Contents

1 Introduction

The Chemical Hygiene Plan provides laboratory personnel first-hand information regarding generic and specific hazards related to college laboratories. The laboratory environment is a unique and hazardous workplace. Laboratory workers are exposed to numerous potential hazards including biological, chemical, physical (electrical), and radioactive hazards via inhalation, ingestion, injection or skin absorption. The Occupational Safety and Health Administration (OSHA) Laboratory Standard (29 CFR 1910.1450) was established to protect laboratory workers from harmful exposures to hazardous substances. This standard was designed specifically for non-production laboratories.

Hartwick College is committed to the health and safety of its employees, students, and visitors. This commitment includes fulfillment of the responsibility under the OSHA Laboratory Safety Standard that requires exposures to hazardous chemicals be maintained at or below the Permissible Exposure Limits (PELs). One element of the compliance program is the development of the Chemical Hygiene Plan. Laboratories may modify or enhance these procedures to meet their specific needs. All laboratory workers should take steps to minimize chemical exposure via all routes of entry.

1.1 Applicability

The Laboratory Standard applies to any person working in any Hartwick College laboratory. Laboratory use of hazardous chemicals includes:

- Chemical manipulations on a laboratory scale and multiple chemicals procedures in used.
- The procedures involved are not part of a production procedure, nor in any way stimulate a production process.
- Protective laboratory practices and equipment are available and in use to minimize the potential for exposure to hazardous chemicals.

1.2 Definitions

ACGIH: American Conference of Governmental Industrial Hygienist.

Action Level: A concentration designated in the OSHA (29 CFR) Part 1910 calculated as an eight-hour time weighted average (TWA), which initiates certain required activities such as exposure monitoring and medical surveillance.

ANSI: American National Standards Institute.

Biohazards: Tissues, organs, blood from humans and primates including contaminated syringes, needles, and sharps.

Chemical Hygiene Plan: A written program developed and implemented by an employer that sets forth procedures, materials, and work practices that are capable of protecting employees from the health hazards presented by hazardous chemicals and hazardous procedures used in that particular workplace, and meets the requirements of OSHA's Laboratory Safety Standard.

Chemical Hygiene Officer: The Chemical Hygiene Officer (CHO) is an employee designated by the employer, and qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan.

Combustible liquid: Any liquid whose flash point is 100 ^{0}F or higher, when tested by closed cup method.

Corrosive: A liquid that corrodes steel at a rate greater than 0.250 per year at a test temperature of 103 ^{0} F or has a pH less than 2 or greater than 12.5 (e.g. acids, bases).

Compressed Gas: A substance in gas or liquid form contained in a vessel under pressure. This includes cylinders, lecture bottles, and aerosol cans. These substances may be flammable, non-flammable, or poisonous.

Cryogenics: Substances that are extremely cold such as liquid nitrogen, liquid helium, and dry ice. These substances can displace air and may become asphyxiation hazards if spilled in poorly ventilated areas.

Designated Area: An area used for work with "select carcinogens", "reproductive toxins", or substances that have a high degree of acute toxicity. A designated area may be the entire laboratory, an area of a laboratory or a laboratory hood.

Explosive: Any chemical compound, mixture, or device that reacts or decomposes with substantial instantaneous release of gas and heat.

Emergency: Any occurrence such as, but not limited to equipment failure, rupture of containers, or failure of control equipment that results in an uncontrolled release of hazardous chemicals in the workplace.

Flammable Liquid: Defined by NFPA and OSHA as a liquid whose flash point does not exceed 100 ^{0}F, when tested by the closed cup test method.

Flammable Solid: Any material in the solid phase of matter that can readily undergo combustion in the presence of a source of ignition under standard circumstance (i.e. without artificially changing variables such as pressure or density or adding accelerants).

Hazardous Chemical: Any chemical classified as a health hazards.

Health Hazard: Classified as posing one of the following hazardous effects: acute toxicity, skin corrosion or irritation, serious eye damage or eye irritation, respiratory or skin sensitization, germ cell mutagenicity, carcinogenicity, reproductive toxicity, specific target organ toxicity, or simple asphyxiant.

Hazardous Material: Any material or substance, which if improperly handled, can be damaging to the health and well-being of humans and the environment.

Laboratory: Workplace where relatively small quantities of hazardous chemicals are used on a non-productive basis.

Lab Worker: Individual employed in a laboratory workplace who may be exposed to hazardous chemicals.

NFPA: National Fire Protection Association.

OSHA: Occupational Safety and Health Administration.

Organic Peroxide: An organic compound containing the chemical bond (0-0), with two oxygen atoms joined.

Oxidizer: Promotes combustion in other materials.

Particularly Hazardous Substances: Chemicals that are select carcinogens, reproductive toxins, or have a high degree of acute toxicity.

Permissible Exposure Limit (PEL): Regulatory limit or maximum concentration of a substance a personnel can be exposed.

Physical Hazard: Any chemical which is classified as explosive, flammable (gases, aerosols, liquids or solids), oxidizer (liquid, solid, or gas), or self-reactive.

Pyrophorics: Self-heating (gas, liquid or solid), organic peroxides, chemicals corrosive to metal, gases under pressure, emit flammable gases when reacted with water, or combustible dusts.

PPE: Personal Protective Equipment.

Principal Investigator (PI): The lead scientist that plans and/or conducts the laboratory research and assumes the overall supervisory responsibility for laboratory operations and project completion.

Reproductive Toxin: Chemicals that affect the reproductive capabilities including adverse effects on sexual function and fertility in adult males and females, as well as adverse effects on the development of the offspring including but not limited to those that damage chromosomes (mutagens) or the fetus (teratogens).

RCRA: Resource conservation and recovery act.

SDS: Safety data sheet.

SOP: Standard Operating Procedure.

Small Quantity Handler of Universal Waste (SQHUW): This handler manages any of the three types of UW. A SQHUW collects less than 5000 kg of the total accumulation of UW at any one given time, not by each type.

TLV: Threshold Limit Value.

US EPA: United States Environmental Protection Agency.

UW: Universal Waste

1.3 Responsibilities

The Chemical Hygiene Officer (CHO) is responsible for developing, implementing and reviewing the written Chemical Hygiene Plan, which will be reviewed annually and updated as needed. The Chemical Hygiene Plan will apply to laboratories engaged in the use of hazardous chemicals and biological agents in all departments. Although ultimate responsibility for the development and implementation of the Chemical Hygiene Plan rests with the CHO, it is important to realize that the responsibility for chemical hygiene involves other levels of the College as outlined below:

I. Department Heads and Principal Investigators (PI) responsibilities include the following:

- Ensure all employees under their supervision (staff and students) are aware of potentially hazardous operations (materials, processes, equipment) that could be encountered in their lab.
- Ensure training requirements are fulfilled.
- Enforce safety rules within the lab, such as the wearing of personal protective equipment.

- Ensure that the correct personal equipment is available.
- Monitor the proper procurement, use and disposal of chemicals used in laboratory operations.
- Seek ways to improve chemical hygiene and laboratory safety within their operation.
- Implement policies and procedures described in this chemical hygiene plan, including the development of written standard operating procedures for hazardous lab operations which involves:
    - Determination/implementation of appropriate control measures.
    - Development/implementation of provisions for additional employee protection from particularly hazardous substances.
    - Establishing criteria for any needed prior approval processes.

II. The Chemical Hygiene Officer, who has overall responsibility for chemical hygiene in all laboratories including responsibility to:

- Develop and implement the Chemical Hygiene Plan.
- Provide regular, formal chemical hygiene and housekeeping inspections.
- Support research and instructional activities by developing legally mandated programs, providing technical guidance, and consulting with and assisting departments in program implementation and maintenance.
- Develop safety education and monitoring programs to maintain a safe and healthy environment for faculty, staff, students and visitors in order to facilitate the research and teaching functions of the college.
- Describe the provisions of the Chemical Hygiene Plan to those attending lab safety trainings and orientations.
- Monitor and evaluate the effectiveness of the Chemical Hygiene Plan.
- In cooperation with, and as a member of the Chemical Hygiene and Safety Committee, advise campus management on the effectiveness of the Chemical Hygiene Plan implementation and make recommendations for program upgrades.

III. Facilities Management.

- Ensure the timely repairs of malfunctioning equipment such as fume hoods, alarms etc.

- Notify lab personnel and/or Chemical Hygiene Officer as appropriate when equipment is inoperable or malfunctioning and may affect the safe operation of college laboratories,
- Any maintenance to be performed that will affect any operations of a laboratory must be relayed to the Chemical Hygiene Officer and appropriate laboratory supervisor prior to the work being performed.

IV. Responsibilities of All personnel who handle hazardous chemicals.

All personnel in research or teaching laboratories that use, handle, or store hazardous chemicals are responsible for:

- Annually reviewing the Chemical Hygiene Plan as well as review of the appropriate safety manuals and policies,
- Following all verbal and written laboratory safety rules, regulations, and standard operating procedures required for the tasks assigned,
- Developing good personal chemical hygiene habits, including but not limited to keeping the work areas safe and uncluttered,
- Planning, reviewing and understanding the hazards of materials and procedures prior to conducting work,
- Utilizing appropriate measures to control identified hazards, including consistent and proper use of engineering controls, personal protective equipment, and administrative controls,
- Gaining prior approval from the PI/laboratory supervisor before using particularly hazardous substance,
- Report all accidents and unsafe conditions to the PI/laboratory supervisor.

2 Components of Chemical Hygiene Plan

OSHA Laboratory Standard (29 CFR 1910.1450) specifies the mandatory requirements of a Chemical Hygiene Plan to protect laboratory workers from harm due to hazardous chemicals exposure. The required Chemical Hygiene Plan elements include:

- Fume hood and other protective equipment performance,
- Standard operating procedures involving use of hazardous chemicals,
- Criteria to determine and implement control measures to reduce exposure,

- Information to be provided to lab personnel working with hazardous substances,
- Medical exams and consultation following acute exposure,
- Prior approval for certain laboratory operation,
- Provisions for additional worker's protection for work with particularly hazardous substance.

2.1 Chemical Hygiene Plan Review and Update

The Chemical Hygiene Plan will be reviewed annually and, if necessary, updated by the chemical hygiene officer. Changes to the plan will be based on regulatory changes, changes in college wide safety policies and practices, feedback from laboratory personnel, and results of laboratory inspections. Updated versions of the Chemical Hygiene Plan will be posted on the Hartwick College website.

3 Common Laboratory Violations

- Improper labeling of hazardous waste containers.
- Failure to perform hazardous waste determination.
- Improper disposal of hazardous waste.
- Improper management of expired hazardous waste.
- Open chemical containers.
- Undated chemical containers.
- Missing standard operating procedures.
- Improper restraining of gas cylinders.
- Not wearing personal protective equipment when working with hazardous chemicals.
- Not segregating chemicals based on hazard class.
- Glass bottles containing chemicals stored on the floor.
- Chemicals stored over edges of shelves.
- Food in lab refrigerators.
- Storage of greater than 10 gallon flammable chemicals outside flammable cabinet.

4 Basic Steps to Comply with Regulations

- Label all containers. Each container must have the chemical name displayed. The components of the waste (if a mixture) must be labeled by percent/volume and the words **Hazardous Waste**.
- To be considered a satellite accumulation area, the waste must be at or near the point of generation (must remain in the lab where generated).
- To have waste moved to 180-day storage area for disposal, the waste must have all labeling as aforementioned and be dated.
- Unwanted hazardous materials must be disposed of in a timely fashion.
- Large accumulations of unwanted hazardous materials should be avoided.
- Lids on containers of unwanted hazardous materials must be securely fastened except when filling or removing materials from the container. Do not leave open funnels in containers or open containers in the fume hoods.
- Hazardous materials must be segregated by hazard class. Do not store solely by alphabetical order.
- Compatible containers and closures must be used. Containers for unwanted hazardous materials must be of good condition and not react with the unwanted hazardous materials they hold.
- Good housekeeping is essential.
- Biohazardous waste is to be stored in double red bags inside rigid, leak proof, and covered containers labeled with the word Biohazard and the international biohazard symbol. Do not overfill containers.
- Keep waste containers closed.
- Review chemical compatibility throughout the lab.
- Secure cylinders with an upper and lower non-combustible restraint.
- Remove the regulator and place the cylinder cap on cylinders that are not in use.
- Keep the chemical spill kit stocked and handy.
- Do not overfill sharps containers. Anything sticking out the top of the container is a violation.
- Properly label sharps containers according to the contents and contaminants present.

5 Hazard Communication

Post a current chemical abbreviation reference sheet in the lab if chemical abbreviations are used for labeling.

