SIMMONS UNIVERSITY

CHEMICAL HYGIENE PLAN

Original Date: May 2016
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CHEMICAL HYGIENE PLAN REVIEW SUMMARY

Revision(s)	Date	Name (print)	Signature
Tracked	8/31/22	Matt Fragala	

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EMERGENCY RESPONSE SUMMARY

FOR ALL CAMPUS EMERGENCIES CALL Public Safety at x 1111
(MEDICAL, CRIME, FIRE/SMOKE, CHEMICAL VAPORS, OR OTHER EMERGENCY)

Emergency Coordinators:
Sean Gelinas 617-212-7118
Chief Paul Lombardo 617-521-2226
Joan Martinez Cuerva 617-521-2282

Public Safety: 1111
Non-emergency, extension 1112
City of Boston: ambulance, police, fire, 9-911

If you discover a fire, smoke, toxic vapors, or a chemical/oil spill:

R* – Rescue*: Rescue anyone in immediate danger from the spill or fire to a safe area if you are able to do it safely.

A* – Alarm:** Fire: Activate the nearest fire Alarm box, leave, and call ***Public Safety.
Chemical Spill/Leak: Leave and notify Public Safety, *x1111*. Provide the location.

***C* – Confine:** IF YOUR SAFETY WILL NOT BE PLACED AT RISK:
Fire: Close doors and windows and turn off exhaust fans.
Spills/leaks: Leave windows open and exhaust fans on. Turn off air supply.
Plan your escape: Never allow fire to get between you and an escape route.

***E* – Evacuate:** Evacuate the building (in case of fire) or the area (in case of a spill/leak). Leave via a safe fire exit. NEVER use elevators in a Fire. Only use the stairs.

R.A.C.E.: If smoke, flames, toxic vapors, or any other emergency is discovered: Leave the area, call **Public Safety, x1111** and provide information about the incident.

- **Alarm Locations:** Fire alarm pull stations are located throughout each building. Alarm signals are located on each floor and are audible bell / siren and / or visual (strobe) and audible alarms.
  Do not attempt to extinguish a fire, unless you have been trained to use an extinguisher.
- **Emergency Exits:** Use the primary or the closest emergency egress route unless it is unsafe. Exits are equipped with illuminated exits signs. Follow these exit signs to the nearest ground level exit.
- **Assembly Areas:** Use the closest egress route, if it is safe, and go to the designated assembly area per instruction by Public Safety or Boston Fire Department. Do not obstruct emergency personnel or vehicle access. Account for all evacuated students, visitors, adjuncts, faculty, and staff. Notify the person-in-charge of unaccounted individuals or observations made during evacuation that require further action.
- **Special Needs:** Identify those people who may need to be alerted or assisted. Provide assistance as required.
- **Check:** Quickly inspect each room in your area as you exit to ensure that everyone has been evacuated. However, **Do not endanger yourself!**
- **Chemical Emergencies***:* It is unlikely that a chemical emergency will require a building evacuation. However, if you discover a chemical emergency, leave the area, secure the room, and notify Public Safety (1111). Simmons University provides trained and authorized response personnel who will evaluate the situation and take appropriate action to control the incident. Evacuate all affected areas as necessary. If trained and authorized to use them, chemical spill kits are available through the Chemistry Lab and Public Safety Department.

Notify Public Safety (1111) if you discover a chemical spill / leak.

EVACUATION GUIDELINES

(Post in Appropriate Locations)

When notified to evacuate, proceed as follows:

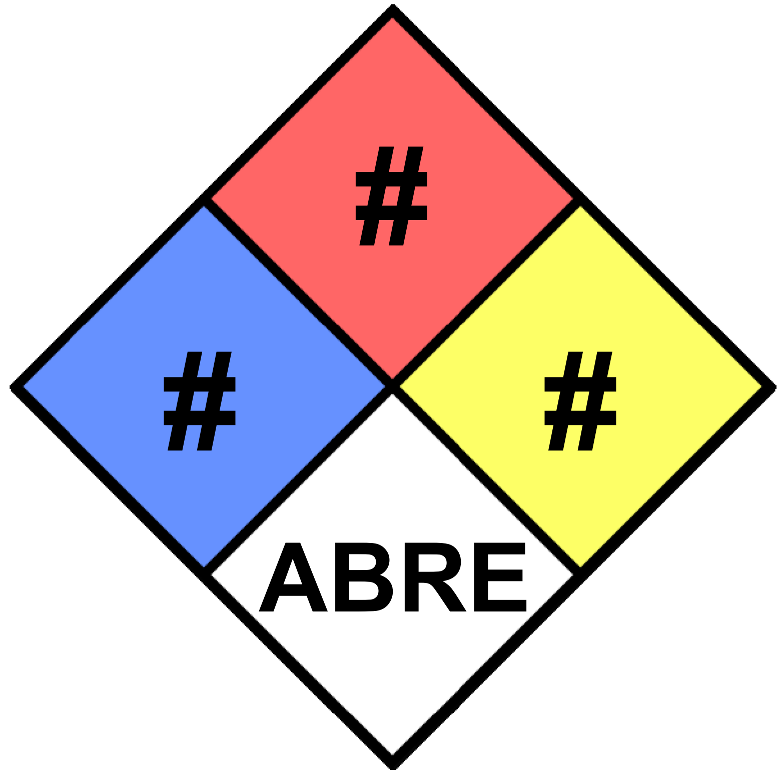
- Alert nearby personnel of the emergency.
- Shutdown operating equipment (e.g., gas or vacuum lines) ONLY if you are able to do so safely.
- Calmly and expeditiously proceed to the nearest exit.
- Close fire and other doors when exiting.
  - If you are an evacuation monitor, check offices, bathrooms, and other spaces as you are proceeding to the nearest exit by following the laminated exit signs.
- Use the nearest exit or emergency stairs to exit the building.
- Walk, do not run.
- Inform all persons seen en-route to the exit per the evacuation notification.
- Upon exiting the building or the affected area, move to the designated assembly area (the Quads) or shelter in place location as directed by Public Safety, Boston Fire Department, or Boston Police Department.
- Upon arrival at the assembly area or shelter in place location, report to Public Safety, Boston Fire Department, or Boston Police Department immediately and provide critical information such as, event causes, injured employees, observations noted during exit, unaccounted people, etc.
- Await further instructions from Public Safety, Boston Fire Department, or Boston Police Department.
- Never leave the assembly area or shelter in place location without authorization from Public Safety, Boston Fire Department, or Boston Police Department.
- Stay at designated location until the affected area is “ALL CLEAR” from Public Safety, Boston Fire Department, or Boston Police Department.

NEVER re-enter a building or affected area until permitted to do so by Public Safety, Boston Fire Department, or Boston Police Department .

Laboratory Hazcom Door Signage

This room contains hazardous materials

In case of emergency, call 617-521-1111.



RESPONSIBLE PERSONS

Laboratory Manager		
Chemical Hygiene Officer	Sean Gelinas	617-212-7118
Director of EH&S	Sean Gelinas	617-212-7118

HAZARDS ASSOCIATED WITH THIS LABORATORY

Biosafety Level:

Chemical Hazards:

Radioactive Hazards:

Personal Protective Equipment:
(at a minimum)

1 INTRODUCTION

The Simmons University (Simmons) Chemical Hygiene Plan (CHP) for Laboratories is required by Occupational Safety and Health Administration (OSHA) standard 29 Code of Federal Regulations (CFR) 1910.1450, "Occupational Exposure to Hazardous Chemicals in the Laboratory" (see also 29 CFR 1910.1450, *Appendices A and B*). This regulation (referred to herein as the OSHA Laboratory Standard) focuses on occupational exposure to hazardous chemicals in laboratories. The requirements associated with the Hazard Communication Standard (HAZCOM) are provided in another plan.

The OSHA Laboratory Standard covers work conducted at laboratory scale. OSHA defines laboratory scale as "work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person. Laboratory scale excludes those workplaces whose function is to produce commercial quantities of materials."

The following Simmons departments that conduct laboratory scale work as defined in the OSHA Laboratory Standard and are required to implement the CHP are as follows:

- Art & Music
- Biology
- Chemistry & Physics
- Psychology

By law, the chemical hygiene plan must be capable of protecting employees from health hazards associated with hazardous chemicals in the laboratory and be capable of keeping exposures below applicable limits. The primary focus of this CHP is to provide students, staff, and faculty with the information and training necessary to improve safety and health and to prevent chemical-related injuries and illnesses in our laboratories and in the Art Department. It provides methods for worker protection to protect Simmons employees and students, our most valuable assets. The CHP is a complete and thorough documentation of the methods, practices, and information necessary to protect students, staff, and faculty from the hazards of the chemicals in use on this campus.

This document outlines how Simmons complies with each of the elements in OSHA's Laboratory Standard. The CHP will be reviewed annually by the Director of Environmental Health and Safety (EH&S), the Chemical Hygiene Officer (CHO), at least one representative from each laboratory department, and a representative from the Art Department. It will be revised as necessary. The CHP must be made readily available to students and employees with access to laboratory spaces. An electronic copy of this document is to be distributed to all laboratory managers and professors, who shall make it readily available to all members of each laboratory.

2 RESPONSIBILITIES

The responsibilities for certain roles outlined in this section were taken from Appendix A of 29 CFR 1910.1450, which summarizes material from *Prudent Practices for Handling Hazardous Chemicals in Laboratories* (National Research Council, 2011 Edition).

2.1 Chemical Hygiene Officer

The Chemical Hygiene Officer (CHO) serves an important function regarding this plan. The CHO must be qualified by training or experience to provide technical guidance in the development and implementation of the provisions of the CHP required by the OSHA Laboratory Standard. The Director of Environmental Health and Safety shall serve as the CHO.

