

Duquesne University

**Office of Environmental
Health & Safety**

Chemical Hygiene Plan

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I. Foreword

The purpose of the Chemical Hygiene Plan is to outline a set of guidelines for safe laboratory operations and to define responsibilities for all persons working in or having supervisory responsibilities for laboratories at Duquesne University. The Chemical Hygiene Plan (CHP) has been developed to protect persons from the hazards associated with laboratory work as required by the Occupational Safety and Health Administration (OSHA) standard, *Occupational Exposure to Hazardous Chemicals in Laboratories (29 CFR 1910.1450)*

II. University Safety Policy Statement

Duquesne University places highest emphasis on protecting the health and safety of all persons, students, faculty, and staff who work in or visit our facilities. Therefore, Duquesne University requires all students, employees, and visitors to strictly adhere to good laboratory practices and occupational health procedures as established in this plan.

The Plan states that responsibility for strict adherence to established safety procedures rest with

- The faculty who carry responsibility for students, employees and visitors in their research and teaching laboratories,
- The chair persons and department heads who have responsibility for facilitating the implementation of chemical hygiene and safety practices in their departments, and
- The Environmental Health and Safety Office who assists chair persons and department heads in the implementation of their responsibilities.

All occupational injuries are preventable. Faculty, students and staff are expected to be committed to this premise and are responsible for their safety in the workplace.

III. EHS/Radiation Safety Committee

The EHS/Radiation Safety Committee is chaired by the Duquesne University Radiation Safety Officer. This committee establishes and recommends guidelines, resources, and activities needed to assure adherence to the Duquesne University Safety Policy. This includes conducting laboratory inspections, reviewing accidents and incidents, reviewing policies and procedures, and discussing safety issues related to our laboratories. The Duquesne University EHS Office assists personnel in their safety efforts.

IV. Chemical Hygiene Plan Maintenance

The EHS Office will regularly review this plan, and will provide updates as needed. Each user of the CHP is asked to review the plan and provide any comments deemed appropriate directly to the EHS Office or their EHS/Radiation Safety Committee representative.

V. Responsibilities

Responsibility for strict adherence to established safety procedures rest with the faculty who carry responsibility for students, employees and visitors in their research and teaching laboratories; the chair persons and department heads who have responsibility for facilitating the implementation of chemical hygiene and safety

practices in their departments; and the EHS Office who assists chair persons and department heads in the implementation of their responsibilities.

A. Faculty and Principal Investigators

The faculty member or the principal investigator is responsible for:

- Ensure the laboratory workers know and follow the safety practices set forth in the CHP.
- Ensure that protective equipment is available, in working order and used for the appropriate function.
- Provide regular, formal chemical hygiene and housekeeping inspections including routine inspections of emergency equipment.
- Ensure that laboratory workers attend all required safety training seminars and receive the proper specific training for their individual research.
- Plan and construct each experiment in accordance with good laboratory practice and the CHP.
- Identify and report maintenance problems with safety equipment, such as safety showers, eyewash stations, first aid kits, fire blankets, and fume hoods to Facilities Management.
- Provide an up-to-date chemical inventory to the EHS Office annually.

B. Hazardous Materials Manager

The Hazardous Materials Manager will serve as Duquesne University's Chemical Hygiene Officer and is responsible for assisting the Principal Investigators, Laboratory Instructors, Laboratory Workers, and department staff in implementing safety practices. These duties include:

- Review experiment hazards and recommend engineering/process control.
- Recommend protective equipment for laboratory workers.
- Explain process control and handling requirements for regulated substances.
- Provide handling guidance for handling and disposal of hazardous waste and biological waste generated in the laboratory.
- Make recommendations to the EHS/Radiation Safety Committee on ways of improving the safety program.
- Provide safety training to all students, principal investigators, and laboratory instructors.

C. Laboratory Worker

The laboratory worker is responsible for the following duties:

- Conducting each operation in accordance with the CHP.
- Wearing the required personal protective equipment for each individual activity.
- Keeping his/her workspace clean and orderly and free from obvious safety hazards.

D. EHS/Radiation Safety Committee

The EHS/Radiation Safety Committee consist of a representative from each department (Pharmacy, Chemistry, Biology, Physics, and Anatomy), the Associate Academic V.P. for Research, the Dean of the Bayer School of Natural and Environmental Sciences, EHS Staff members (Director EHS, Manager EHS, Radiation Safety Officer, Manager Hazardous Materials, and the EHS Coordinator), Instrument Repair Supervisor, Facilities Management Supervisor, and a representative from the School of Nursing. Individual representatives are responsible for conducting routine safety inspections of laboratories within their departments. The committee is responsible for the implementation of the CHP including the following items:

- Recommend changes and amendments to the CHP where needed to meet the needs of changing research.
- Resolve apparent conflicts with the application of safety rules and practices or engineering controls.

II. The Laboratory Facility

A. Design

Duquesne University must have the following minimum safety features:

- Local exhaust ventilation for chemical usage
- Chemical storage areas and cabinets
- Laboratory sinks
- Safety showers and eyewash stations
- Fire extinguishers

B. Maintenance

Facilities Management ensures that the laboratory facilities are maintained in a serviceable condition, and that mechanical and electrical safety equipment performs according to specifications from the EHS Office. Additionally, fire extinguishers are maintained by Facilities Management through an outside contractor who is responsible for annual service and inspection of each extinguisher.

Work orders to repair or renovate laboratory facilities shall be initiated by the respective Department or School. Laboratory supervisors or workers shall notify Facilities Management immediately when a fume hood is in not functioning correctly.

C. Ventilation

1. General Ventilation

General ventilation systems in laboratories provide for comfort and make-up air, and are not designed to control chemical vapors, gases, or mists.

2. Hoods

For the control of toxic chemical vapors, laboratory hoods are provided according to the following specifications:

- As a general rule, a minimum of 2.5 linear feet of hood space per person for every 2-laboratory workers.
- Hood sashes should be kept lowered to the yellow line (6 to 8 inches from the counter top) at all times, when possible.
- An average face velocity of 80 – 100 fpm shall be maintained at all times for the slow speed. While an average face velocity of 120 – 180 fpm shall be maintained at all times for the high speed.