Laboratory Specific Abbreviations (Post in the lab)

HCL	**Hydrochloric acid**
HF	**Hydrofluoric acid**
TCA	**Trichloroacetic acid**
H_2SO_4	**Sulfuric acid**
KOH	**Potassium hydroxide**
NH_4OH	**Ammonium hydroxide**
NaOH	**Sodium hydroxide**
MeOH	**Methanol**
EtOH	**Ethyl alcohol**
IPA	**Isopropyl alcohol**

5.1 Laboratory Workers Education and Training

Laboratory safety training is required at the time of initial work in the lab and when new hazards or processes are introduced. Training is required for principal investigators, visiting researchers, and other personnel working in the laboratory. Training must include physical and health hazards in the work area, including exposure control measures. At a minimum, employee training will include:

- Methods used to detect the presence or release of hazardous chemicals,
- Physical and chemical hazards of chemicals in the area,
- Protective measures used to reduce hazards and exposure,
- Details of the chemical hygiene plan,

Safety training requirements includes:

HAZCOM – conducted initially and as new hazards are introduced to the workplace,

Blood Borne Pathogens – required annually for any personal working with human blood or body fluid, Lab Safety – Required annually for all personnel working in Hartwick College labs,

Hazardous Waste Awareness Training- Required annually for any personnel involved with the generation, handling or storage of hazardous waste,

Carcinogen safety – all university personnel and students working with carcinogens are required to have special training in the handling and use of carcinogen materials.

The primary investigator is responsible for training lab personnel regarding specific hazards and SOPs in their area.

5.2 List of Hazardous Substances

All labs are required to keep their on-line chemical inventory updated at least every 60 days for each hazardous substance in their possession (http://info.hartwick.edu/forms/chemicalinventory/). Specific information on any associated health and safety hazards must be made readily available to all laboratory personnel.

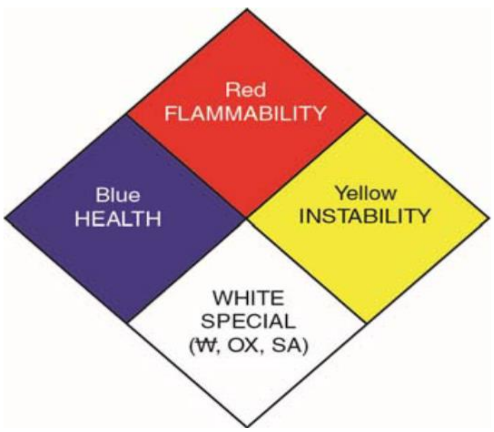
5.3 Laboratory Contact Information and Signage

All laboratories are required to have contact information, room identification, hazard identification, and emergency contact signage posted at all laboratory entrances. This signage will be used in case of emergency or equipment failure in lab space. It is important to keep this signage updated, and reviewed annually and/or whenever there is any information change.

5.4 Chemical Safety Information Sources

The laboratory standard requires employers to provide chemical information to all laboratory personnel. Hartwick College provides numerous sources of chemical information for personnel working in laboratories. Laboratory personnel can identify basic chemical hazards by product labeling on incoming chemical containers as required by OSHA’s Hazard Communication Standard. Laboratory personnel are instructed to label temporary containers with the chemical name and hazard class. Laboratory door placards/signs such as those required by the local fire department provide a visual indicator of the type and degree of hazards. Rooms containing hazardous chemicals are labeled with a NFPA (National Fire Protection Association) door placard that gives an overview of the key chemical hazards contained within that room.

Based on the hazards, the placard may contain 1-4 number rating symbol that quickly supplies the hazard information. 1 indicates a low level of hazard and 4 indicates a high hazard level. The four chemical hazard types correspond to the four color areas. Red indicates a flammability hazard, yellow indicates a reactive hazard, blue indicates a health hazard, and white portion is reserved for special hazards that are identified by hazard symbols or labels to indicate hazards such as radioactivity, biohazard, water reactive chemicals etc.



Each of these hazards has a different set of safety precautions associated with them.

5.5 Safety Data Sheets (SDS)

SDSs must be available for each hazardous substance in a laboratory's chemical inventory. New chemical substances synthesized or produced in a laboratory and used or shared for commercial purposes outside of the lab where it is created require the preparation of an SDS for each synthesized substance.

5.6 Labeling Chemicals

Original labels on incoming containers of hazardous chemicals shall not be removed or defaced until the container is completely empty. All hazardous chemicals must be clearly labeled with the complete chemical name. Chemical formula can be used on the label when the reagent is for short-term use and under control of lab personnel. Proper labeling is beneficial to current and future chemical users. Labeling is also required for emergency personnel. Hazardous reagents prepared by lab personnel must be labeled with contents of the container and hazard warning. If abbreviations are used, there should be a posting listing the abbreviations used, along with the full chemical names. Use the symbols in the Globally Harmonized System of Classification and Labeling of Chemicals.

5.7 Permanent Container Labels

In compliance with OSHA's Hazard Communication Standard, every container in the lab must be labeled. The labeling should entail:

- The identity of the chemical and appropriate hazard warnings must be shown on the label,
- The hazard warning must provide users with an immediate understanding of the primary health and/or physical hazard (s) of the hazardous chemical using words, pictures, symbols or any combination of these elements,
- The name and address of the manufacturer, importer, or other responsible party must be included on the label,
- The hazard label message must be legible, permanently displayed, and written in English.

5.8 Portable (Secondary) Container Labels

Laboratory operations often require transferring chemicals from the original labeled container into a secondary container (e.g., beaker, flask or bottle). Portable containers must comply with the labeling requirements if any of the following events occur:

- The material is not used within the work shift of the individual who makes the transfer,
- The worker who made the transfer leaves the work area,
- The container is moved to another work area and is no longer in the possession of the worker who filed the container,
- Labels on portable containers are not required if the worker who made the transfer uses all of the contents during the work shift.

This label must contain two key pieces of information: the identity of the hazardous chemical(s) in the container (e.g.chemical name) and the hazards present.

5.9 Replacing Container Label

The existing label on a container entering the lab from a supplier must not be removed, altered, or defaced. If a chemical container's original label must be replaced, the new label must contain the same information as the original. Only use labels, inks, and markings that are not soluble in the liquid content of the container.

5.10 Chemical Procurement

Each department should use a centralized purchasing program in which an individual knowledgeable of all chemicals on hand does all purchasing, or links purchasing requests into an inventory tracking system so that excess chemicals in stock can be used before future purchase. Recommended practices for ordering chemicals include:

- Order quantities consistent with the rate of use,
- Order only what will be used within a year or less,
- Order reagents in polyethylene bottles or plastic coated glass bottles to minimize breakage, corrosion, or rust,
- Substituting non-hazardous chemicals or less toxic materials into experiments whenever possible,
- Redistribution of unwanted chemicals within laboratories,
- Modify experiments to decease quantity of hazardous waste generated,
- Determine whether the appropriate mechanism and sufficient ventilation is available for the proper storage of the chemical,
- Utilize inventory management and control to prevent build-up of waste chemicals.

5.11 Receiving Hazardous Materials

Upon receipt of hazardous materials, lab managers should date chemical containers and enter them into the lab inventory (http://info.hartwick.edu/forms/chemicalinventory). Date chemicals when first opened. Do not accept damaged or leaking packages from vendors. Hazardous materials packages must be inspected at the time of arrival to ensure containers are not damaged or leaking. Notify campus safety or chemical hygiene officer if damage or leaks are discovered during chemical storage.

5.12 Planning Operations

The principal investigator must develop standard operating procedures and must approve all new experimental protocols and any significant modifications to existing protocols. The following practices should be observed during the planning stage of all laboratory operations:

- Development and implementation of standard operating procedures,
- Risk assessment of chemicals and materials,
- Plan appropriate safety procedures,
- Review all applicable SDSs before handling chemicals,
- Locate emergency supplies and exists,
- Train all laboratory personnel in emergency response, protocol and procedures to use in the event of a chemical spill,
- Ensure that aisle paths are clear and kept clear during laboratory operation,
- Plan positioning of equipment before beginning of lab operations,
- Understand and follow the proper procedures for working with and disposing of hazardous materials.

6 Hazardous Chemical Waste Management

Federal, state, and local laws strictly regulate the disposal of hazardous materials. The disposal of any hazardous material in the sewer or in regular trash is forbidden. The standard operating procedure must include procedure for hazardous waste management and disposal. Hazardous waste regulations are stringent and penalties for violations can be severe. Treat all waste chemical solids, liquids, and containerized gases as chemical waste. Hartwick College is a generator of Resource Conversation and Recovery Act (RCRA) regulated waste. All generators of RCRA regulated waste are required to determine if the waste is hazardous. Hazardous waste can be determined by specifically listed hazardous waste or if the waste has a regulated characteristic.

6.1 Listed Hazardous Waste

- K listed waste from specific sources.
- F listed waste from non-specific sources.

- U listed waste discarded commercial chemicals.
- P listed waste discarded commercial chemicals designated as acutely hazardous.

6.2 Characteristics of Hazardous Waste

- Ignitability: Liquid other than an aqueous solution which has a flash point of less than or equal to 140F (60C), solids capable of causing fire by friction or absorption of moisture, or spontaneous chemical changes.
- Corrosivity: Aqueous with a pH less than or equal to 2 or greater than or equal to 12.5. Liquid which corrodes steel at a rate greater than 0.25 inches per year at a test temperature of 130F (55C).
- Reactivity: Air/water reactive, shock sensitive, explosive. Normally is unstable and readily undergoes violent change without detonation. Generates toxic gases, vapors, or fumes when mixed with water.
- Toxicity: These materials can cause serious illness or death from exposure by inhalation, ingestion, or absorption through the skin.

6.3 Hazardous Waste Storage

- Store chemical waste in a designated area, label as HAZARDOUS WASTE STORAGE AREA.
- Store chemicals in containers compatible with and durable enough for waste content.
- Liquid waste must be in screw-top containers. Do not overfill – allow for expansion.
- Segregate waste by hazard class.
- Chemical waste containers must be kept closed at all times except to add waste.
- Label chemical waste containers with chemical waste label as soon as waste accumulation begins.
- Store chemical waste with secondary containment. Incompatible waste cannot be stored in the same secondary spill containment so that in the event of commingling there will be no reactivity.
- Laboratories should minimize storage of chemical waste and not accumulate waste for longer than 30 days after filling.

6.4 Hazardous Waste Labeling

In order to comply with Environmental Protection Agency (EPA) regulations regarding hazardous waste a chemical waste collection container must be appropriately labeled as soon as accumulation begins. The container must clearly be labeled with the words **Hazardous Waste**. Chemical waste must be kept at or near (in the same lab) the point of generation in order to be considered satellite accumulation areas. Once the chemical waste is removed from the point of generation for storage, it must be dated and the words Hazardous Waste clearly labeled on the container. The college then has 180 days to properly dispose of the hazardous waste.

- Identify waste by proper chemical name (no abbreviations or chemical structures). List chemical names of hazardous components in the mixture by percent weight.
- Completely deface or remove old labels if reusing a container and the contents are not identical to the original product. Make sure the chemical waste is compatible with the container and its previous contents.

6.5 Hazardous Waste Packaging

Waste storage containers must be non-leaking, chemically compatible, safe, and clearly labeled. Keep all hazardous materials in appropriate closed containers. All hazardous material containers should remain closed at all times except when adding or removing materials. The following guidelines must be followed when packaging hazardous waste for disposal:

- Use a leak-proof container that will safely contain the contents,
- Do not overfill a container with liquid waste, allow an empty space of approximately five percent of the container volume for thermal expansion. This will control pressure buildup inside the container,
- The condition of the container should be first evaluated. Old cans of ether, picric acid, and other peroxide forming or shock sensitive items shall be left in place and not disturbed. Do not mix incompatible chemicals,
- Do not mix hazardous materials with non-hazardous materials,
- Loose solid materials must be placed in a sealed container or in a covered cardboard box lined with two polyethylene bags.

6.6 Hazardous Waste Disposal

- Chemicals may not be disposed in regular trash, sink, or allowed to evaporate. Treatment of unwanted hazardous materials for rendering them non-hazardous is not permitted at Hartwick College. Corrosives may be treated by elementary neutralization. Corrosives must have a pH between 6.5 and 9.75 before disposal down the sanitary sewer.

6.7 Hazardous Waste Minimization Steps

Corrosive acids and bases are common waste generated in laboratories on campus. Corrosivity is the only hazardous waste characteristic that may be treated by a generator onsite without an EPA permit. Generators of corrosive wastes that have no other hazardous characteristics should neutralize the wastes to a pH between 5.5 and 9.5. The neutralized non-hazardous waste may then be drain disposed followed with a good water flush.