Responsibilities of the Chemical Hygiene Officer include:

- Creating and revising safety rules and regulations
- Monitoring procurement, use, storage, and disposal of chemicals
- Conducting regular inspections of the laboratories, preparation rooms, and chemical storage rooms and submits detailed laboratory inspection reports to administration
- Maintaining inspection, personnel training, and inventory records
- Assisting laboratory supervisors in developing and maintaining adequate facilities
- Seeking ways to improve the chemical hygiene program
- Developing and implementing University wide components of the CHP to ensure consistent and well documented program procedures and policy decisions
- Assisting department chairs and laboratory managers with risk assessments for hazardous chemicals and procedures
- Working with departmental chairs and laboratory managers to develop specific components of the CHP
- Developing procedures governing the safe procurement, use, and disposal of chemicals
- Assisting departmental chairs and laboratory managers with conducting training sessions for laboratory workers including faculty, teaching assistants, students, visiting scholars, etc.
- Assisting departmental chairs and laboratory managers with required safety audits and the documentation (record keeping) of audits and employee training sessions.
- Advise departmental chairs and laboratory managers on the implementation of components of the CHP and any specific concerns regarding the appropriate use of audits and employee training sessions.

In addition, the CHO will be responsible for knowing the contents of the relevant regulation (Occupational Exposures to Hazardous Chemicals in Laboratories, 29 CFR 1910.1450) and conduct any required updating of the CHP as regulations require, if an incident or accident warrants a change, or at a minimum, on an annual basis.

2.2 Department Chairs

The Department Chairs

- Assume responsibility for personnel engaged in the laboratory use of hazardous chemicals

- Provide the CHO with the support necessary to implement and maintain the CHP
- After receipt of laboratory inspection reports from the CHO, meets with laboratory staff to discuss cited areas for improvement and to ensure timely actions to protect trained laboratory personnel and facilities and to ensure that the department remains in compliance with applicable codes, regulations, and standards of care

2.3 Faculty/Staff/Adjuncts/Laboratory Managers

Faculty/staff who either purchase or recommend the purchase of hazardous chemicals must obtain a Safety Data Sheet (SDS) prior to purchase and/or use of the material in the laboratories. It is also their responsibility to:

- Ensure that laboratory personnel comply with the CHP and the departmental Standard Operating Procedures (SOPs) and do not operate equipment or handle hazardous chemicals without proper training and authorization
- Perform risk assessments for the hazardous chemicals and procedures
- Always wear personal protective equipment (PPE) that is compatible to the degree of hazard of the chemical
- Follow safety rules when working in the laboratory to set an example
- Review laboratory procedures for potential safety problems before assigning to other laboratory personnel
- Ensure that visitors follow the laboratory rules and assumes responsibility for laboratory visitors
- Ensure that PPE is available and properly used by each laboratory member and visitor
- Maintain and implement safe laboratory practices
- Provide regular, formal chemical hygiene and housekeeping inspections, including routine inspections of emergency equipment
- Monitor the facilities and the chemical fume hoods to ensure that they are maintained and functioning properly. Contact the Facilities Department to report problems with the facilities or chemical fume hoods

2.4 Individual Laboratory Workers and Students

Individual laboratory workers are responsible for their own safety, the safety of co-workers, and visitors to their laboratories. Staff must demonstrate this responsibility in their actions and attitudes. Responsibilities include:

- Reading, understanding, and following the safety rules, regulations, and standards of care which apply to the work area
- Planning and conducting each operation in accordance with the CHP and SOPs
- Promote good housekeeping practices in the laboratory or work area
- Notify the Faculty, Adjunct, and/or Laboratory Manager of any hazardous conditions or unsafe work practices in the laboratory area

- Use PPE, engineering controls, and administrative controls as appropriate for each procedure that involves hazardous chemicals

Students participating in laboratory activities involving hazardous chemicals must attend safety training on the first day of lab each semester. The student must then sign a safety contract as a record that they have read and understand the contents of this plan and will behave in a manner that will protect themselves, other lab occupants, and the environment. Students participating in Biology, Chemistry, Physics, and Psychology laboratories and the Art Department will read and discuss a safety contract specific to these departments and sign it. Contact the Laboratory Manager for each department to obtain a copy of the department-specific safety contract.

2.5 Safety Committee

Simmons' Safety Committee (SSC) has three main purposes:

1. Formulate policies and standard operating procedures (SOPs) governing laboratory safety, hazardous materials, laboratory processes, environmental protection, and occupational safety and health
2. Recommend to the Colleges of Arts and Sciences (CAS) Dean policies and SOPs referenced above
3. Monitor compliance at the University with respect to federal, state, and local regulations, University policy, and University SOPs pertaining to the above

The SSC shall be responsible for:

- Recommending policies and procedures for occupational and environmental safety and compliance in laboratories and in other workplaces where hazardous materials are used, including but not limited to education and training, inspection and compliance, containment, waste disposal, and occupational medicine
- Reviewing the relevant safety and compliance programs on an annual basis or more frequently if requested by the CAS Dean
- Recommending policy development or revision when deficiencies in the safety and compliance programs are noted
- Reviewing incident reports submitted by the individual departments or Public Safety as well as any other information or issues pertaining to occupational and environmental safety and compliance in laboratories and in other workplaces where hazardous materials are used
- Establishing subcommittees or ad hoc committees, as necessary, to carry out its overall responsibilities
- Maintaining a written record of actions taken by the Committee

The CHO will report to the SSC about chemical safety matters.

2.6 Buildings and Grounds

The Department of Buildings and Grounds will assist in the testing and repairs of engineering controls, emergency equipment, and other facility related equipment used to contain or eliminate chemical hazards. In addition, this department oversees the hazardous waste contractor.

2.7 Talent and Human Capital Strategy and Public Safety

Talent and Human Capital Strategy, Simmons' Human Resources Department, and Public Safety will assist with emergencies and exposures involving hazardous chemicals.

3 EXPOSURE MONITORING

3.1 Initial Monitoring

Initial monitoring will be performed when there is reason to believe that exposure levels for an OSHA regulated substance routinely exceed the action level or, in the absence of an action level, the permissible exposure limit (PEL) or occupational exposure limit (OEL).

The PELs for OSHA-regulated substances can be found in 29 CFR 1910, Subpart Z.

An OEL is an upper limit on the acceptable concentration of a hazardous chemical in workplace air. It is typically set by the following national authorities:

- American Conference of Governmental Industrial Hygienists
- National Institute of Occupational Safety and Health (NIOSH)

3.2 Periodic Monitoring

Periodic monitoring will be conducted if the initial monitoring performed demonstrates employee exposure over the action level (or in the absence of an action level, the PEL or OEL). Simmons shall immediately comply with the exposure monitoring provisions of the relevant standard. Please refer to Section 14, Medical Services and Surveillance, for more information.

Within 15 working days after the receipt of any monitoring results, the employee will be notified of these results in writing either individually or by posting results in an appropriate location that is accessible to employees.

Simmons' employees with a reason to believe that exposure levels for a substance exceed the action level or, in the absence of an action level the PEL or OEL, may initiate the monitoring process. Monitoring can be requested by contacting the CHO.

4 STANDARD OPERATING PROCEDURES

Uniformity of practice ensures safety and efficiency. These Standard Operating Procedures (SOPs) create a standard of practice that is to be followed by all students, staff, and faculty working in the Arts and Sciences laboratories on this campus. The intent of the SOPs is to assure that work practices and procedures are in place to protect students and faculty from chemical hazards. These standard work practices include risk assessment, hierarchy of controls, general safety-related practices, prevention of spills and accidents, process for chemical selection, selection and use of PPE, personal housekeeping, glassware handling, and electrical safety. Faculty, Adjunct, and/or Laboratory Managers will add SOPs for their laboratories to Appendix B of the CHP.

4.1 Risk Assessment

The department chairs or laboratory managers with or without assistance from the CHO or Director of EH&S will perform risk assessments for the hazardous chemicals and procedures prior to laboratory work. This risk assessment will include the following:

- Identify chemicals to be used, amounts required, and circumstances of use in the experiment
    - Consider any special conditions that could create or increase a hazard
- Evaluate the hazards posed by the chemicals and the experimental conditions
    - The evaluation should cover toxic, physical, reactive, flammable, and explosive, as well as any other potential hazards posed by the chemicals
- Evaluate the potential for additional hazards and risks associated with a reaction
    - For a variety of physical and chemical reasons, reaction scale-ups pose special risks, which merit additional prior review and precautions
- Select appropriate controls to minimize risk, including use of engineering controls, administrative controls, and PPE to protect workers from hazards

One simple approach to risk assessment is to answer these five questions:

1. What are the hazards?
2. What is the worst-case scenario?
3. What can be done to prevent this from happening?
4. What can be done to protect from these hazards?
5. What should be done if something goes wrong?

Refer to Appendix A for the risk assessment for working with hazardous chemicals.

As part of this process, avoid underestimating the risk. References including but not limited to scientific literature and Safety Data Sheets (SDSs) should be consulted to determine the risk. One should assume that any mixture will be more toxic than its most toxic component and that all substances of unknown toxicity are toxic. In addition, one should consider how the chemicals will be processed and determine whether or not a change of states or forms will alter the nature of the hazard.

4.2 Hierarchy of Controls

The hierarchy of controls is based on the premise that the best way to control a hazard is to remove it from the situation, rather than relying on staff, faculty, and laboratory members to reduce their exposure. Below is a traditional hierarchy of controls (listed from most effective to least effective):

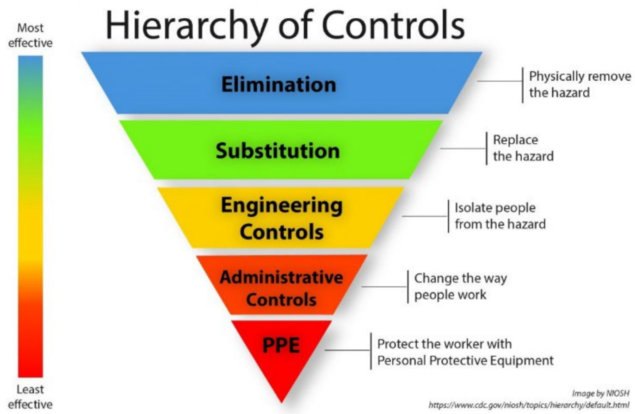


Figure 1 – Hierarchy of Controls

Simmons laboratory and art staff will use this hierarchy of controls to eliminate or reduce the hazards associated with a chemical, process, or reaction.