On an annual basis, each laboratory hood at Duquesne University will be checked by EHS for usage and performance. In cases where hood performance fails to meet specific parameters, EHS will initiate work orders to have the hoods repaired. EHS will measure face velocities upon request if laboratory workers feel that hood are not operating properly.

Non-venting hoods (e.g. laminar flow hoods with in-room venting) shall be clearly labeled as such. Work with volatile toxic chemicals should not be performed in these types of hoods that do not vent outdoors. Inspection and maintenance of such hoods must be done through an accredited company.

3. Modifications

Laboratory hoods are not to be modified without the involvement of the EHS Office. Changes in airflow quantity and airflow patterns can significantly affect laboratory exposure potential, and the EHS Office will ensure that modifications will not degrade the safety of the laboratory environment.

D. Components of the Chemical Hygiene Plan

1. Basic Rules and Procedures

a. Personal Hygiene

- Wash promptly whenever a chemical has contacted the skin. Know what you are working with and have the necessary cleaning/neutralization materials on hand.
- High heels, sandals, or open-toed shoes, are not permitted in any science laboratory.
- Clothing that does not protect against possible laboratory hazards, such as shorts, cutoffs, and skirts above the knee are not permitted in any science laboratory.
- Loose clothing or long hair must be constrained while in the science laboratory
- Lab coats are not to be worn outside the laboratory area, especially in rest rooms or break facilities.
- Inhalation is one of the four modes of entry for chemical exposures; therefore “sniff-testing” shall not be done.
- Never pipette by mouth.

- Do not drink, eat, smoke, insert contact lenses, take medications, or apply cosmetics in the laboratory or chemical storage area.
- Do not use ice from the laboratory ice machines for beverages.
- No food, beverage, tobacco, or cosmetic products are allowed in the laboratory or chemical storage area at any time.

2. Chemical Procurement, Distribution, and Storage

a. Procurement of Chemicals

Before a substance is received, information on proper handling, storage, and disposal shall be known by those who will be involved, including EHS. No container shall be accepted without an adequate identifying label. All chemicals will be procured through either Duquesne University Purchasing or Receiving Department purchasing system.

b. Stockrooms/storerooms

Toxic substances shall be segregated in well-identified areas with proper ventilation. Stored chemicals shall be examined periodically (at least annually) for replacement, deterioration, and container integrity.

c. Initial Storage and Distribution

Initial receipt and storage by receiving personnel will be performed in accordance with written protocols on receipt, handling, and storage of hazardous materials. These protocols and any revisions must be reviewed and approved by the EHS/Radiation Safety Committee.

d. Distribution

Chemicals will be distributed to requesters provided the following safety precautions are taken:

- All packages will be carefully inspected and opened to ensure that no chemicals have spilled or are leaking.
- The chemicals are transported in safety containers or on a wheeled cart with a design capable of containing leakage or spillage and negotiated uneven surfaces (e.g. expansion joints or floor drains) without tipping the chemical container or cart.
- All chemical containers will be transported closed so that no vapors, gases, or mists are emitted to the atmosphere.
- Cylinders will be transported using a gas cylinder dolly specifically designed for that purpose.
- All cylinders will be strapped to the gas cylinder dolly and the cylinder cover caps shall be screwed on hand-tight.

e. Laboratory Storage

Storage in laboratories will be performed as follows:

- Chemicals will be stored so incompatible chemicals are separated. (See Appendix D, Chemicals Compatibility Guide)
- Refrigerators used for storage of flammable liquids must be explosion proof.
- The total volume of all combined flammable chemicals in one laboratory should not exceed 40 gallons.
- Cylinders of compressed gases must be securely strapped to a wall or bench top.
- Compressed gas cylinders will be capped and cylinder valves will be closed when not in use.
- All cylinders and chemical containers will be stored away from heat sources and direct sunlight.

3. Air Monitoring

Routine Instrumental monitoring of airborne concentration is not usually practical in laboratories, but may be appropriate when testing or redesigning hoods or other ventilation devices, or when highly toxic substances are stored or used regularly.

a. Hazards Identification

Prior to the initial start up of a new procedure, the Principal Investigator or Laboratory Instructor must have the procedure evaluated for potential hazards associated with the work. The following methods are acceptable means to do this:

- Use the hazards identification checklist contained in Appendix C, Process Hazards Identification Checklist
- Have the EHS Office perform the process evaluation.
- Perform your own review and document the criteria used and associated findings.

Regardless of evaluation method, the evaluation must be fully documented to identify potential hazards and protective measures to be taken. EHS should be involved in the planning and installation of alarms/sensor to be used to alert researchers or workers of hazardous conditions.

Process Changes

Each process change must be evaluated in a manner similar to the initial evaluation. A simple memo or a specific note in a laboratory will be sufficient to document each change and associated evaluation.

b. Method Determination

1. Air sampling will be performed for any process where a known or suspected carcinogen, allergen, or reproductive hazard is used and a fume hood/filtered glove box is not used to contain the contaminant.
2. Air sampling will be performed where respiratory protection is being worn.

3. Air sampling will be performed upon the request of the Principal Investigator, laboratory instructor, or laboratory worker.
4. NIOSH/OSHA/ACGIH protocols, where they exist, will be used when performing the air sampling.
 - a. Alternative methods may be used provided EHS documents the rationale for using the alternative method.
 - b. Continuous process monitors may be substituted for routine sampling provided the monitor is calibrated for the monitored substance at the concentration of concern.
5. Air sampling will continue until:
 - a. The experiment is terminated, or
 - b. Two consecutive sampling periods taken at least 7 days apart show that air concentrations are less than 10% of the associated OSHA PEL or, where one does not exist, the ACGIH TLV or NIOSH REL.

