Safety Plan*. This includes participating in required training, utilizing appropriate safety equipment and personal protection devices and apparel, observing standard operating procedures and informing the supervisor (i.e., principal investigator or lab supervisor) of any accidents or unsafe conditions.

1.3 Organization and Content

The *Laboratory Chemical Safety Plan* (LCSP) is intended to serve as an operational guide for the incorporation of prudent safety practices into the day-to-day use of chemicals within laboratories. It was developed and issued in a general form that should be adapted and expanded by particular departments and research groups to meet their specific needs. The LCSP was organized in a format that should enable desired information to be quickly found and readily updated. The content of the LCSP was established directly from the requirements of the Lab Standard and includes the following general types of information:

- Designation of the personnel responsible for the implementation of the *Laboratory Chemical Safety Plan*.
- Criteria that the employer will use to implement control measures to reduce individual exposures to chemicals. These measures include administrative controls, engineering controls, procedural controls, and the use of personal protective equipment.
- Standard operating procedures (SOPs) relevant to safety and health considerations that are to be observed for the use of hazardous chemicals in the laboratory. A number of generic SOPs have been included in the LCSP. However, each laboratory group should develop and add specific SOPs that are appropriate for their particular uses of chemicals.
- Provisions for personnel training.
- Provisions for medical consultations and examinations.
- Circumstances under which a laboratory procedure shall require prior approval before implementation.
- Provisions for additional personnel protection for work with carcinogens, reproductive toxins, and chemicals with high acute toxicity.

- A requirement that fume hoods and other protective equipment function properly and that measures will be taken to ensure this.

2.0 CONTROL MEASURES

The OSHA Lab Standard requires that laboratory personnel implement appropriate control measures to ensure that chemical exposures are maintained below regulatory limits and as low as reasonably achievable. In general, control measures can be categorized as administrative controls, engineering controls, procedural controls (i.e., standard operating procedures), or personal protection.

2.1 Administrative Controls

Administrative controls consist of various policies and requirements that are established at an administrative level (e.g., by the principal investigator, laboratory supervisor, department chair, department safety committee, University Laboratory Chemical Safety Committee, or Department of Environmental Health and Safety) to promote safety in the laboratory. They may include:

- Ensuring that all laboratory personnel have been provided with adequate training to enable them to conduct their duties safely (see Section 4.0, *Information and Training*).
- Requiring prior approval and additional control measures for certain particularly hazardous operations or activities.
- Restricting access to areas in which particularly hazardous chemicals are used.
- Posting appropriate signs to identify specific hazards within an area.
- Requiring that various standard practices for chemical safety and good housekeeping be observed at all times in the laboratory.

2.1.1 Prior Approval of Hazardous Operations

The OSHA Lab Standard requires that activities that involve certain particularly hazardous chemicals be reviewed and approved in advance by an appropriate individual or group. Depending upon the specific department, this approving entity could be a department safety committee, the Laboratory Chemical Safety Officer, or the department chair. At the time of approval, any additional required control measures for the project should be specified. Examples of the types of operations that should receive prior approval are those involving the use of select carcinogens, reproductive toxins, acutely toxic chemicals, highly reactive or shock sensitive chemicals, or highly corrosive or oxidizing chemicals (see Appendix B). In addition, any operation that produces unknown but potentially hazardous results should receive prior approval.

2.1.2 Laboratory Entrance Signs

The entrance to each laboratory in which chemicals are used or stored shall be posted with the names and phone numbers of the principal investigator (or lab supervisor) and any other designated personnel who can be contacted in the event of an emergency. In addition, laboratory entrance postings should indicate the presence of certain specific hazards.

2.2 Engineering Controls

Engineering controls consist of various measures for reducing a hazard at its source or for separating personnel from the hazard. In the laboratory, examples of engineering controls include the substitution of less hazardous chemicals in an operation, isolating a particular chemical operation, enclosing a potentially explosive reaction, or utilizing local exhaust such as a fume hood for an operation which produces airborne chemicals (see Section 6.1, *Chemical Fume Hoods*). Because engineering controls function to reduce or eliminate a hazard at its source *before* it is created, they should be fully considered and utilized whenever possible as the *first*

step in chemical hazard control within the laboratory.

2.3 Procedural Controls

Procedural controls (or work practice controls) are typically in the form of standard operating procedures (SOPs) that define the *manner* in which certain types of chemicals are to be handled, or the manner in which specific operations involving chemicals are to be conducted, in order to minimize hazards. Section 3.0 of this Plan contains a number of SOPs that are generally applicable to all laboratories. It is the responsibility of personnel in each laboratory, however, to develop (and incorporate into the LCSP) specific SOPs that reflect the operations and experimental protocols performed in their laboratory.

2.4 Personal Protective Equipment

For many laboratory operations, the risk of chemical exposure cannot be totally eliminated through the use of engineering and procedural control measures. For this reason, it is necessary to supplement such measures with the use of personal protective equipment and apparel (PPE). Because PPE functions as a barrier between the laboratory worker and the chemical hazard, rather than by actually reducing or eliminating the hazard, its use should always be in addition to (and never as a substitute for) appropriate engineering and procedural controls. It is the responsibility of the principal investigator (or supervisor) of the laboratory to ensure that appropriate personal protective equipment is provided to, and used by, all laboratory personnel. Such equipment should be adequate to ensure personnel are protected from chemical exposure to the eyes, skin, and respiratory tract.

2.4.1 Eye Protection

Appropriate PPE for the eyes is *required* whenever there is a reasonable probability that the eyes could be exposed to chemicals. Vented safety goggles are the preferred eye protection to be worn when chemicals are handled in the laboratory. These should be worn *over* prescription glasses (contact lenses should not be worn when handling chemicals). All protective equipment for the eyes must bear the stamp Z87, which indicates that it meets the performance guidelines established by the American National Standards Institute in ANSI Z87.1 "Practice for Occupational and Educational Eye and Face Protection."

2.4.2 Face Protection

A face shield is *required* whenever there is a potential for severe chemical exposure from splashes, fumes, or explosions. Because a face shield alone does not adequately protect the eyes, it must be worn over safety goggles. In general, any operation that requires a face shield should be conducted inside a hood with the sash down as an additional barrier.

2.4.3 Hand Protection

Because the hands are typically the part of the body in closest contact with chemicals in the laboratory, they are particularly vulnerable to chemical exposures. For this reason it is essential that laboratory personnel select appropriate protective gloves and wear them whenever handling chemicals. Because different glove materials resist different chemicals, no one glove is suited for all chemical exposures. Glove selection guides are available from most manufacturers and should be consulted before choosing a glove.

2.4.4 Foot Protection

Safety shoes or other specialized foot protection are generally not required for most laboratory operations. However, footwear that completely covers the skin of the feet must be worn

whenever chemicals are being used (sandals and open-toed shoes are prohibited in the laboratory).

2.4.5 Body Protection

By virtue of its large surface area, the skin is at considerable risk of exposure to chemicals in the laboratory. To lessen this risk, it is essential that laboratory personnel wear clothing that, to the extent possible, covers all skin surfaces (shorts and skirts are inappropriate attire for the laboratory). In addition, a fully buttoned lab coat should be worn during chemical manipulations. Clothing and lab coats should be regarded, not as means of preventing exposure, but as means of lessening or delaying exposure. The effectiveness of clothing as a protective barrier for the skin depends upon its prompt removal in the event that it becomes contaminated.