Procedures for neutralizing acids and bases are described in the following three sections. Neutralization is recommended only for very small volumes of corrosive acids and bases.

General Neutralization Procedures

- Do neutralization in a fume hood behind a safety shield, as vapors and heat may be generated. Wear lab coat or apron, gloves, and goggles. A face shield in combination with safety goggles is recommended.
- Keep containers cool during process, such as placing a beaker in a bucket with slushy ice, and work slowly.
- After neutralization is complete, dispose of down the drain followed by 20 parts water to the neutralized solution.

Acid Neutralization

While stirring, add acids to large amount of an ice water solution (1:10) of base such as sodium carbonate, calcium hydroxide, or sodium hydroxide for concentrated acids. When a pH of at least 5.5 to 9.0 is achieved, disposed of the solution down the drain followed by 20 parts water to the neutralized solution.

Base Neutralization

Add the base to a large vessel containing water (1:10). Slowly add a 1M solution of Hydrochloric acid. When a pH of 5.5 to 9.0 is achieved, dispose of solution down the drain followed by 20 parts water to the neutralized solution.

6.8 Disposal of Empty Containers

Hazardous chemical containers cannot be discarded until they are considered empty. In order to be considered empty, containers holding acutely hazardous P listed waste (the P list includes acutely hazardous waste that are considered especially harmful even in small quantities such as cyanide) must be tripled rinsed, with a solvent able to remove the residue. The rinsate must be collected and disposed of as hazardous waste. Other hazardous chemical containers are considered empty when as much material as possible has been removed and there is less than 3% by weight of the original contents left in the container.

6.9 Sharps Disposal

"Sharp waste" means any device having acute rigid corners, edges, or protuberances capable of cutting or piercing. Glass items contaminated with biohazards like pipettes, microscope slides, and capillary tubes are considered biohazard sharp waste. Biohazard sharp waste should not be disposed of in normal trash.

Sharps Contaminated with Hazardous Chemical Waste

- Deface any biohazards symbols prior to collection of sharps.
- Collect in a rigid, puncture resistant, leak proof container.
- Label the container with a hazardous waste label and include the chemical constituents.

Sharps Contaminated with Biohazardous Waste

- Label the sharps container with the words autoclaved.
- Autoclave sharps containers for a minimum of 30 minutes at 121^0C.
- Collect in approved biohazardous sharps container that is red in color and puncture resistant.

6.10 Universal Waste Management

Universal wastes are hazardous wastes that are regulated by 40 CFR Part 273. Universal Wastes includes, batteries, mercury containing equipment, and lamps. A small quantity handler of universal waste maintains less than 5000kg (11,023 lbs.) of waste on site at any time. A large quantity handler of universal waste maintains 5000kg or more of universal waste on site at any time. All handlers of universal waste must follow a set of rules to comply with 40 CFR Part 273, in addition to state specific rules.

1. Containers used to store universal waste must be structurally sound, closed, compatible with the contents of the containers, and in good condition.

2. Label the containers to identify the type of universal waste.
    a. Batteries can be marked "universal waste – batteries", "waste batteries", or "used batteries".
    b. Mercury containing equipment can be marked "universal waste – mercury containing equipment".
    c. Lamps can be marked "universal waste – lamps", or "waste lamps" or "used lamps".
3. A generator may accumulate universal waste for no longer, than one year from the date the universal waste is generated.
4. A generator must be able to demonstrate the length of time a waste has been in storage by labeling containers with the earliest date that universal waste in the container became a waste, or by maintaining a log that shows the earliest date waste was accumulated.

Some best practices for the storage of universal wastes are to set aside an accumulation area specifically for these wastes, inspect containers regularly to make sure they are closed and structurally sound, monitor the earliest date a material became a waste to ensure disposal within the one year time limit, and maintain certificates of recycling from the receiving facility.

Storage and packaging guidelines

<u>Batteries</u>

- Low or non-mercury containing alkaline and carbon zinc batteries can be recycled or disposed of as non-hazardous solid wastes.
- For sealed lead acid, nickel- cadmium, lithium ion, mercuric oxide, silver oxide, and other alkaline batteries, the following recommendations apply:
    - Store batteries in a safe, leak-proof container in a secure location.
    - Label each container of batteries with the earliest date a battery was discarded
    - Package batteries so terminals will not come into contact with each other (insulate the terminals with tape)

Place clear tape over the terminals/contact points.

Place the same type of batteries together and then place clear tape over the tops.

<u>Lamps</u>

Newer bulbs, such as green end and compact fluorescents, may be managed as non-hazardous solid wastes. Place bulbs in containers that the replacement bulbs came in unless another container is provided. Make sure the containers remain closed while in storage.

Mark the earliest date the bulbs were placed in storage on the container and keep a record to document the one-year storage limit. Crushing bulbs can release mercury into the air and expose employees to mercury via inhalation.

<u>Mercury containing equipment</u>

Examples of mercury containing equipment include electrical relays or switches, thermometers, thermocouples, gauges, barometers, and other devices containing elemental mercury. Handlers of these types of universal waste need to:

- Ensure the waste is recycled,
- Ensure that containers are closed, structurally sound, and compatible with the contents,
- Mark the earliest date the waste was accumulated in the container, and keep a record to document the one year storage limit.

Mercury that has been spilled, along with clean up materials and residues, is not managed as universal waste, but rather hazardous waste.

7. Compressed Gas Cylinder

Compressed gases have a large amount of energy stored in the cylinder from the compression of the gas. Additional hazards can arise from the gas content. The gases used maybe flammable, a combination of hazards, corrosive, explosive, acidic, reactive, or inert gases. Safety strategies are necessary for managing compressed gases, cylinders, regulators, or valves. Compressed gas cylinders can explode, destroying equipment and injuring workers. Cylinders and regulators can become flying projectiles when cylinder valves are damaged. Safety procedures when handling, storing, and transporting compressed gas cylinders include:

- No compressed gas cylinder should be accepted for use that does not legibly identify its contents by name. If the labeling on a cylinder becomes unclear, the cylinder should be marked **contents unknown** and returned to the supplier.
- Do not rely on the color of the cylinder for identification. Color-coding is not standardized and varies with supplier. Tags hung around the necks of the cylinders are not acceptable.
- Cylinders must not be accepted from vendors unless the valve safety covers are in place and tightened properly.

- Cylinders must not be rolled on their sides or dragged. Transported cylinders must be chained on carts.

7.1 Handling and Use of Cylinders

- Reference Safety Data Sheet (SDS) for the gas being used.
- Only use tools that are provided by the cylinder supplier to open or close value.
- Inspect the regulator and cylinder valves for grease, oil, and solvent. Grease or oil will enhance an explosion.
- Make sure the cylinder is equipped with the correct regulator.

7.2 Cylinder Storage

- Use appropriate materials (chains, commercial straps) to secure cylinders.
- Gas cylinders cannot be stored in hallways.
- Cylinders must be segregated. Oxidizers (oxygen) must be separated from flammable gases. Empty cylinders must be segregated from filled cylinders.
- A minimum of 20 feet is required between flammable gas cylinders and oxygen cylinders during storage or by a firewall five (5) feet high with a fire rating of 30 minutes.

7.3 Compressed Gas Leak

A simple gas leak presents no or minimal inhalation or fire hazards. Do not try to repair the leak if the leak is at the junction of the cylinder valve and the cylinder. In this situation, contact the supplier and ask for appropriate response instructions. A major gas leak presents a large or uncontrollable leak. Alert other building occupants and evacuate the area. Contact emergency responders and the manufacturer. In the following example, the amount of leaked gas can be calculated from the given information:

A 1ft ^{3,} compressed gas cylinder containing carbon dioxide gas has a pressure of 500psig at normal temperature. A leak in the cylinder lowers the gauge reading to 250psi. What is the volume of the leaked carbon dioxide gas at normal pressure and temperature?

Solution:

Use the ideal gas law to calculate the change in volume. Where $P_1V_1/T_1 = P_2V_2/T_2$

P= Pressure

V= Volume

T = Absolute Temperature

Initial absolute pressure = 500 psig + 14.7 psi = 514.7 psi

The amount of the gas that leaked = 250 psi / 514.7psi = 0.486 or 48.6%. The initial volume of the amount of gas that leaked = 0.486 ($1 ft^3$) = 0.486 ft^3

(514.7 psi) (0.486 ft^3) = (14.7 psi) V_2

V_2 = (514.7 psi) (0.486 ft^3) / (14.7 psi) = 17 ft^3

7.4 Cryogenic Liquids

Cryogens are substances used to produce very low temperatures (below -153^{0}C (-243^0 F)), such as liquid nitrogen (LN_2), which has a boiling point of -196^{0}C (-321^{0}F). Although not a cryogen, solid carbon dioxide or dry ice which converts directly to carbon dioxide gas at - 78^{0}C (-109^{0}F) is also used in laboratories.

These items present the potential hazards of pressure buildup, embrittlement of structural material, frostbite, and asphyxiation. Work areas must be well ventilated. Cryogenic liquids must be stored, shipped, and handled in containers that are designed specifically for this purpose. Because of the extreme cold and splash hazards, skin protection and eye protection (face shield) should be worn when handling cryogenic liquids. General precautions when working with dry ice or LN_2:

- Avoid eye or skin contact with these substances.
- Never handle dry ice or LN_2 with bare hands.
- Use cryogenic gloves, which are designed specifically for working in freezers below – 80^{0}C and for handling containers or vials stored in these freezers.
- Cryogenic gloves need to be loose fitting so that they can be readily removed if LN_2 splashes into them or a piece of dry ice falls into them.
- Always use appropriate eye protection.
- Do not use or store dry ice or LN_2 in confined areas, walk in refrigerators, environmental chambers, or rooms without ventilation. A leak in such an area could cause oxygen deficient atmosphere.
- Adequate ventilation must always be used to prevent the build up of vapors.
- Never place a cryogen on tile or laminated counters because the adhesive will be destroyed.

- Never store a cryogen in a sealed, airtight container at a temperature above the boiling point of the cryogen. The pressure resulting from the production of gaseous carbon dioxide or nitrogen may lead to an explosion.
- For more information about specific cryogens, read the Safety Data Sheet.
- In case of exposure to cryogens or dry ice, remove any clothing that is not frozen to the skin. Do not rub frozen body parts because tissue damage may result. Obtain medical assistance as soon as possible.
- Place the affected part of the body in a warm water bath (not above 40^0C). Never use dry heat.

8. Chemical Exposure Control

The risk associated with an experiment should be determined before the laboratory work begins. Understanding the hazards of chemicals and the risk of exposure is critical to minimizing and controlling exposures. Elimination of a hazardous substance or substitution with a less hazardous substance should be initiated first. Engineering control, administrative and personal protective equipment are other options to control chemical exposure.

The Chemical Hygiene Officer shall conduct air monitoring to determine student or employee exposure to regulated substances. Air monitoring should be compared to the action level or OSHA permissible exposure limit (PEL). PELs for chemicals can be found in SDSs, OSHA 29 CFR 1910.1000, and the NIOSH pocket guide to chemical hazards.

8.1 Engineering Control

Examples of engineering controls used in laboratories at Hartwick College include dilution ventilation and local exhaust ventilation (chemical fume hoods, ventilated storage cabinets, and snorkel). Engineering controls reduce or eliminate exposure to chemical or biological agents and can be used with administrative controls or personal protective equipment. Whenever possible, substitution of less hazardous chemicals should be used as a primary method of preventing adverse effects due to chemical exposure. Used in conjunction with good work practices, properly designed and operated exhaust ventilation is effective in minimizing air contaminant.

8.2 Building (General) Ventilation

Lab spaces are designed to exhaust 100% air outside and slightly under negative pressure relative to other parts of the building. Lab ventilation should provide at least 6 air changes per hour (ACH) of uncontaminated air. This keeps contaminant level relatively low.