4. Housekeeping, Maintenance, and Inspections

a. Housekeeping

1. The area must be kept as clean as the work allows.
2. Each laboratory employee shall be responsible for maintaining the cleanliness of his/her own areas; this includes work areas such as benches and fume hoods, as well as personal areas such as desks or book shelves.
3. Reagents and equipment items should be returned to their proper places after use. Contaminated or dirty glassware should be placed in specific cleaning areas and not allowed to accumulate.
4. Chemicals, especially liquids should never be stored on the floor, except in closed-door cabinets suitable for the material to be stored.
5. Reagents, solutions, glassware, or other apparatus shall not be stored in hoods. Storage of this type will reduce the available work space, and interfere with proper airflow patterns which may reduce the effectiveness of the hood as a safety device.
6. Counter tops should be kept neat and clean.
7. Stored items, equipment, glass tubing, etc. shall not project beyond the front of the shelf or counter limits. Stored items should not block access to the fire extinguisher(s), safety equipment, or other emergency items.
8. Stairways, hallways, passageways/aisles and access to emergency equipment and/or exits must be kept dry and not be obstructed in any fashion, including storage, equipment, phone or other wiring.

9. Mats and carpeting shall be kept in good condition.
10. All containers must be labeled with at least the identity of the contents and the hazards those chemicals present to users.
11. Floors and working surfaces should be cleaned regularly.

b. Inspections

Annually, EHS will perform laboratory safety inspections to ensure that adequate safety equipment is available and functioning, personal protective equipment is available and in use, chemicals are properly stored, MSDS's are readily available, good housekeeping is being practiced, and that the laboratory hoods are operating properly.

Formal housekeeping and chemical hygiene inspections will be conducted by individual department safety committee representatives, laboratory instructors and EHS staff at least annually. Informal inspections will be performed routinely throughout the year. A Laboratory Inspection Checklist (Appendix H) has been provided for use during these inspections.

Plumbed eyewash stations shall be flushed weekly by operating them (where discolored water is found, the eyewash should be flushed until the water runs clear). Bottled eyewash units must not exceed their expiration date. Facilities Management is responsible for testing safety showers. In addition, Facilities Management will inspect all fire extinguishers annually and ensure that they all have a hydrostatic tested every five years.

5. Medical Program

a. Examination Determination

Medical examinations are required for the following:

- Personnel using respiratory protection.
- Documented exposures above established action levels or airborne concentration above one-half of the PEL, TLV, or other recognized exposure limit.
- Personnel exhibiting signs or symptoms consistent with exposure to the chemicals with which they are working.

Medical exams may be requested by the Principal Investigator or Laboratory Instructor by contacting the EHS office. Medical exams will also be provided, upon request, to personnel exposed to hazardous chemicals as a result of a spill, leak, or explosion.

b. Medical Exam Criteria and Frequency

Exam Criteria

- The licensed physician performing the exam will determine medical exam criteria.
- Where medical exam guidance exists, such as OSHA regulated substances, these criteria will be included in the physician's exam.

Exam Frequency

- For examinations resulting from exposure to OSHA regulated substances, the examination frequency will be the period set within the OSHA standard.
- For examinations resulting from potential overexposure to hazardous substances, the licensed physician will determine the examination frequency.
- All other examinations required for chemical exposure or protective equipment usage will be annual unless otherwise specified by the examining physician

Exam Information and Results

The following information will be provided to the examining physician:

- The identity of the hazardous chemical(s) to which the employee has been or may be exposed.
- A description of the condition under which the exposure occurred, including surveillance data and accident reports.
- A description of the signs and symptoms of exposure that the employee is experiencing as a result of the exposure.

Upon completion of the exam, the physician will provide the following reports:

- Fitness for duty determination to the employer and employee, including duty restrictions.
- Recommendations for further examination.
- Results of the examination to the employee.

6. Personal Protective Apparel and Equipment

Each laboratory shall have the following protective apparel and equipment based on the potential hazards that have been determined:

- Protective apparel compatible with the required degree of protection for the substances being used
- Accessible safety shower within 10 seconds from the hazard
- Eyewash station
- Fire extinguisher
- Respiratory protection
- Fire alarm and telephone for emergency use
- Other items designated by the laboratory supervisor and/or by EHS

a. Respiratory Protection

The use of respiratory protection requires training and approval from EHS, and the implementation of program elements in OSHA's Respiratory Protection standard (29 CFR 1290.134) and OSHA's chemical specific standards in Subpart Z of 29 CFR 1910. Where the need for respirators has been established, or the need must be determined through job safety analysis and evaluation,

contact EHS for assistance. The Duquesne University Respiratory Protection Plan is available on our website.

b. Protective Clothing

Protective clothing such as gloves, lab coats, aprons, or suits should be selected to resist the chemicals being used. The Principal Investigator or Laboratory Instructor is responsible for determining the protective clothing needed for laboratory personnel. Appendix G, Glove Compatibility Guide should be used to determine if a glove is suitable.

c. Hearing Protection

Hearing protection will be provided to anyone working in an area where the noise level exceeds 85dBa. EHS should be consulted so that accurate noise measurements can be made, correct hearing protection can be provided, and the need for noise reduction engineering controls can be evaluated.

d. Eye Protection

Eye protection is mandatory for all entries into and work within a lab, studio, or shop where chemicals are used. The Principal Investigator or Laboratory Instructor should determine the level of eye protection required. All eye protection used will meet ANSI Z87.1 2003 requirements.

VII. Signs and Labels

A. Postings and Signs

All labs using OSHA regulated substances shall post warning signs. Each lab will contain a posting, in a prominent location, that contains the phone numbers to call if an emergency occurs. Signs for emergency response equipment such as safety showers, eyewashes, and fire extinguishers will be clearly visible and unobstructed.

B. Labels and Labeling

All containers in the lab must be labeled at a minimum with a list of the substance names, type of hazard (toxic, flammable, reactive, corrosive, etc.) and the manufacturer's name and address if applicable. Note: If the Principal Investigator or Laboratory Instructor is unable to determine the proper label, EHS will assist in assigning the correct label information.