2.4.6 Respiratory Protection

The implementation of appropriate engineering and procedural controls should always be the preferred strategy for ensuring that any airborne levels of chemicals within the laboratory are well below regulatory limits. However, in rare circumstances where such control measures are not sufficient, laboratory personnel may need to utilize respirators for a particular operation. In such instances, personnel must participate fully in the University's *Respiratory Protection Program* that requires a medical exam, respirator fit-testing, and training prior to respirator use. Contact the Department of Environmental Health and Safety for more information.

3.0 STANDARD OPERATING PROCEDURES

SOP 3.1 General Laboratory Safety Procedures

DO

- Know the potential hazards of the materials used in the laboratory. Review the Material Safety Data Sheet (MSDS) and container label prior to using a chemical.
- Know the location of safety equipment such as emergency showers, eyewashes, fire extinguishers, fire alarms, spill kits, first aid kits, and telephones.
- Review emergency procedures to ensure that necessary supplies and equipment for spill response and other accidents are available.
- Practice good housekeeping to minimize unsafe work conditions such as obstructed exits and safety equipment, cluttered benches and hoods, and accumulated chemical waste.
- Wear personal protective apparel when working with chemicals. This includes eye protection, lab coat, gloves, and appropriate foot protection (no sandals). Gloves should be made of a material known to be resistant to permeation by the chemical in use.
- Wash skin promptly if contacted by any chemical, regardless of corrosivity or toxicity.
- Label all new chemical containers with the "date received" and "date opened."
- Label and store chemicals properly. All chemical containers should be labeled to identify the container contents (no abbreviations or formulas) and hazard information. Chemicals should be stored by hazard groups and chemical compatibilities.
- Use break-resistant bottle carriers when transporting chemicals in glass containers that are greater than 500 milliliters.
- Use fume hoods when processes or experiments may result in the release of toxic or flammable vapors, fumes, or dusts.

DON'T

- Eat, drink, chew gum, or apply cosmetics in areas where chemicals are used and stored.
- Store food in laboratory refrigerators, ice chests, cold rooms, or ovens.
- Drink water from laboratory water sources.
- Use laboratory glassware to prepare or consume food.
- Smell or taste chemicals.
- Pipet by mouth.
- Work alone in the laboratory without prior approval from the lab supervisor.
- Leave potentially hazardous experiments or operations unattended without prior approval from the lab supervisor. In such instances, the lights in the laboratory should be left on and emergency phone numbers posted at the laboratory entrance.

FOR CHEMICAL SAFETY ASSISTANCE CALL THE DEPARTMENT OF ENVIRONMENTAL HEALTH & SAFETY AT 981-4230.

SOP 3.2 Procedures for Proper Labeling and Safe Storage of Chemicals

Proper chemical labeling and storage is essential for a safe laboratory work environment. Inappropriate storage of incompatible or unknown chemicals can lead to spontaneous fire and explosions with the associated release of toxic gases. To minimize these hazards, chemicals in the laboratory must be segregated properly. The storage procedures listed below are not intended to be all-inclusive but should serve instead, to supplement more specific procedures and recommendations obtained from container labels, Material Safety Data Sheets (MSDSs), and

other chemical reference material. For more information about chemical storage contact the Department of Environmental Health and Safety (981-4230).

Labeling

- Manufacturer chemical labels should never be removed or defaced until the chemical is completely used.
- All chemical and waste containers should be clearly labeled with the full chemical name(s) (no abbreviations or formulas) and appropriate hazard warning information. Small containers that are difficult to label such as 1-10 ml vials and test tubes can be labeled as a group and stored together. Unattended beakers, flasks, and other laboratory equipment containing chemicals used during an experiment should be labeled with the full chemical name(s).
- All chemicals should be labeled with the "date received" and "date opened."
- All hazardous waste containers must be labeled with the words "hazardous waste."
- All hazardous waste containers must be marked with an accumulation date. The accumulation date represents the date that the container becomes full (waste containers should NOT be filled to more than 90% of their capacity). All full waste containers should be disposed of promptly (Call DEHS at 981-4230).
- All chemical storage areas such as cabinets, shelves and refrigerators should be labeled to identify the hazardous nature of the chemicals stored within the area (e.g., flammables, corrosives, oxidizers, water reactives, toxics, carcinogens, and reproductive toxins). All signs should be legible and conspicuously placed.
- MSDSs that are received with incoming shipments of hazardous chemicals shall be maintained and readily accessible to laboratory employees.

Storage

Hazard Groups	
Flammable/Combustible Liquid	Unstable (Shock-sensitive, Explosive)
Flammable Solids	Carcinogens, Reproductive Toxins
Inorganic Acids	Toxic, Poisonous
Organic Acids	Non-Toxic
Caustics (Bases)	Toxic Gases
Oxidizers	Flammable Gases
Perchloric Acid	Oxidizing and Inert Gases
Water Reactives	Corrosive Gases
Air Reactives	

- A definite storage place should be provided for each chemical and the chemical should be returned to that location after each use.
- Chemical containers should be in good condition before they are stored. Containers should be managed to prevent leaks.

- Chemicals (including waste) should be separated and stored according to their hazard group and specific chemical incompatibilities. Chemicals within the same hazard group can be incompatible and therefore it is important to review the chemical label and MSDS to determine the specific storage requirements and possible incompatibilities. Appendix B contains a partial list of incompatible chemicals.
- Special attention should be given to the storage of chemicals that can be classified into two or more hazard groups. For example, acetic acid and acetic anhydride are both corrosive and flammable. In addition, perchloric acid is both corrosive and a strong oxidizer. Refer to the MSDS for proper storage procedures.
- Chemicals should be separated by distance. Physical barriers such as storage cabinets and secondary containers should be used to prohibit contact of incompatible chemicals in the event that they are accidentally released or spilled.
- Secondary containers are highly recommended for the storage of liquid chemicals. Secondary container should be made of a material that is compatible with the chemical(s) it will hold and should be large enough to contain the contents of the largest container.
- Liquid chemicals should not be stored above dry chemicals unless they are stored in secondary containers.
- Storage of chemicals within hoods and on bench tops should be avoided.
- Stored chemicals should not be exposed to heat or direct sunlight.
- Storage shelves and cabinets should be secure to prevent tipping. Shelving should contain a front-edge lip or doors to prevent containers from falling.
- Flammable and corrosive storage cabinets should be used when possible.
- Flammable liquids in quantities exceeding a total of 10 gallons in each laboratory must be stored in an approved flammable storage cabinet.
- Only explosion-proof or laboratory-safe refrigerators may be used to store flammable liquids.
- Liquid chemicals should be stored below eye level to avoid accidental spills.
- Chemicals should not be stored in areas where they can be accidentally broken and spilled such as on the floor or on the edge of a bench top.
- Chemicals should not be stored in areas where they obstruct aisles, exits, and emergency equipment.

SOP 3.3 Chemical Fume Hoods—Procedures for Proper and Safe Use

Chemical fume hoods are one of the most important items of safety equipment present within the laboratory. Chemical fume hoods serve to control the accumulation of toxic, flammable, and offensive vapors by preventing their escape into the laboratory atmosphere. In addition, fume hoods provide physical isolation and containment of chemicals and their reactions and thus serve as a protective barrier (with the sash closed) between laboratory personnel and the chemical or chemical process within the hood.