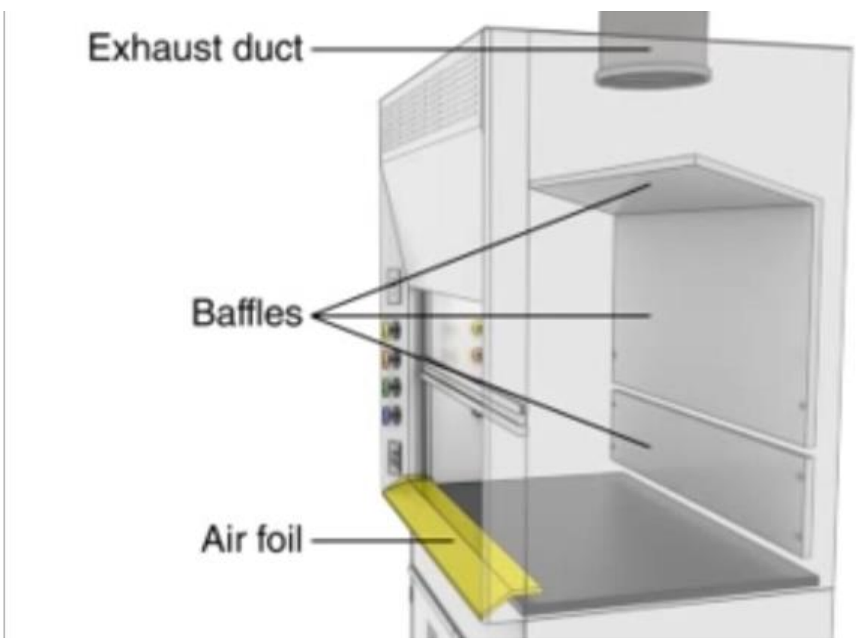
8.3 Chemical Fume Hood

The fume hood is often the primary control device for protecting laboratory workers when working with flammable and/or toxic chemicals. OSHA's laboratory standard requires that fume hoods be maintained and function properly when used. The chemical fume hood is an engineering control used to minimize chemical exposure, but cannot be used when working with regulated infectious agents. Chemical fume hoods must be certified annually and the date of certification indicated on the sticker. College Facilities will be responsible for the annual inspection and certification of fume hoods.

Before beginning work in a chemical fume hood, the lab personnel should confirm the fume hood monitor is functioning properly. The air flowing into the hood should also be confirmed using a Kim wipe.

- Fume hoods are not designed for storage. Keep baffles at the back of the hood unobstructed. Chemical bottles and equipment within the fume hood should be minimized to improve fume hood performance.
- All work should be at least six inches into the fume hood.

- Fume hoods should be operated with sashes lowered as far as possible.
- Rapid arm or body movements, people walking by the hood, open doors/windows all create cross drafts or air currents near the hood. These actions can move contaminated air into the breathing zone.
- Make sure that users understand how the hood works.
- Staff and studenst should be trained to use it properly.
- Know the hazards of the chemical being worked with. Refer to the chemical's Safety Data Sheet if unsure.
- Ensure that the hood is on.
- Make sure that the sash is open to the proper operating level, which is usually indicated by arrows on the frame.
- Make sure that the air gauge indicates that the airflow is within the required range. Reading should be between 80 and 120 cfm.



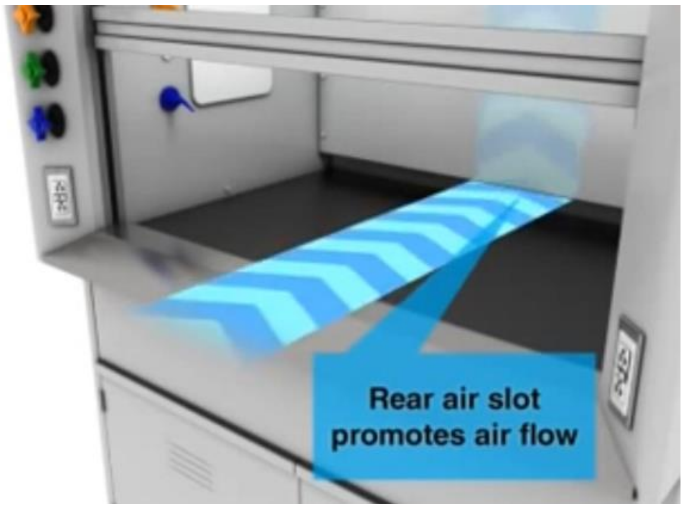
- Never allow users head to enter the plane of the hood opening.
- Use appropriate eye protection.
- Be sure that nothing blocks the airflow through the baffles or through the baffle exhaust slots.

- Promptly report to the supervisor any hood that is not functioning properly.

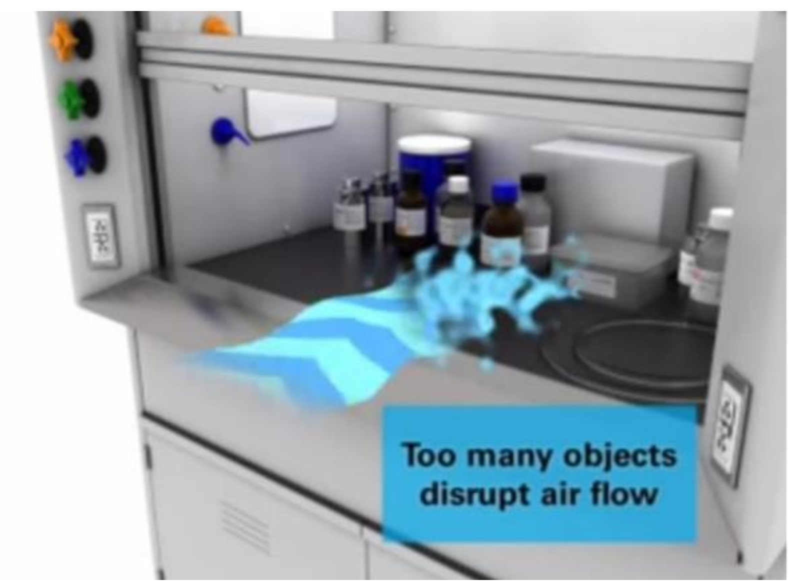
Proper Use of Baffles

Used to create slotted opening along the back of the hood body.

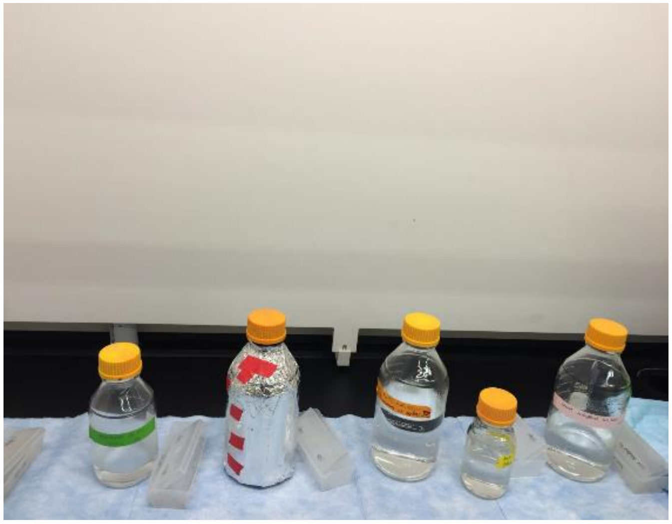
- Baffles keep the airflow uniform across the hood opening.

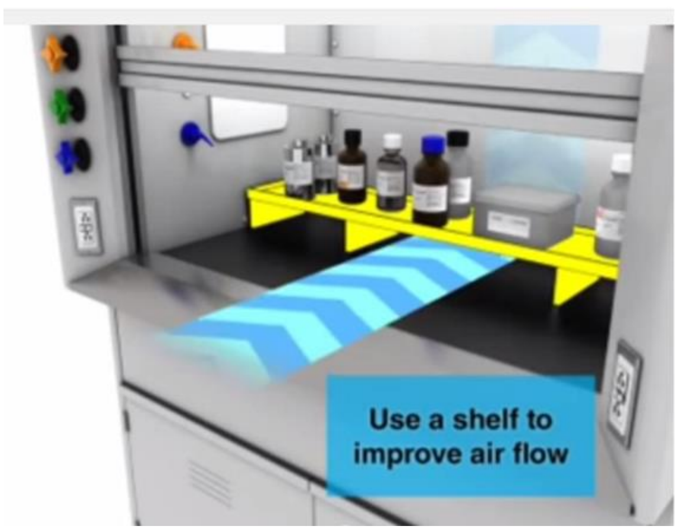


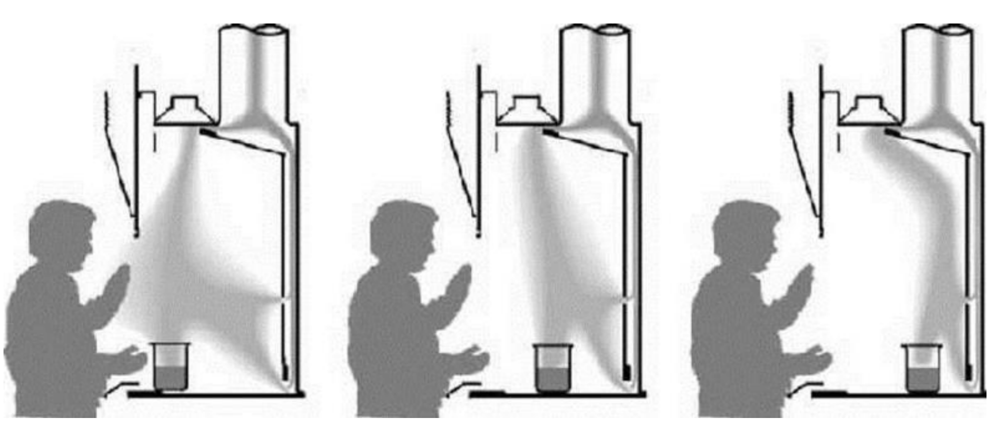
- Storing materials against the back reduce the efficacy of the hood for containing contaminants.



- Moving things a few inches away from baffles improves hood performance.





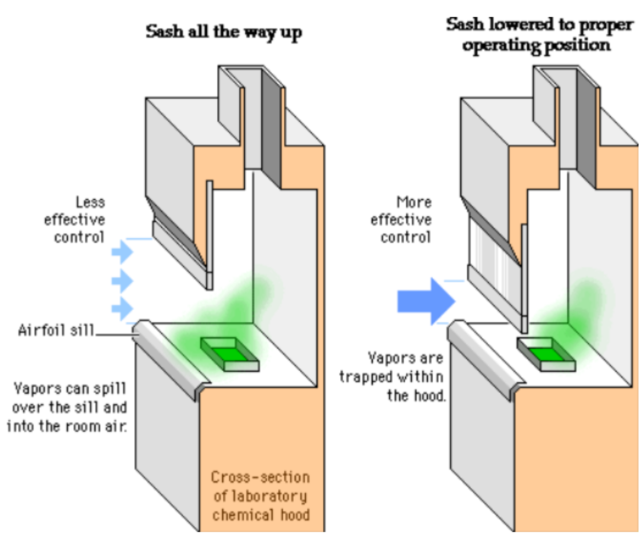


< 6″ ~6″ >6″

- Place all items at least 6 inches inside the hood (6 inches in from the sash).
- Mark a line with tape 6 inches inside on the work on work surface.
- Keep all chemicals and equipment behind that line during procedures.
- This helps keep vapors from escaping the hood.

Consider all things placed in the hood and how they might impede performance.

Proper use: Sash height



- The optimal sash height for proper performance should be marked on the hood and is usually 12-18 inches.
- Work with sash at this height or lower.
- Never raise the sash above marked height while working with hazards in the hood.
- Keep as low as possible when working.

8.4 Snorkel Ducts

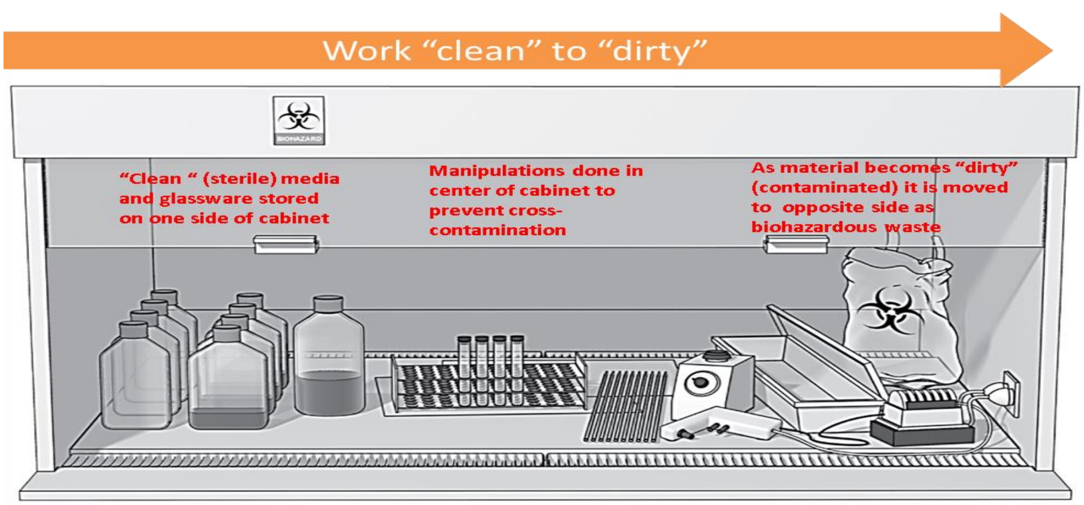
The snorkel ducts consist of a bell mouth and articulated connection to the exhaust system. The snorkel does not fully surround the reaction at the point of release. It is susceptible to cross drafts. Hence, the snorkel is not ideal when working with toxic chemicals. Snorkels generally operate at 45 fpm and can capture contaminants released within 6 inches (15cm) of the unit. Snorkels are better employed in the capture and removal of thermal updrafts from bench top-heated process or gas chromatographs.