VIII. Training

A. Laboratory Safety Training

Anybody that wishes to work in a laboratory shall be provided safety training prior to their initial assignment to the laboratory work area where hazardous chemicals are present and before any new work assignments involving new exposure situations. Ensuring that each laboratory worker receives training will be the responsibility of each individual department. EHS will assist in

training when requested and will hold an Annual Safety Meeting each Spring. Also, during the annual Teaching Assistant Orientation week, each laboratory worker will be required to take the Lab Safety Training through the EHS Blackboard site.

The training will include the following topics:

- The contents of OSHA standard (29CFR1910.1450) and its appendices.
- The location and availability of the Duquesne University Chemical Hygiene Plan.
- OSHA's PELs (Permissible Exposure Limit) regulated substances and ACGIH TLV's (Threshold Limit Value) where OSHA standards do not exist.
- Signs, symptoms, and health hazards associated with exposures to hazardous chemicals in the laboratory.
- The location of reference material on the hazards, safe handling, storage, and disposal of hazardous chemicals found in the laboratory.
- Methods and observations that may be used to detect the presence or release of a hazardous chemical.
- The protective measures an employee or student can take to prevent or reduce exposure to a hazardous chemical.
- Emergency Response Procedures.

EHS will keep on file documentation on who received training and the dates training was provided.

B. Specialty Training

Principal Investigators or Laboratory Instructors will ensure specific training is provided to laboratory personnel for the procedures/experiments they are performing. Principal Investigators or Laboratory Instructors may request additional training for work involving complex or potentially reactive/explosive chemical operations.

C. Emergency Response

Accidents such as spills, personnel injuries, fires or explosions should be immediately reported to Public Safety at extension 2677 (COPS). Public Safety can then expeditiously call the appropriate Duquesne University response personnel or fire/medical/hazmat assistance. Reporting of accidents should be clear and concise with notification including:

- The nature of the accident
- Location
- Name of caller
- Phone where caller can be reached

All accidents (injuries, fires, spills, explosions) must be reported to EHS within 24 hours of the occurrence by filling out an incident report. Personnel at the immediate scene of the accident should take actions that will mitigate the extent of the accident without jeopardizing their health and safety. When

in doubt, warn others in the area, vacate the area, travel to a safe location and make the phone call to Public Safety.

D. Records and Program Assessment

A. Records Retention

All safety training records will be maintained by the EHS Office.

Accident and incident reports will also be maintained by EHS Office.

B. Assessment Review and Evaluations

The Chemical Hygiene Officer will prepare an annual report for the Safety Committee, which will contain the following items:

- Summary of accidents, types, and causes.
- Summary of program deficiencies and recommended corrective actions.
- Progress in meeting goals established by the Safety Committee.

Appendix A – Emergency Response Guidelines

Spilled Substances

General Response Actions

1. Stop the source of the spill.
2. Attend to any person(s) who may have been contaminated.
3. Notify persons in the immediate area about the spill.
4. Evacuate all nonessential personnel from the spill area.
5. If the spilled material is flammable, turn off ignition and heat sources
6. Leave on or establish exhaust ventilation.
7. Notify the EHS Office.
8. Send another individual for the MSDS sheet.

Cleaning and Handling For Spilled Liquids

1. Confine or contain the spill to as small an area as possible.
2. Contact the EHS Office.
3. For small inorganic acids or bases, use a neutralizing agent or an absorbent mixture.
4. For small quantities of other materials, absorb the spill with a non-reactive material.
5. For large spills of all chemical materials do not attempt a clean. Contact the EHS Office immediately.

Cleaning and Handling of Spilled Solid

1. For spilled substances of solids with low toxicity, clean up spill with a broom and dustpan, and place materials in a trash bag for disposal. Label substance and notify the EHS Office.

Handling of Leaking Compressed Gas Cylinder

1. Check for a leak using soapy water.
2. If a leak is detected, notify the EHS Office immediately.

Personnel Injury

1. Warn others and render assistance to person(s) involved.
2. Notify the EHS Office.
3. If further exposure is life threatening, remove the injured person from the affected area.
4. If a chemical exposure is involved, wash the person under a safety shower. (Each lab has an emergency map detailing shower locations.)
5. Notify Public Safety at – x2677 and provide location, type of injury, and number of persons injured.

Appendix B – Laboratory Safety Rules

General Principles

1. Know the safety rules and procedures that apply to the work that is being done. Determine the potential hazards (e.g. physical, chemical, biological) and appropriate safety precautions before beginning any new operation.
2. Know the location of and how to use the emergency equipment in your lab area, as well as how to obtain additional help in an emergency, and be familiar with emergency procedures.
3. Know the types of protective equipment available and use the proper type for each job.
4. Be alert to unsafe conditions and actions and call attention to them so that corrections can be made as soon as possible. Someone else's accident can be as dangerous to you as your own accident.
5. Avoid consuming food or beverages or smoking in areas where chemicals are being used or stored.
6. Avoid hazards to the environment by following accepted waste disposal procedures. Chemical reactions may require traps or scrubbing devices to prevent the escape of toxic substances.
7. Be certain all chemicals are correctly and clearly labeled. Post warning signs when unusual hazards, such as radiation, laser operations, flammable materials, biological hazards, or other special problems exist.
8. Remain out of the area of a fire or personal injury unless it is your responsibility to help with the emergency. Curious bystanders interfere with rescue and emergency personnel and endanger themselves.
9. Avoid distracting or startling any other workers. Practical jokes or horseplay cannot be tolerated at any time.
10. Use equipment only for its designed purpose.
11. Position and clamp reaction apparatus thoughtfully in order to permit manipulation without the need to move the apparatus until the entire reaction is completed. Combine reagents in appropriate order, and avoid adding solids to hot liquids.
12. Think, act, and encourage safety until it becomes a habit.