- A chemical fume hood should be used for any chemical procedures which have the potential of creating:
    - Airborne chemical concentrations that might approach Permissible Exposure Limits (PELs) for an Occupational Safety and Health Administration (OSHA) regulated substance. These substances include carcinogens, mutagens, teratogens, and other toxics (see Appendix A and B).
    - Flammable/combustible vapors approaching one tenth the lower explosion limit (LEL). The LEL is the minimum concentration (percent by volume) of the fuel (vapor) in air at which a flame is propagated when an ignition source is present.

    - Explosion or fire hazards.
    - Odors that are annoying to personnel within the laboratory or adjacent laboratory/office units.
- The hood sash opening should be kept to a minimum while the hood is used. When working with hazardous chemicals, the hood sash should be positioned so that it acts as a protective barrier between laboratory personnel and the chemicals.
- Hood baffles or slots should be positioned properly. The top baffle/slot should be opened when chemicals with a vapor density of less than 1 (lighter than air) are used. The bottom baffle/slot should be opened when chemicals with vapor densities greater than 1 (heavier than air) are used.
- Chemicals and equipment (apparatus, instruments, etc.) should be placed at least 6 inches (15 cm) from the front edge of the hood.
- Equipment should be placed as far back in the hood as practical without blocking the baffles. Separate and elevate equipment by using blocks to ensure that air can flow easily around and under the equipment.
- Chemical fume hoods should be kept clean and free from unnecessary items and debris at all times. Solid material (paper, tissue, aluminum foil, etc.) should be kept from obstructing the rear baffles and from entering the exhaust ducts of the hood.
- Minimize the amount of bottles, beakers and equipment used and stored inside the hood because these items interfere with the air flow across the work surface of the hood.
- Chemicals should not be stored in a hood because they will likely become involved if there is an accidental spill, fire or explosion in the hood, thus creating a more serious problem.
- Sliding horizontal sash windows should not be removed from the hood sash.
- Laboratory personnel should not extend their head inside the hood when operations are in progress.
- The hood should not be used for waste disposal (evaporation).
- Hoods should be monitored daily by the user to ensure that air is moving into the hood. A strip of tissue taped to the hood sash will indicate if the hood is pulling air. Any hoods that are not working properly should be taken out of service and reported to both DEHS and the Physical Plant. DEHS is responsible for inspecting chemical fume hoods annually.
- Perchloric acid must <u>not</u> be used in a regular chemical fume hood. Specially designed Perchloric Acid Fume Hoods must be utilized for this purpose.

SOP 3.4 Corrosive Chemicals—Procedures for Safe Handling and Storage

Corrosives (liquids, solids, and gases) are chemicals that cause visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact. Corrosive effects can occur not only to the skin and eyes, but also to the respiratory tract through inhalation and to the gastrointestinal tract through ingestion. <u>Corrosive liquids</u> have a high potential to cause external injury to the body, while <u>corrosive gases</u> are readily absorbed into the body through skin contact and inhalation. <u>Corrosive solids</u> and their dusts can damage tissue by dissolving rapidly in moisture on the skin or within the respiratory tract when inhaled. In order to minimize these potential hazards, precautionary procedures must be observed when handling corrosives.

Handling

- Safety goggles, protective gloves, and a laboratory coat should always be worn when working with corrosive chemicals. A face shield, rubber apron, and rubber booties may also be appropriate depending on the work performed.
- Appropriate protective gloves which are resistant to permeation or penetration from corrosive chemicals should be selected and tested for the absence of pin holes prior to use.
- Eyewashes and safety showers should be readily available in areas where corrosive chemicals are used and stored. In the event of skin and eye contact with a corrosive chemical, the affected area should be immediately flushed with water for 15 minutes. Contaminated clothing should be removed and medical attention sought.
- Corrosive chemicals should be handled in a fume hood to ensure that any possible hazardous or noxious fumes generated are adequately vented.
- When mixing concentrated acids with water, add the acid slowly to the water. Allow the acid to run down the side of a container and mix slowly to avoid violent reactions and splattering. Never add water to acid.
- Appropriate spill material should be available in areas where corrosive chemicals are used and stored.
- Protective carriers should be used when transporting corrosive chemicals.

Storage

- Containers and equipment used for storage and processing of corrosive material should be corrosion resistant.
- Corrosive chemicals should be stored below eye level, preferably near the floor to minimize the danger of their falling from cabinets or shelves.
- Acids and caustics (i.e., bases) should be stored separately from each other. Secondary containers can be used to help with separation within a corrosive cabinet.
- Inorganic acids should be separated from organic acids and flammable/combustible material (inorganic acids are particularly reactive with flammable/combustible material).
- Acids should be segregated from active metals (e.g., sodium, potassium, and magnesium) and from chemicals that can generate toxic gases (e.g., sodium cyanide and iron sulfide).

SOP 3.5 Flammable and Combustible Liquids—Procedures for Safe Handling and Storage

Chemicals which exist, at ambient temperatures, in a liquid form with sufficient vapor pressure to ignite in the presence of an ignition source are called flammable or combustible liquids (note that the flammable/combustible liquid itself does not burn; it is the vapor from the liquid that burns). "**Flammables**" generate sufficient vapor at temperatures below 100 ^{o} F (37.8 ^{o}C), whereas "**Combustibles**" generate sufficient vapor at temperatures at or above 100 ^{o}F. Invisible vapor trails from these liquids can reach remote ignition sources causing flashback fires. In addition, these liquids become increasingly hazardous at elevated temperatures due to more rapid vaporization. For these reasons, precautionary measures must be observed when handling and storing flammables and combustibles.

Classification

Classification	Flash Point[1]	Boiling Point
Class IA Flammable Liquid	<73 ^{o} F (22.8 ^{o}C)	< 100 ^{o}F (37.8 ^{o}C)

Class IB Flammable Liquid	<73 ^{o}F	>/= 100 ^{o}F
Class IC Flammable Liquid	>/= 73 ^{o}F and <100 ^{o}F	-----
Class II Combustible Liquid	>/= 100 ^{o}F and < 140 ^{o}F (60 ^{o}C)	-----
Class IIIA Combustible Liquid	>/= 140 ^{o}F and < 200 ^{o}F (93 ^{o}C)	-----

[1]The minimum temperature at which a liquid gives off vapor in sufficient concentration to form an ignitable mixture in air near the surface of a liquid.

Handling

- Appropriate personal protective equipment (gloves, lab coat, and safety goggles) should be worn when working with flammable/combustible liquids.
- Flammable/combustible liquids should never be heated using open flames. Preferred heat sources include steam baths, water baths, oil baths, hot air baths, and heating mantels.
- Ignition sources should be eliminated in areas where flammable vapors may be present.
- Flammable/combustible liquids should only be dispensed under a fume hood. Ventilation is one of the most effective ways to prevent the formation and concentration of flammable vapors.
- When pouring from containers of 1 gallon (3.8 liters) or greater capacity, make sure both containers involved are electrically interconnected by bonding to each other and to a ground. The friction of flowing liquid may be sufficient to generate static electricity, which in turn may discharge, causing a spark and ignition.
- Flammable/combustible liquids in containers larger than 1 gallon (3.8 liters) should be transferred to smaller containers that can be easily manipulated by one person.
- Appropriate fire extinguishers should be available in areas where flammables are used.