8.5 Biological Safety Cabinet

A biological safety cabinet (BSC) is used as a primary barrier against exposure to infectious biological agents. A biological safety cabinet has High Efficiency Particulate Air (HEPA) filters. The airflow in a BSC is laminar, i.e. the air moves with uniform velocity in one direction along parallel flow lines. BSCs are not chemical fume hoods. A percentage of the air is recirculated in most types of BSCs. HEPA filters only trap particulates, allowing any contaminant in non-particulate form to pass through the filter.

8.6 Proper Use of Biological Safety Cabinet

- Operate the cabinet for five minutes before and after performing any work in it in order to purge airborne contaminants.
- Before and after use, wipe the surface of the BSC with a suitable disinfectant, e.g., 70% alcohol or a 10% bleach solution.
- Place everything needed inside the cabinet before beginning work, including a waste container. You Do not penetrate the air barrier of the cabinet once work has begun.
- Do not place anything on the air intake grills, as this will block the air supply.
- Always wear a lab coat while using the cabinet and conduct work at least four inches inside the cabinet.
- Do not work in the BSC while the ultraviolet light is on. Ultraviolet light can quickly injure the eye.
- When finished with work procedure, decontaminate the surfaces of any equipment.
- Set up work surface from clean (left) to dirty (right).
    - Sterile cell culture (left).
    - Inoculate culture (center).
    - Contaminated pipettes, biohazard containers (right).



8.7 Administrative Controls

Administrative controls consist of various safety policies, rules, supervision, and training in order to reduce the duration, frequency, and severity of exposure to hazardous chemicals. The following administrative controls should be implemented:

- All laboratory personnel should be provided with adequate lab safety training,
- Prior approval and additional control measures are required when working with particularly hazardous materials,
- Post appropriate signs to identify specific hazards within an area,
- Good housekeeping should be observed at all times in the laboratories,

8.8 Personal Protective Equipment

Personal protective equipment (PPE) is designated as the last line of defense. It should be used in combination with engineering controls or administrative procedures as an additional measure of protection. PPE includes laboratory coats, aprons, safety glasses, and gloves. Personal protective equipment can be issued to laboratory workers only after a hazard assessment made by the Principal Investigator or Chemical Hygiene Officer. Lab personnel should be trained on the use, limitations, and maintenance of PPE.

8.9 Safety Glasses

Safety glasses protect eyes from flying particles and contact with chemicals. To be effective, eyewear must be appropriate for work. A risk assessment should be conducted before appropriate eye and face protection is chosen. Eye protection must meet the ANSI standard Z87.1. Safety glasses should fit for adequate protection. Eyewear should be maintained because scratched and dirty lenses reduce vision. The three types of eye protection include safety glasses, goggles, and face shield. Safety glasses are designed to resist impact from flying particles. Goggles may be vented or non-vented. They are recommended for work with large volumes of chemicals. Non-vented goggles protect eyes from vapors, mists, and fumes. Vented goggles protect from liquids with no vapor or mist danger. Face shields protects the entire face and can be used with goggles.

8.10 Hand protection

Wear proper protective gloves when handling corrosive, toxic, very hot, or cold materials. The type of gloves used should be compatible with the chemicals. There is no universal glove used as protection from all chemicals. Chemicals eventually permeate all glove materials. Wear two gloves on each hand when handling highly toxic or carcinogenic materials. Before each use, inspect gloves for tears and punctures. Disposable gloves can be inflated by mouth to check for pinholes.

It is also essential to note that two similar gloves supplied by two separate manufacturers may not provide the same level of protection to a specific chemical. It is imperative to consult the manufacturer's compatibility chart for best protection. The following gloves selection chart provides examples of gloves compatibility with certain chemicals.

Latex	Good for biological components. Poor against organic solvents. Can trigger latex allergies.
Nitrile	Excellent for solvents, greases, oils, certain acids, and bases. Good alternative for those with latex allergies.
Butyl Rubber	Good for ketones and esters.
Neoprene	Good for acids, bases, fuel, hydrocarbons, and phenols.
Viton	Good for chlorinated and aromatic solvents. Resistant to cuts and abrasions.
Polyvinyl Alcohol	Good for aromatic and chlorinated solvents. Poor for water based solutions.
Polyvinyl Chloride	Good for acids, bases, fats, oils, amines, and peroxides.
Cryogenic Resistant	Used for cryogenic materials.

Material	

Thermal gloves should be used when handling small hot objects. When removing gloves, peel the glove off the hand, starting at the wrist and working toward the fingers, turning inside out. Avoid contacting the working surface area of gloves during removal. Wash hands as soon as possible after removing protective gloves.

8.11 Skin Protection (Lab Coats and Aprons)

Personal protective equipment (PPE) lab coats are a protective layer. Types of lab coats include disposable lab coats and reusable lab coats. They are used to provide coverage of the skin and clothing when working in the lab. A hazard assessment should be conducted prior to selection of skin protection. Typical lab hazard evaluation questions include:

- Toxicity of chemicals being used,
- Inadvertent spread of contamination,
- Types of hazards anticipated (chemicals, biological agents, radioisotopes, or multiple hazards).

One type of lab coat may not work for all lab work. Lab coat material should be reviewed once the type of hazard is identified. Lab coats should be knee-length and long-sleeved. However, short sleeves may be preferable if there is a possibility that long sleeves could be caught in mechanical operation.

Lab coat laundry. Lab coats grossly contaminated with biological, chemical, or radioactive materials should be disposed of as hazardous waste. Never take lab coats/aprons home for cleaning. Contact lab technicians for laundering services.

Disposable lab coats. This option is protective due to an anti-microbial layer that is tied to the main fabric. Disposable lab coats must be discarded after first use. The contaminants will determine if the lab coat should be disposed of as regular trash, biological waste, or hazardous waste. Disposable lab coats are generally made from materials that melt into the cloths and skin when exposed to fire. It is not advisable to select disposable lab coats when handling flammable, explosive, or other reactive materials that produce heat and flame.

Reusable Lab Coats. Assuming weekly laundry, reusable cotton lab coats will last about one year in normal daily use.

Flame-Resistant Lab Coats. These coats are recommended for work with open flames and reactive procedures. They are designed not to burn in air. Nomex materials provide the best protection from fire. They are resistant to a wide range of solvents, but lose integrity when exposed to chlorine bleach.

100% Cotton Lab Coat. These can be degraded by acids and are widely used for general lab practices.

Synthetic/Cotton Blends. These are the most combustible products and are not recommended when working with flammables.

Aprons. An apron is important for additional protection when working with acids due to the risk of chemical/biological splash. Aprons are never a substitute for lab coats and should be worn over a lab coat.

8.12 Respirators

The use of respirators must be coordinated in compliance with OSHA 1910.134. Respirators can only be used as the last means of defense against airborne contaminants or in an emergency. The N95 respirator is the most common respirator. This product filters at least 95% of airborne particles, but is not resistant to oil.

Limitations and use of N95:

- The N95 cannot be used in an atmosphere containing less than 19.5% oxygen or in an environment classified as immediately dangerous to life and health (IDLH).
- Weight change of more or less than 25 pounds, dental changes, and cosmetic surgery alters fit testing. Notify the supervisor should the user experience any of the above physical changes. Also, beards and facial hair render N95 ineffective.
- Users of the N95 should undergo medical clearance prior to fit-testing and fit test for N95 respirator annually.
- A wet N95 is not effective and should be discarded.
- When breathing becomes difficult with N95 or it is damaged or soiled, leave the contaminated area and dispose OF the respirator.

9 Signs and Symptoms of Chemical Exposure

The hazards of laboratory chemicals can be ascertained by referring to labels and chemical hazard reference material such as SDSs. In addition, the ability to recognize the signs and symptoms of chemical exposure is important. If chemical exposure has occurred, seek prompt medical attention at the health services or local hospital and contact the principal investigator or chemical hygiene officer.

Some signs and symptoms of chemical exposure include:

- Skin that has become dried, whitened, reddened, swelled, blistered, and itchy, or exhibits a rash.
- A chemical odor. Many chemicals can be detected at concentrations well below harmful levels or a chemical may be present without a detectable odor.
- A chemical taste. Some chemicals have characteristic tastes.
- Tearing or burning of the eyes.
- Burning sensations of the skin, nose or throat.
- Cough.
- Headache or dizziness.

These general symptoms may also be associated with conditions other than chemical exposure. The signs and symptoms of exposure to specific chemical are contained in the health hazard information section 11 of the SDSs. Laboratory personnel should be aware of the signs and symptoms of exposure to the chemicals they use.

10 Chemical Exposure First Aid

Inhalation: Remove individual to fresh air. If he/she not breathing, give artificial respirator. Seek medical help immediately.

Eye contact: If a chemical splashes into the eyes, immediately remove contact lenses (if applicable) and wash the eyes with a copious amount of water for 15 minutes. Seek medical help immediately.

Skin contact: If minor skin contact occur, remove contaminated clothing and flush affected area with water. If the skin contact is major, remove contaminate clothing while using the safety shower. Seek medical help immediately.

10.1 Exposure information

A licensed physician providing care to a potentially exposed worker must be provided the following information:

- The identity of and SDSs for the hazardous substance to which the worker may have been exposed,
- The conditions that surrounded the exposure,
- The signs and symptoms of exposure that the worker is experiencing.

10.2 Exposure Monitoring

Regular environmental or worker exposure monitoring of airborne contaminants is not usually warranted or practical in laboratories, since chemicals are typically used for a relatively short period of time and in small quantities. However, air monitoring will be conducted if:

- There is reason to believe that exposure levels for a substance routinely exceed either the action level (AL) or permissible exposure level (PEL) set by OSHA.
- Workers suspect or report that they have been overexposed to a chemical in the laboratory.
- A particularly hazardous substance is used on a regular basis or in large quantities.

Monitoring will be conducted in accordance with established sample collection and analytical methodology for the chemical exposure being evaluated. If initial monitoring indicates that worker exposure is above the AL or PEL, the periodic monitoring provisions of the relevant OSHA standard will be met.

11 Eating and/or Drinking Prohibition in labs

The OSHA lab standard and the Hartwick College Chemical Hygiene Plan prohibit eating and drinking in areas where hazardous chemicals or materials are in use. Eating and drinking refers to eating, drinking, applying cosmetics, adjusting contact lenses, taking/storing medicine, and other related activities. Personal safety risks can result from cross contamination and ingestion.

12 Housekeeping and Apparel

In the laboratory, keeping things clean and organized can help provide a safer environment.

- Keep drawers and cabinet doors closed and electrical cords off the floor to avoid tripping hazards.
- Wear clothing that covers the upper torso and arms.

- Wear closed toe shoes that cover the top of the foot.
- In laboratories where a fire danger is present, avoid clothing made of synthetic fibers like nylon.
- Long hair should be tied back.
- Safety glasses and lab coats should be worn at all times while working in the lab.
- Avoid stockpiling chemicals. Purchase only what is needed. Use older stock first. Discard chemicals that are no longer needed or that have expired.

13 Unattended Operation of Equipment

The operation of laboratory equipment overnight and unattended is strongly discouraged. The risk of flooding, fire, or release of hazardous materials associated with such operation is high. When unattended operation of equipment is necessary, the researcher shall:

- Leave the lights on.
- Post a sign on the exterior laboratory door describing the process that might cause a hazardous condition if there is experimental or power failure. The sign must include contact numbers for responsible parties.

14 Working Alone

Working alone is discouraged. In the event of an accident, the worker may be disoriented and need assistance. Always work with another person in the lab. Working in a laboratory alone or in isolated areas presents unique risk. Schedule work so that hazardous tasks are performed during times when the worker is not alone. Prior approval from the principal investigator is required before working alone in a laboratory. Campus Safety should be informed upon entering and leaving the building.

15 Cold Room Safety and Mold Prevention

Surfaces in a cold room often have mold contamination and this can alter research materials. The following are storage protocols in the cold room:

- Keep door firmly shut,
- Spilled liquids (media) should be cleaned up immediately and effectively,

- Discard contaminated media plates,
- Allocate specific storage space for each principle investigator to ensure that each investigator can control his or her space.