4.3 General Laboratory Safety Rules and Procedures

Information in this section was taken from Appendix A of 29 CFR 1910.1450, which summarizes material from *Prudent Practices for Handling Hazardous Chemicals in Laboratories* (National Research Council, 2011 Edition).

Some general safety-related practices include:

- Develop and encourage safe habits; avoid unnecessary exposure to hazardous materials by any route
- Be alert to unsafe conditions and see that they are corrected
- Seek information and advice about hazards and always plan and set up equipment before beginning any new operation
- Never perform hazardous operations alone in a laboratory or chemical storage area. Refer to Simmons' Work Alone Policy for details
- Wear appropriate PPE at all times. Section 5 outlines the specific requirements when using PPE
- Minimize exposure to all chemicals. Because most laboratory chemicals have not been thoroughly tested for safety, their toxicity cannot be fully understood. Therefore, it is prudent to implement procedures that will reduce the likelihood of exposure
- Ensure that sources of ignition are not nearby when working with flammable materials
- Smoking, drinking, eating, applying cosmetics, adjusting contact lenses, and taking medications (unless life threatening) are forbidden in laboratories where hazardous chemicals are used or stored
- Do not store food, food containers, or drink containers in the laboratories or laboratory refrigerators
- Do not dispose of food, food containers, or drink containers in the laboratories

- Do not smell or taste any substance
- Do not use mouth suction for pipetting or starting suction
- Do not use damaged glassware. Use extra care with Dewar flasks and other evacuated glass apparatus; shield or wrap them to contain chemicals and fragments should implosion occur
- Use equipment only for its designed purpose.
- Try to avoid using glass Pasteur pipettes due to their potential to break easily
- Keep work area clean and uncluttered
- Clean up work area upon completion of an operation or at the end of the day
- Avoid unnecessary exposure to chemicals by any route (inhalation, ingestion, injection, and/or absorption)
- Do not store dry ice or release hazardous vapors in cold rooms, since these have contained re-circulated atmospheres
- Thoroughly wash areas of exposed skin with soap and water before leaving all laboratories or the Art Department
- Confine long hair and loose clothing
- Do not store flammable materials in refrigerators or freezers that are not rated to do so. The design specifications of approved refrigerators and freezers should employ external electronic components and appropriately rated wiring and components. They should meet or exceed OSHA and National Fire Protection Association (NFPA) safety requirements. Below is an example of the label attached to those refrigerators or freezers **approved** for flammable storage:

Figure 2 – Flammable Refrigerator Sign

- Mercury containing thermometers and devices should be chosen as a last resort, alternate equipment should be used prior to bringing mercury into the facility
- Work in a fume hood or provide adequate ventilation when working with materials that produce hazardous vapors or fumes
- Avoid exposure to gases, vapors, and aerosols. Use appropriate engineering controls or safety equipment whenever such exposure is likely.
- Do not use ice from laboratory ice machines for beverages or to keep consumable food cold.

4.4 Process for Chemical Selection

Before a chemical is selected for use in an operation or process, the Laboratory Manager or designee will:

- Review the SDS and determine potential hazards of the substance
- Determine whether the chemical is placed into one of the following groups. Table 1 provides a summary of the requirements associated with each group and examples of each group.
  - Group 0 – No special requirements associated with the chemical. General rules identified in Section 3.3 apply to the chemical
  - Group 1 – Certain EH&S guidelines beyond the requirements outlined in Section 3.3 must be followed when using the chemical. A chemical requiring air monitoring to ensure an exposure is below its occupational exposure limit and/or permissible exposure limit
  - Group 2 – Chemicals that require notification to the CHO and/or the Director of EH&S when possessed and prior to usage
  - Group 3 – Chemicals that require approval from the CHO and/or the Director of EH&S prior to ordering or purchasing.

Table 1 – Chemical Groups Requirements

Group	Examples	Risk Assessment	Chemical-Specific SOP Required	Chemical-Specific Training
0	Weak Acids, Weak Bases, Buffers	Not Applicable	Not Applicable	Not Applicable
1	Alkali Metals, Azides, Carcinogens, Chromium Hexavalent compounds, Diaminobenidine (DAB), Dimethylbenzanthracene (DMBA), Ethidium Bromide, Formaldehyde, Mercury compounds, Nitric Acid (>40%), Organic Peroxides, Oxidizing Gases, Peroxide Formers, Perchloric Acid, Phenol, Sulfuric Acid, Tamoxifen, Taxol, Titanium Tetrachloride, Water	Not Applicable	Not Applicable	Prior to Use
	Reactive Chemicals			

2	Flammable Gases, Fuming Nitric Acid, Sulfuric Acid, and Hydrochloric Acid, Hydrofluoric Acid, N-ethyl-Nnitrosoures, Organo-mercury compounds, Phorbol compounds	Prior to Use	Prior to Use	Prior to Use
3	Select Agents or Toxins, Chlorine gas, Dioxins, Highly Toxic, Mustard gas, Nerve agents, Nanomaterials or nanoparticles, Neurotoxins, Poisonous gas, Pyrophorics	Prior to Ordering	Prior to Ordering	Prior to Ordering

- If an SOP is required, then ensure the SOP recommends procedures to protect the user from the hazard of the substance (e.g. PPE, engineering control, etc.)
- Use only the chemicals for which the available ventilation system is appropriate. If unsure, contact the CHO
- Determine if safer alternatives are available for the chemicals or the procedure's equipment
- Purchase only the quantity needed for the work planned. Do not purchase materials at volume pricing if the work planned will not utilize all the chemicals purchased. The perceived dollars saved by purchasing in larger volumes will be spent (two-fold) for waste disposal
- The container size of the hazardous materials purchased should reflect the relative hazard of the material (e.g., the greater the hazard, the smaller the container)
- Determine proper storage conditions and if the appropriate facilities exist
- Determine if disposal options exist for the chemical
- Ensure the appropriate engineering controls are available, if warranted. If required, then ensure the engineering control has been certified or tested within the past year to confirm it functions properly before use
- Ensure the appropriate PPE is available and it is in good condition (e.g., no cracks or holes) for use

4.5 Nanoparticles and Nanomaterials

A nanoparticle/nanomaterial (nanoparticle) is any material that has at least one dimension that is less than 100 nanometers. They exhibit unique properties because of their small size and large comparative surface area. NIOSH has studied in detail the toxicity of incidental exposures to nanoparticles generated from processes involving combustion, welding, or diesel engines. However, less is known about nanoparticles that are intentionally produced (engineered) and uncertainties exist as to whether they pose occupational health risks. These uncertainties arise because of gaps in knowledge about potential routes of exposure, movement of nanomaterials once they enter the body, and the interaction of the materials with the body's biological systems.

Results from existing studies in animals and humans on exposure to incidental nanoscale and other respirable particles provide preliminary information on the possible adverse health effects from exposures to similar engineered nanomaterials.

To minimize laboratory personnel exposure, laboratories will institute the following:

- Work in an enclosure that operates at a negative pressure differential compared to the laboratory personnel breathing zone (e.g., a certified chemical fume hood)
- Develop and train applicable personnel on SOPs for the work
- Wear the appropriate personal protective equipment
- Place waste containers within the engineering control
- Seal and label waste containers within the engineering control

4.6 Highly Toxic and Explosive/Reactive Chemicals/Materials

The Chemical Safety Board (CSB) is concerned about the use of highly toxic and explosive/reactive chemicals and materials being used in academic laboratories and the frequency of incidents involving academic laboratories. Below are ways to determine if a chemical is considered highly toxic, explosive and/or reactive:

- Review SDS
- If there is a 3 or 4 rating in the NFPA diamond
- Check the HAZCOM symbols and hazard statements on the container

The following apply to these types of chemicals:

- Maintain a detailed inventory including the following:
    - Date of receipt, amount, location, and responsible individual
- Audit inventory on an annual basis to confirm amounts
- Develop procedures to report security breaches, inventory discrepancies, losses, diversions, or suspected thefts
- Develop SOPs prior to ordering
- Train affected personnel about the chemical-specific requirements prior to use

NOTE: If possible, substitutes for these types of chemicals should be considered prior to beginning work and used whenever possible.

4.7 Compressed Gases

Table 2 provides the requirements when working with compressed gases.

Table 2 – Compressed Gases Requirements

TRANSPORTATION

- Ensure valve protection caps are in place and tight prior to transporting
- Secure compressed gas cylinders in an upright position to an approved carrier for transportation

SAFE HANDLING AND USE

- Ensure that cylinders are clearly identified. Labels must not be defaced or removed. Do not accept or use containers whose content labels are not legible; segregate containers and return them to the supplier. Do not use the container color to identify the cylinder content; do not repaint the container
- Leave valve protection caps in place (if provided) and hand-tightened until cylinders are secured and in use or connected for use. Some types of gas cylinders have valve outlet caps and plugs that form a gas-tight seal. Keep the device on the valve outlet except when containers are secured and connected
- Have gas supplier install the regulator for the gas to ensure proper installation
- Keep cylinder valves closed except when the cylinder is being used. Closing the valve isolates the cylinder's contents from the surrounding atmosphere and prevents corrosion and contamination of the valve. When opening a cylinder valve, stand to the side of the regulator and open it slowly
- Replace protective caps and outlet caps or plugs before returning empty cylinders to the supplier
- Never tamper with or alter cylinders, valves, or safety-relief devices. Do not tighten connections or leaking fittings or attempt other repairs while the system is under pressure
- Do not subject cylinders to artificially low temperatures or temperatures above 125^{o}F. Do not place them next to heat sources or allow a flame to contact any part of the cylinder
- Do not place cylinders where they become part of an electric circuit or use them as a ground during electric welding
- Transfer of compressed gases from one container to another should be performed only by the gas supplier
- Avoid dragging or sliding cylinders. Do not lift cylinders by the caps. Never drop cylinders or strike them against one another or other surfaces

STORAGE

- Group and store compressed gases based on their hazard class
- Provide adequate space or segregate by partitions and post a conspicuous sign that identifies the gas or hazard class
- Label "FULL", "IN USE", or "EMPTY". Ask gas supplier for these labels
- Store in dry, well-drained, ventilated, and fire-resistant areas. Avoid sub-surface storage. Cylinders can be stored in the open but should be protected from the ground or continuous dampness to prevent rusting. Prevent exposure to salt, corrosive chemicals or fumes
- Protect cylinders from damage; do not store on unprotected platform edges; do not obstruct walkways or exits. Use brackets, chains, or straps around the upper third of the cylinder to secure cylinders in storage or in use. Store charged and empty cylinders apart, if possible
- Empty cylinders have residual pressure and should always be handled as if full.