Storage

- Flammable/combustible liquid in quantities exceeding a total of 10 gallons (38 liters) within a laboratory should be stored in approved flammable storage cabinets or safety cans.
- Flammable/combustible liquid stored outside of flammable storage cabinets in the laboratory should be kept to the minimum necessary for the work being done.
- Containers larger than 5 gallons (19 liters) shall not be stored in the laboratory.
- Flammable/combustible liquid stored in glass containers shall not exceed 1 gallon (3.8 liters).
- Flammable storage cabinets and safety cans should not be altered or modified unless specified by Indiana's Fire Prevention Code/National Fire Protection Agency guidelines.
- Flammable/combustible liquids should only be stored in explosion-proof or laboratory-safe refrigeration equipment.
- Flammable/combustible liquid containers filled or empty should not be stored in hallways or obstructing exits.
- Waste flammable/combustible liquids should be stored in safety cans.
- Flammables and combustibles should not be stored near oxidizers, corrosives, combustible material, or near heat sources. Make sure all chemicals stored near flammable and combustibles are compatible.

SOP 3.6 Oxidizing Agents—Procedures for Safe Handling and Storage

Oxidizing agents are chemicals that bring about an oxidation reaction. The oxidizing agent may 1) provide oxygen to the substance being oxidized (in which case the agent has to be oxygen or contain oxygen) or 2) receive electrons being transferred from the substance undergoing oxidation (chlorine is a good oxidizing agent for electron-transfer purposes, even though it does not contain oxygen). The intensity of the oxidation reaction depends on the oxidizing-reducing potential of the material involved. Fire or explosion is possible when strong oxidizing agents come into contact with easily oxidizable compounds, such as metals, metal hydrides or organics. Because oxidizing agents possess varying degrees of instability, they can be explosively unpredictable.

Examples of Oxidizing Agents

Gases: fluorine, chlorine, ozone, nitrous oxide, oxygen

Liquids: hydrogen peroxide, nitric acid, perchloric acid, bromine, sulfuric acid

Solids: nitrites, nitrates, perchlorates, peroxides, chromates, dichromates, picrates, permanganates, hypochlorites, bromates, iodates, chlorites, chlorates, persulfates

Handling

- Appropriate personal protective equipment (safety goggles, gloves, lab coat, etc.) should be worn when working with oxidizers.
- If a reaction is potentially explosive, or if the reaction is unknown, use a fume hood (with the sash down as a protective barrier), safety shield, or other methods for isolating the material or the process.
- Oxidizers can react violently when in contact with incompatible materials. For this reason, know the reactivity of the material involved in an experimental process. Assure that no extraneous material is in the area where it can become involved in a reaction.
- The quantity of oxidizer used should be the minimum necessary for the procedure. Do not leave excessive amounts of an oxidizer in the vicinity of the process.
- Perchloric acid must not be used in a regular chemical fume hood. A specially designed Perchloric Acid Fume Hood must be utilized for this purpose.

Storage

- Oxidizers should be stored in a cool, dry place.
- Oxidizers should be segregated from organic material, flammables, combustibles and strong reducing agents such as zinc, alkaline metals, and formic acid.
- Oxidizing acids such as perchloric acid and nitric acid should be stored separately in compatible secondary containers away from other acids.

SOP 3.7 Reactive Chemicals—Procedures for Safe Handling and Storage

Reactives are substances that have the potential to vigorously polymerize, decompose, condense, or become self-reactive due to shock, pressure, temperature, light, or contact with another material. All reactive hazards involve the release of energy in a quantity or at a rate too great to be dissipated by the immediate environment of the reaction system, so that destructive effects occur. Reactive chemicals include: 1) **explosives**, 2) **organic peroxides**, 3) **water-reactives** and 4) **pyrophorics**. Effective control is essential to minimize the occurrence of reactive chemical hazards.

1) **Explosives -** cause sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden adverse conditions. Heat, light, mechanical shock,

detonation, and certain catalysts can initiate explosive reactions. Compounds containing the functional groups azide, acetylide, diazo, nitroso, haloamine, peroxide, and ozonide are sensitive to shock and heat and can explode violently.

- Appropriate personal protective equipment (face shield, safety goggles, leather outer gloves, chemical resistant gloves, lab coat, etc.) should be worn when working with explosives.
- Before working with explosives, understand their chemical properties, know the products of side reactions, the incompatibility of certain chemicals, and monitor environmental catalysts such as temperature changes.
- Containers should be dated upon receipt and when opened. Expired explosives should be discarded promptly.
- Explosives should be kept to the minimum necessary for the procedure.
- If there is a chance of explosion, use protective barriers (e.g., fume hood sash and safety shield) or other methods for isolating the material or process.
- Explosives should be stored in a cool, dry, and protected area. Segregate from other material that could create a serious risk to life or property should an accident occur.

2) **Organic Peroxides** - contain an -O-O- structure bonded to organic groups. These compounds can be considered as structural derivatives of hydrogen peroxide, H-O-O-H, in which one or both of the hydrogen atoms have been replaced by an organic group. Generally, organic peroxides are low-powered explosives that are sensitive to shock, sparks, and heat due to the weak -O-O- bond that can be cleaved easily. Some organic compounds such as ethers, tetrahydrofuran, and p-dioxane can react with oxygen from the air forming unstable peroxides. Peroxide formation can occur under normal storage conditions, when compounds become concentrated by evaporation, or when mixed with other compounds. These accumulated peroxides can violently explode when exposed to shock, friction, or heat.

- Appropriate personal protective equipment (safety goggles, gloves, lab coat, etc.) should be worn when working with organic peroxides or peroxide-forming compounds.
- Containers should be labeled with the receiving and opening dates. Unopened material should be discarded within 1 year and opened material should be discarded within 6 months.
- Containers should be airtight and stored in a cool, dry place away from direct sunlight. Segregate from incompatible chemicals.
- Peroxide formers, liquid peroxides, or solutions should not be refrigerated below the temperature at which the peroxide freezes or precipitates. Peroxides in these forms are extra sensitive to shock (never store diethyl ether in a refrigerator or freezer).
- Unused peroxides should never be returned to the stock container.
- Metal spatulas should not be used with peroxide formers. Only ceramic or plastic spatulas should be used. Contamination by metal can cause explosive decomposition.
- Friction, grinding, and all forms of impact, especially with solid organic peroxides should be avoided. Never use glass containers with screw cap lids or glass stoppers. Instead, use plastic bottles and sealers.
- Testing for the presence of peroxides should be performed periodically.
- Containers with obvious crystal formation around the lid or viscous liquid at the bottom of the container should NOT be opened or moved.

3) **Water-Reactives -** react with water or moisture in the air releasing heat or flammable, toxic gas. Examples include alkali metals, alkaline earth metals, carbides, hydrides, inorganic chlorides, nitrides, peroxides, and phosphides.

- Appropriate personal protective equipment (safety goggles, gloves, lab coat, etc.) should be worn when working with water-reactives.
- Water-reactives should be stored under mineral oil in a cool, dry place. Isolate from other chemicals.
- Water-reactives should not be stored near water, alcohols, and other compounds containing acidic OH.
- In case of fire, keep water away. Appropriate fire extinguishers should be available in areas where water-reactives are used (use a Type "D" fire extinguishing media to extinguish active metal fires).

4) **Pyrophorics** - ignite spontaneously in air below 130 ^{o}F (54 ^{o}C). Often the flame is invisible. Examples of pyrophoric materials include silane, silicon tetrachloride, white and yellow phosphorus, sodium, tetraethyl lead, potassium, nickel carbonyl, and cesium.

- Appropriate personal protective equipment (safety goggles, gloves, lab coat, etc.) should be worn when working with pyrophorics.
- Pyrophorics should be used and stored in inert environments.
- Appropriate fire extinguishers should be available in areas where pyrophorics are used.