Implement following cleaning protocol for mold infested cold room.

- Wipe down plastic surfaces with a freshly made 1:10 dilution of household bleach.
- Wipe metal surfaces with 70% ethanol.

Because cold rooms are unventilated, enclosed areas, no chemical reactions should be performed. In addition, no volatile chemicals (even those in closed containers) should be brought into the cold room.

Cold Room Storage Requirement

All containers must be sealed by an appropriate method to prevent vapors/odors from escaping. All containers and trays must be labeled with the chemical name, hazard information, contact person, and date stored. Containers may get wet so, the use of cardboard containers and water-soluble markers is not practical.

16 Centrifuge Operation

The majority of all centrifuge accidents result from user error. To avoid injury, follow the manufacturer,s operating instructions for each make and model of centrifuge.

Follow these steps for the safe operation of centrifuges:

- Ensure that centrifuge bowls and tubes are dry,
- Ensure that the spindle is clean,
- Use matched sets of tubes, buckets and other equipment,
- Inspect tubes or containers for cracks or flaws before using them,
- Avoid overfilling tubes or other containers,
- Ensure that the rotor is properly seated on the drive shaft,
- Make sure that tubes or containers are properly balanced in the rotor,
- O-rings on the rotor should only be checked by staff who are properly trained,
- Apply vacuum grease in accord with the manufacturer’s guidelines,

- Do not exceed the rotors maximum run speed,
- Close the centrifuge lid during operation and make sure that the centrifuge is operating normally before leaving the area,
- Make sure that the rotor has come to a complete stop before opening the lid.

When centrifuging infectious materials, wait 10 minutes after the rotor comes to a complete stop before opening the lid. If a spill occurs, use appropriate decontamination and clean up procedures for the spilled materials. Report all accidents to the supervisor immediately.

17 Chemical Storage and Handling

Hazardous materials must be stored based on their compatibility, not in alphabetical order. Store materials of the same hazard together e.g. oxidizers with oxidizers, flammables with flammables. Flammable materials should be stored in an approved, dedicated, flammable materials storage cabinet if the volume exceeds ten (10) gallons. Proper chemical storage is important to eliminate the risk of a hazardous situation. Laboratory personnel should have chemicals secured in secondary containment during transport and use appropriate PPE. Observe the following rules to ensure safe storage of chemicals:

- Ensure all containers of chemicals are labeled with the chemical content and appropriate hazard warning. Chemical formulas are not acceptable. Relabel chemical bottles that do not have a visible label.
- Store like chemicals together and away from other groups of chemicals that might become reactive when mixed. Do not store chemicals alphabetically. Proper segregation is accomplished via physical barrier, distance, and/or secondary containment.
- The chemical storage room shall have continuous ventilation. The rule is 6 air changes per hour at a rate not less than 1 cubic foot/min.
- Hazardous chemicals should not be stored higher than 5 feet off ground level. Chemicals should be stored no higher than eye level.
- Large bottles should be stored at ground level.

- Keep chemicals pushed back on shelves to prevent them from falling off. The rule of thumb is to set bottles back from the edge a distance equal to the height of the bottle when in an upright position.
- Annually inspect all containers for any sign of decomposition.
- Keep hazardous materials away from heat and direct sunlight to prevent the degradation of chemicals and deterioration of storage containers and labels.
- Do not store hazardous materials (except cleaners) under sinks.
- Avoid chemical stockpiling. Order hazardous chemicals for immediate use.
- Use bottle carriers to transport chemicals. Close caps securely.
- Store acids in a dedicated acid cabinet. Nitric acid should be isolated from others and away from acetic acid.

Secondary Containment

Secondary containment is used to surround primary storage containers to collect hazardous material spillage. A secondary container is also required to separate incompatible chemicals. All liquid hazardous materials must be in approved secondary containment to prevent release. Secondary containment must meet the following requirements:

- It must be compatible with the stored materials and be constructed of materials capable of containing leaks.
- Secondary containment for a single container should be 110% of the primary container.

18 Refrigerators for Chemical Storage

All refrigerators must be labeled with the words "Chemicals Storage Only". Clearly label all materials placed in refrigerators. Flammable chemicals can only be stored in explosion proof refrigerators. Odors tend to accumulate in a refrigerator (in spite of the lower temperatures) and are then released into the laboratory. This becomes another source of chemical exposure. A tray of activated charcoal can be placed in the refrigerator to control vapor from chemical storage. Use only approved and well labeled refrigerators and freezers for storing flammable liquids.

19 Flammable and Combustible Chemical Storage

Flammable liquids easily set on fire. The vapor cloud above the liquid burns if the vapor's concentration is high. The extent of the vapor cloud varies with vapor pressure and temperature. Flammable and combustible liquids present danger of personal injury and property damage hence the strict storage requirements by law. Transfer flammable and combustible liquids within the chemical fume hood when possible. When flammable liquids must be stored outside a flammable storage cabinet, store in NFPA approved flammable liquid containers (safety cans). Flammables should be stored separately from oxidizers, corrosives, compressed gases, water reactive and highly toxic materials. Storage of flammables outside flammable cabinets and safety cans must not exceed 10 gallons per 100 square feet of laboratory space. Flammable storage cabinets are made of double walled steel, and are equipped with flame arresters. Some models have tops that close automatically. The cabinet must bear a label assuring that it is approved by factory mutual or underwriter's laboratories.

- Store flammable and combustible liquids away from oxidizers, heat producers (hot plates), and direct sunlight.
- When dispensing flammable and combustible materials from metal or other conductive containers, proper grounding and bonding of the containers is necessary to prevent static electricity.
- Whenever practical, glass containers should not be used for storing flammable liquids. If a glass container must be used, the maximum allowable container size is one gallon.
- Refrigerators and freezers used for storage of flammable materials must be rated for flammable storage.
- Flame resistant lab coats must be worn when working with large quantities (4 liters or more) of flammable materials and/or with procedures where a significant fire risk is present.

20 Corrosive Liquid Storage

Corrosives initiate a reaction that leads to damage of solid structures. The US Environmental Protection Agency defined corrosive chemicals as having a pH less than or equal to 2 or greater than or equal to 12.5.

The Occupational Safety & Health Administration (OSHA) defined corrosive materials as substances that can cause skin tissue destruction. Major classes of corrosive substances include:

- Strong acids: sulfuric, nitric, hydrochloric acid.
- Strong bases: sodium hydroxide.

Other hazards associated with corrosives include toxicity, flammability, oxidization (perchloric, chromic), and pressure build up. All hazards associated with chemicals should be verified to ensure safe storage location. Symptoms of exposure for inhalation include a burning sensation, coughing, shortness of breath, and nausea. For eyes, symptoms include tearing, pain, and blurring of vision. For skin, symptoms include burns, reddening, and pain. Procedures for corrosive storage include:

- Cabinets and shelves should be constructed from materials that can resist corrosive chemicals.
- The cabinets/shelves should be ventilated or located near the ventilation system.
- A secondary containment or spill tray (plastic bin) is required for acid storage.
- Acids and bases should be separated by a sufficient distance.
- Organic acids (acetic acids, formic acids) are flammable. These must be stored in a flammable cabinet.
- Acids should be isolated from reactive metals, including sodium, potassium, and magnesium.
- Acids and bases should be stored in air tight containers with snug fitting caps. Avoid loose lids or glass stoppers. Use vented caps when necessary to prevent over pressurization.
- Containers of acid and base solutions should be safely transferred using bottle carriers.

Other acid categories include water reactive-oxidizing, water reactive-reducing, aqueous oxidizing and aqueous reducing. These can be stored together, but in separate secondary containers.

21 Oxidizing Agents Storage

Oxidizing agents are chemicals that bring about an oxidation reaction and can initiate combustion. Oxidizers pose fire and explosion hazards. Store oxidizers in containers with tight fitting, screw-top lids. The intensity of the oxidation reaction depends on the oxidizing-reducing potential of the material involved. Oxidizers must be segregated from flammables, organics, alkaline metals, and formic acid. Perchloric acid and nitric acid are both oxidizing acids and should be segregated (secondary container) from other acids.

22 Peroxide Forming Compounds

Certain organic compounds spontaneously form peroxides via a free radical reaction involving hydrocarbon and molecular oxygen. These chemicals become shock sensitive and may explode when subject to heat or friction. The danger is enhanced when the chemical is concentrated by distillation or evaporation. It is imperative that all researchers learn to recognize and safely handle peroxidizable chemicals. Peroxidizable organic materials include ethers, acetals, ketones, etc. Working with these compounds requires the development of lab specific standard operating procedure (SOP).

Researche's who handle peroxidizable compounds should learn to handle these materials safely. Safe handling practices and procedures involve making effective purchasing decisions (order peroxidizable quantities according to short-term needs), implementing a storage control program, periodic testing for peroxides, and proper disposal of hazardous containers.

Peroxides tend to form in materials due to age and exposure to oxygen. Keep peroxide accumulation low by storing it in a partial full container (25% maximum headspace) with a tight caps that can be replaced promptly after use. Shelf life can be extended by flushing the headspace over peroxidizable compounds with nitrogen (inert gas) before closing the container. Isolate these chemicals from combustible and oxidizable materials. Always date peroxidizable compounds upon receipt and upon opening. Ethers tend to form extremely explosive compounds over time. Date all ether cans. Do not keep an open ether can for more than 6 months and an unopened can for more than 12 months. Ethers, liquid paraffins, and olefins form peroxides on exposure to air or light. Containers should be inspected for peroxide formation before opening or moving. If crystals are present around the lip of the container or the liquid appears cloudy, contact the chemical hygiene officer.

Testing for Peroxides

Peroxide test strips provide a simple and convenient mechanism for detection. For volatile organic chemicals the test strip is immersed in the chemical for 1 second, then the tester breathes slowly on the strip for 15 – 30 seconds or until the color stabilizes. Test strip color is compared with a colorimetric scale provided on the test kit bottle.

Never use a metal spatula with peroxides. Contamination by metals can lead to explosive decompositions. If the container has been opened but not tested, and is more than two years old, do not open or test the contents of the container.

Other Shock-Sensitive Materials

- Chemicals containing nitro groups
- Fulminates
- Hydrogen peroxide (30%+)
- Ammonium perchlorate
- Benzoyl Peroxide (when dry)
- Compounds containing the functional group: acetylide, azide, diazo, halamine, nitroso and ozonide

23 Water Reactives

Water reactive materials include alkali metals (sodium, potassium). Do not use these in the presence of water. Water reactives should be stored in inert environments. Know the properties of the material being used for research.

24 Incompatibilities by Hazard Class

Incompatible products should not be stored in close proximity. Perhaps the single most important rule of chemical storage is to segregate incompatible chemicals to prevent accidental mixing that could cause fire, explosion, or toxic gases. Hazardous chemical reactions can occur from improper storage when incompatible materials mix because of:

- Accidental breakage,
- Container failure,
- Fire and earthquakes,
- Mixing of gases or vapors from poorly closed containers,
- Mistakenly storing incompatibles together because of improperly labeled containers.

Inorganic acids should be separated from organic acids.