INSPECTIONS

- Inspect for exterior corrosion, denting, bulging, gouges or dings. If found, contact the gas supplier immediately
- Take leaking regulators, cylinder valves, or other equipment out of service. Contact the gas supplier immediately

SPECIFIC GAS HAZARDS

- Oxygen's primary hazard is an oxidizer, which with an ignition source and a fuel, vigorously accelerates combustion. A minimum of 20 feet must be maintained between oxidizers and flammable gases and other combustible materials
- Acetylene and propane are flammable; both are secondarily asphyxiants. Acetylene's "other" hazard is that it may decompose violently under more than 15 pounds per square inch. Store flammables away from oxidizers, open flames, sparks, and other sources of heat or ignition in a well-ventilated area. Storage areas must have appropriate fire protection (fire extinguishers or fire suppression equipment)
- Argon and carbon dioxide are asphyxiants. Asphyxiants (including inert gases) can displace oxygen and may cause suffocation. Atmosphere-supplying respiratory protection is required in an oxygen-deficient atmosphere, which has less than 19.5% oxygen by volume
- Corrosive and toxic gases present serious hazards: keep exposures as low as possible and avoid inhaling or contact with skin or eyes
- Cryogenic liquids are extremely cold and cause thermal burns upon contact with the body. Provide suitable personal protective equipment. Commonly used liquid cryogens include argon, helium, methane, oxygen, and hydrogen. Hazards vary according to the specific cryogen and include explosion or flammability and asphyxiation

4.8 Corrosive Chemicals

A corrosive material is a liquid or solid that is either very acidic or basic. Corrosive materials can leach into metal or skin, destroying it by a chemical action. The potential health hazards include but are not limited to:

- Corrosives may cause severe burns to skin and eyes
- Corrosives may be toxic
- Corrosives may produce flammable gases on contact with metal
- Corrosives may have a violent reaction with water

4.8.1 Handling

When handling corrosive chemicals, the following procedures must be followed:

- Review the SDS for the corrosive chemical(s) you are planning to utilize for an experiment
- Always wear chemical goggles or a face shield with chemical goggles. It is important to note that face shields are not intended to be worn alone, they should be worn in combination with other eye protection. If a face shield is not used, consider using a mask to protect additional areas of the face whenever there is a possibility of splashing

- Wear disposable gloves at all times in the lab. Remember that disposable (latex or nitrile) gloves react with sulfuric acid and give you very little protection from working with organic materials. As a result, consult a glove guide to select proper gloves. Change your disposable gloves frequently and do not attempt to wash and reuse
- Be aware of the nearest eyewash station and safety shower for your work location
- When acids or bases are used, some form of containment to control spills must be employed
- Do not pipette by mouth. Use a mechanical or vacuum-assisted pipette aid.
- When diluting, always add ACID to WATER, never add water to acid**.** Allow the acid to run down the inside of the container and mix slowly by gentle rotation
- Always keep all containers securely closed
- Dispose of corrosive chemicals and wastes according to the instructions on the SDS. Do not pour anything down the drain without prior verification with the CHO
- Be aware of the methods, materials and procedure for cleaning corrosive spills. In the event of a spill beyond your immediate ability to control, notify Public Safety

4.8.2 Storage

When considering the storage of caustic and corrosive materials, the following practices should be followed:

- It is recommended that all chemicals be stored in appropriate storage cabinets when not in use. Refer to Figure 3 for an example of a corrosive cabinet

Figure 3 – Example of a Corrosive Cabinet

- Store corrosives in a cool (room temperature), dry and well-ventilated area away from direct sunlight. If mechanical ventilation is not available, ensure that there is proper air flow available for these materials
- Use storage materials and cabinets that are resistant to corrosion
  - Store corrosive materials near the floor to minimize danger of bottles falling from shelves
- Segregate acids from bases. Store chemicals according to their primary hazard classification

(e.g. flammable hazard takes precedence over corrosive hazard.)

- Isolate corrosives from the following:
    - Organics, flammables, toxic materials
- Separate containers to facilitate handling. Organic acids are to be store separately from strong oxidizing agents to prevent interaction of fumes and corrosion of storage cabinets
- Acid bottle carriers must be used for all containers over one quart in size

4.9 Flammable and Combustible Chemicals

Flammable materials ignite easily and burn quickly. Several examples of ignitable or flammable materials include: gasoline, acetone, and benzene. A flammable liquid or solid material has a flash point under 140 degrees Fahrenheit (°F) or 60 degrees Celsius (ºC). Combustible chemicals are any liquid having a flash point at or above 100°F (37.8 ºC), which have the capability of igniting and burning.

The flash point is the temperature at which a liquid produces enough vapors to be ignited. The lower the flash point, the potential of the chemical's vapors to ignites increases.

Table 3 provides examples of the OSHA classifications of flammable and combustible materials.

Table 3 – OSHA Classifications of Flammable and Combustible Materials

Class – Description	Flash Point and Boiling Point	Examples
Class IA – Highly Flammable	Flash points < 73ºF (22.8ºC) Boiling points < 100ºF (37.8ºC)	Ethyl ether, petroleum ether, dimethyl sulfide
Class IB – Flammable	Flash points < 73ºF (22.8ºC) Boiling point ≥ 100ºF (37.8ºC)	Acetone, toluene, ethanol, ethyl acetate, hexane, gasoline
Class IC – Flammable	Flash points ≥ 73ºF (22.8ºC) Boiling point < 100ºF (37.8ºC)	Amyl acetate, hexane, xylene
Class II – Combustible	Flash points ≥ 100ºF (37.8ºC) and < 140ºF (60ºC)	Formaldehyde, glacial acetic acid
Class IIIA – Combustible	Flash points ≥ 140ºF (60ºC) and < 200ºF (93.3ºC)	Nitrobenzene, benzaldehyde, ethanolamine
Class IIIB - Combustible	Flash points ≥ 200ºF (93.3ºC)	Diesel fuel, kerosene, oil-based paints

In addition to the physical hazards there are potential health hazards. The potential health hazards include but are not limited to:

- Flammables may be poisonous
- Flammables may irritate or burn the skin and eyes
- Flammables may produce a skin irritation or toxic gas when caught on fire

The following procedures must be followed when handling and storing flammable and combustible chemicals:

- Review the SDS for the flammable and/or combustible chemical(s) you are planning on utilizing for an experiment.
- Use small volumes of solvents (100 milliliter [mL] or less) when performing routine tasks. Store larger amounts in approved flammable containers. Never store flammables with reactive chemicals or oxidizers
- Transfer solvents in a working laboratory hood or well-ventilated area. Smoking and open flames are not permitted when handling solvents
- If possible, use solvents at temperatures 10 to 15 degrees below their flash point
- Note the location and type of fire-fighting equipment. Flammable liquid fires are Class B fires. Extinguishers that are effective on class A, B, and C fires are available throughout the University
- Remember that flammable liquids may have other health consequences as well. Prudent practices need to be observed in storing and disposing of flammable liquids
- Dispose of flammable chemicals and wastes according to the instructions on the SDS. If the SDS does not provide specific disposal information, contact the CHO for guidance
- Approved flammable storage cabinets will be needed for laboratories with a large inventory (10 gallons or more) of flammable chemicals
- Ignitable gases **MUST** be **STORED SEPARATELY** from all other materials
- Flammable or combustible liquids should be stored in explosion-proof cabinets. Do not store flammable or combustible materials in ordinary lab cabinets or those designed to store corrosive materials. Figure 4 provides an example of a flammable cabinet

Figure 4 – Example of Flammable Cabinet

4.10 Reactive Chemicals

Reactive chemicals are characterized by their tendency to release large amounts of energy under certain conditions. Since the catalyst for these reactions frequently is found in the normal environment, special precautions need to be observed to safely use and store these materials. Included in this category are explosives, water reactive materials, air sensitive materials, and mixtures of oxidizing and reducing agents

The following procedures outline practices related to the handling and storage of reactive materials:

- Review the SDS for the reactive chemical(s) you are planning on utilizing for an experiment
- Ensure adequate protection against shock, extremes in temperature, other reactive chemicals, and potential sources of ignition
- Segregate oxidizers from reducers. Store reactive chemicals according to their primary hazard classification
- Isolate reactive chemicals from toxic materials and flammables
- Use adequate personal protective equipment. Many reactive chemicals liberate toxic fumes or gases. Small, easily managed amounts must be used in a ducted fume hood

4.11 Toxic Chemicals

Almost any substance in sufficient quantity can be considered toxic. Toxic chemicals are those that damage biological structure and function through exposure or accumulation in tissues. Usually, this involves relatively small amounts of the toxin. For these purposes, a poison will be defined as a substance that may cause death or serious health effects if relatively small amounts are inhaled, ingested or absorbed by the skin. Poisons may be gas, liquid or solid. Always review a chemical's SDS prior to use.

4.11.1 Handling

When handling and storing toxic chemicals, the following procedures must be followed:

- Isolate, segregate, and clearly label all toxic chemicals
- Adequate room ventilation must be provided at the work site area. A fume hood should be used whenever possible
- The appropriate personal protective equipment must be worn as directed by the chemical label or SDS.
- Limit exposure time
- Practice good personal hygiene

4.11.2 Mercury and Mercury-Containing Chemicals

Some of the special considerations that must be given to mercury which is used in the science laboratories at the University include:

- Use care to avoid spills of elemental mercury
- **CLEAN UP SMALL GROSS** spills with a pipette or "Sweeper." Ventilate area well to remove mercury vapors. Large spills (>1 ml) should be referred to Public Safety
- Chronic exposure and absorption of mercury may lead to a metallic taste in mouth, a gray line around gums and neurological problems
- **NEVER PLACE ELEMENTAL OR IONIC MERCURY IN DRAINS**. Contact your supervisor for proper disposal
- Due to its toxicity and difficulty of disposal, the purchase of mercury and mercury containing items (including thermometers) is prohibited
- Also, there are chemicals that contain low levels of mercury which, if discharged, would exceed MWRA waste water discharge limits. One example is bleach

4.12 Carcinogens

A carcinogen is any agent that can initiate or speed the development of malignant or potentially malignant tumors, malignant neoplastic proliferation of cells, or that possesses such material. Known human carcinogens, which are commonly used in colleges, are provided below.