Health and Hygiene

1. Wear appropriate eye protection at all times.
2. Use protective apparel, including face shields, gloves, and other special clothing or footwear as needed.
3. Confine long hair and loose clothing when in the laboratory
4. Do not use mouth suction to pipette chemicals or to start a siphon; a pipette bulb or an aspirator should be used to provide a vacuum.
5. Avoid exposure to gases, vapors, and aerosols. Use appropriate safety equipment whenever such exposure is likely.
6. Wash well before leaving the laboratory area. However, avoid the use of solvents for washing the skin. They remove the natural protective oils from the skin and can cause irritation and inflammation. In some cases, washing with a solvent might facilitate absorption of a toxic chemical.

Food Handling

Contamination of food, drink, and smoking materials is a potential route for exposure to toxic substances. Food should be stored, handled, and consumed in an area free of hazardous substances.

1. Well-defined areas should be established for storage and consumption of food and beverage. No food should be stored or consumed outside of this area.
2. Areas where food is permitted should be prominently marked and a warning sign (e.g. EATING AREA – NO CHEMICAL) posted. No chemicals or chemical equipment is allowed in such areas.
3. Consumption of food or beverages and smoking is not to be permitted in areas where laboratory operations are being carried on.
4. Glassware or utensils that have been used for laboratory operations shall never be used to prepare or consume food or beverage. Laboratory refrigerators, ice chests, cold rooms, and such must not be used for food storage; separate equipment shall be dedicated to that use and prominently labeled.

Chemical Storage

1. Purchase only the minimum quantities necessary for a research project, to avoid accumulation of excess chemicals.
2. Label all chemical containers appropriately.
3. Place the user's name and the date received on all purchased materials in order to facilitate inventory control of the materials.
4. Provide a definite storage place for each chemical and return the chemical to that location after each use.
5. Avoid storing chemicals on bench tops, except for those chemicals being used currently. Only small quantities (less than 1 liter (L)) of flammable liquids should be kept at workbenches. Larger quantities should be stored in approved storage cabinets.
6. Quantities greater than 1 L should be stored in metal or break-resistant containers. Large containers (more than 1 L) should be stored below eye level on low shelves.
7. Hazardous chemicals and waste should never be stored on the floor.
8. Avoid storing chemical in laboratory hoods, except for those chemicals being used currently.
9. Do not expose stored chemicals to heat or direct sunlight.
10. Observe all precautions regarding the storage of incompatible chemicals.
11. Separate chemicals into compatible groups and store alphabetically within compatible groups.
12. Store flammable liquids in approved flammable liquid storage cabinets.
13. Use chemical storage refrigerators only for storing chemicals.
14. Seal containers to minimize escape of corrosive, flammable, or toxic vapors.
15. Do not store flammable liquids in a refrigerator unless it is approved for such storage. Such refrigerators are designed not to spark inside the refrigerator. If refrigerated storage is needed inside a flammable storage room, it is advisable to choose an explosion-proof refrigerator.

Housekeeping

1. Work area should be kept clean and free from obstructions. Cleanup should follow the completion of any operation or at the end of each day.
2. Wastes should be deposited in appropriate receptacles.
3. Spilled chemicals should be cleaned up immediately and disposed properly. Disposal procedures should be established and all laboratory personnel should be informed of them; the effects of other laboratory accidents should also be cleaned up promptly.
4. Unlabeled containers and chemical wastes should be disposed of promptly, by using appropriate procedures. Such materials, as well as chemicals that are no longer needed, should not accumulate in the laboratory.
5. Floors should be cleaned regularly; accumulated dust, chromatography absorbents, and other assorted chemicals and materials pose respiratory hazards.
6. Stairways, hallways, and office should not be used as storage areas.
7. Access to exits, emergency equipment, and controls should never be locked.
8. Equipment and chemicals shall be stored properly; clutter shall be minimized.

Equipment Maintenance

1. Develop an inspection and maintenance schedule for equipment.
2. Faulty or non-functional equipment should be tagged such that an individual is warned not to use the equipment.

Guarding For Safety

1. All mechanical equipment should be adequately furnished with guards that prevent access to electrical connections or moving parts (such as the belts and pulley of a vacuum pump.)
2. Each laboratory worker should inspect equipment before using it to ensure that the guards are in place and functioning.
3. Emergency shutoff devices should be provided, in addition to electrical and mechanical guarding.

Shielding for Safety

1. Safety shielding should be used for any operation having the potential for explosion, particularly:
 - When a reaction is attempted for the first time (small quantities of reactants should be used to minimize hazards.)
 - When a familiar reaction is carried out on a larger than usual scale (e.g. 5-10 times more material)
 - When operations are carried out under non-ambient conditions.
2. Shields must be placed so that all personnel in the area are protected from hazards.

Glassware

1. Careful handling and storage procedure should be used to avoid damaging glassware.
2. Damaged items should be discarded.

3. Adequate hand protection should be used when inserting glass tubing into rubber stoppers or corks or when placing rubber tubing on glass hose connections.
4. Tubing should be fire polished or rounded and lubricated, and hands should be held close together to limit movement of glass should fracture occur.
5. The use of plastic or metal connectors should be considered.
6. Glass-blowing operations should not be attempted unless proper annealing facilities are available.
7. Vacuum-jacketed glass apparatus should be handled with extreme care to prevent implosions.
8. Equipment such as Dewar flasks should be taped or shielded.
9. Only glassware designed for vacuum work should be used for that purpose.
10. Hand protection should be used when picking up broken glass (Small pieces should be swept up with a brush into a dustpan.)
11. Proper instruction should be provided in the use of glass equipment designed for specialized tasks, which can represent unusual risks for the first-time user (For example, separatory funnels containing volatile solvents can develop considerable pressure during use).

Flammability Hazards

1. Do not use an open flame to heat a flammable liquid or to carry out to a distillation under reduced pressure.
2. Use an open flame only when necessary and extinguish it when it is no longer actually needed.
3. Before lighting a flame, remove all flammable substances from the immediate area. Check all containers of flammable materials in the area to ensure that they are tightly closed.
4. Notify other occupants of the laboratory in advance of lighting a flame.
5. Store flammable materials properly.
6. When volatile flammable materials may be present, use only non-sparking electrical equipment.