SOP 3.8 Carcinogens, Reproductive Toxins, and Acutely Toxic Chemicals— Procedures for Safe Handling and Storage

The Occupational Safety and Health Administration (OSHA) Laboratory Standard requires that special handling procedures be employed for certain chemicals identified as "particularly hazardous substances." Particularly hazardous substances include chemicals that are "select" carcinogens, reproductive toxins, and chemicals that have a high degree of acute toxicity. In addition, many chemicals used (including novel chemicals that are synthesized) in research laboratories have not been tested explicitly for carcinogenic or toxic properties and should therefore be handled as "particularly hazardous substances" since their hazards are unknown.

Carcinogen - substance that either causes cancer in humans, or because it causes cancer in animals, is considered capable of causing cancer in humans. OSHA defines those substances that are known to pose the greatest carcinogenic hazards as "select" carcinogens (see Appendix B). These materials include substances that:

1. OSHA regulates as a carcinogen; or
2. The National Toxicology Program (NTP) lists as "known to be a carcinogen" or "reasonably anticipated to be a carcinogen" in their Annual Report on Carcinogens; or
3. The International Agency for Research on Cancer (IARC) lists under Group 1 ("carcinogenic to humans"), Group 2A ("probably carcinogenic to humans"), or Group 2B ("possibly carcinogenic to humans").

Reproductive/Developmental Toxin - substance that cause chromosomal damage or genetic alterations (mutagens) or substances with lethal or teratogenic (malformations or physical defects) in a developing fetus or embryo.

Acutely Toxic Chemicals - Acute toxicity is the ability of a chemical to cause a harmful effect after a single exposure. Acutely toxic chemicals can cause local toxic effects, systemic effects, or

both. In general, acutely toxic chemicals have an Oral LD50 of < 50 mg (rats, per kg), Skin Contact LD50 of < 200 mg (rabbits, per kg), Inhalation LC50 of <200 (rats, ppm for 1 hr) OR <2000 (rats, mg/m^3 for 1 hr).

Handling

- Designated areas (e.g., fume hoods, glove boxes, lab benches, outside rooms, etc.) for material use should be established and the areas identified by signs or postings.
- Containment devices such as fume hoods (if necessary) and personal protective equipment (gloves, lab coat, and eye protection) should be used when handling these hazardous substances.
- Procedures for the safe use of the material and waste removal should be established prior to use.
- Decontamination procedures should be developed in advance and strictly followed.
- Only laboratory personnel trained to work with these substances should perform the work, and always within the designated area. Prior approval is required by the principal investigator or supervisor (see Section 2.1.1 *Prior Approval of Hazardous Operations*).
- Only the minimum quantity of the material should be used.

Storage

- These materials should be stored in areas designated for "particularly hazardous substances."
- Storage areas should be clearly marked with the appropriate hazard warning signs.
- All containers of these materials (even if the material is in very small quantities such as 0.1%) should be clearly labeled with the chemical name or mixture components and the appropriate hazard warning information.
- Chemical storage areas should be secure to avoid spills or broken containers.
- Storage areas or laboratory rooms should be locked when laboratory personnel are gone.

SOP 3.9 Compressed Gases—Procedures for Safe Handling and Storage

In general, a compressed gas is any material contained under pressure that is dissolved or liquefied by compression or refrigeration. Compressed gas cylinders should be handled as high-energy sources and therefore as potential explosives and projectiles. Prudent safety practices should be followed when handling compressed gases since they expose workers to both chemical and physical hazards.

Handling

- Safety glasses with side shields (or safety goggles) and other appropriate personal protective equipment should be worn when working with compressed gases.
- Cylinders should be marked with a label that clearly identifies the contents.
- All cylinders should be checked for damage prior to use. Do not repair damaged cylinders or valves. Damaged or defective cylinders, valves, etc., should be taken out of use immediately and returned to the manufacturer/distributor for repair.
- All gas cylinders (full or empty) should be rigidly secured to a substantial structure at 2/3 height. Only two cylinders per restraint are allowed in the laboratory and only soldered link chains or belts with buckles are acceptable. Cylinder stands are also acceptable but not preferred.
- Hand carts shall be used when moving gas cylinders. Cylinders must be chained to the carts.

- All cylinders must be fitted with safety valve covers before they are moved.
- Only three-wheeled or four-wheeled carts should be used to move cylinders.
- A pressure-regulating device shall be used at all times to control the flow of gas from the cylinder.
- The main cylinder valve shall be the only means by which gas flow is to be shut off. The correct position for the main valve is all the way on or all the way off.
- Cylinder valves should never be lubricated, modified, forced, or tampered.
- After connecting a cylinder, check for leaks at connections. Periodically check for leaks while the cylinder is in use.
- Regulators and valves should be tightened firmly with the proper size wrench. Do not use adjustable wrenches or pliers because they may damage the nuts.
- Cylinders should not be placed near heat or where they can become part of an electrical circuit.
- Cylinders should not be exposed to temperatures above 50 ^{o}C (122 ^{o}F). Some rupture devices on cylinders will release at about 65 ^{o} C (149 ^{o}F). Some small cylinders, such as lecture bottles, are not fitted with rupture devices and may explode if exposed to high temperatures.
- Rapid release of a compressed gas should be avoided because it will cause an unsecured gas hose to whip dangerously and also may build up enough static charge to ignite a flammable gas.
- Appropriate regulators should be used on each gas cylinder. Threads and the configuration of valve outlets are different for each family of gases to avoid improper use. Adaptors and homemade modifications are prohibited.
- Cylinders should never be bled completely empty. Leave a slight pressure to keep contaminants out.

Storage

- When not in use, cylinders should be stored with their main valve closed and the valve safety cap in place.
- Cylinders must be stored upright and not on their side. All cylinders should be secured.
- Cylinders awaiting use should be stored according to their hazard classes.
- Cylinders should not be located where objects may strike or fall on them.
- Cylinders should not be stored in damp areas or near salt, corrosive chemicals, chemical vapors, heat, or direct sunlight. Cylinders stored outside should be protected from the weather.

Special Precautions

Flammable Gases

- No more than two cylinders should be manifolded together; however several instruments or outlets are permitted for a single cylinder.
- Valves on flammable gas cylinders should be shut off when the laboratory is unattended and no experimental process is in progress.
- Flames involving a highly flammable gas should not be extinguished until the source of the gas has been safely shut off; otherwise it can reignite causing an explosion.

Acetylene Gas Cylinders

- Acetylene cylinders must always be stored upright. They contain acetone, which can discharge instead of or along with acetylene. Do not use an acetylene cylinder that has

been stored or handled in a nonupright position until it has remained in an upright position for at least 30 minutes.

- A flame arrestor must protect the outlet line of an acetylene cylinder.
- Compatible tubing should be used to transport gaseous acetylene. Some tubing like copper forms explosive acetylides.

Lecture Bottles

- All lecture bottles should be marked with a label that clearly identifies the contents.
- Lecture bottles should be stored according to their hazard classes.
- Lecture bottles that contain toxic gases should be stored in a ventilated cabinet.
- Lecture bottles should be stored in a secure place to eliminate them from rolling or falling.
- Lecture bottles should not be stored near corrosives, heat, direct sunlight, or in damp areas.
- To avoid costly disposal fees, lecture bottles should only be purchased from suppliers that will accept returned bottles (full or empty). Contact the supplier before purchasing lecture bottles to ensure that they have a return policy.
- Lecture bottles should be dated upon initial use. It is advised that bottles be sent back to the supplier after one year to avoid accumulation of old bottles.