- Benzene
- Cadmium
- Ethylene Oxide
- Formaldehyde
- Methylene chloride
- Vinyl chloride

Carcinogens are hazardous chemicals capable of increasing the risk of cancer through exposure. Carcinogens or potential carcinogens are reported in the following locations:

- National Toxicology Program, "Annual Report of Carcinogens"
- International Agency for Research on Cancer, "Monographs"
- OSHA, 29 CFR 1910, Subpart Z, Toxic and Hazardous Substances

Prudent practices need to be used in dealing with known or suspected carcinogens. Reduce your exposure to these chemicals to the lowest possible level through limited use and/or using an engineering control (e.g., chemical fume hood).

4.13 Peroxide Forming and Shock Sensitive Compounds

Certain substances can form peroxides on exposure to air and light. Included in this category are ethers, liquid paraffins, and olefins. Since these chemicals are packaged in an air atmosphere, peroxides can form even though the containers may not have been opened. They may detonate when disturbed by elevated temperatures, shock, or friction. Thus, extreme care should be used when handling and storing these chemicals. Never use metal spatulas with peroxides. Contamination by metals can lead to explosive decompositions. Always store highly reactive chemicals and high-energy oxidizers in closed cabinets segregated from the materials with which they react and, if possible, in secondary containers. Always store peroxides and peroxide forming compounds at the lowest possible temperature. Below is a list of example potential peroxide-forming chemicals.

- Acetal
- Dioxane
- Diethyl ether
- Ethyl ether
- Tetrahydrofuran

Shock sensitive refers to the susceptibility of a chemical to rapidly decompose or explode when agitated. Shock sensitivity can increase with the age of the chemical. The label and SDS will indicate if a chemical is unstable or shock sensitive. Table 4 provides a list of example materials that can be shock sensitive.

Table 4 – Potential Shock Sensitive Chemicals		
Acetylides of Heavy Metals	Heavy metal Azides	Picramic Acid
Ammonal	Hexanitrostilbene	Picric Acid
Ammonium Nitrate	Hexogen	Picryl Chloride
Ammonium Perchlorate	Hydrazinium Nitrate	Picryl Fluoride
Ammonium Picrate	Hydrazoic Acid	Polynitro Aliphatic Compounds
Ammonium Salt Lattice	Lead Azide	Potassium Nitroaminotetrazole
Butyl Tetryl	Lead Mannite	Silver Acetylide
Calcium Nitrate	Lead Mononitroresorcinate	Silver Azide
Copper Acetylide	Lead Picrate	Silver Styphnate
Cyanuric Triazide	Lead Salts	Silver Tetrazene
Cyclotrimethylenetrinitramine	Lead Styphnate	Sodatol
Cyclotetramethylenetranitramine	Trimethylolethane	Sodium Amatol
Dinitrophenol	Mercury Oxalate	Sodium Picramate

Dinitrophenolates	Mercury Tartrate	Styphnic Acid
Dinitrotoluene	Nitrated Carbohydrates	Tetranitrocarbazole
Dipicryl Sulfone	Nitrated Glucoside	Tetrytol
Erythritol Tetranitrate	Nitrogen Trichloride	Trinitroanisole
Fulminate of Mercury	Nitrogen Triiodide	Trinitrobenzene
Fulminating Mercury	Nitroglycol	Trinitro-*Meta*-Cresol
Fulminating Platinum	Nitroguanidine	Trinitronaphthalene
Fulminating Silver	Nitroparaffins	Trinitrophenetol
Guanyl Nitrosamino	Organic Amine Nitrates	Tritonal
Guanyltetrazene	Organic Nitramines	Urea Nitrate

4.13.1 Handling and Storage

When considering the handling and storage of peroxide forming and shock sensitive materials, the following practices should be followed:

- The immediate work area must be free of ignition sources
- A test for peroxides must be performed prior to the distillation of ethers
- Leave at least 10% bottoms when distilling peroxide forming compounds because most accidents involve a nearly dry residue
- Absorb small spills onto paper towels and place the paper towels in a chemical hood, which is approved for use with flammable liquids
- Such compounds must be purchased in the smallest quantities practical
- The date received and opened must be placed on each container and dated each time it is opened
- If the manufacturer did not add an inhibitor, sealed containers of ethers and shock sensitive compounds must be discarded as hazardous waste after 1 year

- Opened containers of ether or shock sensitive chemicals must be discarded within 6 months of opening
- The chemical inventory should be checked periodically
- Peroxide forming material must be tested at least **every 3 months**

4.13.2 Peroxide Test Strips

Peroxide test strips are commercially available for qualitative and semi-qualitative testing. However, the strips do not have the universality or the sensitivity of the iodide test and have limited shelf life. The test involves a two-step conversion of oxygen into the peroxy group (including hydrogen peroxide, sodium peroxide, sodium perborate, as well as organic peroxides found in diethyl ether, tetrahydrofuran, and dioxane) to a blue oxidation product.

4.13.3 Disposal

Compounds that are suspected of having very high peroxide levels, because of visual observation of unusual viscosity, crystal formation, or age must be considered extremely dangerous. Only a trained professional should move any materials that appear to be unstable. Once an unstable material is found, care should be taken to isolate the area where the material is stored until an expert can be contacted for evaluation.

It is of **UTMOST IMPORTANCE** that the **CONTAINER NOT BE OPENED**. The act of opening the container could denote peroxide crystals around the container cap or other closure. In addition, **DO NOT TEST or treat any peroxide forming chemicals if you are unsure of the age, there are visible crystals, or a precipitate or oily viscous layer is present.**

In general, a trained professional will carefully remove the material, using explosive handling procedures, from the laboratory to a remote area where it can be safely destroyed, preferably by burning. If a remote opening is required, it is likely that the material will also need some form of treatment to render it less hazardous prior to transportation. If this is required, an emergency hazardous waste treatment permit will be required. This permit is obtained from the DEP.

Simmons will utilize a professional disposal company for assistance since the University does not have adequate personal protective equipment or technical expertise for handling potentially explosive substances. Contact Wayne Lamoureux at the Buildings and Grounds Office if an unstable peroxide forming or shock sensitive compound requires disposal.

4.14 Physical Hazards

Physical hazards in the laboratory include but are not limited to combustible liquids, compressed gases, reactives, explosives, flammable liquids, high pressure/energy procedures, sharp objects, and moving equipment. Laboratory personnel should not wear loose-fitting clothing, jewelry, or unrestrained long hair around machinery or moving parts. To eliminate or reduce exposure to these physical hazards, the following are recommended:

- Review equipment’s operation and maintenance manual before use
- Adhere to the safety recommendations provided by the manufacturer

- Do not remove machine guards or alter the equipment unless trained to do so by the manufacturer
- Incorporate safety requirements into the laboratory protocols
- Train laboratory personnel on the proper procedures when working with equipment and these chemicals

4.15 Designated Area

Highly hazardous chemicals, as defined above, may be used and stored only in designated areas. Designated areas may be: restricted access chemical fume hood or other lab location designated for storage or use of highly hazardous chemicals. The faculty, adjunct, laboratory manager, or designee will identify, specify, and communicate the designated location to laboratory personnel.

4.16 Electrical Safety

The large quantity of electrical power needed in many laboratories can create the potential for numerous electrical and fire hazards. The following recommendations are fundamental to a sound electrical safety program in the laboratory:

- Equipment and appliance cords shall be in good condition
- Extension cords shall not be used as a substitute for permanent wiring. If an extension cord is required, it must be UL approved, rated for the job, and in good condition
- Extension cords should not be used inside chemical fume hoods
- Multi-outlet plugs and extension cords shall not be used unless they have a built-in circuit breaker
- Do not attempt to repair or work on electrical equipment. A Certified Electrician must perform all building electrical repairs, splices, and wiring

5 PERSONAL PROTECTIVE EQUIPMENT AND APPAREL

Personal protective equipment (PPE) and personal hygiene are vital aspects of laboratory safety. Wearing appropriate PPE and practicing good personal hygiene will minimize exposures to hazardous chemicals during routine use and in the event of an accident.