Cold Trap and Cryogenic Hazard

1. Gloves and a face shield may be needed when preparing or using some cold baths.
2. Neither liquid nitrogen nor liquid air should be used to cool a flammable mixture in the presence of air because oxygen can condense from the air, which leads to an explosion hazard.
3. Appropriate dry gloves should be used when handling dry ice, which should be added slowly to the liquid portion of the cooling bath to avoid foaming over.
4. Workers should avoid lowering their head into a dry ice chest, carbon dioxide is heavier than air and suffocation can result.

Systems Under Pressure

1. Reactions should never be carried out in, nor heat applied to, an apparatus that is a closed system unless it is designed and tested to withstand pressure.

2. Pressurized apparatus should have an appropriate relief device. If the reaction cannot be opened directly to the air, an inert gas purge and bubbler system should be used to avoid pressure buildup.

Waste Disposal Procedures

1. Design experiments so that a minimum quantity of waste is generated.
2. Label waste containers with correct chemical names of contents.
3. Do not mix waste types. Separate halogenated solvents from non-halogenated solvents.

Warning Signs and Labels

1. Laboratory areas that have special or unusual hazards must be posted with warning signs.
2. All signs and symbols must be left in place and not altered unless a change to laboratory operations occurs.
3. All chemical containers must be labeled and the original label must not be removed or defaced.
4. Waste containers must be labeled as to the type of chemicals present and that the container is for waste.

Unattended Operations

1. Plan for unscheduled interruptions in utility services such as electricity, water, and inert gas.
2. Operations should be designed to be safe, and plans should be made to avoid hazards in case of failure.
3. Wherever possible, arrangement for routine inspections of the operation should be made and, in all cases, the laboratory lights should be left on and an appropriate signs should be placed on the door.

Working Alone

1. All accidents involving a fire, personal injury, explosion or spill must be reported.
2. Emergency telephone numbers to be called in the event of fire, accident, flood, or hazardous chemical spill should be posted prominently in each laboratory.
3. In addition, the numbers of the laboratory workers and their supervisors should be posted in the hallways directly outside each laboratory.
4. These persons should be notified immediately in the event of an accident or emergency.

Appendix C – Process Hazards Identification Checklist

A. Determination of Chemical Hazards

1. Determine if the chemicals or reaction byproducts can be classified as one of the following:
 - Select carcinogen
 - Allergen
 - Reproductive hazards
 - Acutely toxic
2. Are any of the process chemicals or reaction by products an OSHA regulated substance?
3. Will perchloric acid be used in the process?
4. Can less toxic materials be used in the reaction process?
5. Is the ventilation/containment system the correct type for the materials being used and generated?
6. Does the process require interlocking of the ventilation system with a process component so failure of the vent system shuts down the process?

If yes to any of these then contact the EHS Office for further information on controls and monitoring.

B. Chemical Process Hazards

1. Has the literature for the intended process been researched to identify the accidents that have occurred and their causes/preventions?
2. Will an exothermic reaction occur for any of the following:
 - Quench failure or loss of external cooling
 - Change in purity of material or catalysts
 - Excess or deficiency of one reactant
 - Loss of agitation
 - Local hot spot due to inadequate mixing
 - Excessive point or surface temperature leads to “runaway” reaction
 - Delayed onset of batch reaction while continuing reactant addition
 - Leakage of coolant into reactants
 - Backflow of a reactant due to depressurizing system
 - Excessive preheat
 - High pressure reaction acceleration
3. For experiments being scaled up or down have the following been evaluated for impact on reaction rates?
 - Change in surface area, heat and cooling capacity
 - Degree of agitation and mixing
 - Changes in reactant proportions
 - Rates of additions

4. Are the reactants being used endothermic compounds with low energy activations values?
5. Are ammine metal oxosalts used in a process that is subject to friction, heating, or impact?
6. Are pyrophoric materials used in a process that will result in oxidations or hydrolysis?
7. Are water reactive compounds used in a process that may result in contact with limited quantities of water?
8. Has the oxygen balance of the compounds been evaluated to determine explosive potential?
9. Are peroxidizable compounds used or produced which are concentrated due to heating or evaporation?
10. Has the creation of toxic gas byproducts due to contact between reaction byproducts and reactants or process surfaces been evaluated?
11. Will flammable liquids be used such that the ignition temperature for the vapors produced can be exceeded?
12. Are the reactants or reaction byproducts highly corrosive?
13. Is spontaneous polymerization possible for the reaction process?
14. Is the wrapping material on a dewar flask compatible with the process chemicals?

C. Physical Process Hazards

1. Are precautions implemented to prevent implosions of dewar flasks under vacuum?
2. Are pressure relief valves/devices available for sealed system under cryogenic cooling?
3. Are safety relief devices provided for pressurized processes?
4. Are the safety relief devices capable of operating at the pressure of concern?
5. Are the process flow lines, containers and clamps capable of withstanding process pressures?
6. Are pressure relief devices located so that personnel will not be exposed if these devices are activated?
7. For laboratory work involving continuous cooling (such as condensers) is protection provided to prevent flooding from tube failures, pump failures, blockage in flow lines, electrical failures, connection disruptions and pressure spikes.
8. Are instruments and machines adequately secured to prevent movement or sliding due to process vibration?
9. Are the support stands or tables capable of handling the equipment set-up load including process forces generated during the course of the experiment?
10. For compressed gases, especially CO₂ and corrosive gases, are the proper regulators and valve fitting used?
11. Has the use of glass and plastic equipment been minimized for pressurized or vacuum processes?
12. Has shielding been provided for sealed tubes or glass equipment used in vacuum or pressurized processes?

13. Are pumps adequately protected from the process reactants and byproducts?
14. Are guards provided for belt driven mechanical pumps?