24.1 Chemical Incompatibilities

Chemical	Store Separately from
Acetic acid	Chromic acid, nitric acids, peroxides, and other oxidizers
Acetone	Concentrated nitric and sulfuric acid mixtures and strong bases
Acetylene	Chlorine, bromine, copper, fluorine, and silver
Alkali metals	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, and halogens
Ammonia	Mercury, chlorine, calcium hypochlorite, iodine, bromine, and hydrofluoric acid
Ammonium nitrate	Acids, metal powders, flammable liquids, chlorates, nitrates, sulfur, and finely divided organic materials.
Aniline	Nitric acid and hydrogen peroxide
Arsenic materials	Any reducing agent
Azides	Acids
Bromine	Ammonia, acetylene, butadiene, butane, methane, propane, hydrogen, sodium carbide, turpentine, benzene, and finely divided metals
Calcium oxide	Water
Carbon activated	Calcium hypochlorite and all oxidizing agents
Carbon tetrachloride	Sodium
Chlorates	Ammonium salts, acids, metal powders, sulfur, finely divided organic, or combustible materials
Chromic acid and chromium trioxide	Acetic acid, naphthalene, camphor, glycerol, glycerin, turpentine, alcohol, and flammable liquids
Chlorine	Same as bromine

Chlorine dioxide	Ammonia, methane, phosphine, and hydrogen sulfide
Copper	Acetylene and hydrogen peroxide
Cumene hydroperoxide	Acids, organic and inorganic
Cyanides	Acids
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, and sodium peroxide
Hydrocarbons	Fluorine, chlorine, bromine, chromic acid, and sodium peroxide
Hydrocyanic acids	Acids
Hydrofluoric acid	Ammonia, aqueous or anhydrous bases, and silica
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, and flammable liquids
Hydrogen sulfide	Fuming nitric acid, other acids, oxidizing gases, acetylene, ammonia (aqueous or anhydrous),and hydrogen
Hypochlorites	Acids and activated carbon
Iodine	Acetylene, ammonia (aqueous or anhydrous), and hydrogen
Mercury	Acetylene, fulminic acid, and ammonia
Nitrates	Sulfuric acid
Nitric acid concentrated	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases, copper, brass, and any heavy metals
Nitrites	Acids
Nitroparaffins	Inorganic bases and amines
Oxalic acids	Silver and mercury
Oxygen	Oils, grease, hydrogen, flammable liquids, and solids or grease

Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood , grease, and oils
Peroxides organic	Acids (organic or mineral), avoid friction
Phosphorus white	Air, oxygen, alkalis, and reducing agents
Potassium	Carbon tetrachloride, carbon dioxide, and water
Potassium chlorate and perchlorate	Sulfuric and other acids, alkali metals, magnesium, and calcium
Potassium permanganate	Glycerin, ethylene glycol, benzaldehyde, and sulfuric acid
Selenides	Reducing agents
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds, and fulminic acid
Sodium	Carbon tetrachloride, carbon dioxide, and water
Sodium nitrate	Ammonium nitrate and other ammonium salts
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, and carbon disulfide
Sulfuric acid	Potassium chlorate, potassium perchlorate, and potassium permanganate
Sulfides	Acids
Tellurides	Reducing agents

25 Handling Glassware and Plastics

Before working with glassware, always inspect it for flaws or cracks. Never use chipped or cracked glassware. Determine the compatibility of the glassware with chemicals or process before use. If the process involves temperature or pressure variation, ensure the glassware can withstand changes. Examples of glassware chemical incompatibilities:

- Hydrofluoric acid, hot phosphoric acid, and strong hot alkalis attack glass. Never use glass to contain these processes.
- Mixing sulfuric acid with water inside a cylinder causes an exothermic reaction that cracks the cylinder. Never mix sulfuric acid inside a cylinder.

When broken glassware, pipets, pipet tips, or test tubes do not contain or are not contaminated with chemicals (more than a trace amount) or biological material (any amount), then these waste materials are considered to be clean waste laboratory glassware. If laboratory glass contains or is contaminated with chemicals or biological materials, then dispose of according to hazard.

All Plastics Are Not Created Equal

Differentiating between glass and plastic for chemical storage is fairly intuitive. Lab wares are constructed from a variety of polymers, polyethene, PVC etc. All possess unique and varying degrees of resistance to the list of chemicals. To maintain the structural integrity of the chemical containers and ensure safe handling, consult the chemical resistance tables before transferring materials. Do not store strong oxidizing chemicals in plastic labware except if made of FEP. Other plastics will become brittle after prolonged exposure. Use the charts below as a reference only. They are recommendations, not guarantees of fitness for particular uses.

E – No damage after 30 days of constant exposure.
G – Little or no damage after 30 days of constant exposure
E – No damage after 30 days of constant exposure.
G – Little or no damage after 30 days of constant exposure

Classes of substances Temp 68^{0}F (20^{0}C)	ECTFE	FEP	FLPE	HDPE	LDPE	NYL	PC	PETG	PK	PMMA	PMP	PP/PPCO	PS	PSF	PUR	PVC	PVDF

Acids, weak or dilute	E	E	E	E	E	F	E	E	E	G	E	E	E	E	G	E	E
Acids, Strong/Conc	G	E	E	E	E	N	N	N	G	N	E	E	F	G	F	E	E
Alcohols/ Aliphatic	E	E	E	E	E	N	G	E	G	N	E	E	E	G	F	E	E
Aldehydes	E	E	G	G	G	F	F	N	E	G	G	G	N	F	G	N	E
Bases	E	E	F	E	E	F	N	N	G	F	E	E	E	E	N	E	E
Esters	E	E	E	G	G	E	N	N	E	N	G	G	N	N	N	N	G
Hydrocarbons/aliphatic	E	E	E	G	F	E	F	E	E	G	F	G	N	G	E	E	E
Hydrocarbons/aromatic	E	E	E	G	F	E	N	N	E	N	F	F	N	N	N	N	E
Hydrocarbons/halogenated	E	E	G	F	N	G	N	N	E	N	N	F	N	N	N	N	N
Ketones	G	E	E	G	G	E	N	N	E	N	F	G	N	N	N	N	N
Oxidizing agents, strong	F	E	F	F	F	N	N	N	G	N	F	F	N	G	N	G	G

F – Some effect after seven days of contact exposure. Depending on the plastic, the effect may be cracking, loss of strength, or discoloration. Solvents may cause softening, swelling, and permeation losses with PMP, LDPE, HDPE, PP.
N – Not recommended for continuous use. Immediate damage may occur.

ECTFE: Ethylene – chlorotrifluoroethylene copolymer

FEP: Fluorinated ethylene propylene

FLPE: Fluorinated high-density polyethylene

FLPP: Fluorinated polypropylene

HDPE: High density polyethylene

LDPE: Low density polyethylene

NYL: Nylon (polyamide)

PPCO: Polypropylene copolymer

PC: Polycarbonate

PETG: Polyethylene terephthalate copolyester

PK: Polyketone

PMMA: Polymethyl methacrylate

PMP: Polymethylpentene

PP: Polypropylene

PS: Polystyrene

PSF: Polysulfone

PUR: Polyurethane

PVC: Polyvinyl chloride

PVDF: Polyvinylidene fluoride

TPE: Thermoplastic elastomer

26 Moving Chemicals on Campus

Accidental chemical release and exposure can occur during chemical transportation. The following practices will minimize accidents.

- Do not put chemicals in vehicle's passenger compartment during transportation. Place containers in the truck.
- Chemicals should not be transported off campus.
- Never leave chemicals unattended or stored in a vehicle.
- Use sturdy carts for transporting large containers.
- Use secondary containment that is capable of containing all materials in the event of a spill.
- Individuals transporting chemicals must be familiar with the materials hazards and know what to do in the event of a release or spill.
- Wear appropriate Personal Protective Equipment (safety glasses, lab coat, gloves) if hazardous chemicals spill and splash on skin or eyes if spilled during transport.

27 Safety Equipment

The following safety items should be readily available in laboratories: Telephone with emergency number posted on it, fire extinguishers, spill kits, first aid kits, and eyewash/safety shower. Safety equipment should be present in wellmarked, highly visible, and easily accessible locations in or near all laboratories.

28 Fire Extinguisher

Laboratory personnel should know the locations of all fire extinguishers and be trained in proper use. There are several types of fire extinguishers, rated as to the type of fire it can put out. The type of fire the extinguisher is designed to extinguish is printed on the cylinder: triangle with an "A" denotes class A, a square with a "B" denotes class B, a circle with a "C" denotes class C, and a star with a "D" denotes class D. Fire extinguishers should be easily accessible and free of any obstructions. They must be of appropriate size and mounted properly on a wall. Fire extinguishers must be inspected annually and used fire extinguishers must immediately be serviced. An inspection tag must be attached to each extinguisher and must indicate the date of the last inspection.

29 Chemical Spill Kits

Chemical spill kits should be available in every laboratory and tailored to each laboratory's need. If a spill kit is placed in a drawer or cabinet, the drawer or cabinet must be labeled SPILL KIT. Otherwise, spill kits should be in visible and easily accessible locations. Once a spill kit is used, it should be restocked immediately.

29.1 Management of Minor Spills

Minor spills are those spills that do not fit the requirements of emergency spills. Use a commercial kit or absorbent material from the spill kit to absorb spilled chemicals. Place the absorbent in a plastic bag and label the bag with a hazardous waste tag. Replenish the spill kit supplies for future use.

Below are suggested materials for minor spill control. Items may be added or deleted from the spill kit depending on the type and quantity of chemicals used in the laboratory.

Components	**Purpose**
Clay Absorbent	Absorbent for organic solvents, oil spills
Sodium Bicarbonate	Neutralizes acid spills. All purpose except hydrofluoric acid
Sodium Hypochlorite	Disinfectant for biohazards
Tongs/Forceps	Pick up sharps/syringes
Absorbent Towels	General purpose

29.2 Management of Complex Chemical Releases

Complex chemical releases require outside assistance from properly trained individuals. These involve the release of large amounts of chemicals or chemicals of high toxicity. Evacuate the area and contact campus safety or the chemical hygiene officer. Have all personal involved wait in a predetermined evacuation area.

30 First Aid Kits

First aid supplies must be easily accessible to all lab personnel at all times. If a first aid kit is placed in a drawer or cabinet, the drawer or cabinet must be labeled FIRST AID KIT. Department representatives should periodically restock and remove expired items. Where unique hazards are present, additional items may be necessary (e.g. calcium gluconate for hydrofluoric acids).

31 Eyewash Stations

Eyewash stations are required in any lab where there is the potential for eye injury from exposure to hazardous chemicals. The eyewash station must be capable of providing a continuous, soft stream of tepid water for at least 15 minutes. The location should be marked with a highly visible sign. Eyewash stations should be flushed weekly for 1 minute to assure function and avoid buildup of bacteria. The path to the eyewash station must be free from obstructions.

After any eye contact with a chemical, activate the eyewash station and flush eyes for at least 15 minutes. If the chemical is alkaline, flush for at least 30 minutes. Avoid rinsing the chemical into the uninjured eye. If contact lenses are in place, flush for one minute, remove the lenses, and continue flushing. After flushing for the appropriate amount of time, seek medical attention immediately.

Infections arising from stagnant water can be dangerous, hence eyewash station maintenance is so important. The biggest hazard associated with improperly maintained eyewash stations is infection. When water is stationary over time, it is most likely to contain infection-causing organisms, such as *Acanthamoeba*, and *Pseudomonas.* When workers use eye wash stations with contaminated water, organisms can enter their body via the eye. For OSHA compliance, employers should follow ANSI standard Z358.1. The standard recommends weekly system flushing to clear lines of sediment and minimize microbial contamination.

32 Safety Showers

Safety showers should be provided where chemicals are handled. The shower provides first aid for chemical splashes. Safety showers should provide at least 30 gallons of water per minute. The valve should be simple to activate and should remain activated until intentionally shut off. The valve should be within reach, not more than 69 inches above the floor.

Safety showers should be in an accessible location. The location should be marked with a clearly visible sign. Safety showers should be flushed at least annually, preferably every six months. The path to the safety shower must be kept free from obstructions. In case of skin contact with a hazardous chemical, immediately activate the shower and flush the affected area for at least 15 minutes. For contact with dry solids, brush the contaminant gently off the skin before using the shower. After flushing, seek medical attention immediately.

33 Accidents, Spills and Emergencies

The impact of hazardous chemical spills can be minimized by a plan of action. The following guidelines and procedures are to be implemented in case of chemical emergencies or spills. All laboratory personnel must demonstrate knowledge of the following before embarking on laboratory work:

- Locations of all available exits for evacuation from the laboratory,
- Location of spill control equipment,
- Location of safety showers and eyewash fountains,
- How to report a fire, chemical spill, and other forms of emergencies.

Know what hazardous materials are in the workplace and the danger they present. Report major spills/exposures to campus safety at Ext 4111 or 607-431-4111. Give the following information:

- Location and type of spill,
- Injuries,
- Approximate amount of material involved,
- Who was in contact with the spilled substance.

Evacuate the area of the spill and close the doors to contain the spread.

34 Chemical Health Hazards

As defined by OSHA the term health hazard includes chemicals that are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatoxins, nephrotoxins, neurotoxins, agents that act on the hematopoietic systems, and agents that damage the lungs, skin, eyes, or mucous membranes. The major classes of hazardous and particularly hazardous substances and their related health and safety risks are detailed below.

34.1 Corrosive Substances

As a health hazard, corrosive substances cause destruction of, or alteration in, living tissue by chemical action at the site of contact. Major classes of corrosive substances include:

- Strong acids e.g. sulfuric, nitric, hydrochloric,
- Strong bases e.g. sodium hydroxide, potassium hydroxide.

Symptoms of exposure for inhalation include a burning sensation, coughing, and nausea. For eyes, symptoms include pain, tearing, and blurring of vision. For skin, symptoms may include reddening, pain, inflammation, blistering, and burns. As a physical hazard, corrosive substances may corrode materials they come in contact with and may be highly reactive with other substances. It is important to review information regarding the materials they may corrode and their reactivity with other substances as well as information on health effects.