5.1 General Practices

The following practices are outlined to protect students, faculty, and staff while in the laboratories (or in the art studios working with hazardous substances); observe the following practices:

- All personnel including students, staff, and visitors in laboratories must wear safety glasses with side shields at all times where eye hazards are a possibility. Goggles or a face shield are recommended when chemical splashes are possible. These must be American National Standards Institute (ANSI) approved. Most standard street-wear corrective lenses do not meet these standards
    - Contacts lenses should never be considered “eye protection”

- If you are required to wear prescription glasses, then obtain prescription safety glasses or wear eye protection over the prescription lenses that does not disturb the prescription lenses or protective eyewear
- Use protective apparel, including face shields, gloves, and other special clothing or special footwear as needed
- Wear a lab coat or apron, cover legs (no shorts or skirts) and feet (no sandals or open-toed shoes), no bare midriffs, and confine loose clothing and long hair. Nylons and/or pantyhose are not recommended because they may melt upon contact with acids or solvents. Canvas shoes are not recommended in the laboratory
- Gloves are essential when working with hazardous substances. The proper gloves will prevent skin absorption, infection or burns. Glove materials vary in effectiveness in protecting against chemical hazards. All gloves are not created equal. Consult the glove manufacturer's compatibility chart
- Do not touch phones, doorknobs, etc. with contaminated gloves
- Do not wear gloves outside the lab. In cases where this may be necessary, consider a one-glove technique that makes one clean hand available to open doors
- Full-face shields with goggles must be worn when conducting a procedure which may result in a violent reaction or a splash. Full-face shields with bottom caps to protect the neck are preferred as they provide the best protection
- Currently, the University does not maintain a respiratory protection program, therefore any use of NIOSH approved respirators must be approved by the Director of EH&S. Use appropriate respiratory equipment when air contaminant concentrations are not sufficiently restricted by engineering controls. Please note: there are many NIOSH approved disposable respirators available on the market. The "NIOSH APPROVED" marking on the device can identify these respirators (absence of the marking indicates that the device is not regulated). Use of this type of respirator must also comply with the OSHA Respiratory Protection Regulations
- Use any other protective and emergency apparel and equipment as appropriate.
- Hands should be washed frequently throughout the day, after glove removal, before leaving the lab, after contact with any hazardous material, and before eating, drinking, smoking, or applying cosmetics. Proper hand washing is essential. The steps to take include:

    - Wet hands under running water and, using soap, wash all surfaces thoroughly, including wrists, palms, backs of hands, between fingers, and under fingernails;
    - Rub hand together for 10 to 15 seconds
    - Dry well with a clean or disposable towel
    - Apply appropriate hand lotion to soothe dry skin

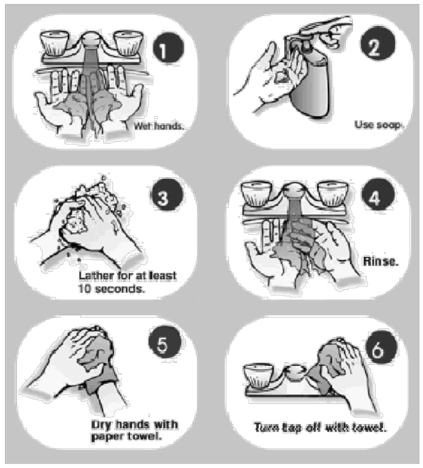


Figure 5 – Proper Hand Washing Technique

Contact the CHO for personal protection equipment selection assistance or information. Table 5 provides a guide to be used when determining when to use PPE and what type of PPE is required for the task involving hazardous chemicals.

Table 5 – PPE Selection Guide by Task

Task/Activity	**PPE**
solids of low or moderate toxicity	Disposable gloves
minimal amounts of liquids (less than 0.1 liters) with acute or chronic toxicity	Safety glasses or goggles Appropriate chemical-resistant gloves
more than minimal amounts of liquids with acute or chronic toxicity (pure chemicals, mixtures or solutions)	Safety glasses or goggles Face shield, if there is a splash hazard Appropriate chemical-resistant gloves Lab coat Corrosive-resistant apron if more than four (4) liters of highly corrosive Flame-resistant if more than four (4) liters of flammable liquids
cryogenic liquids	Safety glasses or goggles Face shield, if there is a splash hazard, or if vials are stored in liquid phase Insulated cryogenic gloves Lab coat Cryogenic apron

potentially-explosive compounds	Safety goggles Face shield Heavyweight gloves Fire-resistant lab coat

pyrophoric (air-reactive) solids or liquids	Safety goggles Face shield Fire-resistant and chemical compatible gloves Fire-resistant lab coat
particularly hazardous substances including carcinogens, reproductive toxins, and reagents of high acute toxicity	Safety glasses or goggles Appropriate chemical-resistant gloves Lab coat Respirators, as needed (DISCUSSING THE MATTER WITH EH&S)

5.2 Cleaning and Maintenance

All PPE must be kept clean and properly maintained. Cleaning is particularly important for eye and face protection where dirty or fogged lenses could impair vision. Inspect, clean, and replace the PPE as needed so that the PPE provides the requisite degree of protection. Laboratory Personnel shall not share PPE until it has been properly cleaned and sanitized. PPE will be distributed for individual use whenever possible.

It is also important to ensure that contaminated PPE which cannot be decontaminated is handled in a manner that protects employees from exposure to hazardous substances and are properly discarded. Speak to the Laboratory Instructor or CHO for guidance cleaning and discarding PPE.

5.3 Outside the Laboratory

PPE is not permitted outside the lab unless transporting a hazardous material to another laboratory. Please remove PPE (e.g., laboratory coats, gloves, etc.) before leaving the laboratory to prevent spreading contamination. Keep a clean, spare coat to wear outside the laboratory. Do not wear gloves outside the laboratory. Use one glove policy when required to transfer chemicals between laboratories.

6 ENGINEERING CONTROLS

Engineering controls are an effective means of controlling hazards in laboratory environments. They do not eliminate hazards, but rather isolate people from hazards. "Enclosure and isolation" creates a physical barrier between personnel and hazards, such as using remotely controlled equipment. Chemical fume hoods (CFHs) and exhaust arms are being used at Simmons to protect against a chemical exposure.

6.1 Chemical Fume Hoods

Laboratory fume hoods are a type of ventilation system with the primary function to exhaust chemical fumes, vapors, gasses, dust, mist and aerosol. Fume hoods also serve as physical barriers between reactions and the laboratory, offering a measure of protection against inhalation exposure, chemical spills, run-away reactions and fires.

A typical CFH has a box like structure with a moveable sash window. Experimental procedures are performed within the hood which is consistently and safely ventilated, usually by means of an extract blower and ductwork. Chemical fumes are exhausted and diluted many times over in the atmosphere and have a negligible effect to human health.

When environmental emissions concerns are of importance, an extract treatment system, often referred to as a scrubber are installed to remove most of the vapors from the exhaust air stream.

CFHs reduce potential exposure hazards to personnel, including contaminant concentrations near the edge of the sash. Any toxic or volatile (tendency of chemical to vaporize) chemical must be used inside of a CFH and according to the SDS and laboratory SOP.

6.1.1 Design

The typical CFH is equipped with a movable front sash and an interior baffle. Depending on its design, the sash may move vertically, horizontally or a combination of the two and provides some protection to the hood user by acting as a barrier between the worker and the experiment.

The slots and *baffles* direct the air being exhausted. In many hoods, they may be adjusted to allow the most even flow. It is important that the baffles are not closed or blocked since this blocks the exhaust path.

The *airfoil* or beveled frame around the hood face allows more even airflow into the hood by avoiding sharp curves that can create turbulence.

Figure 6 demonstrates how a CFH works.

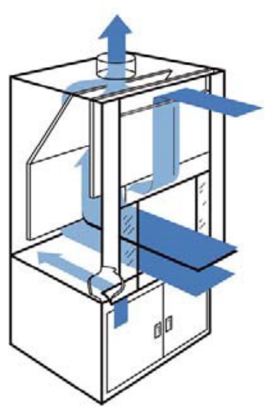


Figure 6 – How a Chemical Fume Hood Works

6.1.2 CFH Types

There are two CFH types:

- **Constant volume** – where the exhaust flow rate or quantity of air pulled through the hood is constant. Therefore, when the sash is lowered and the cross-sectional area of the hood opening decreases, the velocity of airflow (face velocity) through the hood increases proportionally. Thus, higher face velocities can be obtained by lowering the sash.

- V**ariable air volume** – where the exhaust flow rate or quantity of air pulled through the hood varies as the sash is adjust in order to maintain a set face velocity. Therefore, when the sash is lowered and the cross-sectional area of the hood opening decreases, the velocity of airflow (face velocity) through the hood stays the same while less total air volume is exhausted.

Simmons uses constant volume CFHs.

6.1.3 Work Practices

Below are the work practices associated with CFHs:

- As a rule of thumb, use a hood when working with a substance with an OEL or PEL of less than 50 parts per million.
- Never store chemicals or other items in a fume hood.
- Verify that the fume hood is on and functioning properly before use.
- Fume hoods that are not being used for laboratory work should have the sash fully closed and the light off.
- Equipment and chemicals should be placed at least 6 inches from the front of the working surface to prevent emissions from escaping. It is recommended that this be marked with tape as a visual reminder.
- Check to ensure the hood is functioning properly prior to use by putting a Kim wipe where you will be standing. If the Kim wipe is pulled into the hood and there is a current certification, then you are permitted to use the CFH.
- Work should be performed with the hood sash in the lowest practical position. The sash should be placed lower than your neck to help ensure face protection.
- Check certification and restriction labels on hoods before using.
- Never block the fume hood vents.
- Do not alter any fume hood ventilation system.
- Contact the Buildings and Grounds Office (x5-9950 or e-mail at facilities@Simmons.edu) for repair or with alteration questions.
- Always clean the hood when a procedure is completed.
- **DO NOT** use **PERCHLORIC ACID** in **ANY FUME HOOD** unless it is a designated "perchloric acid use" hood.
- Keep all laboratory doors closed. This will minimize crosscurrents, enhance hood performance, and keep odors from spreading throughout the building.
- Minimize pedestrian traffic in front of hoods, especially during an experiment.
- To ensure that the hood is functioning properly, it is recommended that hoods be inspected annually.

6.1.4 Testing Certifications

The CFHs should be tested at least as follows:

- A containment test by manufacturer
- Containment test after installation and prior to use
- Annual velocity and airflow testing
- Performance testing when there is a problem
- Containment testing after significant changes to the ventilation system

The Buildings and Grounds Office manages the CFH testing.

6.2 Exhaust Arms

Another engineering control being used at Simmons is an exhaust arm. An exhaust arm is a piece of flexible duct or hose connected to an exhaust system. Refer to Figure 7 for an example of an exhaust arm. To capture contaminants effectively, it must be closer than approximately one-half a diameter of the exhaust from the end of the hose. Unless the intake for the exhaust arm is placed very close to the point source, it will not provide the appropriate capture. The face velocity of an exhaust arm is 150-200 feet per minute. The velocity and the capture efficiency drop sharply with distance from the intake. Generally, a safe distance is between 2 inches and 6 inches away. In cases where there is a question about efficacy of capture, perform a smoke test to determine if the flow is adequate.

Figure 7 – Example of an Exhaust Arm

7 ADMINISTRATIVE CONTROLS

Administrative controls are changes to the way people work. Examples of administrative controls include procedure changes, employee training, and installation of signs and warning labels. Administrative controls do not remove hazards, but limit or prevent people's exposure to the hazards.