D. Fire and Electrical Process Hazard

1. Is ground fault circuit interruption provided?
2. Is the equipment layout such that flammable materials are segregated from ignition sources?
3. Where electrical equipment is used with flammable liquids is the equipment designed to prevent heating above the auto ignition temperature of the liquid?
4. Is bonding and grounding protection provided for containers, especially large metal drums, of flammable liquids?
5. Are variable autotransformers located so as to prevent contact between the windings and flammable vapors?
6. Are heating mantles properly grounded?
7. Is heating equipment provided with automatic temperature controls and with high temperature limit switches?
8. Are non-sparking tools and motors used for work involving flammable chemicals?
9. Is electrical equipment located to minimize the potential for water or liquids being spilled onto the equipment?
10. Are drying ovens constructed so that temperature controls and heating elements are separated from their interior atmosphere?
11. If flammable materials must be refrigerated, have provisions been made to store in a refrigerator designed as explosion proof?
12. For work involving the generation of flammable vapors are all the laboratory switches explosion proof?
13. For stirring and mixing devices can these devices be remotely shut off?
14. Do all hot plates have their heating elements completely enclosed?

E. Hazardous Waste

1. Have provisions for hazardous waste disposal been addressed in the procedures?
2. Are provisions provided in the procedure to prevent the release of hazardous materials into the drain system?
3. For solvent distillations are trapping devices adequate to prevent entrainment of solvent vapors into discharged process liquids?
4. Have the minimal amount of materials needed been used in this process?
5. Are methods included in the process to render the reactants and byproducts non-hazardous?
6. Are bimetallic thermometers used in place of mercury thermometers?

F. Administrative Preparations

1. Is a detailed and updated written protocol available to all personnel performing part or all of the process work?

2. For continuous run experiments are provisions made for periodically checking the experiment set-up to ensure operation safety?
3. Does the written protocol provide instructions for handling upsets and emergencies?
4. Is there a schedule for providing routine maintenance and check of interlocks?
5. Has training in the protocol been provided to all personnel performing the process?
6. Are suitable materials available for neutralizing and containing materials spilled during the process?
7. What process hazards are introduced by routine maintenance?
8. Are special detectors and alarm devices needed to warn of the generation of hazardous materials?
9. If special detectors and alarm devices are needed, are protocols and equipment available for periodic calibration and testing of these devices?
10. If special detectors and alarm devices are used, have Public Safety and EHS been notified of what they indicate and how to respond?
11. For operations involving liquid nitrogen as a coolant have precautions been instituted to eliminate the condensation of liquid oxygen before charging a trap?

Appendix D – Chemical Compatibility Guide

<u>Group</u>	<u>Name</u>	<u>Example</u>	<u>Incompatible Groups</u>
Group 1	Inorganic acids	Hydrochloric acid Hydrofluoric acid Hydrogen chloride Hydrogen fluoride Nitric acid Sulfuric acid Phosphoric acid	2, 3, 4, 5, 6, 7, 8, 10, 13, 14, 16, 17, 18, 19, 21, 22, 23
Group 2	Organic acids	Acetic acid Butyric acid Formic acid Propionic acid	1, 3, 4, 7, 14, 16, 17, 18, 19, 22
Group 3	Caustics	Sodium hydroxide Ammonium hydroxide soln	1, 2, 6, 7, 8, 13, 14, 15, 16, 17, 18, 20, 23
Group 4	Amines and Alkanolamines	Aminoethylethanolamine Aniline Diethanolamine Diethylamine Dimethylamine Ethylenediamine 2-Methyl-5-ethylpyridine Monoethanolamine Pyridine Triethanolamine Triethylamine Triethylenetetramine	1, 2, 5, 7, 8, 13, 14, 15, 16, 17, 18, 23
Group 5	Halogenated Compounds	Allyl chloride Carbon tetrachloride Chlorobenzene Chloroform Methylene chloride Monochlorodifluoromethane 1,2,4-Trichlorobenzene 1,1,1-Trichloroethane Trichloroethylene Trichlorofluoromethane	1, 3, 4, 11, 14, 17

<u>Group</u>	<u>Name</u>	<u>Example</u>	<u>Incompatible Groups</u>
Group 6	Alcohols Glycols Glycol Ether	1,4-Butanediol Butanol (iso, n, sec, tert) Diethylene glycol Ethyl alcohol Ethyl butanol Ethylene glycol Furfuryl alcohol Isoamyl alcohol Methyl alcohol Methylamyl alcohol Propylene glycol	1, 7, 14, 16, 20, 23
Group 7	Aldehydes Acetaldehyde	Acrolein Butyraldehyde Crotonaldehyde Formaldehyde Furfural Paraformaldehyde Propionaldehyde	1, 2, 3, 4, 6, 8, 15, 16, 17, 19, 20, 23
Group 8	Ketones	Acetone Acetophenone Diisobutyl ketone Methyl ethyl ketone	1, 3, 4, 7, 19, 20
Group 9	Saturated Hydrocarbons	Butane Cyclohexane Ethane Heptane Paraffins Paraffin wax Pentane Petroleum ether	20
Group 10	Aromatic Hydrocarbons	Benzene Cumene Ethyl benzene Naphtha Naphthalene Toluene Xylene	1, 20

<u>Group</u>	<u>Name</u>	<u>Example</u>	<u>Incompatible Groups</u>
Group 11	Olefins	Butylene 1-Decene 1-Dodecene Ethylene Turpentine	1, 5, 20
Group 12	Petroleum Oils	Gasoline Mineral oil	20
Group 13	Esters	Amyl acetate Butyl acetates Castor oil Dimethyl sulfate Ethyl acetate	1, 3, 4, 19, 20
Group 14	Monomers Polymerizable Esters	Acrylic acid Acrylonitrile Butadiene Acrylates	1, 2, 3, 4, 5, 6, 15, 16, 19, 20, 21, 23
Group 15	Phenols	Carbolic acid Cresote Cresols phenol	3, 4, 7, 14, 16, 19, 20
Group 16	Alkylene Oxides	Ethylene oxide Propylene oxide	1, 2, 3, 4, 6, 7, 14, 15, 17, 18, 19, 23
Group 17	Cyanohydrins	Acetone cyanohydrin Ethylene cyanohydrin	1, 2, 3, 4, 5, 7, 16, 19, 23
Group 18	Nitriles	Acetonitrile Adiponitrile	1, 2, 3, 4, 16, 23
Group 19	Ammonia	Ammonium hydroxide Ammonium gas	1, 2, 7, 8, 13, 14, 15, 16, 17, 20, 23