SOP 3.10 Cryogenic Liquids—Procedures for Safe Handling and Storage

Cryogenic liquids are liquefied gases having boiling points of less than -73.3 ^{o}C (-100 ^{o}F). The primary hazards of cryogenic liquids include both physical hazards such as fire, explosion, and pressure buildup and health hazards such as severe frostbite and asphyxiation. Potential fire or explosion hazards exist because cryogenic liquids are capable, under the right conditions, of condensing oxygen from the atmosphere. This oxygen-rich environment in combination with flammable/combustible materials, and an ignition source are particularly hazardous. Pressure is also a hazard because of the large volume expansion ratio from liquid to gas that a cryogen exhibits as it warms and the liquid evaporates. This expansion ratio also makes cryogenic liquids more prone to splash and therefore skin and eye contact is more likely to occur. Contact with living tissue can cause frostbite or thermal burns, and prolonged contact can cause blood clots at have very serious consequences. All laboratory personnel should follow prudent safety practices when handling and storing cryogenic liquids.

Properties of Common Cryogenic Liquids

Gas	Boiling Point (^{o}C)	Volume Expansion Ratio
Helium	-269	757-1
Hydrogen	-252.7	851-1
Nitrogen	-195.8	696-1
Fluorine	-187.0	888-1
Argon	-185.7	847-1
Oxygen	-183.0	860-1
Methane	-161.4	578-1

Handling

- Appropriate personal protective equipment should be worn when handling cryogenic liquids. This includes special cryogen gloves, safety goggles, full-face shield, impervious apron or coat, long pants, and high topped shoes. Gloves should be impervious and sufficiently large to be readily removed should a cryogen be spilled. Watches, rings, and other jewelry should NOT be worn.
- Unprotected body parts should not come in contact with vessels or pipes that contain cryogenic liquids because extremely cold material may bond firmly to the skin and tear flesh if separation is attempted.
- Objects that are in contact with cryogenic liquid should be handled with tongs or proper gloves.
- All precautions should be taken to keep liquid oxygen from organic materials; spills on oxidizable surfaces can be hazardous.
- All equipment should be kept clean, especially when working with liquid or gaseous oxygen.
- Work areas should be well ventilated.
- Transfers or pouring of cryogenic liquid should be done very slowly to minimize boiling and splashing.
- Cryogenic liquids and dry ice used as refrigerant baths should be open to the atmosphere. They should never be in a closed system where they may develop uncontrolled or dangerously high pressure.
- Liquid hydrogen should not be transferred in an air atmosphere because oxygen from the air can condense in the liquid hydrogen presenting a possible explosion risk.

Storage

- Cryogenic liquids should be handled and stored in containers that are designed for the pressure and temperature to which they may be subjected. The most common container for cryogenic liquids is a double-walled, evacuated container known as a dewar flask.
- Containers and systems containing cryogenic liquids should have pressure relief mechanisms.
- Cylinders and other pressure vessels such as dewar flasks used for the storage of cryogenic liquids should <u>not</u> be filled more than 80% of capacity, to protect against possible thermal expansion of the contents and bursting of the vessel by hydrostatic pressure. If the possibility exists that the temperature of the cylinder may increase to above 30 ^{o}C (86 ^{o}F), a lower percentage (i.e., 60 percent capacity) should be the limit.
- Dewar flasks should be shielded with tape or wire mesh to minimize flying glass and fragments should an implosion occur.
- Dewar flasks should be labeled with the full cryogenic liquid name and hazard warning information.

SOP 3.11 Electrical Safety Procedures

Serious injury or death by electrocution is possible when appropriate attention is not given to the engineering and maintenance of electrical equipment and personal work practices around such equipment. In addition, equipment malfunctions can lead to electrical fires. By taking reasonable precautions, electrical hazards in the laboratory can be dramatically minimized.

- Laboratory personnel should know the location of electrical shut-off switches and/or circuit breakers in or near the laboratory so that power can be quickly terminated in the event of a fire or accident.
- Electrical panels and switches should never be obstructed and should be clearly labeled to indicate what equipment or power source they control.
- All electrical equipment should be periodically inspected to ensure that cords and plugs are in good condition. Frayed wires and wires with eroded or cracked insulation should be repaired immediately, especially on electrical equipment located in wet areas such as cold rooms or near cooling baths. Corrosive chemicals and organic solvents can easily erode insulation on wires.
- All electrical outlets should have a grounding connection requiring a three-pronged plug.
- All electrical equipment should have three-pronged, grounded connectors. The only exceptions to this rule are instruments entirely encased in plastic (such as electric pipettes and some types of microscopes) and Glas-Col heating mantels. If equipment does not have a three-pronged plug, replace the plug and cord to ground the equipment.
- Faceplates must not be removed from electrical outlets.
- Electrical wires should not be used as supports.
- Extension cords should be avoided. If used, they should have three-pronged, grounded connectors and positioned or secured as not to create a tripping hazard.
- All shocks should be reported to the principal investigator or supervisor. All faulty electrical equipment should be immediately removed from service until repaired.
- Electrical outlets, wiring, and equipment within a laboratory or building should only be repaired by IU Physical Plant or other professional electricians.
- Proper grounding and bonding of flammable liquid containers should be practiced to avoid the build-up of excess static electricity. Sparks generated from static electricity are good ignition sources.

SOP 3.12 Glassware and Sharps—Procedures for the Safe Handling and Disposal

Handling

- Glassware should be handled and stored carefully to avoid damage.
- Chipped, broken, or star-cracked glassware should be discarded or repaired. Damaged glassware should never be used.
- Only thick-walled, pressure resistant glassware should be utilized under a vacuum.
- Appropriate hand protection should be used when picking up broken glass or other sharp objects. Small pieces should be swept up using a brush and dustpan.
- Appropriate hand protection should be used when inserting glass tubing into a rubber stopper or when placing rubber tubing on glass hose connections. Use of plastic or metal connectors should be considered.

Disposal

- All broken glassware that cannot be repaired should be rinsed thoroughly and collected in a suitable-sized, hard plastic receptacle labeled "Broken Glassware." The custodial staff will discard the contents of these containers.
- All other sharps (needles, razor blades, scalpels, etc.), regardless of contamination, should be placed in cardboard boxes or plastic puncture-proof containers and marked as "Sharps". Uncontaminated sharps containers may then be placed in the normal trash.
- Sharps and glassware that are contaminated with hazardous chemicals should be collected in puncture-proof containers and marked as "Sharps" and "CCI" (Chemically

Contaminated Items). They may then be turned over to DEHS for disposal. A wide selection of sharps containers is available in lab supply catalogs.
- All sharps and glassware contaminated with biological materials must be discarded according to the procedures outlined in the *Bloodborne Pathogens Exposure Control Plan*.

Note: Red biohazard sharps containers are to be used ONLY for biohazardous waste. Regulatory requirements prohibit disposal by the same means as chemically contaminated sharps.

- All sharps and glassware contaminated with radioactive materials must be discarded according to procedures outlined in Indiana University's *Radiation Safety Manual*.

SOP 3.13 Chemical Spill Response Procedures

Despite the best effort of researchers to practice safe science in the laboratory, accidents resulting in the release of chemicals will occur. For this reason, it is essential that laboratory personnel have a spill response plan that includes appropriate procedures and materials to adequately contain and cleanup a spill. The following procedures should be used as a guide to help laboratory personnel design an effective spill control plan for their laboratory (see Section 6.10 *Spill Control Kit* for information on spill kit contents).