7.1 Hygiene and Housekeeping Practices

Students, faculty, adjuncts, and staff should observe the following hygiene practices:

- Laboratories should be kept clean; chemicals and equipment should be properly labeled and stored.
- Work areas should be kept clean and free from obstructions. Cleanup should follow the completion of any operation or work period.
- Wastes should be deposited in appropriate receptacles. Spilled chemicals must be cleaned up immediately and disposed of properly. All containers, including waste chemical containers, must be properly labeled.
- Chemicals that are no longer needed should be properly disposed.
- Floors should be cleaned regularly since accumulated dust and chemicals can pose respiratory and slip hazards.
- Stairways and hallways must not be used as storage areas.
- Stored items or equipment shall not block access to the exits, fire extinguisher(s), safety equipment or other emergency items.
- Equipment and chemicals should be stored properly; clutter should be minimized.
- Reagents and equipment items should be returned to their proper place after use.
- Contaminated or dirty glassware should be placed in specific cleaning areas and not allowed to accumulate. Broken glass should be disposed of in a manner not to cause injury to you or individuals removing the trash from the laboratory.
- Chemicals, especially liquids, should never be stored on the floor. Proper storage in closed-door cabinets suitable for the material is required.
- Large bottles (2.5L or larger) should not be stored above the bench top.
- Hazardous chemicals should not be stored above eye level, especially corrosive materials.
- Move chemicals into and out of the laboratories using bottle carriers or some means to protect the container if it should fail while transporting them in a common space (e.g. hallway, stairway, etc.).
- Reagents, solutions, glassware, or other apparatus shall not be stored in hoods. Proper air circulation in laboratory fume hoods is compromised when there is excessive clutter in the hood. Return surplus chemicals and equipment to their proper storage location prior to beginning work.

7.2 Handling Glassware

Students, faculty, adjuncts, and staff must use the following practices when handling glassware:

- Only glass in good condition should be used.
- Discard or request repair of all broken, chipped, or badly scratched glassware.
- Forceps or other tools and hand protection should be used when picking up broken glass (Small pieces should be swept up with a brush into a dustpan.) Broken glass should be placed in the **DISPOSABLE GLASS BOXES** that are used in all laboratories. They will be labeled **GLASS ONLY**.
- The ends of all glass tubing should be fire polished. Lubricate tubing with glycerin or water before inserting into rubber stoppers or rubber tubing. If possible, purchase rubber safety stoppers.
- Protect hands with heavy gloves when inserting glass tubing.
- Do not store glassware near the edge of shelves. Store large or heavy glassware on lower shelves.

- Use glassware of the proper size. 20% free space is recommended. 50% free space is recommended when autoclaving.
- Conventional laboratory glassware must never be pressurized. All specialized lab glassware approved for pressurized work, should be protected with plastic netting or electrical tape.

8 DESIGN AND VENTILATION

8.1 Introduction

The three goals of design and ventilation in a laboratory are:

- Safety
- Comfort
- Energy Efficiency

8.1.1 Safety

Laboratories are designed to maintain the health and well-being of occupants. Potentially hazardous substances used in different laboratories include chemicals, radioactive materials and infectious biological agents. These materials can be manipulated daily as part of experiments or research. Safety must remain the primary goal of a laboratory.

Regulations, guidelines and standards to ensure laboratory safety have been published by many industry groups, many of which can be found in Section 16. Complying with those requirements is a primary step in achieving laboratory safety objectives.

8.1.2 Comfort

Laboratory safety is balanced with worker thermal comfort by maintaining appropriate temperatures and air velocities. Worker productivity will suffer if the space is too warm or too cool. Similarly, spaces with high air currents are perceived as drafty and cool. Misdirected air currents also impact safety by limiting containment in fume hoods and other protective equipment.

8.1.3 Energy Efficiency

Laboratories are normally designed as once-through systems, without recirculation. Conditioning, supplying and exhausting the large volumes of air used in laboratories consumes sizeable quantities of energy. Appropriately reducing energy usage has a direct cost savings and helps achieve carbon reduction goals. Laboratories must be designed so that energy efficiency gains do not reduce safety and thermal comfort.

8.2 Laboratory Design

In designing a laboratory, the following factors must be considered:

- Relationship between laboratory and office spaces
- Whether or not the laboratory warrants an open laboratory design or closed laboratory design

- Equivalent linear feet (ELF) of workspace (bench and equipment) – Typical chemistry laboratories are designed to provide 28 to 30 ELF per person
- Laboratory layout and furnishing
- Noise and Vibration
- Safety Equipment
- Utilities
- Americans with Disability Act

When designing a laboratory space, the following steps should be implemented:

1. Planning – Facility, EH&S, design engineers, and users should meet to discuss goals.
2. Pre-investigation –Verify systems including the direct digital control or building automation systems, evaluation components that affect energy use, and verify monitoring systems.
3. Investigation – Benchmark utility and energy use data, analyze trends, and test equipment (e.g., CFHs)
4. Implementation – Select which improvements will be made and prioritize them
5. Handoff – Clearly document information and provide training to laboratory, facility, and maintenance personnel prior to handing over the space

8.3 Laboratory Ventilation

The key concept of laboratory ventilation is air entering the laboratory should exit the laboratory and not be re-circulated into other areas of a building. The inflowing air volume, normally composed of supply air and infiltration, will be balanced with the outgoing air volume, or air exhausted through room exhaust, fume hoods, canopy hoods, biological safety cabinets and exfiltration. All airflows must be accounted for when designing a building with laboratories. In practice, the volume of air supplied into a laboratory is less than the amount of air exhausted, creating negative pressure.

Three drivers determine the required volume of supply air in a laboratory: temperature, exhaust, and ventilation. Temperature-driven laboratories contain equipment to perform chemical analysis or ovens and heating elements to speed up chemical processes. Without an adequate supply of cool air, the laboratory housing this equipment will become uncomfortably warm. Lights, laboratory personnel, and even heat transmitted through the building also contribute to the cooling load of a laboratory. By summing up these loads, it determines the necessary supply air volume for the laboratory. Adjustments should be made if a piece of equipment will not be used simultaneously.

Exhaust-driven laboratory (e.g., teaching) are filled with CFHs, exhaust arms, and/or engineering controls. The air being exhaust by the laboratory must be replaced to prevent excessively negative room pressures within the laboratory and the building.

For laboratories, which have low cooling loads and few, engineering controls, these ventilation-driven laboratories still require high supply air volumes to dilute contaminants. The ventilation rate is expressed in units of air changes per hour (ACH), calculated as the total air volume supplied in one hour divided by the room volume. Common ranges for laboratories' ACHs is 4 to 12 ACH and typically between 6 and 8 ACH in academic research or teaching laboratories.

9 CHEMICAL MANAGEMENT

The selection, purchase and use of chemicals in the laboratory and the cost associated with proper disposal of chemical wastes are linked. According to the American Chemical Society, the cost associated with chemical disposal is on average ten times the original purchase price. Specific requirements associated with certain groups of chemicals are provided in Section 3 of this document.

9.1 Procurement

Minimizing the costs and liabilities associated with chemicals can be achieved by asking the following questions:

- Is the chemical available from another laboratory?
- What is the minimum quantity that will suffice for current use?
- What is the maximum size container allowed in the area where the chemical will be stored and used?
- Does the chemical require specific safety requirements or special equipment (e.g., flammable refrigerator) upon arrival?
- Do shipping and receiving personnel need to be notified of the order and given special instructions for receipt?
- Does the chemical present any security risks?
- Is it a controlled substance?
- Does the chemical require any permits or licenses?
- Is the chemical unstable?

The initial purchase order for a chemical should include a request for a SDS.

9.2 Receiving

Chemicals arrive at Simmons in a variety of ways including commercial package delivery, express mail services, and direct delivery from chemical warehouses. Deliveries of chemicals should be confined to the Shipping and Receiving area, laboratory, or Chemistry Department storage area. Chemical deliveries should not be made to offices since offices are not designed for chemical use and storage.

9.3 Storage

The following are considerations for proper storage:

- Ensure containers are properly labeled in accordance with Simmons' HAZCOM Program.
- Record the date of receipt on each container to assist with inventory management. Refer to Section 3.12 for details regarding peroxide formers and shock sensitive chemicals.
- Ensure containers of solutions are labeled and dated when prepared in accordance with Simmons' HAZCOM Program.

- Segregate incompatible chemicals for proper storage by hazard class not alphabetically.
- Only store chemicals alphabetically within each group of compatible chemicals.
- Store oxidizers, reducing agents, and fuels separately to prevent contact.
- Store hazardous chemicals no higher than eye level and never on the top shelf. Do not overcrowd shelves.
- Install a shelf with an anti-roll lip (3/4-inch) if possible.
- Avoid storing chemicals on the floor or extending into traffic aisles.
- Store liquid containers in unbreakable or double-contained packaging, or the storage cabinet tray should have the capacity to hold the contents if the container breaks or leaks.
- Store flammable and combustible materials in a flammable cabinet. Keep cabinet doors closed. See Section 3.9 for details.
- Store acids in a dedicated acid cabinet. Nitric acid, sulfuric acid, perchloric acid, and chromic acid are strong oxidizers. They may be stored within the same acid cabinet only if they are kept isolated from other acids.
- Do not use a CFH for chemical storage. If you are required to store in a CFH, use a shelf to ensure that the baffles are not blocked to ensure proper air flow.
- Do not store chemicals in a cold room or other storage area with re-circulating ventilation.
- Do not store chemicals under a sink, except for water-soluble cleaning solutions.
- Keep chemicals, especially flammable liquids, away from heat and direct sunlight.
- Inspect chemical containers periodically, at a minimum annually, for deterioration and container integrity.
- Restrict access to chemical storage areas.

Additional requirements for specific chemicals are provided in Section 3.

9.4 Inventory

Laboratory managers or designee are required to maintain a chemical inventory for their laboratory(ies). This inventory should be updated upon the arrival of a new chemical into the laboratory. Chemicals at Simmons are managed using an on-line chemical inventory database. On an annual basis, laboratory managers or designee should audit their inventories to confirm that the inventory reflects what is present in the laboratory.