34.2 Irritants

Irritants are defined as non-corrosive chemicals that cause reversible inflammatory effects on living tissue by chemical action at the site of contact e.g. ammonia, halogens, and formaldehyde. Symptoms of exposure can include reddening or discomfort of the skin. Consequently, eye and skin contact with all laboratory chemicals should always be avoided.

34.3 Sensitizers

A sensitizer is a substance that causes an allergic reaction in normal tissue after repeated exposure to the substance. Examples of sensitizers include formaldehyde, nickel, and phenol derivatives. Sensitizer exposure can lead to all of the symptoms associated with allergic reactions, or can increase an individual's existing allergies.

34.4 Hazardous substances with toxic effects on specific organs

Substances in this category include:

- Hepatotoxins: substances that produce liver damage, such as nitrosamines and carbon tetrachloride.
- Nephrotoxins: agents causing damage to the kidneys, such as certain halogenated hydrocarbons.
- Neurotoxins: substances that produce their primary toxic effects on the nervous system such as carbon disulfide.
- Agents that act on the hematopoietic system e.g. carbon monoxide that decreases hemoglobin function and deprives the body tissues of oxygen.

34.5 Particularly Hazardous Substances

Substances that pose significant threats to human health are classified as particularly hazardous substances (PHSs). Particularly hazardous substances are divided into three primary types:

- Acute Toxins
- Reproductive Toxins
- Carcinogens

34.6 Acute Toxins

OSHA interprets substances that have a high degree of acute toxicity as being substances that may be fatal or may cause damage to target organs as the result of a single exposure or exposures of short duration. These chemicals, associated chemical waste, and storage containers must be handled with care to prevent cross contamination of work areas and unexpected contact. These chemicals must be labeled as 'Toxic'. Empty containers of these substances must be packaged and disposed of as hazardous waste without rinsing trace amounts into the sanitary sewer system.

34.7 Reproductive Toxins

Reproductive toxins include any chemical that may affect the reproductive capabilities, including chromosomal damage (mutations) and effects on fetuses (teratogensis). Reproductive toxins can affect the reproductive health of both men and women if proper procedures and controls are not used. For women, exposure to reproductive toxins during pregnancy can cause adverse effects on the fetus. For men, exposure can lead to sterility.

34.8 Carcinogens

Carcinogens are chemical or physical agents that cause cancer. Generally, they are chronically toxic substances that cause damage after repeated or long duration exposure and their effects may only become evident after a long latency period. Chronic toxins are particularly insidious because they may have no immediately apparent harmful effects. These materials are separated into two classes:

- Select Carcinogens
- Regulated Carcinogens

Select carcinogens are materials that have met certain criteria established by the National Toxicology Program or the International Agency for Research on Cancer regarding the risk of cancer via certain exposure routes. It is important to recognize that some substances involved in research laboratories are new compounds that have not been subjected to testing for carcinogenicity.

Regulated carcinogens fall into a higher hazard class and have extensive additional requirements. The use of these agents may require personal exposure sampling based on usage. When working with regulated carcinogens, it is particularly important to review and effectively apply engineering and administrative safety controls as the regulatory requirements for laboratories that may exceed long term (8 hour) or short-term (15 minutes) threshold values for these chemicals.

35 Biohazard and Safety

Persons working in a microbiology lab may handle infectious agents in addition to chemical hazards. Workers can be exposed to potentially harmful microbes when isolating bacteria from environmental materials. Immunocompromised or immunosuppressed individuals may be at greater risk of acquiring infections. A microbiology laboratory is a unique environment that requires special practices and containment facilities in order to properly protect persons working with microorganisms. The three main elements of safe containment of microorganisms are:

- Good laboratory practices and techniques,
- Safety equipment,
- Facility design.

35.1 Microbiology Lab Practices and Safety Rules

- Wash hands with disinfectant soap when arriving at the lab and again before leaving.
- Absolutely no food, drinks, or chewing gum in the laboratory. Do not put anything in the mouth such as pencils, pens, labels, or fingers.
- Always wear lab coat, safety glasses, and gloves when in the lab. Leave protective clothing in the lab and do not wear it to other non-lab areas.
- Wear appropriate shoes. Sandals are not allowed in the laboratory.

- Disinfect work areas before and after use with 70% ethanol. Laboratory equipment and work surfaces should be decontaminated with an appropriate disinfectant on a routine basis, and especially after spills, splashes or other contamination.
- Label everything clearly.
- Replace caps on reagents, solution bottles, and cultures. Do not open petri dishes in the lab unless necessary.
- Treat all microorganisms as potential pathogens. Use appropriate care and do not take cultures out of the laboratory.
- Dispose of all solid waste material in a biohazard bag and autoclave it before discarding in regular trash.
- Dispose of broken glass in the broken glass container.
- Dispose of razor blades, syringe needles, and sharp metal objects in sharps container.

35.2 Cleaning Small Spills

The proper procedures for cleaning small spills of microorganisms or samples:

- Wear a lab coat, disposable gloves, and safety glasses or a face shield.
- Soak a paper towel(s) in an appropriate disinfectant (70% ethanol or fresh 10% bleach solution) and place around the spill area.
- Working from the outer edges into the center, clean the spill area with fresh towels soaked in the disinfectant. Be sure to decontaminate any areas or surfaces that may have been affected by the spill. Allow 10 minutes contact time.
- Place the paper towels and gloves into a biohazard bag and autoclave these materials to sterilize them.
- Properly dispose of any contaminated clothing.
- Wash hands with a disinfectant soap.

Each lab is equipped with a spill response kit for a large spill.

35.3 Biological Safety Levels (BSL)

These levels, which are ranked from one to four, are selected based on the agents or organisms that are being researched or worked on in any given laboratory setting. For example, a basic lab setting specializing in the research of nonlethal agents that pose a minimal potential threat to lab workers and the environment are generally considered BSL-1, the lowest biosafety lab level. A specialized research laboratory that deals with potentially deadly infectious agents like Ebola would be designated as BSL-4, the highest and most stringent level.

The Centers for Disease Control and Prevention (CDC) sets BSL lab levels as a way of exhibiting specific controls for the containment of microbes and biological agents. Each BSL lab level builds upon on the previous level, thereby creating layer upon layer of constraints and barriers.

Biological Safety Level I (BSL- 1)

As the lowest of the four, biosafety level 1 applies to laboratory settings in which personnel work with low, risk microbes that pose little to no threat of infection in healthy adults. An example of a microbe that is typically worked with at a BSL-1 is a nonpathogenic strain of *E.coli.* This laboratory setting typically consists of research taking place on benches without the use of special contaminant equipment. A BSL-1 lab, which is not required to be isolated from surrounding facilities, requires only standard microbial practices, such as:

- Mechanical pipetting only (no mouth pipetting allowed),
- Safe sharps handling,
- Avoidance of splashes or aerosols,
- Daily decontamination of all work surface when work is complete,
- Hand washing,
- Prohibition of food, drink and smoking materials in lab setting,
- Personal protective equipment, such as eye protection, gloves and a lab coat or gown,
- Biohazard signs.

BSL-1 labs also requires immediate decontamination after spills.

Biological Safety Level 2 (BSL-2)

This biosafety level covers laboratories that work with agents associated with human diseases (i.e. pathogenic or infections organisms) that pose a moderate health hazard. Examples of agents typically worked with in a BSL-2 include *staphylococcus aureus.*

BSL-2 laboratories maintain the same standard microbial practices as BSL-1 labs, but also include enhanced measures due to the potential risk of the aforementioned microbes. Personnel working in BSL-2 labs are expected to take even greater care to prevent injuries such as cuts and mucous membrane exposures. In addition to BSL-1 expectation, the following practices are required in a BSL-2 lab setting:

- Appropriate personal protective equipment (PPE) must be worn, including lab coats and gloves,
- All procedures that can cause infection from aerosols or splashes are performed within a biological safety cabinet (BSC),
- An autoclave or an alternative method of decontamination is available for proper disposals,
- The laboratory has self-closing, lockable doors,
- A sink and eyewash station should be readily available,
- Biohazard warning signs.

Access to BSL-2 lab is far more restrictive than BSL-1 lab.

Appendix I Chemicals that can form peroxides

This list is illustrative, but not exhaustive:

Acrylic acid Tetrafluoroethylene

Acrylonitrile Vinyl Acetate

Butadiene Vinyl acetylene

Chlorobutadiene (Chloroprene) Vinyl Pyridine

Chlorotrifluoroethylene Vinylidene Chloride

Methyl methacrylate

Styrene

Acetal Diethylene glycol dimethyl ether (diglyme)

Cumene Ethylene glycol dimethyl ether (glyme)

Cyclohexene furan

Cyclooctene Methyl acetylene

Diacetylene Methyl cyclopentane

Dicyclopentadiene Methyl-I- butyl ketone

Diethyl ether Tetrahydrofuran

Dioxane (p-dioxane) Tetrahydronaphthalene

Vinyl ethers

Divinyl Ether Potassium Metal

Divinyl acetylene Potassium amide

Isopropyl ether Sodium amide (sodamide)

Vinylidene chloride

Appendix II Electrical Safety in Laboratory

A typical laboratory contains a wide variety of electrically powered equipment. Potential electrical hazards include electric shock, arc blasts, electrocutions, fire, and explosions. These can result from faulty electrical equipment, wiring, or unsafe work practices. To avoid electrical hazards and minimize risk, follow these practices.

- Always follow manufacturer's recommendation for using electrical equipment.
- Do not use extension cords as a substitute for permanent wiring
- Know the location of electrical panels and disconnect switches in or near the laboratory in the event of an electrical accident.
- Never obstruct electrical panels. A minimum 3-foot clearance must be maintained around electrical panels at all times to permit ready and safe operation.
- Never overload circuits or wiring.
- Inspect all electrical equipment (hot plates, stirrers, oven, extension cords, etc.) before use to ensure that cords and plugs are in good condition. Equipment with damaged or defective cords or plugs should be taken out of service.
- Ensure that all electrical outlets have a grounding connection requiring a three-pronged plug.
- Electrical outlets, wiring, and other electrical equipment integral to the building may only be serviced and repaired by facilities operations qualified personnel.
- Limit the use of extension cords. They are for temporary, short-term use only.
- Ensure that all extension cords used are carefully placed, visible, and not subject to damage. Cords must not run across aisles or corridors where they might be damaged or create a tripping hazard.
- To prevent fire, ensure that the wire size of an extension cord is adequate for the current to be carried.
- Keep corrosive chemicals and organic solvents away from electrical cord as they can easily erode the insulation on wires.
- Keep flammable materials away from electrical equipment.
- Keep electrical equipment away from wet or damp locations or potential water spillage, unless specifically rated for use under such conditions.

Appendix III Standard Operating Procedure Sample

Each laboratory must write specific standard operating procedures (SOPs) for work involving the use of hazardous chemicals. The definition of Hazardous Chemical is clearly stated in the definitions section of this document.

SOP Format

Sect. 1. Process, Hazardous Chemical, or Hazard Class.

Sect. 2. Describe Process, Hazardous Chemical, or Hazardous Class.

Process – Describe the process, which involves hazardous chemicals. List all chemicals used in the process.

Hazardous Chemical – Name the hazardous chemical for which the SOP is being developed. Include International Union of Prue and Applied Chemical (IUPAC), common name, and any abbreviations used for the chemical.

Hazard Class – Describe the hazard associated with a particular group of similar chemicals and list the chemicals used in the laboratory.

Sect. 3. Potential Hazards – Describe the potential hazards for each process, hazardous chemical, or hazard class, including physical and health hazards. Consult SDS and other chemical literature.

Sect. 4. Personal Protective Equipment (PPE) – Identity the required level of PPE and hygiene practices needed for each process, hazardous chemical, or hazard class. PPE includes gloves, aprons, lab coats, safety glasses, googles, etc.

Sect. 5. Engineering Control – Describe engineering controls that will be used to minimize or eliminate employee exposure to hazardous chemicals during the process.

Sect. 6. Special Handling and Storage Requirements – List storage requirements for the hazardous chemicals involved with the SOP, including specific storage areas, temperatures, and policies regarding access to chemicals.

Sect. 7. Spill and Accident Procedures – Indicate how spills or accidental releases will be handled and by whom. List the location of appropriate emergency equipment (spill kits). Any special requirement for personal exposure should also be identified in this section.

Sect. 8. Decontamination Procedures – Specify decontamination procedures to be used for equipment, glassware, and clothing, include equipment such as hoods, lab benches and designated areas within the laboratory.

Sect. 9. Waste Disposal Procedures – Indicate how waste will be disposed. Include the name of the person responsible for managing laboratory waste.

Sect. 10. Safety Data Sheet Location – Indicate the location of SDSs for each hazardous chemical used.

Sect. 11. Principal Investigator Approval – Sign and date to indicate the SOP has been approved.