<u>Group</u>	<u>Name</u>	<u>Example</u>	<u>Incompatible Groups</u>
Group 20	Halogens	Chlorine Fluorine	3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 19, 21, 22
Group 21	Ethers	Diethyl Ether THF	1, 14, 20
Group 22	Phosphorus	Phosphorus, Elemental	1, 2, 3, 20
Group 23	Acid Anhydrides	Acetic anhydride Propionic anhydride	1, 3, 4, 6, 7, 14, 16, 17, 18, 19

Appendix E – Glove Compatibility Guide

Chemical Resistance Chart

Glove Material	Mineral Acids	Organic Acids	Caustics	Alcohols	Aromatics	Petroleum	Ketonic	Chlorinated Solvents
Natural Rubber	G	E	E	E	P	E	G	NR
Neoprene	E	E	E	E	F	E	G	F
Buna-N	E	E	E	G	F	E	F	F
Butyl	G	E	E	E	F	F	E	NR
Polyvinyl Chloride	G	E	G	E	P	P	NR	NR
Polyvinyl Alcohol	P	F	P	F	P	P	F	E
Polyethylene	G	E	E	E	E	E	G	G
Nitrile-Butadiene Rubber (NRB)	E	G	G	E	E	E	F	G

Key: E-Excellent, G-Good, F-Fair, P-Poor, NR-Not Recommended

Physical Performance Chart

Glove Material	Abrasion Resistance	Cut Resistance	Puncture Resistance	Heat Resistance	Flexibility	Dry Grip	Wet Grip
Natural Rubber	G	E	E	E	E	E	G
Neoprene	F	E	E	E	G	G	F
Buna-N	G	E	G	F	F	G	G
Butyl	G	G	G	P	G	F	F
Polyvinyl Chloride	G	F	F	P	F	E	E
Polyvinyl Alcohol	G	E	E	F	F	E	E
Polyethylene	E	F	E	P	G	G	G
Nitrile- Butadiene Rubber	E	E	E	F	G	G	F

Appendix F – Laboratory Inspection Checklist

Date of Inspection: _____

Professor in Charge: _____

Inspectors: _____

HAZARD COMMUNICATION	YES	NO	N/A	COMMENTS
MSDSs - main location and links on desktop				
Current inventory posted near entranceway, with date of update				
Outside door posting present				
NFPA - is it posted on the door posting and filled out				

PROTECTIVE EQUIPMENT	YES	NO	N/A	COMMENTS
Protective gloves present				
Lab coats present				
Splash goggles/face shield present				
Sharps containers present				
Broken glass container present				

FUME HOODS and GLOVE BOXES	YES	NO	N/A	COMMENTS
Sufficient engineering controls present				
Current inspection, status label				
Red-tagged hoods are shut down				
Sufficient working space in hood				
Hood sash maintained at correct level				
Users aware of procedures for hood alarm				
Is procedure followed for perchloric acid fume hood				

PHYSICAL HAZARDS	YES	NO	N/A	COMMENTS
Extension cords for temporary use only				
Extension cords pose a trip hazard				
Overloaded outlets present				
Wires in good condition				
Laser warning signage present				
Laser eye protection present				
Compressed gas cylinders secured				
Protective cap on stored gas cylinders				
Flammable/oxidizer gases stored separately				

INSTRUMENT & EQUIPMENT	YES	NO	N/A	COMMENTS
Refrigerators clean and maintained				
Vacuum pump & pulley belts guarded				
Spill trays under mercury instruments				
Hose clamps - are all clamps tight and secure				
Recirculating pumps - are they being used properly				

CHEMICAL STORAGE & USAGE	YES	NO	N/A	COMMENTS
All chemical containers identified with chemical name				
Containers in good condition				
All containers capped/sealed				
Expired material properly addressed				
Oxidizers and solvents segregated				
Acids and bases segregated				
Volatile materials used in fume hood				
Perchloric acid used properly				
Sufficient flammable storage (see guidelines)				
All chemical containers stored in proper cabinets				

EMERGENCY RESPONSE	YES	NO	N/A	COMMENTS
Campus emergency phone number listed - COPS				
Internal emergency phone numbers posted				
Emergency exits unobstructed				
Shower location sign present				
Eyewash station present & clearly marked				
Eyewash solution has not expired				
Plumbed eyewashes routinely tested				
Spill response kit stocked				
Fire extinguisher location marked				
Fire extinguisher properly maintained				

HOUSEKEEPING	YES	NO	N/A	COMMENTS
Sufficient bench-top space				
Benches clean and orderly				
Hoods clean and orderly				
Sinks clean				
Walkways free of obstructions				
Safety showers free of obstructions				
Eyewash stations free of obstructions				
Fire extinguishers free of obstructions				
Electric boxes free of obstructions				
Acceptable storage				
Food and/or beverages present				

HAZARDOUS WASTE	YES	NO	N/A	COMMENTS
Container near accumulation point				
Container is properly labeled				
Container is kept closed				
Container is in secondary containment				

BIOHAZARDOUS AREAS	YES	NO	N/A	COMMENTS
Work area warning signs present				
Proper waste containers used				
Materials properly labeled				
Proper decontamination procedure				

RADIOACTIVE AREAS	YES	NO	N/A	COMMENTS
Work area warning signs present				
Lab door locked when not in use				
Designated work areas marked				
Proper waste containers used				
Materials properly labeled				