Spill Response - Major Spill

In the event of a spill which: 1) involves the release of a type or quantity of chemical which poses an immediate risk to health; 2) involves an uncontrolled fire or explosion; or 3) involves serious personal injury; follow the steps outlined in the *Emergency Information* section at the beginning of this Plan.

Spill Response - Minor Spill

In the event of a spill involving the release of a type or quantity of chemical which does not pose an immediate risk to health:
- Notify other laboratory personnel of the accident.
- Isolate the area. Close laboratory doors and evacuate the immediate area if necessary.
- Remove all ignition sources and establish exhaust ventilation. Vent vapors to outside of building only (open windows and turn on fume hood).
- Choose appropriate personal protective equipment (goggles, face shield, impervious gloves, lab coat, apron or coveralls, boots, respirator, etc.) (All laboratory personnel must be properly fit tested before using a respirator). Contact DEHS for more information.
- Confine and contain the spill. Cover with appropriate absorbent material. Sweep solid material into a dustpan and place in a sealed plastic container. Decontaminate the area with soap and water after cleanup and place residue in a plastic bag or another sealed plastic container. Call DEHS for pickup and disposal.

FOR CONSULTATION OR ASSISTANCE CALL DEHS AT 981-4230 OR 980-6501.

4.0 INFORMATION AND TRAINING

The OSHA Lab Standard requires that individuals who will be working with chemicals in the laboratory be provided with sufficient training to enable them to conduct their work safely. Training must be provided prior to the time when individuals begin their duties involving chemicals and whenever there is a significant change in the types or quantities of chemicals used. Departments and, ultimately, principal investigators (or laboratory supervisors) are responsible for ensuring that all individuals working in their laboratories have been adequately trained.

4.1 Required Training Content

The general training topics required by the Lab Standard are the:

- Content of the Lab Standard.
- Location and availability of the *Laboratory Chemical Safety Plan* (i.e., Chemical Hygiene and Safety Plan).
- Permissible exposure limits (PELs) for OSHA regulated substances (see Appendix A) or recommended limits for other materials that have no OSHA limits.
- Signs and symptoms associated with chemical exposure.
- Location and availability of known reference material on the hazards, safe handling, storage, and disposal of chemicals. This includes, but is not limited to, Material Safety Data Sheets (MSDSs).
- Methods to detect the presence or release of chemicals.
- Physical and health hazards of chemicals.
- Measures that laboratory workers can take to protect themselves from chemical hazards, including control measures, personal protective equipment, SOPs, and emergency procedures.

4.2 Training Resources

The Department of Environmental Health and Safety (DEHS) provides a number of types and formats of safety training to the university community. Among the training routinely offered is a *Laboratory Chemical Safety Plan Orientation* that is designed to cover, in a general way, many of the topics required by the OSHA Lab Standard. This *Orientation*, however, is not intended to be the sole means of training laboratory workers but must be supplemented by additional safety instruction from the principal investigator (or laboratory supervisor) on the potential hazards associated with an individual's specific duties. This individualized training should include a review of the laboratory's safety features and equipment (Laboratory Safety Review Form in Appendix E has been prepared to assist principal investigators in this process). For information on other safety training resources available from DEHS (such as specialized training sessions, videotapes, safety guides, chemical references, and MSDSs), individuals should call 981-4230.

4.3 Training Documentation

Departments and principal investigators are responsible for documenting the safety training provided to individuals working within their laboratories. For each individual, a record should be maintained not only for formal training sessions attended such as the DEHS *Laboratory Chemical Safety Plan Orientation*, but also for informal safety instruction or training provided in the laboratory (Laboratory Safety Training – Individual Documentation Form in Appendix E may be used for this purpose).

5.0 MEDICAL CONSULTATIONS AND EXAMINATIONS

In accordance with the requirements of the OSHA Lab Standard, Indiana University Northwest provides all employees who work with chemicals the opportunity to receive medical consultations and examinations under the supervision of a licensed physician. Medical examinations are provided without cost to the employee, without loss of pay, and at a reasonable time and place.

5.1 Examination Criteria

Medical examinations are available to employees who work with chemicals in the laboratory whenever:

- An employee develops signs or symptoms associated with a chemical to which exposure may have occurred in the laboratory.
- Exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the PEL) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements.
- A spill, leak, explosion, or other event occurs in the laboratory resulting in the likelihood of chemical exposure.

5.2 Information to the Physician

The employee's department or principal investigator must provide the physician with the following information regarding the employee's potential exposure:

- The identity of the chemicals to which the employee may have been exposed.
- A description of the conditions under which the exposure occurred.
- A description of the employee's symptoms.

5.3 Physician's Written Opinion

Upon completion of the employee's consultation or examination, the department or principal investigator must obtain a written opinion from the examining physician that includes the following information:

- Any recommendations for further medical follow-up.
- Results of the medical examination and associated tests.
- Any medical condition found as a result of the examination that may place the employee at increased risk from further chemical exposure in the laboratory.
- A statement that the employee has been informed by the physician of the results of the consultation or examination.
- The physician's written opinion shall not reveal specific findings of diagnoses unrelated to occupational exposure.

6.0 LABORATORY SAFETY EQUIPMENT

The availability and use of a number of types of safety equipment is essential to the practice of safe science. Safety equipment should be present in well-marked, highly visible, and easily accessible locations in or near all laboratories that use hazardous chemicals. For more information regarding safety equipment or specific regulatory requirements, please call the Department of Environmental Health and Safety (981-4230).

6.1 Chemical Fume Hoods

Chemical fume hoods are one of the most important items of equipment used for the protection of workers in the laboratory. A standard fume hood is a chemical and fire resistant enclosure with a movable window (sash) at the front to allow the user access to the interior. Chemical fume hoods capture, contain, and expel chemical emissions. In addition, chemical fume hoods (with the sash down) provide a protective barrier between laboratory personnel and chemicals or chemical processes. A properly functioning hood draws between 60-100 linear feet per minute of air at full-open sash. The storage of large numbers of chemical bottles or other items within the hood can dramatically impair this functioning. To ensure that fume hoods are operating properly, periodic inspections are conducted by the Department of Environmental Health and Safety. Any hoods that are not functioning properly are serviced by IU Physical Plant. (See SOP 3.3 *Chemical Fume Hoods – Procedures for Proper and Safe Use*.)

6.2 Safety Showers

Safety showers are required in areas where hazardous chemicals are used. Safety showers provide an effective means of initial treatment in the event of chemical contamination of the skin or clothing. The shower area should be readily accessible, clear of obstructions, and clearly labeled. DEHS inspects safety showers biannually to ensure that they are working properly. In the event of chemical contamination of an individual's body, immediately flush the body for 15 minutes under the shower, remove all clothing, and seek medical attention.

6.3 Eyewash Stations

Eyewash stations are required in areas where hazardous chemicals are used. Eyewashes should be easily accessible, unobstructed, and clearly labeled. The use of the hands should not be required to activate and maintain the water flow. Plumbed eyewash units are best and strongly recommended. Eyewashes should be inspected routinely by laboratory personnel to ensure that they are working properly. In the event of chemical contamination of the eyes or face, immediately flush the eyes/face for 15 minutes and seek medical attention.