9.5 Transporting and Transferring

Transportation of hazardous chemicals and compressed gas cylinders associated with laboratories occurs within the Simmons campus. When these materials are transported inside and outside buildings, they may present added concerns for other occupants of the building or the Simmons community. The following are required when transporting hazardous chemicals throughout the Simmons campus:

- Must be in break-resistant secondary containers, placed in a suitable outside container or bucket, or in carts specifically designed for safe transportation;
- Compressed gas cylinders must always be strapped in a cylinder cart with the valve protected by a cap; and

- Containers must be labeled in accordance with Simmons' HAZCOM Program.

When transferring a small amount of a highly hazardous chemical, use an engineering control (e.g. CFH). Refer to Section 3.6 for information regarding highly hazardous chemicals.

10 CHEMICAL WASTE

Safe and environmentally sound management of hazardous waste is an integral part of Simmons environmental management mission. Failure to comply with regulatory requirements can result in significant fines and liability, increased costs, and adverse publicity. Simmons is committed to meeting stringent federal, state, and local hazardous waste regulations. Responsibility for compliance with hazardous waste regulations begins with those generating waste material.

In laboratories, hazardous chemicals that have been used and are no longer needed *may be* classified as hazardous waste. There are numerous requirements, obligations, restrictions, etc., on how waste must be stored, managed, disposed, etc. Although beyond the scope of this program, a brief description of the critical requirements that are relevant to laboratories is provided below.

The Buildings and Grounds Department is Simmons' resource for management and disposal of hazardous waste generated in laboratories. Buildings and Grounds manages the collection, processing, and disposal of chemical waste and provides resources for other hazardous waste and environmental compliance responsibilities.

Accumulation: To effectively manage hazardous waste in Laboratories, Simmons University has established "Satellite Accumulation Areas", (SAA), in each laboratory. SAA's are clearly labeled and delineated and contain bins for storage of containers holding hazardous waste material, pending off-site disposal. Once a hazardous material is no longer needed and will be discarded, **it must never** be discharged to a drain, but must be transferred to an appropriate container and then relocated to the SAA. Once the container is full, notify the Buildings and Grounds Department to arrange for the container's removal to Simmons' Main Accumulation Area. The disposal occurs at an approved hazardous waste management facility.

11 TRANSPORTING AND SHIPPING CHEMICALS

Import, export, and interstate transport of chemicals are subject to requirements and laws from the Department of Transportation that regulate the transport of hazardous materials by rail, air, vessel, and public highway. The guidelines and regulations of the International Air Transport Association (IATA) ICAO also apply when shipping substances by air. Import permit and export permit requirements are regulated by the Bureau of Customs and the Department of Commerce.

Faculty, staff members, or laboratory managers, who may be shipping chemicals internationally or within the U.S., must receive shipping training **PRIOR TO SHIPPING** to comply with these international and federal regulations and guidelines. This training will include information on:

- Properly packaging, labeling and marking the shipment;
- Accurately completing the paperwork;
- Making advance arrangements as needed with the recipient and the carrier; and
- Obtaining any permits needed to import or export chemicals.

Individuals who fail to comply with the regulations may have their shipments refused by airlines or other carriers. They are also at risk for the fines and/or jail terms.

NOTE: It is illegal to carry hazardous materials on an airplane. For example, if you visit another lab and want to bring a hazardous chemical back to your lab, you CANNOT take it on an airplane. You must ship it using a certified carrier.

12 TRAINING

Chemical safety training is required for all individuals, faculty, adjunct, staff, or student, prior to the start of any work in a laboratory or classroom with chemicals. Faculty members are responsible for providing students with information regarding the chemicals present in the laboratory or classroom. Faculty members should work with the CHO or Director of EH&S to schedule any other necessary trainings. The CHO, Director EH&S, Faculty, or Laboratory Manager will deliver a holistic training on working with hazardous materials prior to each semester. Students, faculty and student employees are required to attend.

Additional training, provided by the faculty, adjuncts, or laboratory manager should be specific to the activities conducted in the laboratory or classroom. It should include:

1. Health risks posed by experimental procedures conducted in laboratory or classroom.
2. Chemical waste training and proper disposal methods for chemicals.
3. The existence and location of all areas in the laboratory or classroom that are specified for only certain procedures.
4. The selection and use of PPE appropriate for tasks to be completed in the laboratory or classroom.
5. The proper use of engineering controls and equipment used with chemicals to prevent exposures and spills.

Simmons will maintain written training records containing the names of employees trained, the training provided, and training dates. The CHO or Director of EH&S will maintain training records.

13 MEDICAL SEVICES AND EXAMINATION

Simmons' faculty, adjunct, staff, or student who is exposed to hazardous chemicals has the right to medical examination and follow-up treatment, if the physician deems it necessary, under the following circumstances:

- If symptoms develop that are associated with the chemical(s) to which they were exposed.
- When air monitoring reveals an exposure level routinely above the PEL or OEL.

- Whenever an event such as a spill, leak, explosion, or fire occurs which results in the likelihood of a chemical exposure.

If warranted, a Simmons employee or student has access to an emergency room in one of the hospitals located within the Longwood Medical Area. The following information will be relayed to the physician or emergency room staff:

- Name of chemical
- SDS
- Conditions under which the exposure occurred
- A description of the signs and symptoms experienced by the faculty, adjunct, staff, and/or student.

This information is relayed over the phone or in person, with a follow-up in writing, if necessary. The physician will provide Simmons HR or Student Affairs with required information after medical evaluation or consultation while maintaining patient confidentiality.

The physician must provide a statement in writing to the affected person, stating the person has been seen and whether or not additional restrictions apply to the person. If restrictions are required, then another statement from a physician will be required prior to the faculty, adjunct, staff, or student returning to Simmons. This statement or these statements must be submitted to HR or Students Affairs and a copy of the statement to the Director of EH&S. The physician(s) will maintain the medical records.

14 SECURITY

The areas, which lead into the laboratories, are card access only. In addition, the laboratories are locked when not in use. Lastly, Simmons' Public Safety provides roving security patrols 24 hours/7 days/week.

15 INSPECTIONS

Laboratory inspections are performed in accordance with Simmons Laboratory Inspection Protocol. Contact the Director of EH&S to obtain a copy of the protocol.

16 EMERGENCY RESPONSE EQUIPMENT

To assist in an emergency, Simmons has installed emergency response equipment in the laboratories. This equipment must be accessible at all times (e.g., not blocked by storage). In addition, fire sprinkler and alarm systems have been installed by Simmons. These systems are not discussed in this CHP.

16.1 Portable Fire Extinguishers

Fire extinguishers are provided where required by building, (Massachusetts State Building Code, 780 C of Massachusetts Regulations), or other, applicable life safety codes, NFPA. Simmons uses NFPA 10 - Standard for Portable Fire Extinguishers and OSHA standard, 29 CFR 1910.157, Portable Fire Extinguishers, for guidance selecting, distributing, inspecting, maintaining, and testing fire extinguishers and to train and educate portable fire extinguisher users. Only Simmons trained and authorized employees are authorized to use portable fire extinguishers. Public Safety will visually evaluate extinguishers monthly and Buildings and Grounds will ensure equipment is inspected annually.

16.2 First Aid Kits

First aid kits are not required in a Simmons laboratory due to Simmons' location adjacent to the Longwood Medical Area. If a department decides to have a first aid kit in its laboratories, then the laboratory manager or designee will be responsible for ensuring that the first aid kit adheres to the OSHA and American National Standard Institute's requirements for contents. For more information, contact the Director of EH&S.

16.3 Drench Showers and Eye Wash Stations

Where provided, emergency washing facilities will meet the requirements of ANSI Z358.1, "*Emergency Eye Wash and Shower Equipment*". Simmons will reference the latest edition of ANSI Z358.1 when installing new or modifying existing emergency washing facilities for the proper selection, installation, and maintenance of this equipment. Emergency washing facilities are provided in locations where the eyes or body of an employee may be exposed to "corrosive" materials. All such facilities will be located where they are easily accessible in an emergency.

16.4 Inspections

Simmons conducts periodic functional evaluations of designated exposure control and safety equipment to ensure that they maintain the designed level of capability.

Table 6 – Safety Equipment Inspections

Equipment	Frequency	Responsibility
Eye Wash Stations	Weekly	Designated person within the department
Emergency Showers/Eye Wash Stations	Prior to each semester	Buildings and Grounds
Fire Extinguishers	Annual	Buildings and Grounds
Fire Extinguishers (Visual)	Monthly	Public Safety
First Aid Kits	Monthly	Designated person within the department

17 STANDARDS, REFERENCES, AND REGULATIONS

The following standards, references, and regulations were reviewed or used to develop this CHP:

- *Chemical Hygiene Plan*, Emmanuel College, June 2004, updated annually
- *Chemical Hygiene Plan,* National Institutes of Health, March 2014
- *Highly Hazardous Chemicals Standard Operating Procedure,* HIM/NRB EH&S Webpage, http://www.himnrbehs.com/himnrbehs/pdf/Highly.Hazardous.Chemical.List.Final.pdf, viewed December 1, 2014
- *Laboratory Safety Standard,* 29 CFR 1910.1450, viewed December 1, 2014
- *Laboratory Design Handbook*, TSI, 2014
- *Laboratory Ventilation ACH Rates Standards and Guidelines,* Aircuity, January 3, 2012
- *Pocket Guide to Chemical Hazards,* NIOSH, September 2005

- *PPE Selection Guide by Task,* Harvard University, May 9, 2013
- *Prudent Practices in the Laboratory – Handling and Management of Chemical Hazards,* National Resource Council, 1995 updated 2011
- *Recommendations for Chemical Protective Clothing Database,* NIOSH, http://www.cdc.gov/niosh/ncpc/ , viewed December 1, 2014
- *Subpart Z – Toxic and Hazardous Substances,* 29 CFR 1910, viewed December 1, 2014

APPENDIX A

RISK ASSESSMENT

APPENDIX B

STANDARD OPERATING PROCEDURES