6.4 Fire Extinguishers

Fires are one of the most common types of laboratory accidents. Laboratory personnel should know the location of all fire extinguishers in the laboratory, the type of fires for which they are appropriate, and how to operate them correctly. The DEHS provides free fire safety training to IUN employees. Fire extinguishers in the laboratory should be the appropriate type for the expected fire emergency. Extinguishers are classified according to a particular fire type. Type A are used on combustible (wood, paper, rubber, plastic) fires, Type B are used on flammable liquid fires, Type C are used on energized electrical equipment fires, and Type D are used on combustible metal (lithium, sodium, magnesium, potassium) fires. Multipurpose (Type ABC and Type BC) extinguishers are available. Fire extinguishers should be easily accessible, mounted

properly on a wall, and unobstructed. The DEHS inspects fire extinguishers monthly. Used fire extinguishers should be immediately serviced.

6.5 Fire Blankets

Fire blankets are recommended in all laboratories that use flammable liquids. Fire blankets should be easily accessible and unobstructed. In the event that a person's body or clothing catches fire, the person should immediately drop to the floor and roll to help extinguish the fire (STOP-DROP-and-ROLL method). A fire blanket should be used only as a last resort to help smother a body or clothing fire. Fire blankets can also be used to keep shock victims warm.

6.6 Flammable Liquid Storage Cabinets

Flammable liquids in quantities exceeding a total of 10 gallons in a laboratory must be stored in approved (Factor Mutual) flammable liquid storage cabinets or safety cans. Flammable storage cabinets shall be designed to meet NFPA (National Fire Protection Agency) and Indiana's Fire Prevention Code guidelines. Cabinets are generally made from No. 18 gage sheet steel with double-walled construction or one-inch exterior grade plywood. Approved cabinets should be marked in conspicuous lettering "FLAMMABLE-KEEP FIRE AWAY." Fire cabinets are not required to be vented (cabinets are generally vented only if the flammable liquids generate noxious fumes), but if venting is desired it shall meet NFPA and Indiana's Fire Prevention Code requirements (call the IU Department of Risk Management at 855-9758 for details on venting requirements). Only flammable and combustible material should be stored in flammable storage cabinets.

6.7 Safety Cans

A safety can is a container of not more than five-gallon capacity, having a spring closed lid, spout cover, and flame arrestor and so designed that it will safely relieve internal pressure. Safety cans should be UL (Underwriters' Laboratories, Inc.) listed and should be compatible with the chemical that they are to contain.

6.8 Explosion-Proof and Laboratory-Safe Refrigeration Equipment

The use of domestic refrigeration equipment for the storage of flammable liquids presents a significant hazard to the laboratory work area. Refrigerator temperatures are commonly higher than the flash points of the flammable liquids stored in them. In addition, domestic refrigerators contain readily available and exposed ignition sources such as thermostats, lights, and heater strips. Flammable liquids should only be stored in two types of laboratory refrigerators: explosion-proof and laboratory-safe models. Explosion-proof refrigeration equipment is designed to protect against ignition of flammable vapors both inside and outside the refrigerated storage compartment. Laboratory-safe refrigeration equipment (also called explosion-safe) is designed to eliminate ignition of vapors on only the inside of the storage compartment, although other safety design features like self-closing doors, magnetic door gaskets, and compressors and circuits located at the top of the refrigeration unit have been incorporated. All flammable liquids that need to be stored in a cool environment should be stored in these types of approved refrigerators. Containers should be tightly closed to minimize the amount of vapor released. Every laboratory refrigerator should be clearly marked to indicate whether or not it is safe for the storage of flammable liquids. Although not considered optimum protection, it is possible to modify some domestic refrigerators to hold flammable liquids. Please call DEHS for more details.

6.9 First Aid Kits

First aid kits should be easily accessible to all laboratory personnel. First aid kits should be regularly inspected and restocked as necessary. As a general guideline, first aid kits (Appendix F) should contain adhesive tape, bandages (small and large), pressure bandage compresses, premoistened cleansing wipes, antiseptic cream/spray, gauze pads, gauze wraps, latex gloves, and a CPR barrier/shield. First aid kits can be purchased through any laboratory safety supply vendor.

6.10 Chemical Spill Kits

Every laboratory that uses hazardous chemicals should have access to a spill control kit. The keys to an effective spill kit are location and content. Spill kits should be strategically located around work areas in fixed spots so they will be easily accessible. In general, a spill kit should contain absorbent material, appropriate personal protective equipment, a container for spill residue, and a plastic dustpan and scoop. Laboratories that use mercury or mercury filled thermometers and manometers should also have a mercury spill kit available. Once a spill kit has been used it should be immediately restocked. Spill kits can be purchased through most vendors that sell chemicals or safety supplies. The following is a list of recommended items that should be contained in a chemical spill kit. However, it is important that spill kits be tailored to meet the specific spill control needs of each laboratory.

Absorbents:

- Universal Spill Absorbent Material - 1:1:1 mixture of Flor-Dri (or unscented kitty litter): Sodium Bicarbonate: Sand. This all-purpose absorbent material is good for most chemical spills including solvents, acids, and bases.
- Acid Spill - Sodium Bicarbonate, Sodium Carbonate, or Calcium Carbonate
- Alkali (Base) Spill - Sodium Bisulfate
- Solvents/Other Organic Liquids - Inert absorbents such as vermiculite, clay, sand, Flor-Dri, and Oil-Dri

Personal Protective Equipment:

- Goggles and Face Shield
- Plastic Vinyl Booties
- Disposable Coveralls and Apron
- Disposable Vinyl Gloves and Heavy Neoprene Gloves

Clean-Up Material:

- Plastic Dust Pan and Scoop
- Plastic Bags (30 gallon, 3 mil thick)
- One empty 5 gallon, plastic bucket with lid for spill and absorbent residues

Other:

- Hydrofluoric Acid Antidote Gel - Calcium Gluconate
- Mercury Spill Kit

6.11 Portable Safety Shields

Portable safety shields can provide limited protection against explosions, fires, and chemical splash hazards. When a hood sash cannot provide proper shielding, portable safety shields should be used. It should be noted that portable safety shields do not provide protection on the sides and back of equipment and therefore work best if used in conjunction with a fume hood. Laboratory

equipment/chemical apparatus should be shielded on all sides so that there is no line-of-sight exposure to laboratory personnel.

7.0 Records and Recordkeeping

Keep copies of all records in your departmental files. Follow these guidelines:

RECORD TYPE	RETENTION
MSDS	As long as product is used/stored in department
MSDS (employee exposure incident)	Indefinitely
Chemical inventory	As long as it is current
Training	Indefinitely
Monitoring (exposure)	Indefinitely
Medical consultations and examinations	Indefinitely
Written medical opinions and recommendations	Indefinitely
Other	Call DEHS

APPENDICIES

Appendix A: OSHA Standards
29CFR1910.1450 OSHA's Laboratory Standard
29CFR1910.1000 Table Z-1 Limits for Air Contaminants

Appendix B: Chemical Lists
(AVAILABLE IN PRINTED LCSP—call 981-4230 for a copy)

- Select Carcinogens
- Reproductive Toxins
- Acutely Toxic Chemicals
- Peroxidizable/Unstable Compounds
- Chemical Incompatibilities-Partial List

Appendix C: Chemical Safety Summaries (MSDSs)
(AVAILABLE IN PRINTED LCSP—call 981-4230 for a copy)

Appendix D: Hazardous Waste Management Guide

Appendix E: Standard Forms

- Laboratory Safety Audit
- Laboratory Safety Review
- Laboratory Safety Training-Individual Documentation

Appendix F: Approved First Aid Kit Supply List